

## POLLUTION IN SRI LANKA

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Pollution has become a source of public concern in Sri Lanka in recent times. This development is probably the outcome of several contributory factors. A primary factor is the increasing population and the increasing industrial and agricultural activities in recent years. This would lead to the increasing emission of pollutants into the surroundings — including the contamination of our waterways and water bodies, for example, with sewage and domestic and municipal garbage. Another important factor is the rapidly increasing public awareness on matters relating to the environment. It must be emphasised, however, that monitoring for pollutants in the environment is practised quite insufficiently in Sri Lanka and it is more than likely that many problems of pollution remain to be uncovered. In other countries experience has shown that sometimes pollution (say from a dump for toxic chemicals) may lie undetected for some decades before its damaging effects reveal its presence.

Another problem in Sri Lanka is the insufficient availability of sensitive and reliable instrumentation for detecting pollutants and the inadequate scientific infrastructure in general. It should be noted that other countries in this region have developed an awareness of the importance of Science to the well being of the nation and are giving every incentive for their scientists to make their contributions. It is particularly important in the field of pollution control that we do not rely on "Crisis Management" but develop a monitoring and prevention capability.

There are many types of pollution being experienced in Sri Lanka today and it will not be possible to review all of them in the space available. However, some examples will be selected for discussion to indicate the variety of pollutants

which are possible and some of the ill effects they can cause.

### 1. Human, domestic and urban wastes

There are many instances which come to mind of pollution due to human, domestic and urban wastes. When human and domestic wastes are released into waterways such as the Colombo Canals, this can lead to the water becoming unfit for any hygienic use and also to the breeding of mosquitoes etc., once the mosquito larvae-consuming fish population has been reduced or died out.

Another consequence of organic matter pollution of freshwater bodies is the developing of eutrophication which can be seen in the Beira Lake in Colombo. Construction of toilets etc. in unsuitable locations can also lead to pollution of domestic wells and other sources of water supply.

Dumping of refuse without proper disposal practices, such as covering with a layer of soil, can lead to unhygienic situations and examples may be seen in numerous towns. Dumping of refuse on hill slopes can, for instance, eventually lead to the pollution of the streams, which frequently flow in the valleys, thereby causing problems in downstream areas, as well.

### 2. Vehicle exhaust emissions

Vehicle exhaust emissions are a major problem in Sri Lanka. Most motor vehicles in Sri Lanka burn either petrol or diesel. Vehicles burning petrol emit carbon dioxide, carbon monoxide, particles and unburnt hydrocarbons, oxides of nitrogen and lead. Vehicles burning diesel fuel emit carbon dioxide, carbon monoxide, particles and unburnt hydrocarbons, oxides of sulphur and oxides of nitrogen. Insufficient action has been taken so far to control excessive emissions from motor vehicles.

A number of harmful effects can arise from the pollutants in vehicle exhaust emissions. The carbon dioxide which is released is believed to add to the global greenhouse effect which is expected to result in raising the atmospheric temperature in the years ahead. However the contribution made by Sri Lankan sources to the global load is probably negligible.

Unburnt hydrocarbons are effectively unburnt fuel and it has been estimated that some of the badly belching vehicles may be emitting well over 10—15% of the fuel in an unburnt form, which thus amounts to a considerable financial loss, both as foreign exchange as well as local expenditure. Some hydrocarbons found in fossil fuels have been proven to be cancer-causing and would thus carry a health hazard, as well. Carbon monoxide is well known as being a gas which is readily fatal but in lower concentrations can also cause drowsiness and the slowing down of ones reflexes; thus contributing to accidents on the road. Oxides of nitrogen and sulphur can cause problems of the respiratory system and in the developing of acid rain. Lead may have an effect on the nervous system particularly in young children and on the production of components of the blood.

Emissions from motor vehicles are believed to be the principal factor leading to the “smog” or haze reported over Colombo from time to time in recent years.

### **3. Noise**

Noise is an ever-growing problem in many countries. Many complaints in Sri Lanka concern noise produced by road traffic and industries and during the use of loudspeakers. Recent research world-wide is providing evidence that the effects of excessive exposure to noise can include not only damage to ones hearing but also the causing of high blood pressure, and heart and psychological problems and the alteration of the functioning of some enzyme systems in the liver. Awareness of noise problems has not been highly developed in Sri Lanka up to now and the problem has been allowed to escalate to a very large extent. Due to the lack of concern about this problem in previous years, industries have been allowed to go up next to private homes, heavy commercial traffic travels on roads through residential areas etc; the correction of such problems at the present time will be expensive and time-consuming. Urban planning taking noise-related factors into account from some decades ago would have resulted in the non-development of the existing situation. Other effects

such as the depression of property values also result when undesirable environmental noise levels develop.

## **4. Agricultural**

Increasing numbers of problems related to agriculture are being reported. However, insufficient monitoring is being done due largely to insufficient analytical facilities and other scientific infrastructure being available.

### **a. Pesticides**

The problems with pesticides are very many. They include problems caused to the farmers during the use of pesticides, problems to the consumer caused by the presence of pesticides in food, development of pesticide resistance in the target species, damage caused to non-target species such as honey bees etc.

Malathion has been designated for use only for mosquito-control purposes in order to avoid or delay the build-up of resistance to the pesticide (as did happen with DDT).

### **b. Fertilizer**

Improper use of fertilizer has resulted in the damage of groundwater supplies in certain areas of the Jaffna peninsula. Storage of fertilizer in unprotected areas has created similar problems in Hunupitiya. Reports from Western Europe also suggest that the large quantities of cattle manure produced in West European agricultural areas may, through liberation of ammonia, be contributing to the death of trees.

### **c. Food additives**

Insufficient controls are routine in Sri Lanka with regard to food additives such as preservatives and colouring. Reports have appeared from time to time of the use of materials like formalin and malathion for the preservation of fresh food and the use of textile dyes etc. in the manufacture of sweets and other foods.

It should, however, be noted also, that proper storage and recommended methods of food preservation must be used where necessary to prevent food spoilage and development of natural health hazards such as the aflatoxins, which are cancer-causing in small amounts.

#### **d. Agro-based industries**

Huge amounts of pollutants are known to be released from industries based on agricultural and forestry products. These include volumes of smoke generated in cocount shell charcoal manufacture and large amounts of cocount husk coirdust and saw dust. These pollution problems can be relieved if suitable uses are made of these materials. Paddy husks which are a waste product are being used as a fuel in some areas.

