Meena

Proceedings
of
Jaffna Science Association

Presidential Address
Sectional Chairpersons' Addresses
Theme Seminar Presentations
Review and Popular Lecturers

Volume : 17 No : 02

Seventeenth Annual Sessions
21-23 April 2010
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Editor's Review

The Jaffna Science Association, an NGO, was established in 1991 by the founder President late Prof.A.Thurairajah with the primary objectives such as dissemination of scientific knowledge among the intellectuals in Jaffna region, encouraging national as well as regional research studies and presenting them in the Jaffna society and advancement of scientific knowledge among the secondary school students and at the undergraduate level. With these primary goals, the Association has conducted seventeen Annual Conferences under the guidance of seventeen executive committees throughout the completed two decades of services.

Every year, specific themes relevant to the region depending on the socio-cultural, socio-economic, and socio-political dimensions dominated the situations were identified and focused. With the guidance of the executive committees several seminars, workshops, popular talks etc. relevant to the themes were conducted. The Annual Conferences too focused with themes seminars, popular talks, review lectures and Sectional Chairmen addresses from all four sections of the Association, which are published in the proceedings of the Association.

The present eighteenth executive committee has arranged its eighteenth Annual Conference during 6-8 April 2011 and undertook the responsibility of publishing the presentations held in the seventeenth Annual Conference held during 21st -23rd April 2010. The manuscripts submitted by the contributors as presented in the conference have been compiled, organized and appropriately edited in this volume of release.

It is my great pleasure in releasing this volume of the proceedings of addresses delivered in the Seventeenth Annual Sessions of the Jaffna Science Association held on 21st, 22nd and 23rd of April 2010.

Prof.C.Elankumaran
Chief Editor / JSA

Department of Economics,
University of Jaffna.

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Health and Traditional Food in Jaffna

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1. Introduction

Nature has its own mechanisms to cater the needs of all organisms which are part of its biosphere. Human beings deviated from their life pattern which had gone with the nature ever since where their thought processes advanced to a level at which they were able to manipulate their environment to suit their needs.

This has its inevitable impacts on nature and on the course of event in the human history. Population boom and the resultant urbanization along with industrialization caused considerable damage to the nature and also caused scarcity of resources. This made the man to seek ways and means to fulfill his needs and man became more dependent on artificial means to fulfill his needs.

In the Ancient time's human was also fed by the surrounding environment. With time experiences have led to strengthen human himself to make/modify an environment to supply food periodically with less effort and injuries. The food items supplied by the natural/modified environment were adopted and tolerated by the systems of the human body and made them healthy. So a particular people in an environment were happy with rice, some people in another environment were happy with wheat and some others in a different environment were happy with potatoes/meat.

Those food items consumed by a particular group of people of a territory/region became as their traditional food. As these traditional foods were received from the same environment of the people, it makes them healthy. Globalization makes the things to cross the barriers and food also has no exception. So food made in a different environment can reach a different environment and this may increase the susceptibility of individuals to diseases.

With evolution, the role of cortex of brain in controlling the parts of the brain responsible for the "eating/hunger" and human habits is remarkable in socialization/civilization. Though it helps a lot to control the urge of eating in scarcity of food, indirectly it helps to the multinational companies to modify the preference and eating habits of people by advertisements. This may lead the people to prefer the readymade food than the traditional food.

This has paved way to new diseases because of the constituents of those food items and their proportions. For example most of these readymade food items contains high levels of fat and sugar and often contain preservatives which might cause problems to human health.

In other words food items from the same environment act as medicines and prevent diseases. The readymade food items lead to diseases and people ingest medicines as part of their food.

2. Why do we eat?

Most people eat to stop hunger; considerable amount of people consume food to enjoy the eating or to get pleasure; at the same time around same number of people could not get things to eat even to stop hunger. But every person should eat balanced diet to have a healthy life.

- **Health**

Health is an optimum state of physical, mental, social and spiritual well-being of an individual. So our daily diet should help us to achieve it.

- **Balanced diet**

Balanced diet is a diet with the correct quantity and quality of nutrients/components needed for the individual according to his/her age, sex and level of function.

3. Basic Components (and Functions) of the Food

Different kinds of food contain different types and amount of nutrients. The current science has revealed the following basic nutrients and their important functions.

✓ **Water**

This is the main component of most natural food. In the body it functions as a medium of (biochemical/physiological) life.

✓ **Protein**

This is the main component of most dried natural food especially of animal origin. It provides the elements for structure and function of the body. During starvation it is also used as source of energy.

✓ **Carbohydrate**

This is the main storage food of plants and animals. This is the usual source of energy. Some complex carbohydrates also form some structures of the body.

✓ **Lipid**

This is also stored in plants and animals. It is a source of energy and basic components of some structure, helps as a medium and takes parts in some functions.

✓ **Vitamins**

These are several types of micronutrients and help in cellular functions.

✓ **Minerals**

There are different types of minerals which are micronutrients and help in cellular functions and in formation of some structures.

✓ **Fibers**

There are several types of fibers and they help in several functions. The main health benefits of dietary fibers are:

- Fiber adds mass to the feces and reduces constipation and its complications
- Prevents diverticulitis.
- Reduces obesity.
- May reduce cholesterol.
- May control blood sugar.
- May prevent cancer of the large intestine.

✓ **Others (artificial addictives etc.)**

These are chemicals with no nutritive value. They help in preservation and attraction of food.

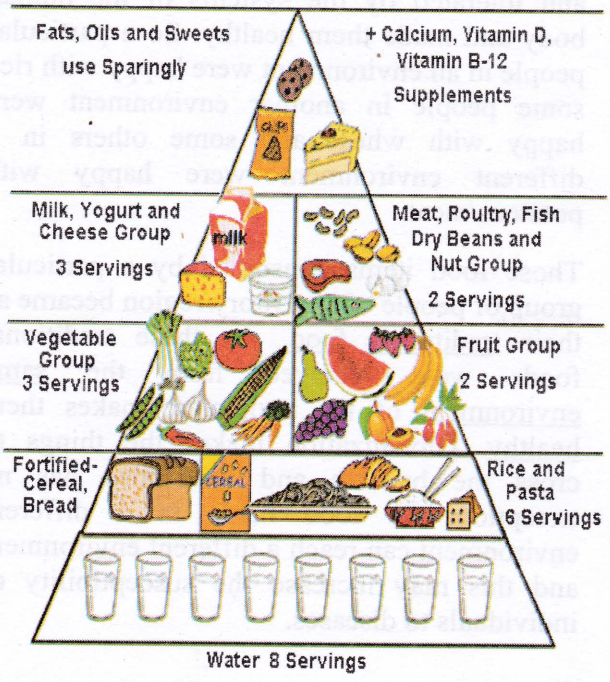
- **Nutrition**

Nutrition is interpreted as the study of the organic process by which an organism assimilates and uses (Process of Ingestion, Digestion, Absorption and Utilization) food and liquids for normal functioning, growth and maintenance and to maintain the balance between health and disease. It also included the idea of an optimal balance of nutrients and whole foods, to enable the optimal performance of the body.

If the Nutrition is not maintained it leads to diseases, Directly-nutritional problems or Indirectly-communicable and non-communicable diseases.

4. Healthy Food Vs Risky Food

So to prevent any disease it's important to have healthy meal daily. A diet with adequate protein, Less/sufficient carbohydrate, Low fat, high fiber and adequate vitamins will be healthier than a diet with Low fibre, Energy dense, Low anti oxidants and Preserved food. The following figure shows a healthy food pyramid. Here, one serving is equal to 200ml.



5. The Current Food Consumption Pattern in Jaffna

Though all know that our eating behavior has changed a lot the following table from a recent study revealed that it was very unhealthy / risky.

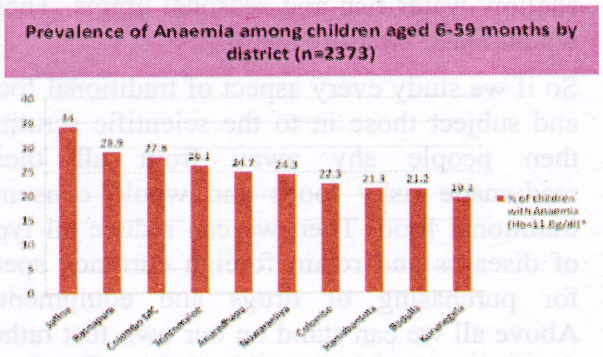
Food item	Number and (%) of subjects with failed* food domain				
	Male (N=363)		Female (N=437)		P value
	No	%	No	%	
Dietary fiber					
Vegetable	81	22.3	76	17.4	0.83
Fruits	158	43.5	153	35.0	0.01
Grain products	29	8.0	18	4.1	0.02
Pulses and legumes	219	60.3	253	57.9	0.48
Energy –dense food					
Milk and dairy products	15	4.1	11	2.5	0.20
Whole egg and products	53	14.6	59	13.5	0.65
Red and processed meat	18	5.0	17	3.9	0.46
Deep fried food	16	4.4	10	2.3	0.10
Commercially baked food	15	4.1	11	2.5	0.20
Sugar and sweet items	321	88.4	379	86.7	0.46
Preserved foods					
Preserved foods	22	6.1	25	5.7	0.74
Antioxidants contain food items					
Beta Carotene	210	57.9	246	56.3	0.66
Fish and fish products	73	20.1	98	22.4	0.42
Plant derived oestrogen products	69	19.0	92	21.1	0.47

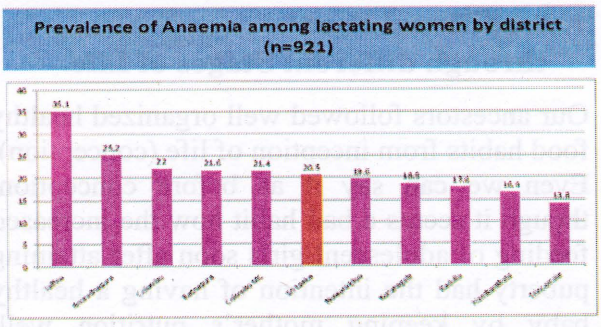
*For food domains related to dietary fibre and antioxidents inadequate consumption is categorized as failed. For food domains related to energy dense and preserve food over consumption is categorized as failed.

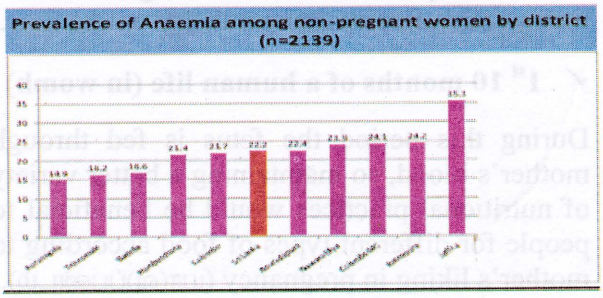
Source: Surendrakumaran, 2010

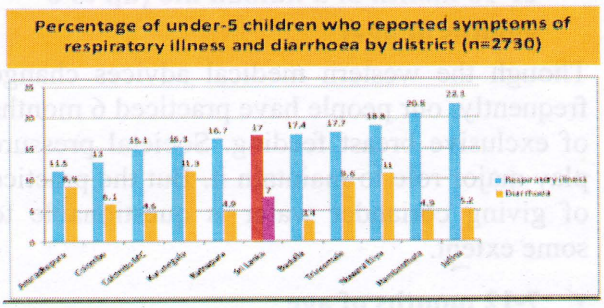
Current nutritional status

The effects of the above unhealthy behavior have been revealed in another study done by Medical Research Institute (MRI, 2010). It is as follows.









The respiratory illness and diarrhea are being taken as proxy measures of micronutrient deficiency like vitamin A, iron and Zinc as well protein deficiency.

6. Current / Past Non-Communicable Dïsease Epidemiology

The following table shows the trends of some common non-communicable diseases (Cases per 100,000 population) mainly due to un-healthy diet and lifestyle.

Diseases (Hospital Admission)	1965	1983	2000	2007
DM (நீரிழிவு)	NA	NA	205	307
HT (உயர் குருதி அழுக்கம்)	129	336	428	470
IHD (இதய சுற்றோட்டகுறைவு)	NA	NA	313	427
Malignancy (புற்று நோய்)	122	134	260	329

All the above evidences show in the past people eat healthier diet and have a healthy life style when compared to now.

7. Traditional Food through different Stages of Life.

Our ancestors followed well organized healthy food habits from inception of life (conception). Even we can say it as before conception, though it seems a bad habit now the increased feeding of adolescent girls soon after attaining puberty had the intention of having a healthy baby by keeping mother's nutrition well. Because in past most adolescent girls used to marry soon after attaining puberty unlike now.

✓ 1st 10 months of a human life (in womb)

During this period the fetus is fed through mother's blood, so maintaining a better variety of nutritional practices would be beneficial to people for different types of food according to mother's liking in pregnancy (யா(வு)ப்பண்டம்).

✓ 11-16 month of a human life (up to 6 months of age)

Though the western medical advices change frequently, our people have practiced 6 months of exclusive breast feeding. Societal pressure play major role to maintain it. But the practice of giving coriander water is questionable to some extent.

✓ 7-12 months of age

At the completion of 6 months of age the initiation of complementary feeding will be celebrated as a ceremony and the 1st feeding will be given by the uncle (mother's brother). But it affects the child if the ceremony is delayed due to astrological reason. After 1st feeding different food items will be introduced to the child. In Most of the houses food is cooked separately for the child. They feed a special locally prepared cereal mix which is high nutritive. And with the eruption of 1st tooth they celebrate a ceremony by preparing a special sweetened nutritive food "kolukkaddai" which is made up of locally available legume, grains and sugar. But some people restrict introduction of new food due to some beliefs ("hot food", "cold food", "mantham" etc.).

✓ 13-60 months of age(1-5years)

This period strengthens sustained ingestion of previously introduced food items. By introducing different native food and fruits from cultivation, farm, water source and living environment children are fed with almost all macro and micro nutrients. Grains with sufficient protein, rich in carbohydrate, fibres and several micronutrients are fed (வரகு-புர.8.3 காபோ.66 நார் 09 அரிசி(நெல்)- புர.7.5 கா.77 நார் 0.6 சோளம் குரக்கன் சாமை. Legumes with high protein, carbohydrate, fat, fibres and several micronutrients are also fed (பயறு எள் கச்சான் உழுந்து கௌபி முதலியவை). Likewise sea foods which have high protein and good fat are available almost all days and children are fond of their taste.

✓ 6-18 years of age

With the above this age group has the freedom to access their environment and they used to enjoy the seasonal products especially fruits (மா வாழை பலா தேசி தோடை பனை விளாத்தி பப்பாசி இலந்தை இலுப்பை ஈச்சை நாவல் நெல்லி கொய்யா வேம்பு கத்தாப்பு...).

✓ 19-45 years of age

This age group is engaged in family or prepare them for a new family with some type of income, so they have the power to choose and they used to enjoy different recipes of food(கூட்டாஞ்சோறு கொழுக்கட்டை கூழ் கஞ்சி. வடகம் ஊறுகாய் மிளகாய்ப்பொரியல் தயிர் மோர் சம்பல் பால் மிளகாய்த்தூள்க் கறி தாம்புலம் தரித்தல்). At the same time they are exposed to more risks like hot/spicy foods, high sugar intake and betel chewing.

✓ 46-65 years of age and Above

In the past most of our people were manual workers. During this period they were less productive and relatively economically unstable and their anatomy and physiology have not enough to stand all types food items. So they used to consume less but mostly depend on items locally available like palmera products, shallow water fish and seasonal grains. These would make their life healthy.

So if we study every aspect of traditional food and subject those in to the scientific scrutiny then people shy away from all these readymade risky foods and would consume traditional food. Then we can reduce all type of diseases and retain foreign currency spent for purchasing of drugs and equipments. Above all we can stand on our own feet rather than expecting ships and containers for food.

Vulnerability Assessment of Water Resources - An Effective Tool for Ground Water Management

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1. Introduction

Groundwater resources are being managed much more aggressively and resulting depletion of groundwater in Jaffna Peninsula. Also groundwater quality is deteriorating year by year due to several man made actions and natural influences (Rajasooriyar *et al.*, 2002). De Vries and Simmers, 2002 said that groundwater is often the only water sources, is vulnerable to contamination and is prone to depletion. Also they specifically stated that unconfined aquifers are often the most readily available and affordable source of water in semi arid and arid regions and these aquifers are most susceptible to depletion and contamination with the recharge.

The fresh groundwater is an important natural resource. Hence protection from the contamination sources and management of fresh available groundwater is emerging as important task in many region of the world. The term aquifer vulnerability describes the intrinsic characteristics that determine the sensitivity of an aquifer to bring adversely affected by an imposed contaminant load. Simply aquifer vulnerability is the probability of groundwater pollution in the event of a pollutant is released at the ground surface. Susceptibility is a qualitative measure of the relative ease with which a groundwater can potentially be contaminated by anthropogenic activities. Hence the demarcation of groundwater protection zones are necessary to protect the areas which will act as recharge zones for the aquifer. These zones will be considered as sensitive zones and the activities such as the groundwater extraction beyond safe yield, establishing a negative groundwater balance, and possible contamination causes should be avoided for better management of the aquifer.

In the absence of quality and quantity of groundwater, no reliable decisions could be made for the present and future behavior and use of the groundwater resources. Water quality and quantity are interdependent and should be managed in an integrated manner, which is consistent with management approaches. Therefore development of conceptual methodology for groundwater management based on assessment of quality and groundwater balance of limestone aquifer is imperative for arriving conclusions for better management.

2. Conceptual Model

The importance of groundwater assessment and the need for groundwater protection measures was highlighted by De Silva and Hohne, 2005 in a study in Tanum Municipal area in Sweden. They analyzed chemical properties of the groundwater and explained the possible contamination sources of pollution. According to De Silva and Amarasinghe (2006) the vulnerability areas were identified in Vavuniya district to assess agro well water quality for the use of agriculture and domestic purposes and it could be used to better management and conservation of the groundwater. In 2008, Ratnayake and De Silva conducted a study in Hambantota which is dry area where people use dug wells to meet their domestic use. In this area three main problems have been reported such as water scarcity, poor quality of water and salinity. Results of vulnerability study showed that precautions have to be taken when using well water during the wet season as the rainfall flushed the solute in the soil zone to the groundwater.

