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Non conventional Environmental Hazards

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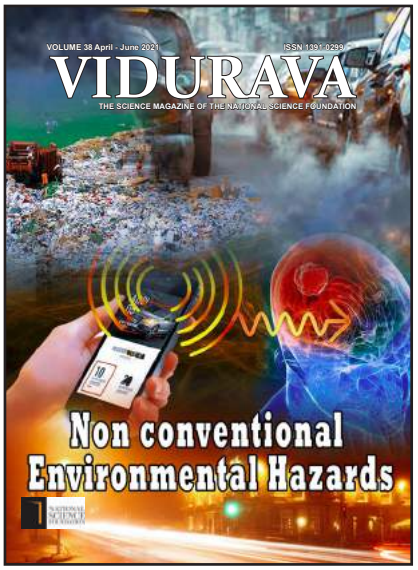

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Editorial

TRADITIONS IN MANAGEMENT OF ENVIRONMENTAL POLLUTION

The variety of agents responsible for polluting the living environment are numerous as evident from the discussions in the current as well as the preceding journals of *Vidurava*. However, the element Sodium as a polluting agent of irrigation waters is exceptional, and has not been taken note of in the past. Hence it deserves a closer examination.

According to the author of this article, a phenomenon called "Sodium Adsorption Ratio" (SAR) of irrigation waters gives an indication of the permeability or impermeability of soils, and consequently also of the fertility of soils. The author retraces an episode where during monarchial times, water from an irrigation tank had been used to irrigate a 100 hectare paddy field for over 1000 years. But about 50 years ago, a canal with a source of poor quality water had been diverted to this tank to increase the availability of water. The farmers though initially pleased due to the higher availability of water, had to experience a tragic crop failure, causing the farmers to abandon their paddy fields. This was claimed to be the consequence of increasing the quantity rather than the quality of water for irrigation work.

The adverse effects of a particular quality of water on the plant-soil system is claimed to depend on the total salt concentration; relative proportion of sodium to other cations; boron concentration; and bicarbonate content. Water with low electrical conductivity contains mostly sodium and chloride ions. The relative proportions of sodium to other cations is claimed to be determined by the Sodium Adsorption Ratio (SAR). It is said that soon after an irrigation activity, precipitation may occur changing the supply of calcium, and establishing an equilibrium at a calcium concentration different to that in the applied water. The SAR equation does not account for these changes, and is therefore somewhat in error.

Taking as a critical example, the author shows that the dam built across Kalaweva by King Dhathusena, (in 6th Century AD), was to fulfill his wishes of providing adequate irrigation water. However, three to four hundred years later, the continuous use of Kalaweva waters had resulted in the Anuradhapura Kingdom getting shifted to Polonnaruwa, attributed to continuous crop failures due to loss of soil permeability.

Let us now sit back and review how our visionary forefathers engaged in meaningful lifestyles, developed the means of responsible consumption and production of natural resources, and disposed waste in compliance with nature's own turn-over cycle. In this process organic waste components were re-cycled by collecting and allowing these to decompose in small heaps or shallow pits to generate *in situ* organic manure. Some components were in fact incinerated, usually under anaerobic conditions in pits to produce ash. Such ash containing inorganic fertilizer components such as potassium, magnesium as well as micronutrients, were also subsequently applied to soil to supplement the organic fertilizers.

It is also known that traditional knowledge on plant species facilitated *Wannietto* to refrain from burning wood that produced excess of smoke, which they apparently realized would pollute the air. The popular timber tree *Milla* (*Vitex pinnata L.*), was known to emit excess of smoke, and hence was never burnt. It seems obvious that *Wannietto* were convinced that excess smoke could pollute the air, and consequently have adverse effects on their living environment, which constitutes a life supporting earth resource.

M. Asoka T. De Silva

Air Pollution due to Transportation: A Case Study for Sri Lanka

Dr Neetha Dayanthi Wanniarachchi

1. Background

Oil-based road transport system is the main source of ground level urban concentrations of air pollutants that harm human health and the environment because these pollutants are emitted near nose height and in proximity to people. All the motor vehicles in the world consume large amounts of fuel and emit large amounts of pollutants. International shipping also causes health and environmental impacts.

The pollutants emitted by motor vehicles include carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbon (HC), particulate matter (PM), carbon dioxide (CO_2), water vapor, organic compounds produced from petrol, lead compounds and carbon particles in the form of smoke. Sulfur oxides (SO_x), NO_x and fine-particle emissions are major shipping pollutants. Ship emissions may also contain carcinogenic particles.