There appear to be opportunities in the country today for individuals or firms who can effect the development of a good idea, e.g. use of waste sawdust as a fuel, into a viable and functioning commercial enterprise.

### **5. Industrial**

Several sources and types of industrial pollution exist in the country at the present time. Some industry-related examples are.

#### **a. Cement manufacture**

The cement factories were provided, where necessary, with electrostatic precipitators for the cleaning of dust from the atmospheric emissions. However, problems developed with these precipitators and they are presently being replaced.

#### **b. Paper and pulp manufacture**

The paper and pulp factories in Valaichchenai and Embilipitiya are causing considerable pollution of the Valaichchenai Lagoon and of the Walawe river respectively. The chemical recovery system obtained for the Embilipitiya factory does not work effectively due to the presence of significant amounts of silica in the paddy straw used as raw material.

#### **c. Leather manufacture**

Certain processes of manufacture of leather results in the release into the environment of, among other pollutants, chromium compounds. In some forms, chromium compounds are known to be cancer-causing.

#### **d. Food processing**

Food processing industries, such as fruit

canning and milk factories, release a considerable amount of organic materials into waterways, together with numbers of putrefying microorganisms.

#### **e. Emission of gases**

Gases emitted by industrial establishments in Sri Lanka have included ammonia from the former urea factory at Sapugaskanda. Oxides of sulphur and nitrogen are also liberated from factories and power plants burning diesel and furnace oil as fuel.

#### **f. Oils**

A large quantity of oil is released into the surroundings from garages, petrol stations etc.

Concern is growing worldwide regarding hydrocarbons emitted into the atmosphere from these sources and refineries as well as in motor vehicle exhaust emissions.

### **6. Thermal**

Fears have been expressed that the coal-fired power plant proposed to be constructed at Trincomalee could result in significant thermal pollution of the water in the vicinity of the discharge point.

### **7. Indoor air pollution**

In Sri Lanka, this area mostly concerns cigarette smoke and certain industrial work places; in addition to that arising from poorly maintained toilet facilities. In other countries, however, other forms of indoor air pollution may take on greater significance.

The above account is a brief sketch of some of the pollution problems of relevance to Sri Lanka at the present time. We have not, as yet, perhaps encountered to a significant extent, problems such as sonic booms and electromagnetic and light pollution which are being experienced in the industrialized countries of the world. However, it is possible that many instances of chemical pollution exist already and await detection. In this connection, close and continuing surveillance should be made of methods employed for the disposal of industrial wastes.

It is probably a worthy challenge to Sri Lankan scientists to develop a programme for the identification of the existence of pollution by the observation of living plants and animals, without resorting to the use of expensive instrumentation in the first instance.

## THE ENVIRONMENT — ROLE OF EARTH SCIENTISTS

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Environmental science is perhaps the most multidisciplinary of all sciences and as Thomas Malone in a preface to the book on "Global Change", published by the International Council of Scientific Unions (ICSU) has stated:

"The rapid growth in the study of Earth, its environs, and life in the biosphere has progressed to a point where it is now possible to think seriously of fashioning a bold, holistic approach that will deepen and strengthen our understanding of the planets subtle and often synergistic physical, chemical and biological processes.

Such a framework would examine the oceans, atmosphere, hydrosphere, biota and the solar-terrestrial domain as a single system"

It is therefore vital that our scientists appreciate the interdisciplinary nature in what is best termed as the Science of the Total Environment. Such an environment awareness is surely though slowly, now being created in Sri Lanka. Even though much of the contributions have come from non-governmental and governmental organisations, one must realise that the environment is everybody's concern, no matter how small or large the domain is.

While such emphasis is often laid on the influence of man in modifying and polluting the environment, the effect of the natural environment on human, animal and plant life very often passes unnoticed. This is mainly due to the time factor that is often observed in the 'cause and effect' relationship of many processes involving interactions of the lithosphere, hydrosphere and atmosphere with the biosphere.

However, the geochemical interactions among the above mentioned spheres are as important as the influence of man on the environment, particularly

in the general health of the population. Sri Lanka provides an almost ideal testing ground for the researcher in environmental geochemistry, in that

- (a) Nine out of the ten soil groups are present in Sri Lanka.
- (b) Clearly defined climatic zones exist within a narrow area enabling one to study the influence of climate on geochemical processes.
- (c) Nearly 80 per cent of the population depend on chemically unpurified groundwater for drinking, thereby accentuating the importance of water chemistry on health.
- (d) There is an uneven distribution of the population in various geographical regions of the country. This enables one to study the effect of population density on environmental degradation and vice versa.
- (e) There are major irrigation projects involving the impounding of vast stretches of land. The changes in the geochemistry of the soil and water in these regions will have a noteworthy impact on future agricultural programmes.

The relationship between organisms and the environment is very intricate and delicate, and is to a great extent influenced by the chemistry of the environment and the natural resources. A change in the chemical composition of the soil for example, which may apparently have no visible effect on plants growing in it could be detrimental to the life of a particular species of organism living in it.

The geographical distribution of elements and their compounds result in a wide variety of environmental conditions and problems. The problems facing the environmentalists are therefore multi-

disciplinary and will change from one environment to the other. In the area of soils and plant nutrition these could mean a deficiency or an excess of an essential plant nutrient, both of which can cause problems to plants or animals that feed on plants.

Some environment based problems in Sri Lanka are of particular interest to earth scientists. Among these are

- \* Problems of iron toxicity in paddy cultivation, notably in the southwestern and southern parts of Sri Lanka.
- \* Trace element deficiencies in soils caused by excessive leaching, in the wet zone of Sri Lanka.
- \* Excessive chemical weathering of rocks and the formation of unique geochemical landscapes, with their characteristic excesses and deficiencies of trace elements.
- \* Irrigation schemes, salinity and agriculture
- \* Iodine geochemistry and incidence of endemic goitre
- \* Fluoride geochemistry and dental health of school children
- \* Landslides, erosion and human settlements
- \* Tube wells, water quality and health
- \* Waste disposal and groundwater pollution
- \* Coastal management.

Many of these problems, so commonly seen in Sri Lanka, could result in dire consequences if proper attention is not given them. The compilation of data banks and the preparation of background geochemical maps are of vital importance. The basic background chemical data are of use in a variety of disciplines, notably in epidemiology, agriculture, delineation of areas suitable for human settlements and forestry.

The case of endemic goitre should draw the special attention of the Sri Lankan earth scientists. In some parts of Sri Lanka, notably in the Kalutara District, endemic goitre often reaches a level of 45%. While iodine deficiency is certainly the main cause for endemic goitre, there appears to be other factors such as trace elements acting as goitrogens that appear to play a major role.