In all studies, the following parameters; physio chemical parameters and fecal coliform, seasonal variation or fluctuation of above parameters and compared with those of Sri

Lankan drinking water standard, occurrence of lineaments, areas with basement rock outcrop, location of suitable water bodies, recharge amount, shallow depth to groundwater, groundwater balance, proximity to contamination sources such as closeness to sea, near to pit latrines, agricultural lands, live stock raring areas industrial landfills, solid waste disposal places and mining activities were considered. Major three aquifer vulnerability areas were identified with above said parameters and areas were mapped considering the factors that would increase the risk of aquifer pollution. Finally they delineated three aquifer vulnerability areas based on the available quantity and quality data for different groundwater potential areas to formulate guide lines and policy aspects to avoid environmental hazards to groundwater resources.

3. Delineation the area

The aquifer vulnerability areas was mapped with all the measured data such as physical and chemical characters of the groundwater by critically examined with Sri Lankan drinking water standard and grouped into three classes such as aquifer vulnerability area 1 (AVA 1), AVA 2 and AVA 3. Some characters used to classify AVA 1, AVA 2 and AVA 3 were greater than permissible level of Sri Lankan drinking water standard, between permissible to desirable level and below the desirable level and shown in table 1 as example. In case of other well physical characters, correlation between the character and chemical parameter values were checked and if it is sensitive, well physical characters are included. Other physical parameter limits are shown in table 1. Accordingly all the wells are grouped into three groups and same representative areas of each group is marked by over laying.

The usage of identified aquifer vulnerability area is for the selection of suitable location for water supply schemes, extension of agricultural activities and urbanization. Suppose if a well location needed for water supply then area under AVA 3 could be recommended and for the development activities and urbanization the area under AVA 1 could be recommended. The stress on groundwater is due to abstraction of large quantities of groundwater through pumping for irrigation which threaten the sustainability. Groundwater balance studies shows the over extraction from the aquifer. It is advisable to extract the groundwater at maximum of 50% of the recharge. The flow chart 1 explains how groundwater resource could be managed without over extraction. Abstraction of groundwater could be minimized by introducing modern water saving such as providing sufficient micro irrigation system drip and sprinkler to the farmers. In some areas water conservation will not reduce groundwater use to the safe yield of 50% of the normal recharge of the aquifer and land use changes with reduction in cultivable extent will be inevitable. Further recommendation is crop diversification by adopting low water consumption crops during water shortage period.

Table 1: Critical conditions of each characterized group

Parameters	AVA 1	AVA 2	AVA 3
Nitrate – N (mg/l)	>10	8 - 10	< 8
Chloride (mg/l)	>1200	1200 – 200	< 200
EC (µS/cm)	> 3500	3500 – 1500	< 1500
Total hardness (mg/l)	> 600	600 – 250	< 250
Proximity to latrines (m)	< 10	10 – 15	>15
Proximity to Agricultural area (m)	< 5	5 - 100	> 100
Proximity to Animal shed (m)	< 10	> 10	> 10
Proximity to Lagoon (m)	< 1000	> 1000	> 1000
Proximity to Ponds (m)	< 100	> 100	> 100

The flow chart 2 explains the methodology to identify the different aquifer vulnerability areas with the recommended management aspects. The wells grouped into AVA 3 were with very good physical and chemical groundwater quality and with good physical conditions. Hence only the conservation is important in these areas. The groundwater from AVA 1 was not satisfied for the drinking purposes or wells were in a critical situation. Hence management through bioremediation and best management practices are recommended. But AVA 2 was in between the critical and good condition. Hence both management and conservation practices are recommended to improve the conditions of the well.

4. An Example for AVA3

The Puttur well was famous even a century ago, for the earliest scientific investigations and report available data back to 1896. It was noted that the Puttur well presented such greatly abnormal features with regard to depth, volume and other characteristics. Pumping tests were carried out in June 1826 and pumping for 12 hours did not make any depression in the water level of the well. The formation of the interior of the cavern has not been explored. It is stated that it extends to the unknown distance beneath the root and sides of the well. Again observation were made in 1890, the following measurements North, South, East, West and Centre of the side of the well depth were 145, 120, 136, 121 and 130 ft respectively. In 1894, water at varying depths from 10 ft to 80 ft were collected and were send to chemical analysis to England. The result indicates that the water was fairly good and able to drink after filtration.

Pumping test were again carried out in 1896, and 388,000 gallons of water were pumped daily between 18th August to 27th October with following breaks 27th 28th August, 3rd, 4th, 21st and 22nd September, 1st 17th and 25th October 1896. The conclusions from the test were that the salt water level remained unchanged and the fresh water level dropped only 3 inch. The test seemed to show existence of apparently inexhaustible stores of fresh water at the site. The depth to brackish water was observed as 80 ft and definitely fresh water was up to 70 ft below the surface level. Again in 2008, the electrical conductivity was measured from the top to 50 m vertical depth and change of electrical conductivity value was observed at the depth of 25 m which indicates that presence of fresh water up to 24 m (Mikunthan *et al.*, 2008) as 130 ft, the sample of water was brine impregnated with sulphurated hydrogen. This observation made that there was no indication of the tidal action influenced the water level (Arumugam, 1974).

All these tests indicate that the water source present in the Puttur well was AVA 3 group and conservation is needed to this area.

5. Management aspects in water balance

Efforts should be initiated to tap the surface runoff water by creating and renovating storages at suitable sites to increase the recharge. Conjunctive use of the surface water from the main land for water supply and groundwater for agricultural activity with water conservation practices will help to arrest the progressive decline in groundwater aquifer and for successful management. Amount of groundwater could be saved and over extraction could be limited by adopting micro irrigation system. Restrictions to construction of new wells and usage of high power mechanical water pumps, limit the duration of extraction of water and allow for recovery of well and constructing rainwater reservoirs in public places are some of recommendation to have positive storage in the aquifer. Rainwater harvested from roof can be passed through filter bed and made to percolate underground to recharge groundwater. Percolation tanks or small storage structure could be constructed across natural streams to collect spread and impound surface runoff to facilitate infiltration and percolation of water. Formation of Institution of a groundwater regulatory frame is recommended for successful sustainable groundwater management. The proper maintenance of wells such as cement lining of wall, extension wall above the soil surface to prevent the inflow of surface runoff, and removal of vegetation around the well are important.

6. Best management practices

Improving of nitrogen management in agricultural production is the main approach to reduce the nitrate leaching. The strategy is to increase the nitrogen efficiency in agricultural production as a way to reduce nitrate losses mean while support the plants with adequate nitrogen for better yield. The increase in efficiency can be achieved through the rationalization of each step of production by implementation of the Best Management Practices (BMP). The activities aimed to mitigate the nitrate leaching from agricultural soils. Sivasakthy and Gnanavelrajah, 2009 stated that nitrate leaching loss was highest in urea treated plots and significantly reduced in organic manure treatments. Locally available nitrification retarders such as neem and *Lantana camera* leaf powders have the potential to reduce groundwater pollution by nitrate due to intensive agriculture. BMP are crop rotation, rates and time of fertilizer and manure application, spot application, usage of slow releasing inorganic fertilizers, bio intensive gardening, pot culture, and organic farming and ban inorganic fertilizers during unfavorable conditions. Promotion of crop diversification is another method to increase the nitrogen efficiency.

Bawatharani *et al.* (2004) stated that N fertilizer applications should be recommended with the appropriate irrigation rates since the fertilizer application and irrigation had a significant effect on nitrate leaching. Introducing the micro irrigation system promotes water use efficiency and it reduces the leaching of ions from the soil profile. Premanandarajah *et al.,* 2003 reported that the addition of organic manure increases nitrogen retention capacity and reduces nitrate loss by leaching in sandy soils, therefore crops can efficiently utilize the applied fertilizer and residual N will remain in the soil for next crop. Concept of nitrogen fertilizer management and prevention of groundwater pollution from nitrate was explained by above studies. Usually BMP do not limit the yield or farmers benefit and in many cases increase both. In addition to BMP, this problem could be easily solved or improved through education and creating awareness among farmers.

7. Bioremediation

Bioremediation is one of the most promising frontiers of environmental research. It is the use of natural to breakdown or degraded hazards substances into less toxic components and thus repairs environmental damage. The high level nitrate-N in groundwater was observed in Kalpitiya peninsula, Sri Lanka where the research was carried out successfully to reduce the nitrate levels from the groundwater. The immediate area around the well was planted with several deep rooted mostly native species of trees. They were planted in a dense manner so as to form a root mat below the surface. The main objective was to facilitate the uptake of the contaminants by the roots of the trees. Some of the species used were *Terminalia, Madhuca, Manilkara, Diospyros, Berrya, Pongamia, Casuarina* and *Pisonia*. In addition to cleaning the well water, provide an income, food, medicine, fire wood and biodiversity. The efficacy of bioremediation was evaluated by conducting tests on the water. The same principle could be applied in the area to see the possibility of application in the field since the area has higher nitrate-N.

8. Summary

Groundwater resources need proper management strategies for sustainability. Identification of aquifer vulnerability area is important to recommend suitable management strategies according to the vulnerability. The explained methodology could be successfully used to identify the vulnerability area by measuring physical and chemical characters of the groundwater quality, groundwater balance and with the physical condition of the well. Also the conceptual model based on the groundwater balance could be adopted to arrest negative groundwater balance. The methodology could be used to develop the vulnerability zones and protection zones measures for groundwater in other part of the Sri Lanka to introduce proper management and conservation practices. However the success of the groundwater management programme will

depend on the community awareness regarding the risk of health.

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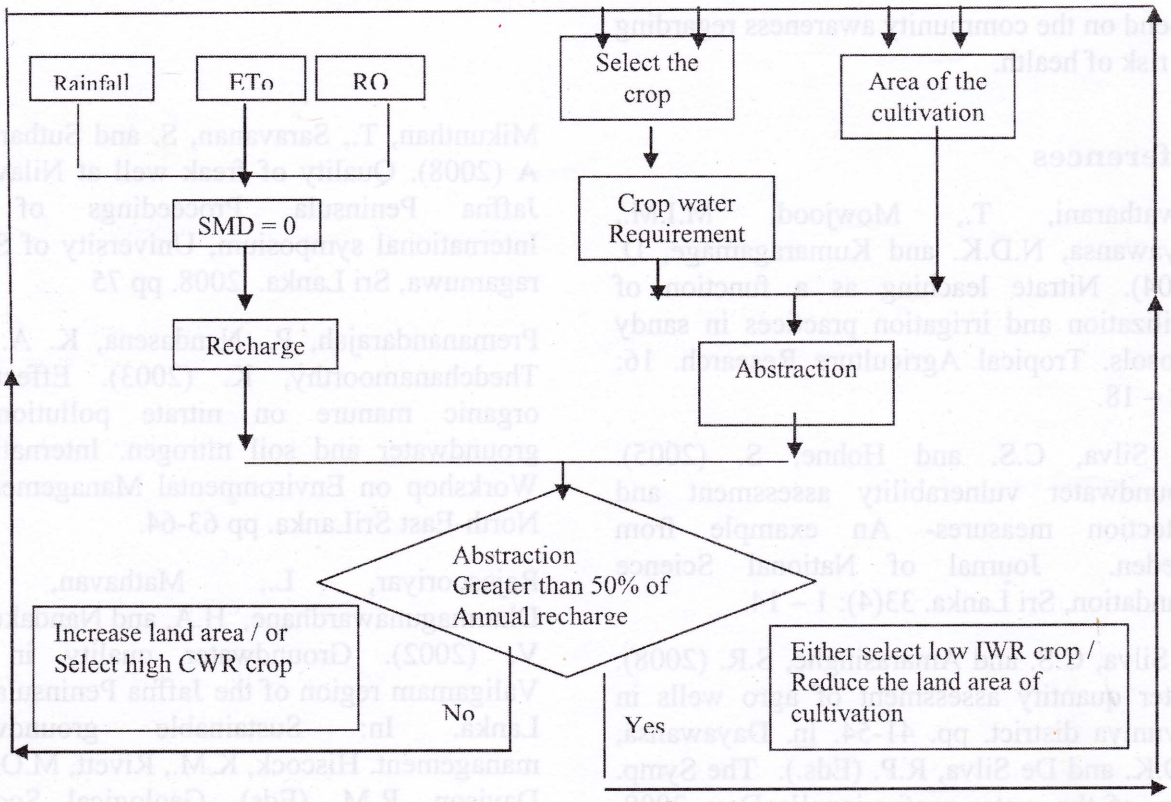
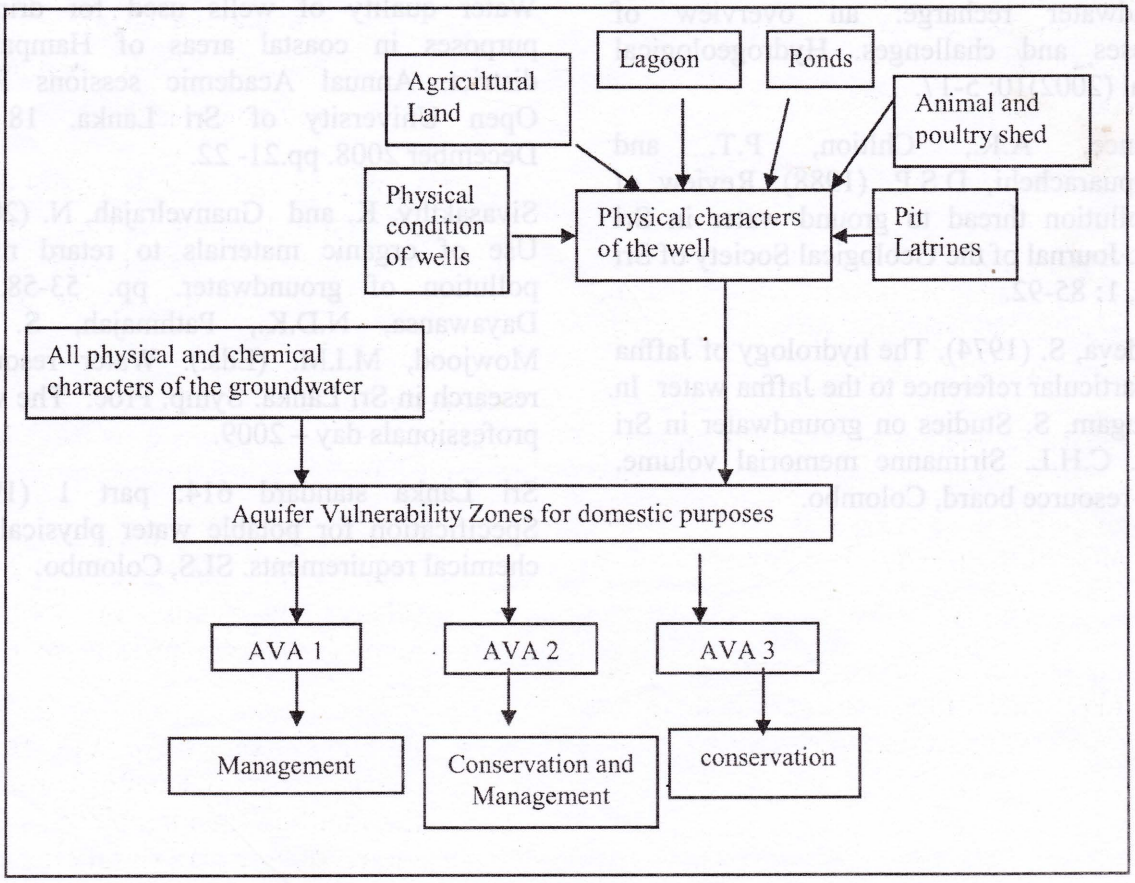


Flow chart 1: Groundwater resource management



Flow chart 2: Methodology for the delineation of aquifer vulnerable zones

Safe Use of Radiation in Medicine

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1. Introduction

Radiation is natural and all around us. It comes from the ground as terrestrial radiation, from the atmosphere as cosmic radiation, and even from within our own bodies as internal radiation.

2. Historical Perspective

Wilhelm Conrad Roentgen noticed an extraordinary glow while investigating the behavior of light outside a cathode tube on the 8th of November 1895. He named it as X-ray which made a shadow of the bones of his hand when held between the tube and a fluorescent screen.

Naturally occurring radioactive materials were discovered in 1896. Later physicists discovered that radioactive elements can be artificially created as well.

All these discoveries allowed millions of people around the world benefit in the diagnosis and treatment using X-rays and radioactive substances in the field of Medicine particularly in Radiology, Nuclear Medicine and Radiotherapy.

Many early researchers suffered painful injuries or death from their work with the ionizing radiation. Efforts to devise practical dose measurement and protective shielding soon followed.

Hence beneficial aspects of radiation should be applied with caution to avoid bad effects to human when it exceeds the tolerable dose.

3. *Physical Characteristics of Radiation*

Radiation is classified into two main categories, non-ionizing and ionizing, depending on its ability to ionize matter.

- Non-ionizing radiation that cannot ionize matter.
- Ionizing radiation that can ionize matter either directly or indirectly.
    - Directly ionizing radiation (charged particles): Electrons, Protons, Alpha particles and Heavy ions.
    - Indirectly ionizing radiation (neutral particles): Photons (X rays and γ rays) and Neutrons.

Directly ionizing radiation deposits energy in the medium through direct Coulomb interactions between the directly ionizing charged particle and orbital electrons of atoms in the medium.

Indirectly ionizing radiation (photons or neutrons) deposits energy in the medium through a two step process.

- In the first step a charged particle is released in the medium (photons release electrons or positrons, neutrons release protons or heavier ions)
- In the second step the released charged particles deposit energy to the medium through direct Coulomb interactions with orbital electrons of the atoms in the medium.

Both directly and indirectly ionizing radiations are used in the treatment of disease, mainly but not exclusively for malignant disease. The branch of medicine that uses radiation in the treatment of disease is called radiotherapy, therapeutic radiology or radiation oncology. Diagnostic radiology and nuclear medicine are branches of medicine that use ionizing radiation in the diagnosis of disease.

4. *Radiobiology*

When cells are exposed to ionizing radiation the physical effects between radiation and the atoms or molecules of the cells occur first and the possible biological damage to cell functions follows later. The biological effects of radiation result mainly from damage to the DNA, which is the most critical target within the cell and consequently lead to cell death.

When ionizing radiation is absorbed in biological material, the damage to the cell may occur either in direct or indirect way. In direct action the radiation interacts directly with the critical target, the DNA, in the cell. The atoms of the target itself may be ionized or excited through Coulomb interactions, leading to the chain of physical and chemical events that eventually produce the biological damage.

Direct action is the dominant process in the interaction of high Linear Energy Transfer (LET) particles with biological material.