Interestingly, even in some areas where iodine is found in sufficient concentrations in the soil, goitre appears to be prevalent, indicative of other factors related perhaps to the soil chemistry.

In view of the prevalence of water-borne diseases in Sri Lanka, the quality of water must be continuously monitored. This is of special importance to Sri Lanka since nearly 80 per cent of the people do not use piped water. The chemical quality of water in an area depends on the chemistry of the soil and the parent rocks and it is interesting to note the wide variation of the chemical quality with respect to the rock types found in Sri Lanka.

As a result of this, community water supplies do have a noteworthy effect on the health of the people in many ways.

Water management must also take priority and in this context the environmental effects of the Mahaweli scheme need to be continuously monitored. Salinity and water quality deterioration caused by large hydroschemes have been known to occur in other countries and earth scientists play a major role in such environmental investigations.

The quality of the water in tube wells in Sri Lanka has caused concern among many, owing to the high fluoride and iron contents in some areas particularly in the Northcentral, Eastern and Southeastern parts of Sri Lanka.

Nearly 25000 such deep wells may be drilled in the near future and a detailed study of the chemical variation of water quality with depth and with location is necessary. It has been found that certain deep wells have fluoride contents exceeding the WHO danger limits by nearly 10 times. Research into mechanisms of defluoridating such water at the village level using commonly available local raw materials is of immediate necessity.

The highlands of Sri Lanka are prone to erosion and landslides, very often resulting in loss of life and property. With the onset of the monsoon rains such natural disasters become an annual feature. The preparation of maps showing areas susceptible to such landslides is a national need and earth scientists could make significant contributions in this venture.

Another area of great national concern is coastal erosion and coastal management, where the services of marine scientists and land geologists could be effectively combined. Timely advice could be given by the earth scientists to those pursuing development schemes along the coastal belt.

With the Law of the Sea convention and the granting of a 200-mile exclusive economic zone, oceanographic research has assumed a very

important role in Sri Lanka. Sea bed mining and other maritime activities could quite conceivably lead to marine pollution and the work now being carried out by the National Aquatic Resources Agency (NARA) is indeed laudable and should be fully supported by all earth scientists.

Oceanographic research holds great promise for the earth scientists of Sri Lanka, particularly in view of the fact that our land to sea ratio is as much as 1:8.

The ocean is the 'dumping ground' for many pollutants. Industrial waste and municipal sewage discharge reach the sea by stream and river. Other types of waste are transported in barges for offshore disposal or discharged directly into coastal water through outfalls. Rivers carry polluted materials from mines, farm operations, and land development activities to the ocean.

Insecticides, toxic metals, radioactive and other polluting substances reach the ocean through runoff by air movements and by direct discharge from pipelines. Dredges remove wastes from harbours and barges dump them at sea. Severe coastal pollution problems are evident in many local areas and regional pollution problems are increasing.

Sri Lanka being an island state should well be aware of these impending environmental problems and mitigatory measures should be planned for immediately.

The environment knows no boundaries. Earth scientists are often called upon to tackle a variety of environmental problems, which are essentially multidisciplinary. Obviously a close interaction between earth scientists and scientists from many other disciplines is necessary in the handling of such environmental problems.

## ERODING COAST — A SERIOUS ENVIRONMENTAL PROBLEM

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### INTRODUCTION

Environmental problems are a part of the human environment and in all stages of his civilization man had been coping with these problems. Droughts, famines, and epidemics are examples of environmental problems. Coastal erosion experienced by many people living in coastal areas of the world is a similar problem. It is a secular environmental problem compared with catastrophic earth-quakes and floods etc. which are relatively sudden events. This paper examines some aspects of the problem of coastal erosion in Sri Lanka.

First, it is relevant to define some key terms in this context. 'Coast (is) a strip of land of indefinite width (may be several kilometres) that extends from the shore line inland to the first major change in terrain features' (Swan 1983:160). 'Shore' is the area between the highest and the lowest water levels of the sea or a body of water. A beach is a shore area made up of unconsolidated material deposited by fluvial or marine processes. The coastal environment may be defined as the sum total of all related phenomena of the coast. The coastal environment is a very dynamic, geomorphological system which is subject to continual disturbance and change over time and space. Coastal changes can be long-term events probably measurable only in the geological time scale and coastal erosion is a major cause of coastal change.

'Coastal erosion' can be defined as the removal of geological material of the coast by the action of waves. It may be stressed that coastal erosion is a

natural phenomenon. However, human factors contribute to aggravate this hazard and therefore, coastal erosion aggravated by man may be taken into account as a 'quasi-natural phenomenon' (see Park 1983:7) which differs from a man-made hazard. Natural erosion of the coast may be looked upon as an evolutionary process, which does not have to be controlled except in very extreme situations. Nevertheless, when coastal erosion is intensified by human activities, it can be mitigated by controlling such factors.

Before the coastal areas of Sri Lanka were densely populated, erosion of the cost-line was primarily due to natural causes. The arrival of the Portuguese in Sri Lanka (1505 A.D.) Mark the beginning of a very intensive utilization of the resources of coastal area by man. In the next centuries the Dutch (1628) and the British (1796) occupied the coastal belt of Sri Lanka which exerted an increasing pressure on the natural resources of these areas. Up to the present our coastal environment has been subject to an ever increasing pressure due to human activities. More than 50% of the population of Sri Lanka live in coastal areas.

### COASTAL EROSION STUDIES IN SRI LANKA

Although coastal erosion might have perpetuated since very early times, it attracting Scientific attention has been a recent event. More importantly, coastal erosion has been of national concern only in the last few decades. Therefore, it is pertinent at this point, to look at some work done on the erosion of our coast. As coastal erosion studies

in Sri Lanka are a fairly new trend, there is a dearth of comprehensive literature on this subject. Most of the coastal research done early this century has not been specifically focused on erosion. The written works of Sommerville (1905), Coates (1935), Shepard and Beard (1938) and Wadia (1941), for instance, are descriptive accounts of our coastal land forms, rather than erosion studies. Deraniyagala (1958) attempted to define the Quaternary coast of the island in relation to the Pleistocene epoch. Swan (1964) has analysed 'eustatic changes' (i.e. sea level changes due to climatic and geological factors) of the geological past and of the South-west coast. According to him our south-west coast is a 'polygenetic coast (i.e. a coast that has evolved under the influence of a combination of causes).

Dissanayake (1928), Paranathala (1954) and Kahawita (1954) have analysed coastal erosion of the island from an engineering view point.

Zeper (1964) studied our coastal erosion hazard and made some recommendations. Cooray (1968) made coastal geomorphological studies of the localities of Negombo, Kalpitiya and Mannar. Swan (1974) paid special attention to the coastal erosion problem of the south-western coast.

In the 1980s more coastal studies have been carried out which reflect an increasing awareness on the coastal zone of Sri Lanka. For example, Madduma Bandara (1982), Swan (1983), Katupota (1985), Madduma Bandara *et al.* (1985) and Weerakkody (1985) have made case studies on coastal changes. From among the above work of Wilson (1984) and Weerakkody (1985) was done by applying remote sensing techniques.

Amarasinghe (1971), Gerritsen (1974) and Wickramaratne (1985) have analysed engineering aspects of coastal erosion.

Verstappen's (1987) 'Geomorphological Map of Sri Lanka' depicts the continental shelf of the island

and submarine canyons, with areas of strong coastal abrasion.

#### SPATIALITY OF THE PROBLEM

Sri Lanka's coastline is about 1600 kilometres and this entire length is not uniformly subject to intensive erosion. Swan (1983 op. cit) has attempted to rank sectors of the coast according to erosion intensity and has found that the most severely affected part is the south-western coast. Northern coast is the next most affected area and there are several other localities where coastal erosion is considerable (Madduma Bandara 1982, Swan 1974 and 1983). This problem is least experienced in the north-west and the south-east, and more specifically, these two coastal segments are, rather, accretional environments showing growth of beach. The Colombo-Puttalam main road extends away from the shore-line, as opposed to the Colombo-Hambantota road which often runs very close to the shore, and this observation supports the above statement. A number of scientists have identified the coastline between Kalpitiya and Tangalle as the most eroded segment. Even within this segment, however, there are localities of severe erosion. A number of field evidence documented conform this (Dissanayake 1928, Wadia 1941, Paranathala 1984, Eaton 1961, Swan 1974, and 1983 and Gerritsen 1974). According to Paranathala (1954 op.cit.) the localities where severe erosion is taking place are: Negombo, Mt. Lavinia, Beruwala, Hikkaduwa, Ahangama and Weligama.

As for the rate of erosion, Paranathala (1954) and Eaton (1961) have estimated the average rate for Sri Lanka to be 0.3-1.0 metre per year. Madduma Bandara (1982) who surveyed the entire coastline estimated this rate for the island as 1 metre per year. A team of experts of the Danish Hydraulic Institute (see Master Plan 1982) have given more accurate data in this regard as shown in Table 1.

| SECTOR      | DISTRICT    | COASTLINE<br>IN KM | EROSION %<br>OF COAST | EROSION<br>LEVEL<br>M/YR | MCT<br>AREA<br>LOSS 1000 M <sup>3</sup> |
|-------------|-------------|--------------------|-----------------------|--------------------------|-----------------------------------------|
| WEST        | PUTTALAM    | 300                | 30-40                 | 0.3-0.4                  | 60-120                                  |
|             | GAMPAHA     | 40                 | 60-70                 | 1.0                      | 35-40                                   |
| SOUTHWEST   | COLOMBO     | 40                 | 40-50                 | 0.0-0.1                  | 0.5                                     |
|             | KALUTARA    | 40                 | 70-80                 | 0.1-0.5                  | 10-20                                   |
|             | GALLE       | 75                 | 70-80                 | 0.3                      | 10-20                                   |
| SOUTH       | MATARA      | 55                 | 80                    | 0.9-1.0                  | 20-30                                   |
|             | HAMBANTOTA  | 135                | 40-50                 | 0.2                      | 20-30                                   |
| EAST        | AMPARAI     | 110                | 40-50                 | 0.2                      | 20-25                                   |
|             | BATTICALOA  | 100                | 60                    | 0.1-0.2                  | 10-20                                   |
| NORTHEAST   | TRINCOMALEE | 210                | 40                    | 0.2                      | 10-0                                    |
|             | MULLAITIVU  | 50                 | 20-30                 | 0.2                      | 0-10                                    |
| NORTH       | JAFFNA      | 275                | 60-70                 | 0.3                      | 50-60                                   |
|             | MANNAR      | 155                | 60-70                 | 0.3                      | 70-80                                   |
| ALL COUNTRY |             | 1 565              | 45-55                 | 0.30-0.35                | 300-500                                 |

Table 1. Some Coastal Erosion Data for Sri Lanka  
(Source: Coast Conservation Dept. 1985 Master Plan)

## CAUSES OF COASTAL EROSION

Coastal erosion is a function of a number of factors and it is convenient to recognize two principal groups out of them:

1. Natural factors
2. Human factors

### 1. NATURAL FACTORS

Coastal erosion is a natural process of coastal evolution experienced by many maritime nations. There are numerous natural factors of coastal erosion, some of which are explained below:

#### (a) Wind Factor

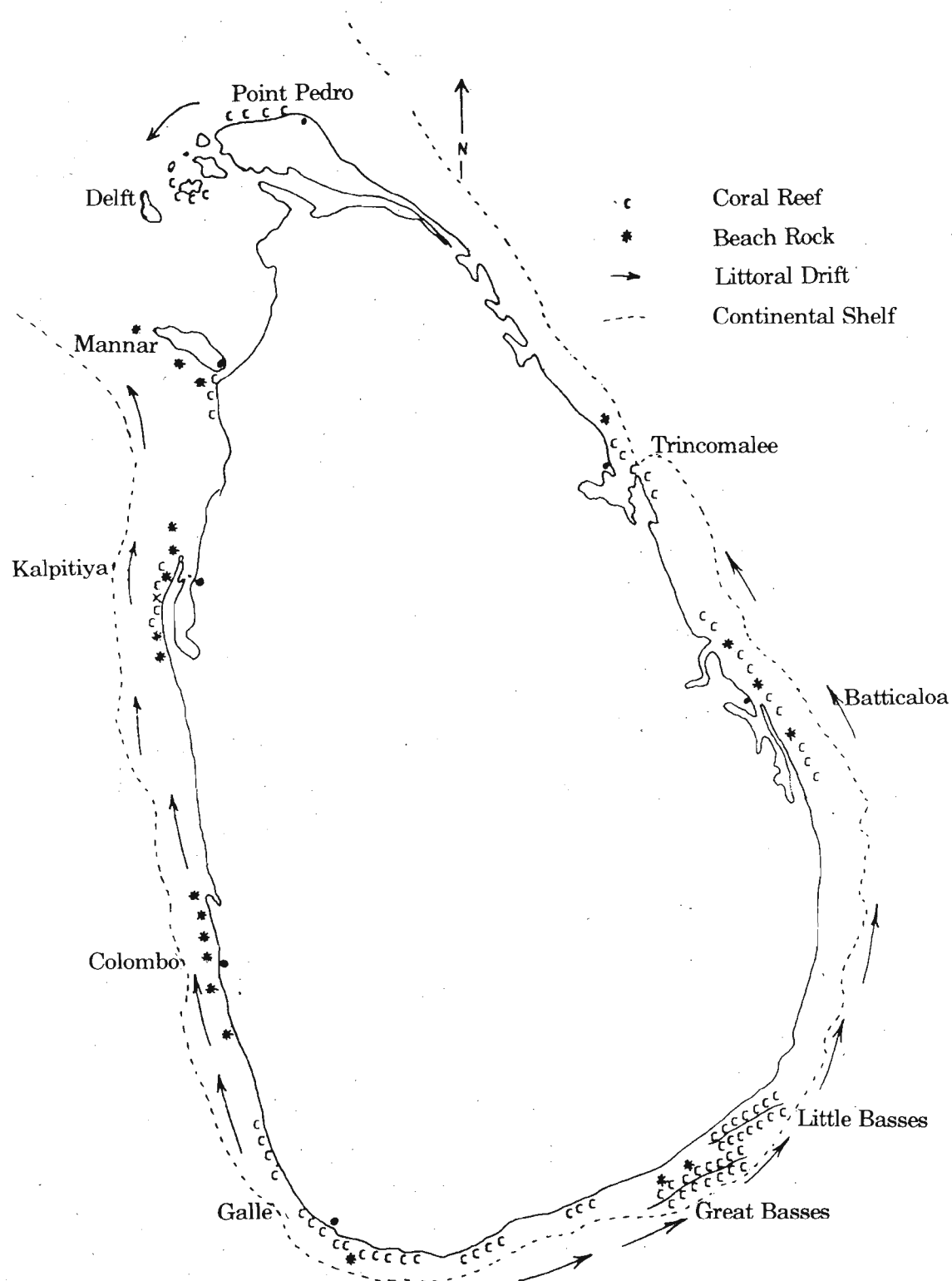
This is a climatic factor as opposed to the other natural factors that are primarily geological. In Sri Lanka coastal erosion is severe in the two monsoon seasons as strong winds provide more energy to the waves. During the south-west monsoon period of the May-September months intense erosion occurs in the south-west. Likewise, erosion is more acute in the north-eastern coastal belt during the north-east monsoon winds of the December — February period.

#### (b) Orientation

This means the direction of the coast with respect to winds and waves. Orientation of a coast determines the angle of attack of winds and waves and, even influences the movement of littoral drifts. Usually a coast that is more or less perpendicular to the waves and winds is more prone to erosion. Our south-west coast faces winds and waves heading very perpendicular during the south-west monsoon. However, the north-eastern coast is relatively less perpendicular to the attack of north-east monsoon winds and resulting waves.

#### (c) Littoral Drift

The littoral drift, also known as the longshore drift, is a nearshore current created by the kinetic energy of breaking waves. Therefore, it is more prominent in the monsoon months. In the south-west monsoon season, the south-west monsoon drift moves in a northerly direction transporting eroded material to be deposited north of the points of erosion. Part of this drift moves south too. Similarly, in the north-west monsoon season a less strong littoral drift prevails in the north-east. (Map 1).



Map 1. Map of Sri Lanka Showing the Continental Shelf, Beach Rock Coral Reefs and the Littoral Drift.

(d) *Compartmentalization*

This means the effect of the irregularities of the coast line due to the presence of bays, lagoons, estuaries, headlands, etc. plus man-made structures such as breakwaters, harbours and groynes. Compartmentalization tends to modify the nearshore circulation, particularly of the littoral drift. As a result eroded materials are intercepted especially behind bars and structures and moreover, new stretches of the coast are open to erosion.

(e) *Natural Sand Supply*

The natural supply of sand-sized material to the coast is very important for beach development, as it helps determine whether a particular shore environment is depositional or erosional. Sand for the coastal environment is supplied by the fluvial process of rivers. In Sri Lanka there are 103 drainage basins discharging some 44 million m<sup>3</sup> of sand per year (Madduma Bandara *et al.* 1987). If any natural or human factors interfere with this sand supply, the effects will be adverse on our coast-line.

(f) *Lithology*

The geological foundation of the coastal zone of Sri Lanka is made up of crystalline rocks of the types found inland, together with beach-rock (see p. 13), coral, unconsolidated beach sand, rock debris etc. Nine-tenths of our coast-line is made up of unconsolidated, fluvio-marine sediments and rocky areas are limited. A good portion of the south-eastern coast line which shows high rates of erosion is composed of such unconsolidated material. The presence of coral reefs and beach-rock in the sea near the shore in many parts of Sri Lanka protects the coast from erosion, by acting as barriers that help dissipate the kinetic energy of waves.

(g) *Continental Shelf Topography*

The island is surrounded by a relatively narrow 'continental shelf' that extends about 7 kilometres towards the ocean. The

100-fathom (about 180 metres) isobath is considered the outer limit of this continental shelf. The continental shelf is wider in the north towards India and much narrower in the south-west, the area most severely affected by erosion (Map 2). It is also narrow between Kokkilai and Trincomalee in the north-east, the coast of which area is also subject to intense erosion. Next, it is narrow in the areas between Potuwil and Kumana of the south-eastern coast, too. However, the coast of this area is not much affected by erosion due to the 'safe' orientation of the coast relative to winds and waves.