In indirect action the radiation interacts with other molecules and atoms like water molecule within the cell to produce short lived and extremely reactive free radicals such as H_2O^+ (water ion) and $OH^\bullet$ (hydroxyl radical). These free radicals can diffuse in the cell and damage the critical target, the DNA, by breaking the chemical bonds resulting in chemical changes that lead to biological damage.

About two thirds of the biological damage by low LET radiations such as X rays or electrons is due to indirect action. Indirect action can be modified by chemical sensitizers or radiation protectors.

5. *Radiology*

Radiologic procedures use diagnostic type imaging equipment to assist a physician in the treatment of a patient's various medical conditions. These procedures frequently provide favorable medical results with minimal radiation exposure. This imaging involves simple X Rays, CT Scanning, Barium Studies, Mammogram and PET Scanning.

In some cases interventional radiological procedures are extensively performed. These procedures avoid the need for conventional surgery or improve the prospects for a favorable outcome from surgery. With interventional radiology procedures using x-rays, the level of risk depends on the type of procedure because some use very little radiation, while complex procedures use much more. In general, the risk of the exposure is not a major concern when compared to the benefits of the procedure.

6. *Radiotherapy*

Radiotherapy is one of treatment modalities in the management of cancer. Radiation therapy either used alone or in combination with surgery and/or chemotherapeutic modalities. It acts in the local region where it was delivered. Radiation therapy is delivered by external beam, an interstitial implant, or internal means.

The aim of radiation therapy is to cause damage to the cancerous cells whilst minimizing the risk to surrounding healthy tissues. Unfortunately, a small fraction of healthy cells can also be damaged by the radiation. There are ways to reduce the damage to critical organs:

1. Fractionation.
2. Use of radio protectors.
3. Use of targeted chemo sensitizers.
4. Sophisticated computer based planning.

A therapeutic advantage of fractionated radiation may be gained by one of four hypothetical mechanisms: repair of damage, reoxygenation of the tumor, redistribution within the cell cycle, and repopulation of tumor cells.

The probability of controlling cancerous lesions with radiotherapy depends on the size of the tumor and the dose of radiation given. The dose-response relation for small, tumours is steep, because they are relatively homogeneous, are well oxygenated and have approximately the same number of cells.

Bulky tumors, however, are more heterogeneous with considerable variability in number of cells and oxygenation. Therefore, the dose-response curve is much shallower. As the size of the tumor increases, and the dose needed for local control too increases, the risk of injury to normal tissue becomes greater.

The treatment strategy for an individual patient with cancer is based on the size and location of the primary lesion, the presence or absence and extent of regional or distant metastatic disease, and the general condition of the patient. Early stage cancer usually is effectively managed with either surgery or radiation therapy alone.

A course of radiotherapy is usually delivered using a shrinking field technique. This is based on the concept that tumor cell killing by radiation is an exponential function of dose.

Surgery is ideal for removal of gross tumor, and most radiation failures are the result of an inability to control bulky masses. Radiotherapy is very effective in controlling microscopic disease, and often surgical failures occur as a result of leaving subclinical tumor extensions, or microscopic disease, behind. Intuitively, combining the two modalities effectively counteracts the limitations of the other. Radiation can be administered either pre- or post-operatively.

Preoperative radiotherapy may decrease tumor bulk to facilitate dissection. Also, microscopic disease may be more effectively controlled prior to disturbing its blood supply. Tumor cell seed may be diminished, and it may be possible to use smaller treatment portals preoperatively.

Postoperative radiotherapy, on the other hand, enables more accurate surgical staging. The dissection is much less difficult in tissues that have not been previously irradiated, and surgical complications are often reduced because healing is generally better.

Complications due to radiation do occur like acute tissue reactions like mucositis which can be managed well. On the other hand late tissue reactions like xerostomia, fibrosis, soft-tissue necrosis, bone necrosis, cartilage necrosis, and damage to the eye, ear, and central nervous system from radiotherapy are a concern because the injury is often permanent.

7. *Biological Effects of Ionizing Radiation.*

The effects that may manifest in the exposed individuals can be referred to as somatic effects or that may manifest in the descendants of the exposed individual can be referred to as hereditary effects.

Radiation-induced effects have been observed in man when individuals have been exposed to very large radiation doses and it is from such doses that our knowledge of biological effects from radiation exposure is derived. It is considered that there is no threshold dose below which the probability of such an

effect occurring is zero. On the other hand, non-stochastic effects are those for which the severity of the effect varies with the dose to which the individual is exposed and a threshold may occur, below which such an effect does not occur.

From the studies undertaken, it is known that the induction of malignancies, including leukaemia is a stochastic effect of radiation, although such malignancies may not become manifest until many years after the radiation exposure. Mutagenic effects are also stochastic effects and these may be propagated through the population for many generations.

Non-stochastic effects arising are specific to particular tissues, for example, damage to the skin, cataract development, gonadal cell damage leading to impaired fertility etc. For many of these effects a minimum or threshold dose may be required for the effect to be manifest. If an individual receives a dose greatly in excess of the threshold dose the manifestation of the effect will occur in a relatively short period after the irradiation.

From our knowledge of biological effects arising from exposure to radiation, it is possible to identify the risks of stochastic effects occurring with the doses received by the various organs and tissues of the body. These risks are derived from exposure of persons to very high doses.

8. *Radiation Protection.*

It is important that the effects are kept minimal by ensuring that all radiation exposure of Individuals is kept As Low As Reasonably Achievable (referred to as the ALARA principle) and that there be a demonstrated net benefit for each exposure. Radiation protection is concerned with the protection of individuals involved in various radiation practices as well as with the protection of members of the public. It recognizes that various practices involving radiation exposure are necessary for the well-being of individuals and for the good of mankind. In undertaking such practices, individuals as radiation workers or as members of the public, may be irradiated and the exposure resulting from those practices must be minimized in accordance with the ALARA principle.

In conclusion,

Radiation is very useful to the mankind in many ways including in medical diagnosis and treatment. It should be used with caution to prevent any catastrophe due to malpractices or natural calamity that can break the sophisticated protective systems to make the radioactive substance to leak to the environment.

Essential Fatty Acids of Fish

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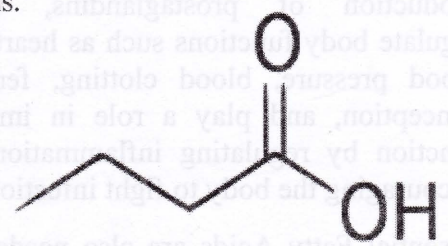
What are fish fatty acids?
Whether these are healthy fats?
Whether these are essential for our body?

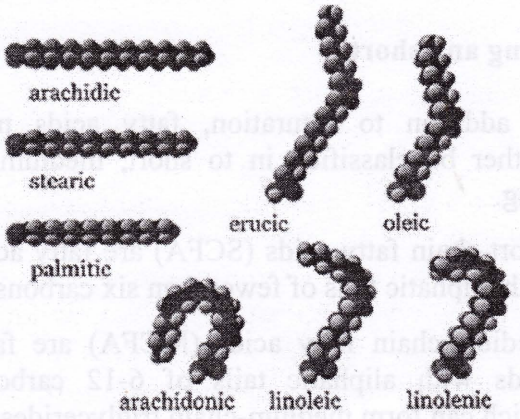
1. Introduction

Fish is the prime source of food for human beings. It provides a significant amount of poly unsaturated fatty acids in the diet for large proportion of people in the developing countries. Fatty acids and other lipids offer a good taste while consumption. Fatty acids are the basic units of lipids. In other words, lipids are a heterogeneous group of compounds related either actually or potentially to the fatty acids. They are relatively insoluble in water and soluble in non polar solvents such as ether, chloroform and benzene. The lipids include fats, oils, waxes and related compounds. Lipids are important dietary constituents. They have high energy value and fat soluble vitamins and the essential fatty acids contained in the fat of natural foods. In the human body fat serves as an efficient source of energy. It serves as a thermal insulator in the subcutaneous tissues and around certain organs.



Butyric acid, A short chain fatty acid

Fatty acids occur mainly as esters in natural fats and oils but do occur in the unesterified form as free fatty acids, a transport form found in the plasma. Fatty acids that occur in natural fats are usually straight – chain derivatives and contain an even number of carbon atoms, because they are synthesized from 2-carbon units. The chain may be **saturated** (containing no double bonds) or **unsaturated** (containing one or more double bonds).



Three dimensional representations of several fatty acids

2. Types of Fatty Acids

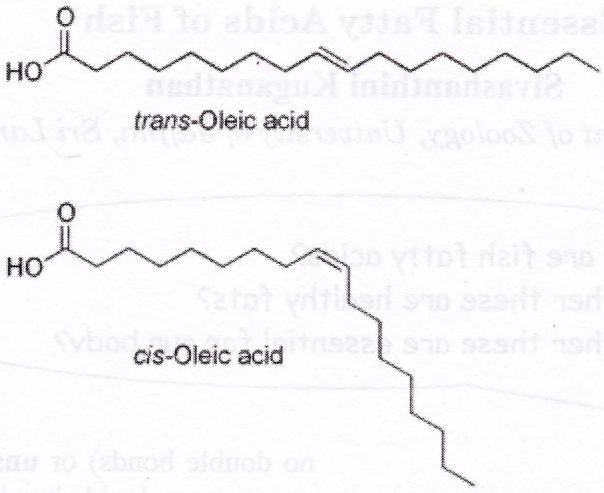
Unsaturated fatty acids

In unsaturated fatty acids the two carbon atoms in the chains that are bound next to either side of the double bond can occur

Saturated fatty acids

Saturated fatty acids are a long-chain carboxylic acid that usually has between 12 and 24 carbon atoms that has no double bonds. Thus, saturated fatty acids are saturated with hydrogen (since double bonds reduce the number of hydrogens on each carbon).

example; 1) Lauric acid (12 C) 2) Myristic acid (14 C) 3) Palmitic acid (16 C) 4) Stearic acid (18 C) 5) Arachidic acid (20 C)



Comparison of the trans isomer (top) Elaidic acid and the cis-isomer oleic acid

Long and short

In addition to saturation, fatty acids may further be classified in to short, medium or long.

Short-chain fatty acids (SCFA) are fatty acids with aliphatic tails of fewer than six carbons.

Medium-chain fatty acids (MCFA) are fatty acids with aliphatic tails of 6-12 carbons, which can form medium-chain triglycerides.

Long-chain fatty acids (LCFA) are fatty acids with aliphatic tails longer than 12 carbons.

Very-long-chain fatty acids (VLCFA) are fatty acids with aliphatic tails longer than 22 carbons.

3. Essential Fatty Acids

Essential Fatty Acids are an important topic that has to be shared. Essential Fatty Acids are the "good fats" all over the news these days, and a very hot research topic. More is known about them every week as more studies come forward.

- Essential Fatty Acids (EFAs) are necessary fats that humans cannot synthesize, and must be obtained through diet. EFAs are long-chain polyunsaturated fatty acids derived from linolenic, linoleic, and oleic acids. There are two families of EFAs: **Omega-3 and Omega-6.** Omega-9 is necessary yet "non-essential" because the body can manufacture a modest amount on its own, provided essential EFAs are present.
- The number following "Omega-" represents the position of the first double bond, counting from the terminal methyl group on the molecule. Omega-3 fatty acids are derived from Linolenic Acid, Omega-6 from Linoleic Acid, and Omega-9 from Oleic Acid.
- EFAs support the cardiovascular, reproductive, immune, and nervous systems. The human body needs EFAs to manufacture and repair cell membranes, enabling the cells to obtain optimum nutrition and expel harmful waste products.
- A primary function of EFAs is the production of prostaglandins, which regulate body functions such as heart rate, blood pressure, blood clotting, fertility, conception, and play a role in immune function by regulating inflammation and encouraging the body to fight infection.
- Essential Fatty Acids are also needed for proper growth in children, particularly for neural development and maturation of sensory systems, with male children having higher needs than females. Fetuses and breast-fed infants also require an adequate supply of EFAs through the mother's dietary intake.
- EFA deficiency is common in the United States, particularly Omega-3 deficiency.

An ideal intake ratio of Omega-6 to Omega-3 fatty acids is between 1:1 and 4:1, with most Americans only obtaining a ratio between 10:1 and 25:1. The minimum healthy intake for both linolenic (Omega-3) and linoleic (Omega-6) acid via diet, per adult per day, is 1.5 grams of each. One tablespoon of flaxseed oil can provide this amount, or larger amounts of other linolenic-rich foods. Because high heat destroys linolenic acid, cooking in linolenic-rich oils or eating cooked linolenic-rich fish is unlikely to provide a sufficient amount.

- EFA deficiency and Omega 6/3 imbalance is linked with serious health conditions, such as heart attacks, cancer, insulin resistance, asthma, lupus, schizophrenia, depression, postpartum depression, accelerated aging, stroke, obesity, diabetes, arthritis, ADHD, and Alzheimer's Disease, among others.

Most Americans are Omega-3 deficient because of their over-processed diets, and one of the most common symptoms of Omega-3 deficiency is depression, among other mental health symptoms. Of course depression is common among Americans. There are other causes of depression, however most depression in America is mostly due to Omega-3 deficiency.

Good fats compete with bad fats, so it's important to minimize the intake of trans fats and cholesterol (animal fat) while consuming enough good fats. Also, good fats raise your HDL or "good cholesterol". One of the jobs of this High Density Lipoprotein (HDL) or "good cholesterol" is to grab your bad cholesterol, LDL (Low Density Lipoprotein), and escort it to the liver where it is broken down and excreted.

In other words, these good fats attack some of the damage already done by the bad fats. This is very important in an age when so many Americans are struggling to get their cholesterol down, and fight heart disease and obesity.

In a study with genetically similar populations of Icelanders and Canadian islanders, it was found that Icelanders had significantly less heart disease comparatively even though Icelanders had high cholesterol levels, including total and LDL cholesterol (the cholesterol related to cardiac risk) and they had 3 times higher the levels of omega 3 fatty acids when compared to Canadian-Islanders (Skuladottir et al., 1995). The researchers concluded that "omega 3 poly unsaturated fatty acids may be cardio protective (Skuladottir et al., 1995).

A study by Magnusson in 2000, proved a lack of seasonal affective disorders related to winter seasons in Iceland. Cott, 2001 related it to the high intake of fish in their diet (225 lb per person per year). He also noted similar findings in Japan, who also has a high intake of fish (147 lb per person per year) whereas other countries had higher rates of the disorder which correlated with their lower intakes of fish, for example, Finland (72 lb per person per year), Sweden (59 lb per person per year), Netherlands (25 lb per person per year), Canada (51 lb per person per year) and United States (48 lb per person per year).

Omega-3 (Linolenic Acid)

Alpha Linolenic Acid (ALA) is the principal Omega-3 fatty acid, which a healthy human will convert into eicosapentaenoic acid (EPA), and later into docosahexaenoic acid (DHA). EPA and the gamma linolenic acid (GLA) synthesized from linoleic (Omega-6) acid are later converted into hormone-like compounds known as eicosanoids, which aid in many bodily functions including vital organ function and intracellular activity.

Omega-3s are used in the formation of cell walls, making them supple and flexible, and improving circulation and oxygen uptake with proper red blood cell flexibility and function. Omega-3 deficiencies are linked to decreased memory and mental abilities, tingling sensation of the nerves, poor vision, increased tendency to form blood clots, diminished immune function, increased triglycerides and "bad" cholesterol (LDL) levels, impaired

membrane function, hypertension, irregular heartbeat, learning disorders, menopausal discomfort, itchiness on the front of the lower leg(s), and growth retardation in infants, children, and pregnant women.

List of *n*−3 fatty acids

Table 1 lists several different names for the most common *n*−3 fatty acids found in nature.

Omega-3 fatty acids found in certain fish oils. Fish as well as krill are the major source of omega-3 fatty acid.

Fish do not synthesize them they obtain them from the algae or microalgae or plankton in their diet. Fatty acid composition in few important fish is given below in table 2.

Omega-6 (Linoleic Acid)

Linoleic Acid is the primary Omega-6 fatty acid. A healthy human with good nutrition will convert linoleic acid into gamma linolenic acid (GLA), which will later be synthesized, with EPA from the Omega-3 group, into eicosanoids

Some Omega-6s improve diabetic neuropathy, rheumatoid arthritis, PMS, skin disorders (e.g. psoriasis and eczema), and aid in cancer treatment. Table 3 gives the list of omega 6 fatty acids.

Table 2. Grams of *n*−3 per 3 oz serving of popular fish (Anonymous, 2010).

Common name	grams *n*−3
Tuna	0.21–1.1
Pollock	0.45
Salmon	1.1–1.9
Cod	0.15–0.24
Catfish	0.22–0.3
Flounder	0.48
Grouper	0.23
Halibut	0.60–1.12
Mahi mahi	0.13
Orange roughy	0.028
Red snapper	0.29
Shark	0.83
Swordfish	0.97
Tilefish	0.90
King mackerel	0.36

Omega-9 (Oleic Acid)

Essential but technically not an EFA, because the human body can manufacture a limited amount, provided essential EFAs are present. Table 4 gives the list of omega 9 fatty acids.