(h) *Sea Level Changes*

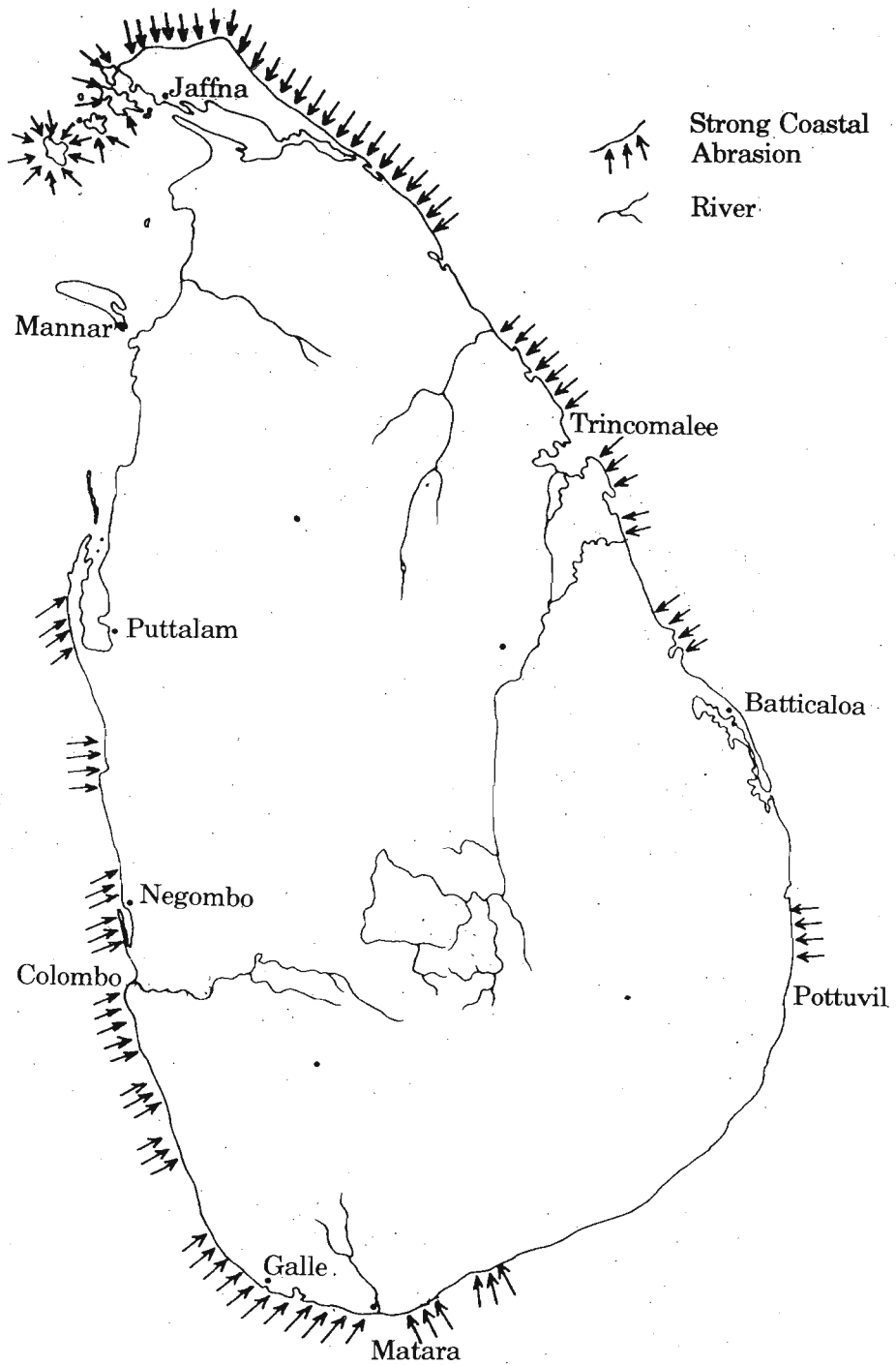
Both field and laboratory studies have shown that sea level rises and coastal erosion are generally correlated. Even the 'Small States Conference on Sea Level Rise' of Nov. 14-18, 1989 was mainly focussed on the sea level rises expected in the next hundred years. Although various predictions indicate a sea level rise ranging from a few millimetres to several centimetres per year, it is not possible to express a definite view on this at present.

## 2. HUMAN FACTORS

The principal ways in which human activities contribute to coastal erosion in Sri Lanka are discussed next.

(a) *Coral Mining*

A coral reef is a unique tropical marine ecosystem consisting of a number of animals and plant life forms, in addition to coral polyps. In addition to the many ecological uses of coral reefs, their role in checking coastal erosion is understood. The corals of Sri Lanka, occurring as 'fringing reefs' are found in many parts of the near-shore area. Excessive coral extraction as a source of lime is a serious threat. In 1977, 7000 tons of coral have been extracted and today more than 10,000 tons of coral are extracted annually, mainly from the south-western coast (Wickramaratne, 1985) the area mostly affected by erosion, even without human influence.



Map 2. Map of Sri Lanka Showing Principal Areas of Coastal Erosion.

(b) *Sand Mining*

Commercial sand mining in shore areas as well as in rivers and estuaries contribute to accelerate coastal erosion. Sand mining in rivers and estuaries adversely affect the natural sand supply to the coast, and extraction of beach sand disrupt the natural equilibrium of the shore areas. Usually permits for sand mining are issued by the Coast Conservation Department, and therefore, legal sand mining can be controlled depending on seasonal and regional conditions. However, illicit extraction of sand does a great damage which is difficult to control. In the Kelani Ganga estuary the rate of sand extraction has been estimated to exceed natural replenishment. In the Vallipuram-Ampan area of the Jaffna Peninsula, daily sand removal has been estimated to be 350 tons, which is beyond the safe limits (CCD/USAID/URI 1986).

(c) *Destruction of Beach-Rock*

Some parts of our coast line are protected by the 'beach rock' that occurs more or less parallel to the shore. In some instances it is found adjacent to the shore (e.g. Galle Face, Ahangama) or it is found in the near-shore sea (e.g. Pitipana). Being a geologically recent formation of sand, calcium carbonate and rock debris etc. cemented together, the beach rock forms reefs that harbour a variety of biota like coral reefs. In addition to its ecological importance to fisheries etc., the beach rock protects our coast line from erosion. Yet, blasting of the beach rock, especially to facilitate sea-going vessels has been reported, which is detrimental.

(d) *Construction*

More and more buildings were constructed in the coastal areas, with the expansion of tourism and therefore, retaining walls etc. have been put up on the shore. Not only such constructions are poor in stability, they also deflect winds and hinder free spreading of waves. As a result, waves seeking a new equilibrium erode a new point of the nearby coast. Likewise it is suspected that, breakwaters in harbours

obstruct transport of material by the littoral drift and due to this reason some areas of our coastal belt has been left vulnerable to erosion.

(e) *Destruction of Vegetation*

Unlike walls and similar structures built on the coast, coastal vegetation allows movement of wind and waves, although creating some resistance. Even the ground vegetation of the shore composed of such species as *Ipomoea pescaprae* and *Spinifex littoreus* cover the unconsolidated sand, holding the material together. However, such vegetation does not obstruct the free flow of waves on the shore. In coastal lagoons and marshes, the role of mangrove plants in protecting the land is understood. Yet, denudation of coastal areas of vegetation had taken place in many areas.