Table 1. Different names for the most common *n*−3 fatty acids

Common name	Lipid name	Chemical name
n/a	16:3 (*n*−3)	*all-cis*-7,10,13-hexadecatrienoic acid
α-Linolenic acid (ALA)	18:3 (*n*−3)	*all-cis*-9,12,15-octadecatrienoic acid
Stearidonic acid (SDA)	18:4 (*n*−3)	*all-cis*-6,9,12,15-octadecatetraenoic acid
Eicosatrienoic acid (ETE)	20:3 (*n*−3)	*all-cis*-11,14,17-eicosatrienoic acid
Eicosatetraenoic acid (ETA)	20:4 (*n*−3)	*all-cis*-8,11,14,17-eicosatetraenoic acid
Eicosapentaenoic acid (EPA)	20:5 (*n*−3)	*all-cis*-5,8,11,14,17-eicosapentaenoic acid
Docosapentaenoic acid (DPA), Clupanodonic acid	22:5 (*n*−3)	*all-cis*-7,10,13,16,19-docosapentaenoic acid
Docosahexaenoic acid (DHA)	22:6 (*n*−3)	*all-cis*-4,7,10,13,16,19-docosahexaenoic acid
Tetracosapentaenoic acid	24:5 (*n*−3)	*all-cis*-9,12,15,18,21-docosahexaenoic acid
Tetracosahexaenoic acid (Nisinic acid)	24:6 (*n*−3)	*all-cis*-6,9,12,15,18,21-tetracosenoic acid

Table 3. List of omega-6 fatty acids		
Common name	**Lipid name**	**Chemical name**
Linoleic acid	18:2 (*n*−6)	9,12-octadecadienoic acid
Gamma-linolenic acid	18:3 (*n*−6)	6,9,12-octadecatrienoic acid
Eicosadienoic acid	20:2 (*n*−6)	11,14-eicosadienoic acid
Dihomo-gamma-linolenic acid	20:3 (*n*−6)	8,11,14-eicosatrienoic acid
Arachidonic acid	20:4 (*n*−6)	5,8,11,14-eicosatetraenoic acid
Docosadienoic acid	22:2 (*n*−6)	13,16-docosadienoic acid
Adrenic acid	22:4 (*n*−6)	7,10,13,16-docosatetraenoic acid
Docosapentaenoic acid	22:5 (*n*−6)	4,7,10,13,16-docosapentaenoic acid
Calendic acid	18:3 (*n*−6)	8E,10E,12Z-octadecatrienoic acid

Table 4. List of omega-9 fatty acids		
Common name	**Lipid name**	**Chemical name**
oleic acid	18:1 (*n*−9)	9-octadecenoic acid
eicosenoic acid	20:1 (*n*−9)	11-eicosenoic acid
mead acid	20:3 (*n*−9)	5,8,11-eicosatrienoic acid
erucic acid	22:1 (*n*−9)	13-docosenoic acid
nervonic acid	24:1 (*n*−9)	15-tetracosenoic acid

4. Summary

Food tips

- High heat, light, and oxygen destroy EFAs, so when consuming foods for their EFA content cooked or heated forms should be avoided. For example, raw nuts are a better source than roasted nuts. Flaxseed oil should not be used for cooking, and any type of oil should not be re-used.

- When we **fry fish we destroy most of the omega 3** available and form lots of Trans Fats. Very unhealthy for our heart. We would have to eat it uncooked in order to get the omega 3.

- High heat, light, and oxygen destroy EFAs, so when consuming foods for their EFA content **cooked or heated forms should be avoided.**

- Hydrogenated fats (like margarine), cholesterol-based fats (butter/dairy products), and poly-saturated fats (common cooking oils) should be replaced with healthy EFA-based fats when possible. For example, instead of margarine or butter on warm (not hot) vegetables, flaxseed and/or extra virgin olive oils can be used with salt. (This tastes similar to margarine, as margarine is just hydrogenated oil with salt).

Dosage

- Earlier the UK ditary guidelines for cardiovascular disease specified average omega-3 PUFA could be 0.1 to 0.2 g day^{-1}.

The Committee on Medical Aspects of Food Policy (COMA) recommended intake of omega-3 can be well above 0.2 g day^{-1}. In 2004, the food standards agency changed its advice and decided to revise it.

Fish and fish oil are brain food certainly! As our population ages, we'll continue to look for natural supplements such as fish and fish oil supplements to help keep us healthy while we age.

Fish oil as mood Stabilizers

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Phytoremediation: A Low-Technology Bioremediation

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1. Preamble

Natural resources have been impacted by human activities. On the other hand quality and availability of natural resources have profound effect on human life. Over exploitation and mismanagement of the natural resources has resulted in contamination in many sites. Past industrial activities have been the main causes of contamination, which was attributed to the lack of awareness of the health and environmental effects connected with the production, use, and disposal of hazardous substances. At present, knowledge about contamination exist, still, new contamination occur worldwide mainly due to negligence and mismanagement. It is now widely recognized that contaminated land / water is a potential threat to human health, and its continual discovery over recent years has led to international efforts to remedy many of these sites. There have been many remediation techniques used over the past with varying degrees of technology, cost and success. This paper attempts to summarize the remediation techniques and discuss the low technology bioremediation technique, phytoremediation.

2. Methods of Remediation

2.1 Land fill

Very old technique of remediation was to dig up the contaminated site and fill it into a land fill. This method just moves the contamination from one place to another. There are also risks associated with this method; during excavation, handling and transport of contaminated hazardous material. Moreover as land is a limited expensive resource, getting new sites for land filling is another problem of concern.

2.2 Cap and contain method

In this method the contamination is capped by proper barriers so that contamination will not spread to other areas. In this method also the hazardous material is not reduced or removed but stay in the place of contamination. This is only a temporary solution for the problem as the contamination remains on site requires monitoring.

2.3 High Temperature Incineration

This is a better approach than traditional methods as the contamination is destroyed. However this may increase the contamination of workers and nearby residents.

2.4 Decomposition

This includes technologies such as base-catalyzed dechlorination and UV oxidation which are effective to reduce various types of contaminants. However, the technology involved is complex and the cost is high.

2.5 Bioremediation

Bioremediation is the process of biologically degrading organic wastes under controlled conditions to an innocuous state, or to levels below concentration limits established by regulatory authorities (Mueller *et al.*, 1996). It uses relatively low-cost, low-technology techniques, which generally have a high public acceptance and can often be carried out on site. Although the methodologies employed are not technically complex, considerable experience and expertise may be required to design and implement a successful bioremediation program, due to the need to thoroughly assess a site for suitability and to optimize conditions to achieve a satisfactory result.

3. Bioremediation Strategies

The bioremediation techniques may be either insitu or exsitu. Insitu techniques are defined as those that are applied to soil and groundwater at the site with minimal disturbance. Exsitu techniques are those that are applied to soil and groundwater at the site which has been removed from the site via excavation (soil) or pumping (water).

3.1 In situ bioremediation

Insitu Bioremediation techniques involve lower cost and limited disturbance due to the

treatment in place avoiding excavation and transport of contaminants, hence are generally the most desirable options. The most important land treatments are bioventing, biosparging and bioaugmentation (Vidali, 2001).

Bioventing is the most common in situ treatment and involves supplying air and nutrients through wells to contaminated soil to stimulate the indigenous bacteria. Bioventing employs low air flow rates and provides only the amount of oxygen necessary for the biodegradation while minimizing volatilization and release of contaminants to the atmosphere. It works for simple hydrocarbons and can be used where the contamination is deep under the surface.

Biosparging involves the injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria. Biosparging increases the mixing in the saturated zone and thereby increases the contact between soil and groundwater.

Bioaugmentation involves the addition of microorganisms indigenous or exogenous to the contaminated sites.

3.2 Ex situ bioremediation

These techniques involve the excavation or removal of contaminated soil from ground. Landfarming, composting, biopiles and bioreactors are the main types ((Vidali, 2001).

Landfarming is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded. The goal is to stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants.

Composting is a technique that involves combining contaminated soil with nonhazardous organic amendments such as manure or agricultural wastes. The presence of these organic materials supports the development of a rich microbial population and elevated temperature characteristic of composting.

Biopiles are combination of landfarming and composting. Essentially, engineered cells are constructed as aerated composted piles. Typically used for treatment of surface contamination with petroleum hydrocarbons. They are a refined version of landfarming that tend to control physical losses of the contaminants by leaching and volatilization.

Bioreactors are engineered containment systems where bioremediation in reactors involves the processing of contaminated solid material (soil, sediment, sludge) or water. A slurry bioreactor may be defined as a containment vessel and apparatus used to create a three-phase (solid, liquid, and gas) mixing condition to increase the bioremediation rate of soil-bound and water-soluble pollutants as a water slurry of the contaminated soil and biomass (usually indigenous microorganisms) capable of degrading target contaminants.

4. Phytoremediation

Phytoremediation is the use of green plants to clean-up contaminated hazardous waste sites. It is defined as the use of green plants (including grasses, and woody species) to remove, contain, or render harmless environmental contaminants such as heavy metals, trace elements, organic compounds, and radioactive compounds in soil or water (Henchman *et al.*, 1997).

4.1 History of Phytoremediation

The historic accident at Chernobyl Nuclear Plant Reactor 4 in the Ukraine on April 26, 1986 caused severe radioactive contamination. Families within a 30-km zone of the power plant were evacuated, and in the months that followed, extensive contamination was discovered in areas up to 100 km from the site. Scientists were hopeful that plants may play a key role in cleaning up some of the contamination.

In 1989, three years after the explosion, the Soviet government asked the International Atomic Energy Agency (IAEA) to assess the radiological and health situation in the area surrounding the power plant. Among the most significant findings were radioactive emissions and toxic metals--including iodine, cesium-137, strontium, and plutonium--concentrated in the soil, plants, and animals. Such

substances are potentially harmful to human health. Since 1991, the Canadian Nuclear Association has noted a marked increase in the incidence of thyroid cancer in the area surrounding the nuclear accident probably due to inhalation and accumulation of iodine in thyroid glands. Cesium-137, radioactive cesium with a mass number of 137, can enter the food chain and deliver an internal dose of radiation before it is eliminated metabolically. Apparently these toxic substances entered the food chain via grazers, such as cows and other livestock that fed on plants grown in contaminated soils. The toxins then accumulated and concentrated in the meat and milk products eventually consumed by humans. Additionally, wild foods, such as berries and mushrooms, are expected to continue showing elevated cesium levels over the next few decades.

To prevent further spread of these toxins, it was determined that livestock should be allowed to feed only on uncontaminated plants and on plants not tending to accumulate toxic metals within their tissues. Then a soil cleanup method was employed using green plants to remove toxins from the soil. This technique is phytoremediation, a term coined by Dr. Ilya Raskin of Rutgers University's Biotechnology Center for Agriculture and the Environment, who was a member of the original task force sent by the IAEA to examine food safety at the Chernobyl site (McGrow Hill, 2000). Phytoremediation is a process that takes advantage of the fact that green plants can extract and concentrate certain elements within their ecosystem.

4.2 Capacity of plants to remediate

Plants are able to accomplish the phytoremediation function mainly by two ways. Importantly they facilitate favorable conditions for microbial degradation specifically by rhizosphere microbes. Secondly plant root itself provides a simple inexpensive way of accessing contaminants in soil and water (Suresh and Ravishankar, 2004). In the rhizosphere, microbial population is supported by plant nutrients in the form of decaying biomass and root exudates (Macek *et al.*, 2000). Plant root exudates also stimulate co-metabolic transformations, leading to degradation of some organic contaminants. Lynch (1982) reported that rhizosphere soil supports 10–100 times more microorganisms per gram than unplanted soil, due to a supply of carbon-containing compounds exuded by plant roots. Plants can maintain aerobic conditions in the rhizosphere, leading to microbial degradation. It is best applied at sites with shallow contamination of organic, nutrient, or metal Pollutants that are amenable to one of five applications namely, Phytotransformation, Rhizosphere Bioremediation, Phytostabilization, Phytoextraction, or Rhizofiltration (Schnoor, 1997).

4.2.1 Phytotransformation

Phytotransformation refers to the uptake of organic and nutrient contaminants from soil and groundwater and the subsequent transformation by plants. It is important that the metabolites which accumulate in vegetation be non-toxic or at least significantly less toxic than the parent compound. Potential applications include phytotransformation of petrochemical sites and storage areas, ammunition wastes, fuel spills, chlorinated solvents, landfill leachates, and agricultural chemicals such as pesticides and fertilizers.

The absorbed chemical may be stored into new plant structures or it can be volatilized, metabolized, or mineralized completely to carbon dioxide and water. Chlorinated aliphatic compounds such as trichloroethylene (TCE) have been reported to be mineralized to CO_2 and less toxic aerobic metabolites (trichloroethanol, trichloroacetic acid, and dichloroacetic acid (Newman et al., 1997). Such enzymatic breakdown of organic pollutants such as trichloroethylene (TCE) and herbicides, both internally and through secreted plant enzymes is also referred to as phytodegradation.

Another form of phytotransformation is phytovolatilization, whereby volatile chemicals or their metabolic products are released to the atmosphere through plant transpiration (Vroblesky *et al.*, 1999). Unlike other remediation techniques, once contaminants have been removed via volatilization, there is a loss of control over their migration to other areas. Despite the

controversy surrounding phytovolatilization, this technique is a promising tool for the remediation of Se and Hg contaminated soils (Vroblesky *et al.,* 1999).

Many organic chemicals that are recalcitrant in the subsurface environment react rapidly in the atmosphere with hydroxyl radicals, an oxidant formed in the photochemical cycle. The transfer of contaminants from the soil or groundwater to the atmosphere is not as desirable as in situ degradation, but it may be preferable to prolonged exposure in the soil environment and the risk of ground-water contamination. Nitroreductase and laccase enzymes in plants can break down ammunition wastes such as TNT (2,4,6-trinitrotoluene), and they may incorporate the broken ring structures into new plant material or organic detritus that becomes a part of sediment organic matter. Detoxification mechanisms may transform the parent chemical to non-phytotoxic metabolites that are stored in plant tissues (Schnoor *et al.,* 1995).

4.2.2 Rhizosphere Bioremediation

Rhizosphere bioremediation is also known as phytostimulation or plant-assisted bioremediation (Schnoor *et al.,* 1995). Rhyzosphere bioremediation is possible due to either increased microbial population around the root zone by release of exudates to the soil environment that help to stimulate the activity of existing bacterial populations, stimulating growth of new species that are able to degrade the wastes, and/or increasing soluble substrate concentrations for all microorganisms (Jordahl *et al.* (1997). Plant enzymes namely dehalogenase, nitroreductase, peroxidase, laccase, and nitrilase were reported to be present in sediments and soils (Schnoor, 1997). Among these, dehalogenase enzymes are important in dechlorination reactions of chlorinated hydrocarbons, nitroreductase is needed in the first step for degradation of nitroaromatics,while laccase enzyme serves to break aromatic ring structures in organic contaminants and peroxidase and nitrilase are important in oxidation reactions. These enzymes are active in rhizosphere soils in close proximity to the root (1 mm) for transformation of organic contaminants that would not occur in the absence of the plant. In a TNT breakdown study in EPA, USA it was reported that increased soil water pH from 3 to 7 and sorbtion of high concentration of metals while plants remaining healthy (Schnoor, 1997).

4.2.3 Phytostabilization

Phytostabilization refers to the holding of contaminated soils and sediments in place by vegetation, and to immobilizing toxic contaminants in soils. Most of the organic chemical contaminants are lypophilic and are attracted to the hydrophobic surfaces on organic matter, such as humus and plant cell wall components or soil particles (Novak *et al.,* 1995). Due to this the bioavailability of contaminants are reduced in the environment. Phytostabilization, known as phytorestoration, is a plant-based remediation technique that stabilizes wastes and prevents exposure pathways via wind and water erosion (Prasad and de Oliveira Freitas, 2003). With this method of phytoremediation the plant root system releases chemicals into the surrounding soil which bind to the contaminant making it less bioavailable to the surrounding environment.

Phytostabilization is especially applicable for metal contaminants at waste sites where the best alternative is often to hold contaminants in place. Vigorously growing plants are necessary to exert hydraulic control and immobilization at the site; plants cannot die or be removed during the phytostabilization design period. Soil amendments such as phosphate, lime, and organic matter are sometimes needed to immobilize toxic metals such as lead, cadmium, zinc, and arsenic.

4.2.4 Phytoextaction

Phytoextraction refers to the use of metal-accumulating plants that translocate and concentrate metals from the soil in roots and above ground shoots or leaves. This technique is generally used for metals like nickel, zinc, copper, lead, chromium and cadmium (Blaylock *et al.,* 1997).

As a plant-based technology, the success of phytoextraction is inherently dependent upon several plant characteristics. The two most important characters include the ability to accumulate large quantities of biomass rapidly

and the ability to accumulate large quantities of environmentally important metals in the shoot tissue (Cunningham and Ow, 1996; Deepa *et al.*, 2006).

Some researchers suggest that the incineration of harvested plant tissue dramatically reduces the volume of the material requiring disposal (Kumar *et al.*, 1995). However in some cases valuable metals can be extracted from the metal-rich ash and serve as a source of revenue, thereby offsetting the expense of remediation (Cunningham and Ow, 1996; Comis, 1996). Phytoextraction should be viewed as a long-term remediation effort, requiring many cropping cycles to reduce metal concentrations (Kumar *et al.*, 1995) to acceptable levels. The time required for remediation is dependent on the type and extent of metal contamination, the length of the growing season, and the efficiency of metal removal by plants, but normally ranges from 1 to 20 years. This technology is suitable for the remediation of large areas of land that are contaminated at shallow depths with low to moderate levels of metal- contaminants (Kumar *et al.*, 1995; Blaylock *et al.*, 1997).

4.2.5 Rhizofiltration

Rhizofiltration refers to the use of plant roots to sorb, concentrate, and precipitate metal contaminants from surface or groundwater. Roots of plants are capable of sorbing large quantities of lead and chromium from soil water or from water that is passed through the root zone of densely growing vegetation. Commonly used for treatment of industrial discharge, agricultural run off, metals and radioactive contamination. The movement of organic contaminants in soil depends on the chemical's relative water solubility, vapor pressure, molecular size and charge and on the presence of other organics in the soil (Cunningham and Ow, 1996).

5. Phytoremediation potential of plants for Different Chemicals

Different plants have been identified to have potential against accumulation of a wide range of chemicals in soil and water. The most relevant chemicals include pesticides, nutrient contamination, heavy metals and explosives.

5.1 Pesticides and phytoremediation

The potential of water hyacinth (Eichhornia crassipes) to remove a phosphorus pesticide ethion was reported by Xia and Ma, 2006, suggesting that plant uptake and phytodegradation might be the dominant process for ethion removal by the plant. Pistia stratiotes L. seems promising for phytoremediation of atrazine-polluted water (Del campo *et al.*, 2007).

5.2 Phytoremediation of Nutrient Contamination

The potential of water lettuce (Pistia stratiotes) to remediate eutrophication of nitrogen and phosporus has been reported (Qin Lu *et al.*, 2008; Fonkou *et al.*, 2002) .

Similarly, successful water treatment system to remove nitrogen and P (Olguin *et al*, 2010; Sangeeta, 2007; Gamage and Yapa, 2001; Weisner *et al.*, 1994 Gupta, 1982) also has been reported by many workers. Water spinach (Ipomoea aquatica) used in floating bed to control pollution in China proved it has better removal effect on total phosphorus of 30-81 %.(Zhang *et al.*, 2006). Similarly wastewater treatment using water spinach was found to successfully remove both N and P (Hu *et al.*, 2008 ;Sensai and Suttibak, 2004).

5.3 Phytoremediation of Heavy metals

Eichornia crassipes has the potential to serve as a phytoremediation plant in the cleaning up of metals such as Cr, Cd, Pb and As from contaminated coastal areas in Nigeria. Moreover it can serve as a plant for both phytoextraction and rhizofiltration in phytoremediation technology (Foluso *et al.*, 2009). Studies in Srilanka using water hyacinth found that it could also phytoremediate Fe contamination (Jayaweera *et al.*, 2008), Mn contamination (Kularatne *et al.*, 2009) and Al contamination (Jayaweera *et al*,(2007). Vetivergrass (Vetiveria zizanioides L.) can be used to phytoremediate Pb contamination of soils probably by phytoextraction (Paz-Alberto *et al.*,2007).

A study to evaluate the potential of Amaranthus dubius (marog or wild spinach) for the phytoremediation of Chromium (Cr), Mercury (Hg), Arsenic (As), Lead (Pb), Copper (Cu) and Nickel (Ni) revealed that it

sequester Hg from the soil and translocate it to the shoots (Mellem, 2008). Further, Cr could only be removed from the soil and stored in the roots, and limited amounts were translocated to the aerial parts. Pb, As, Ni, and Cu have some degree of transportability from the soil to the roots but not to aerial parts. It was concluded by Mellem, 2008 that Amaranthus dubius showed limitations in its potential to remove Pb, Cu or Ni from contaminated sites but can phytoremediate As by hyperaccumulation.

5.4 Phytoremediation of Explosives

Aquatic plants enhanced removal of explosives such as TNT, TND contaminated ground water has been reported (Best et al., 1997). Phytoremediation of soils contaminated by TNT by plant species barnyard grass (Echinochloa crusgalli), sunflower (Helianthus annuus), Indian mallow (Abutilon avicennae) and Indian joint vetch (Aeschynomene indica) is also reported (Lee *et al.*). The potential of narrow leaf cattail, a common marsh plant to remove TNT also reported (Miller *et al.,* 1997).

6. Advantages and Limitations

The eco-friendly and aesthetically pleasing to the public, no requirement of disposal site and capability to remediate wide range of contaminants are the main advantages of this technique(Macek *et al.,* 2003). In addition, this method causes limited disturbance of the soil and surrounding environment and reduce the spread of contamination via air and waterborne wastes. Phytoremediation does not require expensive equipment or highly-specialized personnel, and it is relatively easy to implement. It is capable of permanently treating a wide range of contaminants in a wide range of environments. However, the greatest advantage of phytoremediation is its low cost compared to conventional clean-up technologies (USEPA, 2000; Raskin and Ensley, 2000). It was estimated that cost of bioremediation of unit land is 2-5 fold less than the traditional capping method (Flathman *et al.,* 1999).

Non-accessibility of plant roots to the contaminants below the rooting depth. Inability of plants to grow at high toxic levels of contaminants and the long-term application of the process, takes years to regulate the contamination levels are the major limitation of this technique (Salt *et al.,* 1995; Cunningham *et al.,* 1993). Moreover, in case of highly lipophilic, persistent chemicals such as polycyclic aromatic hydrocarbon (PAH), PCB the bioavailability of contaminants even in the upper rooted layers of soil pose limitations (Paterson *et al.,* 1990). The use of invasive, nonnative species can affect biodiversity. The consumption of contaminated plants by wildlife is also of concern. Harvested plant biomass produced from the process of phytoextraction may be classified as a hazardous waste, therefore subject to proper handling and disposal (Henry, 2004). Unfavorable climate is another important consideration because it can limit plant growth and phytomass production, thus decreasing process efficiency (USEPA, 2000).

7. Conclusion

As phytoremediation does not require any specialized equipment, structures or skill it is a low cost low technology remediation technique. Different aquatic and terrestrial plants have been identified to posses the ability to phytoremediate a range of contaminants in water and soils. However, plants differ among them in terms of their capacity to remove contaminants. On the other hand same plants differ in potential to remove same contaminants depending on the experimental and environmental conditions. Therefore local research is vital to manage the contaminants effectively.

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Enigma of Emerging Typhus in Jaffna – A Public Health Challenge

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1. Introduction

There is a remarkable increase in reporting of typhus cases in Sri Lanka in the recent past. In 1999, 48 cases were reported but in 2009 it increased up to 1200 cases. The people in Jaffna are well aware about typhoid but not about Typhus. Typhus caused high mortality in the past; and there is a misconception about prevention and control of typhus in Jaffna district. The above topic was chosen for the chairperson address with a view to enlighten the audience regarding typhus and to clear the misconception regarding control and prevention of typhus.

The name "Typhus" came from the Greek word for "hazy" and is given for the stupor that is seen in severe cases of epidemic typhus. Typhus fevers were prevalent during crisis situations like wars, famine and great migrations and have caused massive mortality (Cowan 2000). Typhus had been one of the greatest killers of people in recorded history. It was suspected of having been responsible for the Athens plaque during the 5thCentury B.C and the disease was recognized in 16th Century by presence of fever and rash.

For many years rickettsiologists have had the risk of losing their lives to this potentially hazardous disease. The three pioneer scientists contacted this infection while researching this disease- Ricketts,Von Provazek and Nicolle. Unfortunately Ricketts and Von Provazek died of Typhus infection and only Nicolle survived to collect the Nobel prize in 1928. It was an emerging infectious disease all over the world. As it is a potentially hazardous organism, it probably could be used in Bioterrorism as biological weapon.

Rickettsial fevers are acute bacteraemic illnesses characterized by fever and rash, spread by insects. Sometimes a small black eschar is formed at the site of insect bite. They are caused by members of the Genus Rickettsia. Rickettsial organisms are Gram negative intracellular bacilli or cocco bacilli. The species of the genus rickettsiae have been sub divided into three groups of antigenically related microorganisms, namely the scrub typhus group, typhus and spotted fever group (SGF) (La Scola and Raoult 1997). All these rickettsial organisms are transmitted through different arthropode vectors. Rickettsiae get into the blood vessels where rickettsial organisms proliferate on the endothelium of small blood vessels and releases cytokines which damages the endothelial integrity with consequent fluid leakage, platelet aggregation and proliferation of polymorphs and monocytes which lead to occlusive endangitis and causing micro infarctions in skin, lungs and kidney. The complication may vary depending on the species. However, main complications are meningo encephalitis,DIC and interstitial pneumonia

Scrub typhus was first described in Japan and was a major cause of febrile illness in Asia and Pacific regions. It was an ancient disease and caused by *Rickettsiae tsutsugamushi*, which was recently renamed *Orienta tsutsugamushi* of which antigenic types of three prototype strains Gallian, Karp and Kato are well known. This organism was removed from the genus rickettsia and moved to the new genus because of significant differences in 16s rRNA and cell wall structures which lack lipopolysaccharide and peptidoglycan typical of other members of the genus, (Kelly,2002). Antigenic types such as Shimokoshi, Kawasaki and Kuroki, are different from the initially described prototype strains. The causative organism is transmitted to humans through the bite of larval trombuculid mites, living on waist high imperata grass growing in previously cleared jungles around villages and in plantations.

The typhus group includes epidemic (louse-borne) typhus and murine (Flea-borne) typhus. Epidemic typhus is transmitted by the human body louse, *Peduculus humanus* from active

human cases or from healthy or sub clinical cases. In outbreaks in the Burundi prison in 1995, infection spread among malnourished inhabitants, causing over 50,000 cases with a mortality of 2.6%. Murine typhus is also called rat flea typhus. The bacteria naturally resides in rats, mice and other rodents and are transmitted to humans via the bite of fleas which live on rodents.

The spotted fever group (SFG) rickettsiae includes more than twenty species. Among them 16 species are found to cause human rickettsioses. Other species of SFG found only in ticks with no known pathogenicity towards human. They are mainly transmitted through ticks of dog, cattle, rodents and wild animals. It caused 30% of mortality in pre-antibiotic era.

2. Diagnosis of rickettsial infections

Although there are many recent developments in the laboratory diagnosis of typhus, careful clinical examination and epidemiological investigations remain important for diagnosis. As these are potentially hazardous organisms, only research laboratories that have level 3 containment facilities and extensive personal experience in cultivating rickettsia were able to involve in isolating rickettsia from clinical specimens.

The Weil-Felix test is the simplest and commonest test used in poorly resourced countries where more sophisticated facilities are not available. Antigens from the proteus strains *P.vulgaris,* OX-2 , P.vulgaris OX-19 and *P.mirabilis* OX-K are used. This test is based on serological cross-reactions between the two genera. This test is however negative in upto 50% of cases. Although this test lacks sensitivity and specificity, it has historically been used for laboratory diagnosis.

Lack of a group specific antigen confers an inherent limitation for most existing serological assays. Each assay is limited by the detectable antigen. Testing the sera against different species using multiple IFA or Immunoperoxidase is therefore an essential component of laboratory diagnosis.

Rickettsia may also be detected by PCR amplification from a variety of samples that includes blood, skin, biopsy samples and arthropod tissues. Moreover, this method is useful when immunological techniques or isolation of the causative agent is difficult. (Furuga 1993).

3. Treatment of Typhus

Typhus responds to tetracycline or doxycycline very well. As these drugs are having side effects, chloramphenicol is used in children.

4. Rickettsiosis in Asia & Sri Lanka

Sri Lanka was described as one of the risk areas for scrub typhus (Cowan, 2000). In 1938 two cases of 'urban typhus' were diagnosed by Weil-Felix reaction at General hospital, Colombo. This was assumed to be the first report of murine typhus in Sri Lanka. Van Peenen *et al* (1976) reported that scrub typhus was not a major public health concern in Sri Lanka on the basis of a 6% prevalence rate in a sero-prevalence study in the Colombo district. In 1995, Vasanthathilaka and Senanayake, and in 2003 Amarasinghe et. al described the murine typhus in Sri Lanka. However, specific serological tests were not carried out on these studies.

In Sri Lanka, typhus like fevers had been often diagnosed clinically. One important clinical criterion for the diagnosis of typhus by Sri Lankan clinicians was the rapid recovery noted with tetracycline or chloramphenicol. Sporadic outbreaks of such fevers have been diagnosed using only clinical criteria due to unavailability of specific diagnostic tests in Sri Lanka. The Weil-Felix test, though known to be non specific and of low sensitivity is the only test available in Sri Lanka. Absence of readily available tests of high specificity and sensitivity is a limitation when laboratory confirmation of the clinical diagnosis is required. In addition, many aspects of the disease including specific aetiology, epidemiology and suitable preventive measures cannot be studied in the absence of a suitable diagnostic test.

5. Study in Nawalapitiya

In July 2001 - June 2002 there was a study conducted by Nagalingam *et.al* at District General Hospital Nawalapitiya, where all the patients presenting with fever and rash were included. Apart from fever and rash, other signs exhibited were arthralgia (32%),

headache (4.8%) and vomiting (2.4%) among the 53 patients. None of the patients had hepatomegaly or lymphadenopathy. All the patients were followed up for a period of 3 years and there were no relapse or complication observed.

An erythematous maculopapular rash was the most characteristic feature of the illness and found in all the patients. The rash involved the face, trunk, limbs, palms and soles in majority (76.5 %) of the patients. No patient developed haemorrhagic / purpuric rash which is supposed to be associated with several rickettsial infections. Duration of fever on presentation to the hospital ranged from 2-15 days with a mean of 6.22 ±2.99. Majority of the patients (86%) were below 6 years of age. Increased admissions were noted from December to March each year (75%).

As there is no specific diagnosis available in Sri Lanka, Serum samples were freeze dried and sent to the Reference Laboratory (RRL), France where serological diagnosis using IFA, Western blot and cross adsorption studies carried out. Serum specimens were tested using 13 rickettsial antigens which include SFG(*R.conorii* Indian, *R.japonica, R .helvetica, R.slovaca,* AT1 Rickettsia, *R.felis, R.heilongjiangii*) ,Typhus group (*R.typhi*) and Scrub typhus *O tsutsugamushi* strains (Gillian,Kato,Karp and Kawazaki). All the positive sera had very high titers to *R.helvetica, R.japonica, R.felis R.honei.* and *R.slovaca.* Western blot assays and cross adsorption studies revealed they are mainly *R honei , R felis* and some were undetermined.

6. Study in Kandy

A study conducted by Kularatne *et al* during the same period in January 2000 to December 2001 in Kandy shared similarities and differences with this study. In their study serological testing was done in 2 Reference Laboratories in Thailand and Japan, these workers demonstrated a positive antibody response to the antigens of SFG *O tsutsugamushi* and *R typhi* in their cohort of patients, the results of both studies show clearly that rickettsial disease, in particular due to SFG group of rickettsiae is prevalent in the areas from which the patient populations lived and/or worked.

Serological tests are limited in several ways. The absence of a group antigen means that antisera to individual species are required for precise aetiological diagnosis. However, even when such antisera are available, cross reactions between different species limits the usefulness of these tests (Raoult and Roux 1997; Raoult and Dasch 1987).

Therefore in 2004 Nagalingam *et.al* developed a reckettsial genus specific PCR test in which all the typhus cases other than scrub typhus can be detected. Also, the results can be obtained within 24 hours and 1ml of single blood sample is enough to perform the test. It can be used for mapping of rickettsial disease in Sri Lanka.

7. Mapping of rickettsial disease in Sri Lanka

A study was done by Nagalingam *et.al* in 2004 to map the rickettsial disease in Sri Lanka. In this study, samples from all 9 provinces were collected and screened by genus specific PCR and scrub typhus ELISA. In this study Northern, North central, Eastern, North Western and southern province were positive for scrub typhus; Central province was positive for SFG and Sabragamuwa and Uva provience were positive for both scrub typhus and SFG. None of the samples were positive in Western province. From Northern province all ten samples tested were received from Jaffna Teaching Hospital and were only positive for Scrub typhus.

8. Study on Typhus in Jaffna

Nagalingam *et.al* conducted a study in Jaffna Teaching Hospital from December 2004 – November 2005 where 46 patients were included in the study. Seasonality pattern was noted with high number of cases from December to March. Mean duration of fever was 6.3±2.6 days. All the patients presented with fever and responded to doxycyclin. Majority of the patients had eschar. None of them had rash.

Nine patients' samples were tested for spotted fever and scrub typhus. All 9 were positive for scrub typhus and negative for spotted fever.

Further research studies should be carried out in all the suspected Typhus cases presenting to Jaffna Teaching Hospital by using the Genera specific PCR and scrub typhus ELISA IgG and IgM. Also the risk factors for scrub typhus in Jaffna to be studied.

9. Seasonal Variation

A seasonal variation was observed with increased admissions between December to March in all the studies. The climatic condition from December to March may have an influence on the ecology of vectors responsible for transmitting rickettsiae. Seasonal variation of Rickettsial diseases may be related to the characteristics of vectors. Halim *et al* (1983) have investigated the seasonal variation of some vectors such as ticks in Sri Lanka. There is also a generally held assumption that all the vectors have a seasonality pattern in their natural setting. Seasonal variation may also be a result of changes in human-vector interaction due to changes in human behavior.

In 2010 January to March period there were 63 cases reported from Jaffna district. Reasons for increasing trends of typhus fever are not known but there have been important changes on conditions that bring human to contact with rickettsia infected larval mites. This may become to actual increase in the number of mites or more likely increased human contact with the habitat of infected larvae. In 2008 and 2009 high numbers of cases were found to be in Kopay, Manipay and Tellipalay area.

All the studies in Jaffna revealed that the scrub typhus is the prevalent disease and its vector is mite. Some authorities responsible for the control of typhus in Jaffna appear to think that it is a tick-related disease and direct the health team and the public to control ticks in domestic animals. Any meaningful program to prevent scrub typhus should concentrate on mite control.

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Political Regimes and Economic Growth: A Review of Literature

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1. Introduction

Some developing countries like Sri Lanka have predominant natural resources, human resources, technology and financial resources made by foreign assistants. But they are unable to attain rapid growth which is precondition for economic development. Why? Are there any relationship between Non-economic factors, particularly, political regimes and economic growth? This study attempts to show the key findings of literatures in the relation to political regimes and economic growth.

Increasing of real gross domestic production (GDP) or gross national production (GNY) is called as economic growth. Economic growth is precondition for economic development. But, it is not a sufficient condition. Economic growth is like horse and economic and social development is like cart. Horse pulls cart, not cart pulls the horse. The development without economic growth is like tree without root.
Economic Growth = f (Physical capital, Human Capital, Technology and Non-Economic factors)

Non-economic factors for growth include political regimes/ liberty, political leadership, religion, culture of nation, history of nation, ethnic homogeneity etc. These forces attract the economist's attention in recent past to explain success and failure of economic development in the rest of world.

> *"Increasing national production, rising level of living, and promoting widespread employment opportunities are all as much function of the local history, expectations, values, incentives, attitudes and beliefs, and institutional and* ***power structure of both the domestic and global society****.... Looking back over years, it is now clear that, in their preoccupation with growth and its stages and with the provision of capital and skills, development theorists have paid sufficient attention to institutional and structural problems and to the power of historical, cultural, and religious forces in the development process" Michael P. Todaro (2006), pp.17-18*

Political regimes are defined as methods of politician must use to gain and maintain controls of states. Political regimes are distinguished according degree of political liberty such as democratic regime (India-10), autocracy (Mao Zedong in China-0), authoritarian regime, Neo-authoritarian regime (Deng Xiao Ping in China-0), partial authoritarian regime (Executive presidents in Sri Lanka), soft dictatorship (Lee Kuan Yew in Singapore-02), dictatorship (Adolf Hitler in Germany), Military regime (deferent periods in Pakistan) and other types of regimes.

2. Conceptual Linkage between Political Regime and Economic Growth

Political regimes based on degree of democracy in an economy influences on economic growth in following channels.

1. **Physical capital accumulation from internal sources.** (Local saving, consumption and investment) Liberal democracy makes social welfare state and induces the public and private expenditures on consumption for maintaining voting bank of politicians. It leads to falling of national saving and investment. The economy fails to accumulate the physical capital which is foundation for economic growth at initial stage of economic development. Politicians in welfare state ignore the expenditures on quality of high ways, train roads, harbor, airport, large scale faming and industry. Instead, they are very enthusiastic to provide social services in the name of human development such as free education, health, medicines, subsidized foods, micro finance VS macro finance, land distribution etc. Even these types of services contribute to economic development in long run; they slash the root of development. Welfarism does not have direct linkage with human capital development. Political freedom and democracy may undermine the

effectiveness of government in maintaining of disciplines, law and order. Democratic regime in LDCs promotes the consumption at the cost of saving. In contrast, the **authoritarian government are said to limit the consumption, increasing national savings, and thereby promoting economic growth".**

2. **Physical capital accumulation from external sources.** (Foreign Aids, FDI & technology, other external financial sources) Countries get financial resources from external sources for physical capital accumulation. These sources are encouraged via political system they have. Foreign aids, FDI and technology which an economy received are determined by political regimes.