MAGNITUDE OF THE PROBLEM

Thus far, the areas and causes of coastal erosion of the island has been examined and now, it is necessary to discuss the magnitude of this problem.

The 'Master Plan for Coast Erosion Management' of the Coast Conservation Department (1985) has compared Sri Lanka's coastal erosion problem with that of some other countries (Figure 1). According to this, our erosion problem is generally similar to the same problem of Denmark, New Jersey (USA) and the world. The Master Plan also stated that between 45% — 55% of Sri Lanka's coast line is eroding. In the western, south-western and southern segments of the coast alone, a length of some 340 Kilometres is being eroded.

Although accurate figures of land areas engulfed by the sea cannot be given, the following information may help imagine the dimension of coastal erosion in Sri Lanka. The Alexandria Park of Mattakkuliya which is seen on topographic maps, published early this century has been eroded by mid 1950s. A number of near shore islands in the sea (geomorphologically known as 'tombolos') are found in southern Sri Lanka. Sinigama near Hikkaduwa is a good example. Barbeyrn Island of Beruwala, Pigeon Island of Weligama and Crow Island near Kotuwegoda, Matara are some other examples of tombolos. These islands were originally parts of the mainland, subsequently separated due to the recession of the coast.

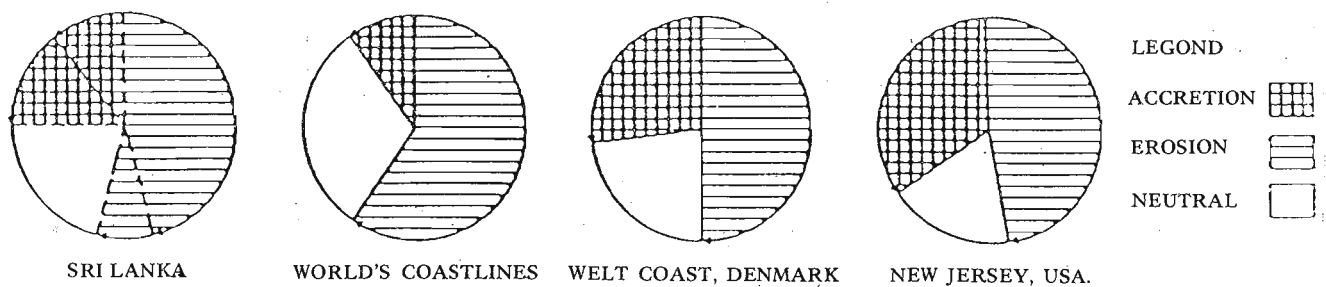


Fig.1. Graph Depicting Coastal Erosion in Sri Lanka, Denmark, New Jersey (US) and the World. (Source: Coast Conservation Dept. 1985 Master Plan)

### COASTAL EROSION CONTROL

The enormity of coastal erosion has necessitated erosion control action by the government. The first steps for erosion control of the modern era was taken by the Colombo Port Commission in the late 1930s. The pioneering method adopted was dumping of large boulders in places of erosion. Later in the mid 1960s groynes more or less perpendicular to the shore line were set up to abate erosion. Although these structural measures may have some importance, they were inadequate, as a more comprehensive system was in need. Such a comprehensive system was not formed until the establishment of the Coast Conservation Department in 1978, followed by the Coast conservation Act of 1981. Presently, erosion control is not confined to its engineering aspects alone. Control of sand mining in shore areas as well as in rivers and estuaries and the prohibition of coral extraction are examples of a more comprehensive scheme in practice, in spite of the fact that many practical limitations are experienced in these measures.

As coastal erosion is a natural process, people will have to adapt to this natural phenomenon. Yet, coast conservation measures supported by a good awareness on the coastal environment will allow us to maintain coastal erosion within natural limits without accelerating it.

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## ENVIRONMENTAL POLLUTION & ITS CONSEQUENCES

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It is only recently that environmental pollution has become a major problem in Sri Lanka. Our country has been mainly an agricultural country, dependent on an agricultural economy but intensive industrialisation is now contemplated to improve the standards of living of the people. In this effort, industry would turn out to be a polluter of the air and water. Industries are springing up all over the country without proper plans and the public are now concerned with the pollution of the air and water, which are the primary necessities of life. It is therefore appropriate that the government should now contemplate to make progressive legislation at all levels to bring pollution under control.

Industrial pollution is almost a problem of unmanageable magnitude in Sri Lanka today. The smoke stacks of industry, incinerators and exhausts of motor vehicles especially buses and lorries and other internal combustion engines contaminate the atmosphere by discharging a wide range of toxic substances into air.

The discharge of industrial waste and sewage in the seas and oceans of the world is already beginning to show disturbing results in many parts of the world. The capacity of these waters to absorb waste and sewage are being stretched and will soon reach dangerous limits affecting the entire planet. These pollutants not only affect the world's fisheries, but also enter our bodies as a result of our utilising them as a major source of food.

Some of the industries that could cause pollution of the atmosphere and water in this country are Paper, Agro-chemicals, Cement, Petroleum, Leather, Ceramics, Textiles, Rubber, Rice and Saw mills, Construction industry, Asbestos and Chemical factories.

Environmental hazards through agriculture in Sri Lanka may arise from the following sources.

1. Sediments from land erosion
2. Fertilizers
3. Agrochemicals

### 1. Sediments from land erosion

Soil eroded from cultivated land is the chief source of sediment in rivers, streams and reservoirs but road construction, stream bank and gully erosion, housing development and logging operations are also important contributory sources. These sediments contain and absorb compounds which supply plant nutrients such as nitrogen and phosphorus and thus promote excessive growth of bacteria, algae and other plant life.

In consequence, a depletion of dissolved oxygen occurs, especially on the death and decay of these organisms, and this results in harmful effects on fish and the onset of conditions conducive to foul odours and undesirable tastes in the water. The process of enrichment of water with nutrients is known as eutrophication.

### 2. Fertilizers

Agricultural output is determined to a large degree by adequate fertilizer inputs. The two main fertilizer nutrients affecting water pollution are nitrogen and phosphorus.

Nitrogen in excess of crop needs is partly leached from the soil as nitrate to the surface and groundwater and partly dispersed elsewhere, in the eco-system. Excess nitrate in potable waters may indirectly affect human health and that of infants in particular. The necessity for restricting levels of nitrogen application to approximate crop needs is therefore obvious.

Phosphorus is the key element in water pollution. Though only low concentrations are found as soluble phosphate in streams, reservoirs, etc., with the inflow of runoff carrying phosphate-laden materials, the water is considerably enriched with the element and ill-effects will result.