3. **Peace/social and political stability and economic growth**. What type of political regime brings peace and social stability? Degree of democracy is linked with peace. Even democratic regime have peace in developed industrial nations, liberal democracy in most of developing countries does not have social and political stability.

4. Good governance and economic growth (Maintenance of roles and regulation, lowering the corruption. Political freedom and democratic government in developing countries are likely to lead corruption and bribery among the politicians and bureaucrats. Democratic regimes retard growth by promoting rent seeking, the "dollar –bill game" activities of pressure (Interest) groups whose primary goal is to grab the major share of nation's economic pie. Democratic governments encourage trade and labor unions to demand unduly high wages, which leads to strikes and lockouts and the consequent loss of national output.

5. **Political continuity hence policy continuity and growth**. Outcomes of economic policies are received by economy in long run. Liberal democratic regimes change the government often and economic policies are changed. Discontinuity of policy adversely affects economic growth.

Reasons for why democratic regime may be good for economic growth.

I. Only governments with some legitimacy will be able to implement and sustain policies that may bear high short-term costs.

II. Several of the institutional characteristics of a democracy, like an independent legal system, are also required for a successful liberalization. As North (1993) puts it, "well specified and enforced property rights, a necessary condition for economic growth, are only secure when political and civil rights are secure; otherwise arbitrary confiscation is always a threat.

III. Democratization may limit rent-seeking due to its system of checks and balances. Recently, Rodrik (2000) has argued that democratic institutions - political parties, elected representatives, free speech, and the like - can be viewed as the ultimate institutions of conflict management, as they allow for differences among social groups to be resolved in a predictable, inclusive, and participatory manner.

But, Democratic regime may lead to policies that hamper economic growth (rich-to-poor redistribution, large public sector, high taxes) due to majority voting. Influence of interest groups (Olson) will reduce flexibility of the economy.

Reasons for why an authoritarian regime may be good for economic growth.

I. Only an authoritarian government is in a position to introduce unpopular measures; electorates often turn down economic reform even when it is known in the end that they would benefit a majority of voters. Policies that would be popular ex post are often not implemented in a democratic regime.

II. The demand for comprehensive state action requires strong state: there has

been no case of successful economic development during this century without comprehensive political action, involving massive state intervention in the economy.

III. Supporters of this view often refer to the experience of countries such as Chile, South Korea and Taiwan
But, Dictators may also be forced to follow opportunistic policies if their survival in office is threatened. Authoritarian regimes are not homogeneous. While the apparent association of high economic growth with authoritarian regimes is suggested by the experience of several non-democratic "technocratic" regimes (such as those in South-Korea and Taiwan), it is at the same time evident that there are many counter examples of "kleptocratic" and/or inept authoritarian regimes whose rule has led to slow economic growth rates. Authoritarian rule can mean arbitrary rule and undue interference, which may hinder economic growth. A strong state and an authoritarian state are not necessarily the same thing.

3. Democracy Fosters Economic Growth

The relationship between political factors and economic growth has came to concern by works of Lipset in 1959. His study examined that how economic development is delayed by political regimes. Since then, political environment plays an important role in economic growth. Dick (1974) in cross country analysis in regard the effect of democracy, autocracy and bureaucracy on growth in 59 underdeveloped countries during the period of 1959-1968 comes to conclusion on that democracy has positive effect on growth. Kormendi and Meguire (1985) in cross country analysis in the effect of democracy, autocracy and bureaucracy on growth in 47 countries during 1950-1977 concludes that democracy grew the growth faster.

Scully (1988, 1992), Remmer (1990) and Barro (1989) in cross country study in the effect of democracy, autocracy and bureaucracy on growth in115 countries during 1960-1980, 11 Latin American countries during 1982-1988, and in 72 countries during 1960-1985 conclude that democracy grew the growth faster. Grier and Tullock (1989) show the different affect in different regions. In cross country analysis of the effect of democracy, autocracy and bureaucracy on growth in 59 countries during 1961 -1980, they show that effect of democracy on growth better in Africa and no regime difference on growth in Latin America. Brunetti, Kisunko, and Weder (1997) with surveys of business establishments around the world to contract and index of the credibility of rules composed of the perceptibility of rule-making, subjective perceptions of political instability, security of persons and property, predictability of judicial enforcement, and corruption cross firm and cross country regressions illustrates that credibility made by democratic regime promotes investment and economic growth.

Dani Rodric (1997) in a cross-country analysis by using democracy index in 100 countries during 1970 -1994. He uses five year's average for all measures, (1970-74, 75-79, 80-84, 85-99, and and1990-94) with 388 observations and demonstrates that democracy affects economic performances positively.

Gupta K.D, Madhavan M.C, and Andrew .B (1998) with pooled time series cross country analysis during 1965-1986, three 7 years periods 1965-71, 1972-79 and 1980-86 in 120 countries by using index of political freedom and index of democracy with political instability measures show that democracy affects economic growth positively without totalitarianism of majority.

Panther (1999) by using factor analytic methods, a civicness indicator is extracted for 11 economies in transition that reflects trust in impersonal institutions and the attractiveness of non- democratic regimes to democratic government show that Civicness promotes both liberal-democratic institutional reforms and economic performances.

Douglas A. Hibbs, Jr (2001) with qualitative approach for growth theory by using theories of growth with mathematical treatment illustrates that politics, policies and institutions effects the factors input and marginal productivities hence output and growth. John C.Bluedorn (2001) with pooled decadal data analysis in 60 countries during 1960s, 1970s, and 1980s by using democracy

measures explain that democratic institutions have positive influences on growth. However, democracies in homogeneous ethnic nation negatively affect the growth. Ludovic and Comeau (2003) in cross sectional analysis by using five political variables including initial democratic capital as proxy for sociopolitical instability.(Standard deviation of political rights index means absent of stability) in 82 countries during1979-1989 shows that democratic types of political regimes are more favorable economic prosperity, that a non liner relationship exists between growth and regime type, It also shows that sociopolitical stability which is achieved by democratic regime most likely is necessary complementary condition for economic growth. James L. Butkiewiczand Halit Yanikkaya (2006) in cross country analysis by using measures of political and institutional variables in 100 countries concludes that rule of law and democratic institutions promote the growth.

John Gerring et al (2006) in longest discussion, democracy are viewed as stock of social capital rather than level. It is viewed as T-10 and T a panel data analysis including more than 180 countries during 1950-2000. They rejected the conventional wisdom on that there no contemporary negative relationship between democracy and growth. They find long-term democracy positively affect economic growth. Democratic capitals, institutionalization are key determinants to economic growth. They show that democracy in a time accumulation positively contributes to economic development.

4. Democracy Hinders Economic Growth

At the most basic form, political instability made by democracy, bureaucracies or autocracies would increases the uncertainty, discouraging investment and eventually hiding the economic growth. Przeworksi (1966) in cross country analysis of the effect of democracy, autocracy and bureaucracy on growth in 57 countries during 1949-1963 concludes that dictatorship at medium development level grew fastest economic development. Adelman and Morries (1967) in cross- country analysis of the effect of democracy, autocracy and bureaucracy on growth in 74 underdeveloped countries (including communist bloc) during 1950 -1968 affirms that authoritarianism helped to increase growth in less and medium developed countries. Marsh (1979) in cross- country analysis in the effect of democracy, autocracy and bureaucracy on growth in 98 countries during 1950-1970 concludes that authoritarian grew the growth faster. Weede (1983) in cross-country analysis in the effect of democracy, autocracy and bureaucracy on growth in124 countries during 1960-1974 shows that authoritarian grew the growth faster.

Landau (1986) in cross country analysis in the effect of democracy, autocracy and bureaucracy on growth in 65 countries during 1960-1980 shows that authoritarian grew the growth faster. Sloan and Tedin (1987) in a cross- country analysis in the effect of democracy, autocracy and bureaucracy on growth in 20 Latin American countries during 1960-1979 concludes that Bureaucratic – authoritarian regimes do better than democracy and traditional dictatorships do worse on growth. Traditional dictatorship concentrates power to hands of one man. New dictatorship and neo-authoritarianism concentrates the political power to hands of groups of leaderships which represents the leaders from all parts of nations (One party system in China-CCP), all communities in the nation (One party leading system in Singapore-PAP), all ethnics of nations (One party dominant system in Malaysia-BP), and religions etc.

Some studies have not reach to conclusion whether democracy affect growth or not. For example Kohli (1986) in a cross country analysis in the effect of democracy, autocracy and bureaucracy on growth in 10 underdeveloped countries during 1960-1982 comes a conclusion on that there was no difference in 1960s, but, authoritarian was slightly better in 1970s.

Pourgerami (1991) with evidence from 106 less developed countries shows that democracy grew the growth slower. Helliwell (1992) in a cross country regression analysis the in effect of democracy, autocracy and bureaucracy on growth in 90 countries during 1960-1985 shows that democracy has a negative but statistically insignificant effect on growth.

Nelson M.A and Ram D. Singh (1998) in 67 developing countries with cross sectional analysis for period 1970- 1989 with divisions of 1970-1974, 1975-1979, 1980-1984 and 1985-1989 explains that economic freedom, not political freedom or democracy that is relevant

for growth in developing countries. South Korea, Taiwan and Singapore are cited in support of such contentions. There is no evidence for democracy, political and civil liberties are detrimental to growth.

Hamid Mohtadi and Terry L Roe (2003) in two-sector endogenous growth model by proving of mathematical approach shows that higher democracy associated with higher corruption (rent seeking) and higher corruption leads to low growth. Albert Saiz (2006) in cross- country analysis by using democracy index on quantity and quality of roads in 75 countries illustrates that dictatorship regimes have higher quality and quantity roads than democratic regimes. Since highways is economic infrastructure, dictatorship positive affects economic growth. Democracy negatively affects growth. Selvarathnam Santhirasegaram (2007) in cross- country analysis by using democratic index and economic growth in 70 developing countries during 2000-2005 concludes that democracy in developing countries affects economic growth negatively.

Acemoglu D et al (2008) rejects that democratic societies are usually associated with higher level of economic development than non- democratic societies. They argue two ways relationship between democracy and economic development. On one hand, democracy has linkages with economic development, on other hand, economic development leads to democratization. It is difficult to conclude that democracy promote economic growth. Success of economic development with concerning political regime depends not only democratic freedom but also other socio-political factors such as leadership, mentality of people, history of nation, international political environment, regional political environment, role of religion in politics, role of language policies, ethnic homogeneity, cast system, gender equality, colonization, and nature of independent etc.

5. Conclusion

Findings are mixed. Democratic regime positively influence on growth in mostly. Less democratic regime (Autocracy / military regime/ one party regime/ authoritarian regime) is positively related with economic growth in some East Asian Countries. Other factors related with political regimes such as political leadership, time of independence, nature of people's mind set are also key factors to come conclusion whether autocracy influence on growth positively or not.

Top leader with proper vision and decisive action is crucial for economic development. Not all strong leaders are effective leaders. Economic literacy rather than political literacy is the key requirement for successful of economic development based on rapid growth. A good leader is the primary force in institutional change, because he/she can build other necessary conditions and systems.

East Asia has Adopted Authoritarian *Developmentalism (AD) during* the take-off (for a few decades). It has key ingredients of AD. First, Succeeded nations had powerful and wise (economically literate) top leader. Second, Economic development without ethnic, language, religious cohesion was as a supreme national goal. Third, Technocrat group have supported to leader and execute policies in the lines of economic development. Legitimacy for leaders derived from successful development not by ethnic, language or religious Chauvinism and get hold of popular support from people. AD emerges through election as well as a coup. AD is more likely to rise when the nation's existence is threatened external enemy, internal ethnic/social instability and incomepetent and corrupt leader, The rise and fall of AD is conditional mainly on the development stage of each country, but international environment also influences them. Eg. Cold War – reduced global criticism of AD.

Economic growth requires a critical mass of mutually enforcing policies. A free hand of the state is needed to mobilize resources quickly and flexibly. Private dynamism is weak in most developing countries. The state must lead initially. If broad participation is allowed, policies are too slow and can't achieve critical mass due to the power struggle, party politics, interest groups, etc. Processes which require patience and compromise, including parliamentary debate and consensus building and some groups refuse to cooperate with state purposes.

Over time, views on the relationship between political regimes and economic development have changed. In the 1960s and 1970s democracy and economic growth were often considered as competing concerns. Bhagwati (1966, pp. 203-204): "the political economy of

development poses a cruel choice between rapid (self-sustained) expansion and democratic process". More recently, after ending gold war, authors often came to more optimistic conclusions on that democratic regime promotes the growth.

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The Beauty and Magic of Numbers

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Ladies and Gentleman,

I am extremely happy to deliver this Presidential address while assuming the Presidency of the Jaffna Science Association with which I have been associated since its inception in 1992 in numerous ways, especially as the Assistant General Secretary for two years and then as General Secretary for four years and as the President-elect last year. First I wish to thank the Past President, Professor K Sivapalan, for introducing me to you by recalling my contribution to JSA and to the local and international mathematics community in a nice and thoughtful way, unique to him.

Before I introduce the theme of the address, I like to state that my presentation will be more in the nature of a leisurely excursion than of an organized journey. I may not reach a specific destination at a scheduled time. Rather I like to allow myself on many occasions the luxury of stopping and looking around. So much effort is being spent on bringing active experience in Mathematics.

Mathematics as an expression of the human mind reflects the active will, the contemplative reason and the desire for aesthetic perfection. Its basic elements are logic and intuition, analysis and construction, generating and individuality. Without doubt, all mathematical development has its psychological roots in more or less practical requirements. But once started under the pressure of necessary applications, it inevitably gains momentum in itself and transcends the confines of immediate utility. This trend from applied to theoretical science appears in ancient history as well as in many contributions to modern mathematics by engineers and physicists.

The topic of my address today "The Beauty and Magic of Numbers" originates from the greatest discovery of all humankind: the natural numbers. The natural or "counting" numbers have been with us since prehistoric times, assisting us in our struggle to emerge from the primitive lifestyle of the hunter-gatherer to become the modern human being of the 21st century we are. For many past centuries, philosophers and mathematicians have studied the sequence of natural numbers, uncovering startling and mystifying truths. Mathematics, itself, began with the natural numbers and the study of their relationships. The demand for solutions to new and sophisticated problems encountered in our march from simple farmers to merchants, priests, scientists, and finally modern industrialists, forced us to use the natural numbers to construct the great edifice of modern mathematics.

Mathematicians, in their search for these solutions, progressed beyond the natural numbers, discovering fractions, and irrational, transcendental, transfinite, and surreal numbers. However, the majority of

professional mathematicians recognize that the most important problems in mathematics today still involve the natural number sequence.

By studying the natural numbers in their wonderful ordered sequence, we discover a perplexing and utterly charming characteristic of mathematics - its interconnectedness. The reasons why seemingly unrelated mathematical truths are connected in simple and beautiful equations continue to stump mathematicians. For example the Goldbach Conjecture: "Every even number (>2) is a sum of two primes and every odd number (>2) is a sum of three primes" certainly stumped thousands of mathematicians for more than 250 years.

In general, numbers have three uses, and are given three names to reflect these uses. Cardinal numbers are used to find how many objects are in a collection. We call the objects "elements" and the collections "sets." This is the first and most important use of numbers. Ordinal numbers are used to find the proper order of elements in a set. If you graduated number three in your college class, then you were after two other students. The "three" does not tell how many students graduated, but only where you stood among those graduates. Therefore, the "three" is used as an ordinal number but not a cardinal number. Hence, ordinal numbers give us information about an element's position within a set, without identifying the cardinal number of the set. There are many uses of ordinal numbers. For example, street addresses are ordinal numbers. An address of 452 Temple Road does not tell us how many houses are on Temple Road or how many houses are in the town. But the number 452 does tell us that this house comes before 512 Temple Road and after 300 Temple Road. Some numbers may be used as both cardinal and ordinal numbers, e.g., counting on our fingers while speaking the counting words. In this case we not only determine the total number of fingers (cardinal number), but we also assign each number to a specific finger, and, hence, determine an ordering for the fingers.

The last use of numbers is simply to give a unique name to an object. These are tag numbers. Phone numbers, airline flight numbers, and bus numbers are all tag numbers. Tag numbers give us no information about the number of phone customers, airline flights, or bus routes, nor do they give us any information about the order of items in a set. We can't say flight 302 leaves before or after flight 1601. As numbers, tag numbers are of the least interest because they are really used in the place of proper names.

A natural number sequence also represents our first encounter with the idea of infinity, an idea that still puzzles and entertains us. We will now consider the famous farmer's problem to see how an infinite series arises in a natural problem.

THE FARMER'S PROBLEM

Since recorded history, beginning around 3100 B.C. in the City of Sumer (present day Iraq), we find references to both sequences and series. However, we can make a strong indirect argument that both series and sequences were known even before the invention of writing.

Pretend we are farmers living along the Tigris River in summer during the year 6001 B.C. One question that we frequently ask is "how much grain should we plant in the spring for an adequate supply of food for the next year, with enough grain left over to plant again for the following year?" Suppose that we know that our seeds will increase three fold because of our farming efforts. Hence, 1/3 of a bushel planted in the spring will yield one whole bushel in the fall. We also know that we need one large bushel of grain to feed our family through the winter. All right, let's plant 1/3 bushel of grain. This yields a full bushel in the fall, and we can survive the winter. The problem is this: We don't have any grain to plant the following spring. So, we must plant a little more than 1/3 bushel. How much more? If we want 1/3 bushel of grain next spring for planting, we have to plant 1/9 bushel this spring to generate that 1/3 (since 1/9 bushel will triple to 1/3). Therefore we must plant at least 1/3 + 1/9 of a bushel. So we do. We get 1 + 1/3 bushel in the fall. We eat the bushel and have 1/3 to plant during the next spring. But wait! That 1/3 bushel to be planted next spring yields only one bushel the following fall. We won't have anything left over to plant the following spring.

You can now see our conundrum. We must plant 1/3 bushel for the grain we will eat, plus 1/9 bushel for next spring's planting, and 1/27 bushel for the following spring and 1/81 bushel for the spring after that, and so on. In fact, the correct solution to this problem is the infinite series:

$$\sum_{n=1}^{\infty} \frac{1}{3^n} = \frac{1}{3} + \frac{1}{9} + \frac{1}{27} + \frac{1}{81} + \ldots.$$

We may question whether ancient farmers considered solving this infinite series, or even whether they formulated it as an infinite series. In all likelihood, they probably figured that it was best to plant 1/3 bushel to produce enough to eat, and then simply planted another fraction to handle all the rest. However the farmer's problem is so common that it must have been worked on at various times by individual farmers, elders of farm villages, and even advisors to kings during the thousands of years before the invention of writing. Surprisingly, an exact solution (1/2 bushel) is available for the kind of multiplicative infinite series with common ratio 1/3 represented by the farmer's problem.

Finally, the very notion of numbers forces us to deal with the question of what reality is. Do numbers exist without humans to think of them? If so, what exactly are these "ideas" and how is their existence different from the material world we see around us? Yet, there is no valid reason to hold that any one number has more of a claim to existence than any other. To say that 3, 5, or 9 has more existence than say, 17, 73, or even 3982, places an unnecessary condition on the notion of existence. In whatever way numbers do exist, they share in existence equally. This is not to say that all numbers share all the same qualities. Some numbers do, indeed, have unique and fascinating characteristics, and it is the discovery of these characteristics that makes the study of mathematics so intriguing. Our entire adventure into mathematics will be to uncover the characteristics of individual numbers and the relationships between collections of numbers. Let us describe a few of those examples. Take zero - 0 which is

considered to be the discovery of Indians to represent omnipresence (vishnum aspect) of the indictable consciousness, because "a+0 = a and a-0 = a for all a".

Take another direct non-trivial example "1729" about which the genius Srinivasan Ramanujan spontaneously (at the hospital ward when the famous Hardy told the sickly Ramanujan that 1729 was an inauspicious taxi number) pointed out that "1729 is the smallest number expressible as a sum of two cubes in two different ways: $1729=1^3+12^3=9^3+10^3$.

As we all know a set of commensurable numbers (basically integers and fractions) is generated in a natural way by performing the usual operations "addition, subtraction, multiplication and division" on the set of natural numbers.

It is interesting to note that two kinds of commensurable numbers in common use, decimals and percentages, are really fractions. A percentage is the numerator of a fraction that has a denominator of 100. For example 37% is really the fraction 37/100. A decimal is really the sum of a series of fractions. For example, the decimal 31.47 is the sum of the following three fractions: 31.47=31/1 + 4/10 + 7/100 or the single fraction 3247/100 .

Decimals come in three flavors: terminating decimals (e.g. 3.5), non-terminating, periodic decimals (e.g. 0.13131313...), and non-terminating, non-periodic decimals (e.g. 5.973821...). By non-terminating, we mean that the digits to the right of the decimal in the decimal number continue on for an infinite number of places. By periodic we mean that a fixed number of digits repeat indefinitely, beginning somewhere to the right of the decimal point. If the decimal is both non-terminating and periodic, then the repeating digits continue to repeat without end. A simple example is the fraction 1/3 which is equal to the decimal, 0.33333....

Both terminating and non-terminating, periodic decimals can be rewritten as either a finite sum of fractions or a convergent infinite sum of fractions. (The third kind of decimal, the non-terminating, non-periodic decimal, we will comment on later.) Since these two kinds of decimals can be represented by a series of fractions, we have a nice correspondence between fractions and decimals involving finite and infinite series. For example, consider again the fraction 1/3. If we use long division to divide 1 into 3, we begin with a decimal of the form 0.3333... and the process of division never ends, because we repeatedly get a remainder in the division. This means that we have the following identity:

$$\sum_{n=1} \frac{3}{10^n} = \frac{3}{10^1} + \frac{3}{10^2} + \frac{3}{10^3} + \frac{3}{10^4} + \ldots = \frac{1}{3}$$

Here we have the kind of bounded infinite series we searched so long for, and it is equal to the fraction 1/3. In fact, we can expand this idea even further. Since every fraction has a corresponding decimal number, we can see that every fraction is equal to a corresponding convergent series.

If the fraction is terminating, such as 1/5=0.2, then the corresponding series will be finite. If the decimal is a non-terminating, periodic decimal then the corresponding series will be bounded and infinite. Hence, every fraction is equal to a bounded, infinite, or finite series.

Infinite repeating decimals can be mysterious as their meaning can only be understood in a limit sense. To illustrate this point consider decimal 0.99999.... where the ellipsis in indicates the 9s go on forever. One may claim that this decimal is exactly equal to the number one. One may not accept this claim and think that the decimal should be less than one. Let us validate the above claim. First we multiply the decimal by 10 getting 9.99999... which is the original decimal point shifted one place to the right. We subtract the original decimal from this new one:

$$10X = 9.99999...$$

$$\underline{-X = -0.99999....}$$

$$9X = 9.00000....$$

Now we divide both sides by 9 to get X=1. Our intuition tells that 0.99999... is some infinitesimal amount less than 1. Thus to make a claim in mathematics the proof of justification is necessary and intuition alone is not sufficient.

We shall now move on to the third kind of decimal, the non-terminating, non-periodic decimal. Such decimals are basically non-fractions and thus incommensurable numbers. As it was known, and was proven by the Greeks, any square root of a whole number that is not a perfect square is one of these incommensurable numbers. Therefore $\sqrt{3}, \sqrt{5}, \sqrt{6}, \sqrt{7},$ and $\sqrt{8}$ are all incommensurable numbers. The only kinds of numbers we leave out are $\sqrt{4} = 2, \sqrt{9} = 3$, and any other number which is a perfect square. This means there are an infinite number of these new numbers. We will call such numbers *radical* numbers. Actually the n^{th} root of an integer is called a **radical**.

If we now consider all the numbers we have discovered, including the rational numbers (commensurable numbers) and our radical numbers, our new and bigger set of numbers is called the ***algebraic* numbers**. The reason they are called algebraic leads to an interesting insight. Consider the equation: A.X + B = 0 where X is our unknown number and both A and B are known, integer numbers (we exclude the possibility that A = 0). We can solve for X in terms of A and B to get: X = -B/A. The value for X will always be a rational number. This kind of equation, A.X + B = 0, is called a *linear* equation because X is not raised to a power other than 1. Therefore, we can say that all linear equations have solutions that are rational numbers.

We usually write polynomials in standard form which means we begin on the left with the term containing the largest exponent of X and proceed in descending order. Using this technique we can write the general form for a polynomial of the *n*th degree as:

$$a_0X^n + a_1X^{n-1} + a_2X^{n-2} + ... + a_{n-1}X + a_n$$

where the different a_i's are all integers, and n is always a positive integer. For thousands of years mathematicians have been interested in the solutions to polynomials, that is, the value of X that makes the polynomial zero. The real solutions to this kind of polynomial

equation (if they exist) are known as algebraic numbers. This is a powerful piece of mathematics. It would appear that expanding our collection of numbers to include the radicals has allowed us to account for the solution of many more equations.

OF COURSE, THEN THERE WAS π

We know that π is the ratio of the circumference of circle to its diameter. It has the approximate value of 3.14159265..... What kind of number is π? Is it a fraction? No. Early civilizations used fractions to approximate π For example, one Egyptian estimate was $(16/9)^2$, which yields a value of 3.16049..., a value only about 6/10 of 1% in error. One estimate by the Chinese mathematician Tsu Ch'ung-Chih (430-501AD) was 355/113, which is even better, accurate to seven decimal places. However, no fraction exactly equals π Therefore, it must be some other kind of number. Is it algebraic, some kind of radical? If πis algebraic, then it will be the solution to some polynomial that has integer coefficients.

If πis not algebraic, then it must be some other kind of number, a number that **transcends the algebraic numbers**. It would be a transcendental number. Do such transcendental numbers even exist? This question was not answered until the middle of the 19th century. In 1844 Joseph Liouville (1809-1882) proved that transcendental numbers existed by actually constructing examples. He used an infinite series to do this.

In order to understand how he wrote his transcendental numbers, we must examine a special kind of mathematical notation called a factorial. The sign for a factorial is !. When we write N! we mean all the natural numbers up to and including N all multiplied together. Therefore, 1! = 1; 2! = 1.2 = 2; 3! = 1.2.3 = 6. you can see at once that factorials increase very quickly in size, since 10! = 1.2.3.4.5.6.7.8.9.10 = 3,628,800.

Using factorial notation we can now show an example of one of Liouville's transcendental numbers.

$$\sum_{n=1}^{\infty}\frac{1}{10^{n!}}=\frac{1}{10}+\frac{1}{10^{2}}+\frac{1}{10^{6}}+\frac{1}{10^{24}}+\cdots\cdots\cdots$$

If we write the first few digits out in decimal form we get:

$$\sum_{n=1}^{\infty}\frac{1}{10^{n!}}=0.110001000000000000000001000$$

....

The decimal expansion of this number contains zeros everywhere except those locations n! (n factorial) places from the right of the decimal point, where n are consecutive numbers beginning with 1. Hence, we have a 1 at positions 1!=1, 2!=2, 3!=6, 4!=24, etc. The next digit 1 will appear at 5!=120 or 120 places right of the decimal. Any number of the form

$$\sum_{n=1}^{\infty}\frac{A}{10^{n!}}$$

where A is a constant is a Liouville number.

Liouville proved that such numbers cannot be the solutions of polynomial equations with integer coefficients, and hence were not algebraic. This means they are not any kind of numbers we have studied so far.

Even though Liouville proved that transcendental numbers exist, it was still 38 years later, in 1882, that C.L.F. Lindemann (1852-1939) proved that π was not the solution to any polynomial (add 90).

Euler's Discovery – e

Leonhard Euler – one of the great mathematicians of all time introduced the famous transcendental number, the natural logarithm base – e which indeed is used for providing the solution for simple dfferential equation $y' = k\,y$ describing natural decay/growth.

$$e = 1 + 1 + \frac{1}{1\cdot 2} + \frac{1}{1\cdot 2\cdot 3} + \frac{1}{1\cdot 2\cdot 3\cdot 4} + \ldots\ldots + \frac{1}{n!} + \ldots\ldots$$

More Transcendentals

We come now to our final question. What about the transcendental numbers? We have only learned of three such numbers, the example of a Liouville number, π and *e*. Could we possibly expect that the transcendental numbers form a larger infinite set than all the algebraic numbers? Gorge Canter proved that the transcendental numbers formed a larger infinite set, designated as C (for continuum). It is impossible to make a one-to-one mapping of the transcendental numbers with natural numbers. Why? There are just too many of them. These transcendental numbers – numbers so strange and exotic that they were only discovered 150 years ago, and so rare in common usage that the only familiar one is π – actually represent the great bulk of all numbers on the number line. If we consider the algebraic numbers, we can devise a scheme to make an infinitely long list of these numbers, and the list will include every one. However, because there are so many more transcendental numbers we could never make a list of them all, even if we allowed the list to be infinitely long.

If we imagine the number line with only the algebraic numbers in plane and the transcendental numbers left out, then such a line would have more holes than number points.

SO MANY NUMBERS!

We have covered the territory we wanted. We took the number line and found all the numbers that fill this line up.

Naturals numbers	1,2,3,4.....
Zero	0
Negative whole numbers	-1,-2,-3,-4,.....
All of the above = integers	
Fractions	½,3/7,-2/9,23/6.....

All of the above =Rational numbers

Radicals $\sqrt{2}, \sqrt{3}, \sqrt{14}$ .....

All of the above = Algebraic numbers

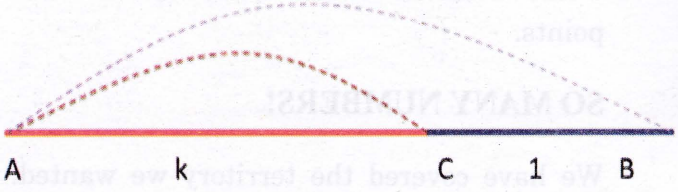
Transcendental numbers e, π $\sum_{n=1}^{\infty} \frac{1}{10^{n!}}$

All of the above = Real numbers

Therefore, all of the numbers on the number line are designated as real numbers, or sometimes just the reals. We also know that the real numbers form a set that is infinitely larger than the algebraic numbers. Algebraic numbers are represented by the cardinal number N_0 and the transcendental numbers by the cardinal number C.

Golden mean and Fibonacci numbers.

Of course, we have left the best for the last. One area of mathematics with considerable aesthetic implications grew out of the 'division into mean and extreme ratio' (DEMR) in Greek geometry, where a line with extremities A and B was split into two unequal parts by a point C.



AB: AC= AC:CB. Let AC:CB =k :1. Then, the DEMR requirement tells that

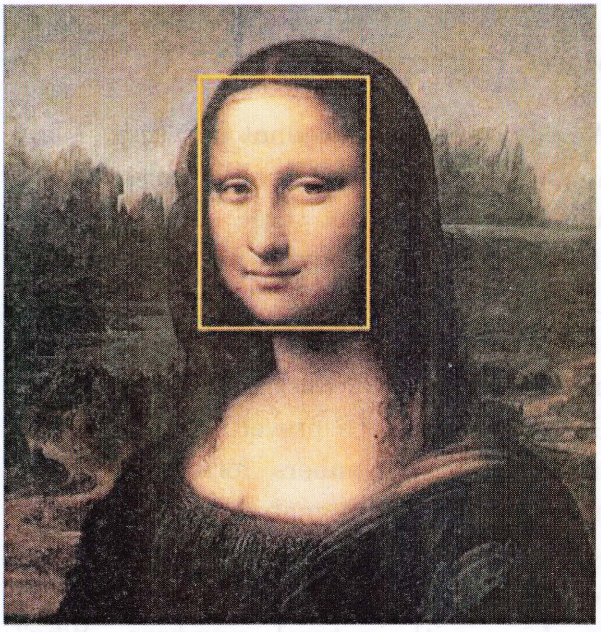
$\frac{k}{1} = \frac{k+1}{k}$ or $k^2 - k - 1 = 0$.

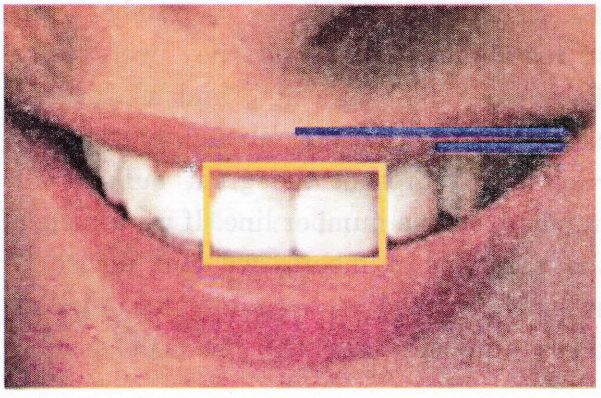
Hence $k = \frac{1+\sqrt{5}}{2} = 1.61803...$ and Martin Ohm introduced the name **'golden number'** (usually denoted by Phi) for DEMR. This wonderful number Phi(ϕ has a tendency to turn up in a great number of places, a few of which will be discussed in this lecture.

This ratio turns up all over on the regular shapes: isosceles triangles, pentagon, decagon etc.

In fact, it is said that any geometrical shape that has the Golden Ratio in it is the most pleasing to look at of those types of figures. Anyhow, here is a famous picture of the Golden Rectangle, very pleasing to look at.

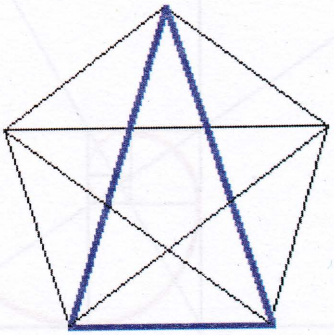
Mona Lisa's face is a perfect golden rectangle

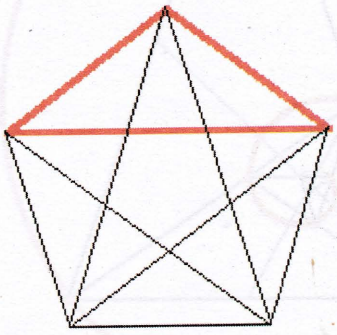




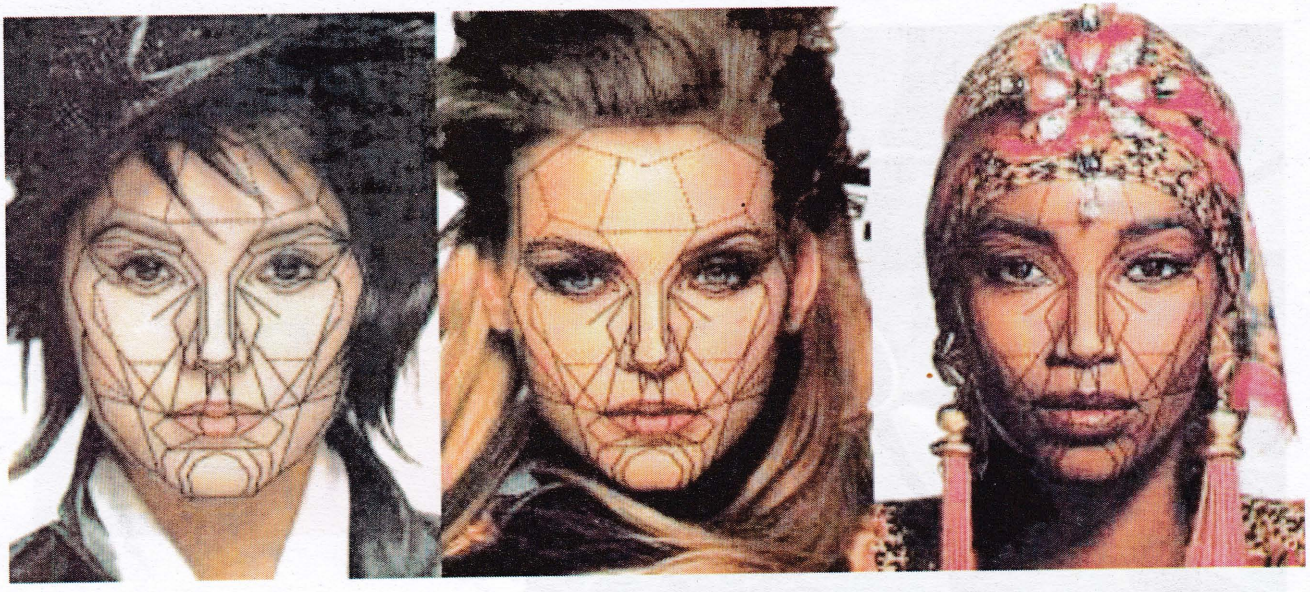
The above picture is of a perfect smile: the front two teeth form a golden rectangle. There is also a *Golden Ratio* in the height to width of the middle two teeth.