### 3. Agro-Chemicals

These are organic and inorganic chemicals used for controlling plant pests, plant diseases and weeds, and are known respectively as insecticides, fungicides and herbicides (weedicides). There is little doubt that these agro-chemicals have been responsible for an appreciable increase in the production of man's food and other requirements. Further, some of them have also been used for controlling human diseases, e.g., DDT, in the control of malaria, at low cost and with great efficacy.

When tested insecticides are used with proper care and in the concentrations recommended for agricultural purposes, obvious ill-effects on man are rarely noted. Side-effects of an adverse nature may, however, occur in other sectors of the biosphere and even in man. Most of these pesticides are decomposed in the soil or changed within the plant or insect and leave little or no residues. The organochlorine insecticides like D.D.T. are the important exceptions, and are widely found in the environment in varying amounts and in the tissues of plants, animals and man. Though only very slightly soluble in water and occurring in it in traces, they are readily dissolved by fats and are absorbed by sediments.

These pesticide residues are taken-up selectively from the sediments by plankton or earthworms and then by small fish which in turn may be taken up by larger fish or birds.

The concentration of pesticidal residues is thus magnified at each stage of the food chain. This biological magnification is known to have harmful effects on certain species of fish, birds and wild life, and several such instances have been reported from different parts of the world.

Weedicides are mainly organic chemicals, being increasingly used in Sri Lanka. In general, organic herbicides decompose relatively rapidly in the soil and do not present toxic hazards to mammals.

Fungicides are inorganic or organic compounds used for controlling plant diseases both in temperate and tropical regions. There is little likelihood of contamination of food stuffs through the rational use of fungicides for disease control, if

instructions for their use are correctly adopted. Many countries have introduced legislation in regard to the sale and use of agro-chemicals so as to ensure that these products are not a hazard to public health.

Beach and coastal water pollution in Sri Lanka can be examined under the following:

#### (i) Faecal Pollution

Faecal pollution occurs directly as well as indirectly. Direct occurrence is the use of the beach for toilet purposes, and indirect occurrences, the discharge of sewage effluent into the sea without proper purification or contamination of river water flowing into the sea.

Shanty settlements on the shore have added to the problem, the beaches becoming the dumping ground for disposal of garbage, sewage and domestic effluents.

Several measures have been attempted to eliminate this problem. Some of the measures are the provision of toilets to the households situated in the neighbourhood of tourist areas, community education and even patrolling of the beach.

Due to lack of supervision of Town Authorities outside Colombo, conservancy labourers do not hesitate to empty buckets of urine and at times faeces into the river or the sea.

Serious attention should be paid to the systems of sewer disposal on a national basis.

#### (ii) Oil Pollution

Waste oil clots, travel down to the coastal waters and settle on the sea shore. They range from tiny bits to large masses. It is a major constraint on the use of the beach as well as the coastal waters. Swimming becomes difficult with the bodies of swimmers getting smeared with oil. Walking on the beach becomes a nuisance with oil clinging onto footwear or the soles of the feet. No recreational activity is possible on such beach stretches. The waste oil also settles on the reef, rock and sandy crevices, affecting the living environment.

In the ports, sufficient facilities for disposal of wastes, waste oil etc. by ships coming into the ports are not available due to lack of

funds. Also any form of monitoring or surveillance of our ports requires financial outlays for personnel and equipment.

### **(iii) Waste and Storm Water Pollution:-**

Waste water pollution is common in our urban areas where the domestic wastes are discharged into the coastal waters.

Storm water too carries with it the urban wastes into the sea. Storm water outlets have become waste water outlets too. Hoteliers too are offenders in certain areas.

### **(iv) Industrial Pollution:-**

The development of offshore industrial areas and the pollution by industrial waste of waterways discharging into the sea contaminate coastal waters. A few instances are the outlet for leading coconut husk water into the sea off Induruwa & Bentota, waste from saw mills in Bolgoda lake, the flour mill wastes at Mutuwal, and effluents from the Paper Factory at Valachchenai.

An occupation which (common knowledge) is removal of coral off our coasts. The dynamiting of fish also damage the coral. A public corporation too purchased coral removed from the East coast. The coral reef is a protection against sea erosion. The effects of sea erosion is evident on a drive down South.

The coral reef also serves as the home of varieties of fish including the erotic coral fish. Lobsters too depend on the coral reef. Removal of coral has adverse effects on fish.

Another problem which is approaching serious proportions is the collection of erotic fish. This occurs on the South coast and the North-East coast. Their conservation is an urgent necessity.

The main three sources, by which toxic substances may enter the human body are by ingestion, absorption through the skin and by inhalation. It is reported that the greatest majority of occupational diseases are caused by inhalation as it affords rapid intake of contaminants by the body.

### **Some pollutants in air and their effect on human health**

#### **1. Carbon Monoxide**

By combining with haemoglobin deprives tissues of oxygen; individuals suffering from cardio-respiratory disease are more sensitive;

psycho physiological effects are possible even at low concentrations; smoking is an important source, perhaps more significant than a exposure to motor vehicle exhausts.

#### **2. Oxides of Sulphur in combination with airborne particles (smoke)**

Aggravation of existing respiratory diseases and contribution to their development, impairment of lung function, sensory irritation.

#### **3. Oxidants including ozone**

Eye irritation, possible association with asthmatic attacks, impairment of lung function in diseased persons.

#### **4. Airborne particles**

Increase in the effects of gaseous pollutants such as sulphur dioxide, possible toxic effects depending on chemical composition (e.g. particles containing lead or asbestos)

#### **5. Lead**

Intake through water, air and food enhances the total body burden of this element, in excessive amounts it may be poisonous.

#### **6. Asbestos**

A possible factor in the incidence of lung diseases along with other air pollutants and smoking — pleural calcification observed also in non-occupational exposure.

#### **7. Beryllium**

“Neighbourhood” cases of chronic beryllium poisoning observed near beryllium production plants.

### **Some pollutants in land & water and their effect on human health**

#### **1. Industrial and radioactive waste:-**

Effect from stored toxic metal and other substances through food chains.

#### **2. Human excreta:-**

Schistosomiasis, taeniasis, hookworm and other infections.

#### **3. Sewage:**

Urban filariasis, flies and other disease vectors.

#### **4. Garbage and vectors inhabiting it:-**

Rodent borne disease, pollution of water and air from disposal practices.

#### **5. Pesticides:-**

Contamination of vegetation and secondary food stuffs and entry into food chain.



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