If we connect the vertices of the regular pentagon, we can get two different **Golden Traingles**. The blue triangle has its sides in the golden ratio with its base, and the red triangle has its base in the golden ratio with one of the sides.



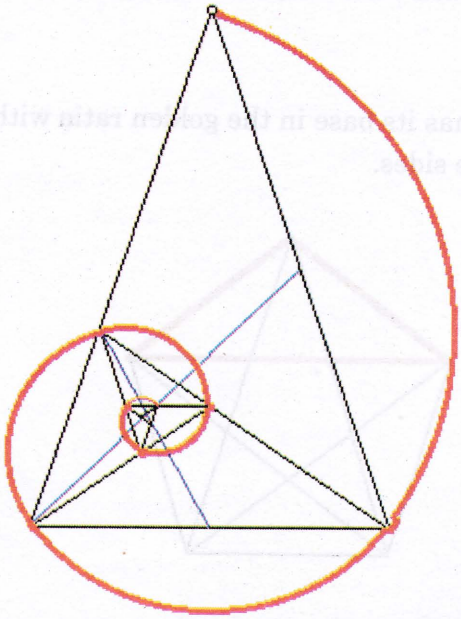


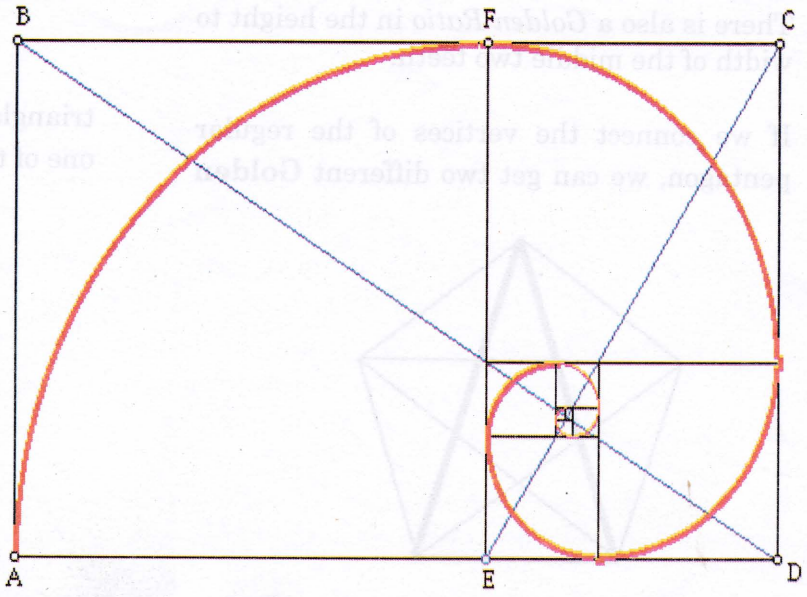
Dr. Stephen Marquardt, a former plastic surgeon, has used the golden section and some of its relatives to make a mask that he claims is the most beautiful shape a human face can ever have, it used decagons and pentagons as its function that embodies phi (ϕ in all its dimensions.



Let's turn back to one of the Golden Triangles for a moment. If we take the isoceles triangle that has the two base angles of 72 degrees and we bisect one of the base angles, we should see that

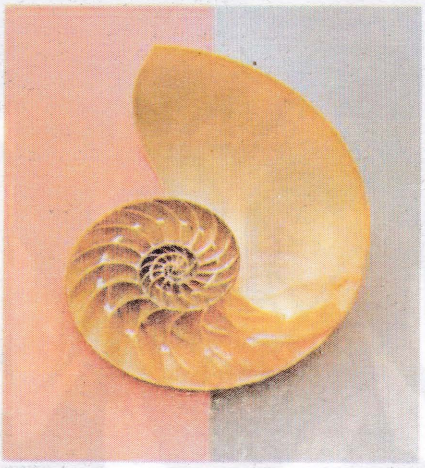
we get another Golden triangle that is similar to the first. If we continue in this fashion we





should get a set of Whirling Triangles.

We can do a similar thing with the Golden Rectangle. We can make a set of Whirling Rectangles that produces a similar logarithmic spiral. Again this spiral converges at the intersection of the two blue lines, and the ratio of the lengths of these two lines is in the Golden Ratio. These whirling shapes are readily found in nature in abundance: curving plants, sea shells etc.

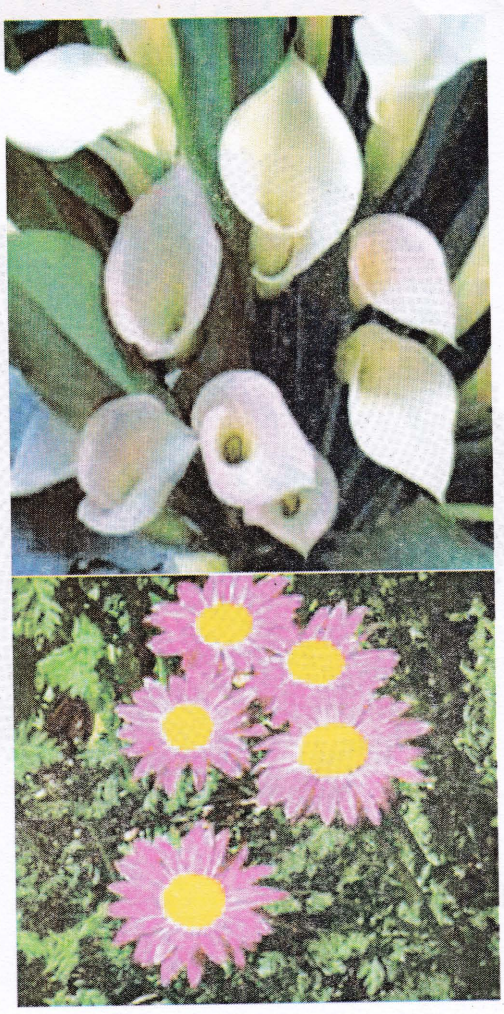


Fibonacci Numbers and Nature

Today, Fibonacci's name is associated primarily with the sequence of integers that starts with 0 and 1 and proceeds by adding the last two together, to obtain

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144,....

Fibonacci had presented it in his *Liber abbaci* (1202) as the successive population sizes of pairs of rabbits breeding each month from one parent pair. In addition the ratio of successive numbers tends to the golden number. This connection played a role in many natural phenomena. A fine example is that the petals of the different flowers contain the Fibonacci Numbers. The examples are that the buttercup has 5 petals, delphiniums have 8 petals, ragwort has 13 petals, aster as 21 petals, plantain has 34 petals, and the asteraceae family has 55 petals, and some of them have 89 petals.

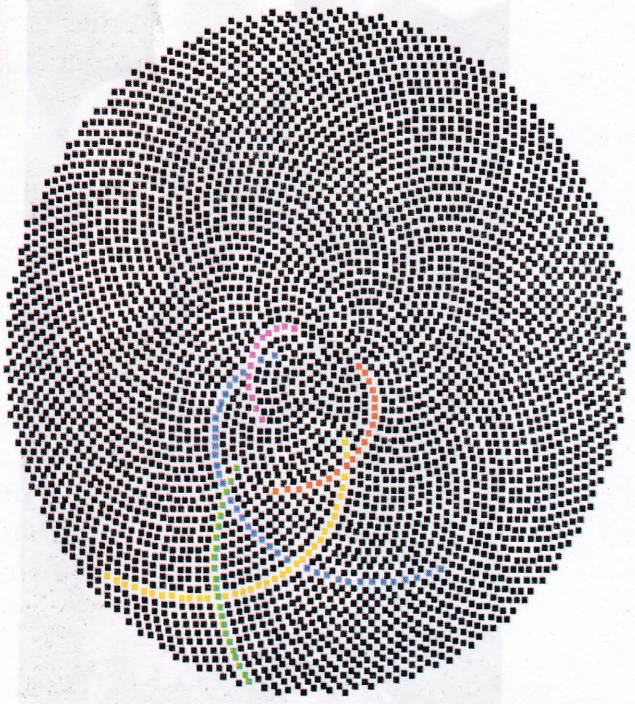


If you count those spiralling to the right as you go outwards, there are 55 spirals. A little further towards the centre and you can count 34 spirals. How many spirals go the other way at these places? You will see that the pair of numbers (counting spirals curving left and curving right) are neighbours in the Fibonacci series.

The same happens in many seed and flower heads in nature. The reason seems to be that this arrangement forms an **optimal packing** of the seeds so that, no matter how large the seed head, they are uniformly packed at any stage, all the seeds being the same size, no crowding in the centre and not too sparse at the edges.

The spirals are patterns that the eye sees, "curvier" spirals appearing near the centre, flatter spirals (and more of them) appearing the farther out we go.

So the number of spirals we see, in either direction, is different for larger flower heads than for small. On a large flower head, we see more spirals further out than we do near the centre. The numbers of spirals in each direction are (almost always) neighbouring Fibonacci numbers!



Go down deep enough into anything and you will find mathematics.

Thank you for patience listening.

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http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fib.html

Jaffna Science Association

Themes of the Years

EXCO	Year	Themes
01	1991/92	----
02	1992/93	Foods and Food habits
03	1993/94	Educational Reform
04	1994/95	Natural Hazards
05	1995/97	NA
06	1997/98	NA
07	1998/99	NA
08	1999/00	Changing Ecology – Challenges and Solutions
09	2000/01	Development Challenges of the 21st Century
10	2001/02	Agro-Industries and Health
11	2002/03	Peace Building
12	2003/04	Challenges in Tertiary Education
13	2004/05	Welfare and Society
14	2005/06	Health Care and Practices
15	2006/07	Childhood Needs
16	2008/09	Flood Hazards
17	2009/10	Traditional Foods
18	2010/11	Sustainable Development

NA – Records not accessible.

Jaffna Science Association
Office Bearers in Executive Committee

EXCO	Year	President	Secretary	Treasurer	Chief Editor
01	1991/92	Prof.A.Thurairajah	Prof.V.K.Ganesalingam	Dr.R.S.Navaratnam	Prof.G.F.Rajendram
02	1992/93	Prof.N.Balakrishnan	Prof.V.K.Ganesalingam	Dr.R.S.Navaratnam	Prof.G.F.Rajendram
03	1993/94	Prof.C.Sivagnanasundram	Prof.V.K.Ganesalingam	Dr.R.S.Navaratnam	Dr.S.Krishnarajah
04	1994/95	Prof.S.Mageswaran	Dr.K.Chitravadivel	Dr.K.Sivapalan	Prof.K.Kandasamy
05	1995/97	Prof.V.Navaratnarajah	Dr.K.Chitravadivelu	Dr.K.Sivapalan	Mrs.R.Mahesan
06	1997/98	Prof.S.V.Parameswaran	Prof.K.Chitravadivelu	Mr.A.Panchalingam	Mrs.R.Mahesan
07	1998/99	Prof.V.K.Ganesalingam	Dr.L.Jeyanathan	Mr.A.Panchalingam	Dr.(Ms).V.Arasaratnam
08	1999/00	Prof.P.Balasundrampillai	Dr.S.Srisatkunarajah	Mr.A.Panchalingam	Dr.N.Sivayogan
09	2000/01	Prof.K.Balasubramaniam	Dr.S.Srisatkunarajah	Mr.V.Easwaran	Mr.K.K.Arulvel
10	2001/02	Dr.N.Sivarajah	Dr.S.Srisatkunarajah	Mr.V.Easwaran	Dr.(Ms).S.Ramesh
11	2002/03	Mr.A.Panchalingam	Dr.A.Senthuran	Mr.K.Sivarajah	Prof.K.Kugabalan
12	2003/04	Prof.R.Kumaravadivel	Dr.S.Srisatkunarajah	Mrs.R.Yogendrarajah	Prof.R.Sivachandran
13	2004/05	Prof.S.Rajadurai	Dr.A.Senthuran	Mrs.R.Yogendrarajah	Dr.K.Visakaruban
14	2005/06	Prof.A.Sanmugadas	Dr.G.Mikunthan	Mrs.R.Yogendrarajah	Dr.(Ms).S.Sivapalan
15	2006/08	Prof.K.Kandasamy	Dr.G.Mikunthan	Dr.J.P.Jeyadevan	Mrs.R.Mahesan
16	2008/09	Prof.(Ms).V.Arasaratnam	Dr.S.Mahesan	Mr.S.S.Uthayakumar	Dr.E.Y.A.Charles
17	2009/10	Prof.K.Sivapalan	Dr.S.Kannathasan	Mr.S.S.Uthayakumar	Dr.E.Y.A.Charles
18	2010/11	Dr.S.Srisatkunarajah	Prof.P.Ravirajan	Mr.S.Srikanthan	Prof.C.Elankumaran

The Annual General Meetings were not held for the years 1996 and 2007 due to unsettled conditions in Jaffna region and hence new Executive Committees were not elected.

Jaffna Science Association

Sectional Chairmen in Executive Committee

EXCO	Year	A - Pure Science	B - Applied Science	C - Medical Science	D - Social Science
01	1991/92	Prof.S.Mageswaran	Prof.V.Navaratnarajah	Prof.C.Sivagnanasundram	Prof.P.Balasundrampillai
02	1992/93	Prof.R.Kumaravadivel	Prof.V.Navaratnarajah	Prof.S.V.Parameswaran	Dr.S.K.Sitrampalam
03	1993/94	Prof.(Ms).R.Mageswaran	Mrs.M.A.Gnanarajan	Prof.S.V.Parameswaran	Mr.S.Balachandran
04	1994/95	Prof.G.F.Rajendram	Dr.S.Mahesan	Dr.R.S.Navaratnam	Dr.S.K.S.Nathan
05	1995/97	Prof.K.Kandasamy	Dr.S.Mahesan	Dr.N.Sivarajah	Mr.N.Shanmugalingam
06	1997/98	Dr.M.Skantharajah	Prof.S.Mohanadas	Dr.N.Sivarajah	Prof.A.Sanmugadas
07	1998/99	Mr.K.Selvavinayagam	Prof.(Ms).V.Arasaratnam	Dr.R.Rajendra Prasad	Dr.K.Kugabalan
08	1999/00	Prof.K.kandasamy	Prof.(Ms).V.Arasaratnam	Prof.C.Sivagnanasundram	Prof.K.Sinnathamby
09	2000/01	Mr.A.Panchalingam	Prof.A.Navaratnarajah	Dr.K.Sivanesan	Mr.V.P.Sivanathan
10	2001/02	Ms.N.Ravimannan	Mr.S.Rajadurai	Dr.(Ms).G.Bavani	Prof.R.Sivachandran
11	2002/03	Mr.R.Raveendranathan	Dr.(Ms).S.Sivachandran	Dr.R.Rajarajeswaran	Mrs.N.Selvanayagam
12	2003/04	Mr.K.S.Kugathasan	Dr.s.Mahesan	Dr.K.Sivapalan	Dr.S.T.B.Rajeswaran
13	2004/05	Dr.S.Sivayogan	Dr.S.Mahesan	Dr.K.Sivapalan	Dr.P.Pushparatnam
14	2005/06	Dr.N.Sivayogan	Dr.C.Elankumaran	Dr.P.Lukumar	Dr.K.Ragunathan
15	2006/08	Dr.R.Ravirajan	Dr.C.Elankumaran	Dr.K.Sivapalan	Dr.T.Kalamany
16	2008/09	Dr.J.P.Jeyadevan	Dr.G.Mikunthan	Dr.N.Sivarajah	Dr.K.Suthakar
17	2009/10	Dr.(Ms).S.Kuganathan	Dr.(Ms).N.Gnanavelrajah	Dr.(Ms).K.Murugananthan	Dr.S.Santhirasekaram
18	2010/11	Dr.(Ms).M.Senthilnantha	Mr.K.Thabotharan	Dr.N.Rajeshkannan	Mr.S.S.Uthayakumar

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02	1992/93	Prof.R.Kumaravadivel	Prof.V.Navaratnarajah	Prof.S.V.Parameswaran	Dr.S.K.Sriramplasm
03	1993/94	Prof.(Mrs).R.Mageswaran	Mrs.M.A.Gnanarajan	Prof.S.V.Parameswaran	Mr.S.Balachandran
04	1994/95	Prof.G.T.Rajendram	Dr.S.Mahesan	Dr.R.S.Navaratnam	Dr.S.K.S.Nathan
05	1995/97	Prof.K.Kandasamy	Dr.S.Mahesan	Dr.N.Sivarajah	Mr.N.Shanmugalingam
06	1997/98	Dr.M.Skanthararajah	Prof.S.Mohanadas	Dr.N.Sivarajah	Prof.A.Sammugadas
07	1998/99	Mr.K.Selvavinayagam	Prof.(Mrs).V.Arasaratnam	Dr.R.Rajendra Prasad	Dr.K.Kugabalan
08	1999/00	Prof.K.Kandasamy	Prof.(Mrs).V.Arasaratnam	Prof.C.Sivaganesundram	Prof.K.Shanthamby
09	2000/01	Mr.A.Panchalingam	Prof.A.Navaratnarajah	Dr.K.Sivanesan	Mr.V.P.Sivanathan
10	2001/02	Ms.N.Ravimannan	Mr.S.Rajaburai	Dr.(Mrs).G.Bavani	Prof.R.Sivachandran
11	2002/03	Mr.R.Raveendranathan	Dr.(Mrs).S.Sivachandran	Dr.R.Rajaleswaran	Mrs.N.Selvanayagam
12	2003/04	Mr.K.S.Kugathasan	Dr.s.Mahesan	Dr.K.Sivapalan	Dr.S.T.B.Rajeswaran
13	2004/05	Dr.S.Sivayogan	Dr.S.Mahesan	Dr.K.Sivapalan	Dr.P.Pushparatnam
14	2005/06	Dr.N.Sivayogan	Dr.C.Elankumaran	Dr.P.Lukumar	Dr.K.Ragunathan
15	2006/08	Dr.R.Ravirajan	Dr.C.Elankumaran	Dr.K.Sivapalan	Dr.T.Kalamary
16	2008/09	Dr.J.P.Jeyadevan	Dr.G.Mikunthan	Dr.N.Sivarajah	Dr.K.Suthakar
17	2009/10	Dr.(Mrs).S.Ruganathan	Dr.(Mrs).N.Gnanavelrajah	Dr.(Mrs).K.Murugananthan	Dr.S.Santhirasekaram
18	2010/11	Dr.(Mrs).M.Senthilnantha	Mr.K.Thabothavan	Dr.N.Rajeshkannan	Mr.S.S.Uthayakumar

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