On occasions, these components of the exhaust gas may react with each other to produce unpleasant secondary products such as 'smog'. Smog is formed by the reaction of the oxides of nitrogen and some of the hydrocarbons. Smog formation is affected by bright sunlight and the topography of the region. Through chemical reactions in the air, SO_2 and NO_x are converted into fine particles, sulphate and nitrate aerosols. NO_x comprises a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). In the air, NO is rapidly converted to NO_2, which will also react in the air to form nitrate particles and ozone (O_3). NO_2 is a toxic gas harmful for health. NO_x emissions also contribute to acidification and heavy growth of unnecessary microscopic plants, causing serious damage to ecosystems. In addition to the pollutants directly emitted by motor vehicles, these secondary particles increase the health impacts on human beings. Tiny airborne particles are linked to premature deaths. The particles get into the lungs and are small enough to pass through tissues and enter the blood. They can then trigger inflammations, which eventually cause heart and lung failures.

How smog is seen in the atmosphere

2. The transportation sector in Sri Lanka

2.1 Introduction

Road and rail are the main transport systems in Sri Lanka. Air transport and water transport are insignificant compared to road and rail transport systems. The transport sector accounts for about 60% total fuel consumption in Sri Lanka. Sri Lanka's land transport system

is predominantly road transport (93%), which is based mainly on a road network centered in Colombo. The transportation categories include normal and trade goods transportation, international goods transportation and necessary items transportation. Foods, electronic items, textiles, different products, chemicals and medicines, minerals like crude oil are considered as the goods being transported frequently. The existing rail network will no longer meet the modern transportation requirements of the country. Over years, uncontrolled roadside development as well as poor road maintenance have decreased travel speeds, hindering the economic growth of regions outside the Colombo Metropolitan Area (CMA). Past investments in the road sector have focused mostly on the rehabilitation of the existing road network and have not been addressing the rapidly growing freight and passenger traffic.

2.2 Air pollution issues due to transportation in Sri Lanka

More recent data revealed that current air pollution levels in Colombo have exceeded recommended values for Sri Lanka. Emissions from motor vehicles are the most significant contributor to air pollution in Sri-Lanka like in most newly-industrialized countries. PM is the primary air pollutant of concern in Sri Lanka because it has consistently exceeded WHO guidelines. SO_2 has shown increasing trends. The results of a monitoring carried out by the Central Environmental Authority (CEA) showed that NO_2 concentration in the CMA is far above the safety levels, whereas CO concentration is below the minimum level even during peak traffic hours. Another research showed a high correlation between the levels of total suspended particles and traffic density in Colombo. Overall, it can be expressed that the Colombo city is very unhealthy in terms of its particulate pollution. Findings of a research conducted in 1994 gave clear evidence of significantly higher lead levels in blood in some members of the tested population who are exposed to vehicle emissions than the control group. Traffic policemen were the worst affected.

In Sri Lanka, the air pollution problem in the transport sector arises due to the following factors together with sharp increase of vehicle population: Poor maintenance of vehicles that increases the air pollution by airborne particles from diesel vehicles and carbon monoxide and volatile organic compounds from petrol vehicles; high traffic congestion because of not having a proper road network and a traffic control system; poor maintenance of roads (especially in urban areas); and the absence of a proper and well-planned public transport system. Normally engines of most of the passenger transport buses are kept started and idling at the bus halts polluting the air environment. Long and heavy vehicles like containers travelling in the day time create huge congestion, especially in urban areas. That has caused a great deal of fuel consumption on the national level and an increase of the working time of the workforce, enhancing the air pollution. The standardization and efficiency have not been undertaken properly, thus carbon is released to the environment with toxic smoke. The heavy vehicles, of which the maximum speed limit is 40 kmph causes other vehicles capable of surpassing this speed to be trapped by the traffic congestion leading to more emissions. A lot of carbon can be seen having deposited on tree-leaves interfering the process of photosynthesis. It also inhibits the process of transpiration. This alteration to the natural processes has posed adverse impacts on plant growth. Carbon particles have cause the increase of hearing problems in human beings. Motor vehicles having large capacities causes rapid depreciation of tires and large consumption of fuel leading to enhancement of air pollution, i.e from the residuals left by the rapidly depreciated tires etc.

The low educational level of drivers and their assistants contributes to air pollution significantly. They lack in knowledge of the speed limit, vibration, as well as the safety of the goods. Most of the drivers have no proper training of technical knowhow, and dangers associated with their occupation. On top of all, most of them are addicted to alcohol. They misunderstand the traffic signals, speed limits and capacities. Most of the agencies providing transportation facilities to harbors and aviation services companies are not up to the

standard. They are agencies with lack of training and technical knowhow, and under the control of political intimidation. Most of the motor vehicles provided by these service providers are not suitable for the demanded transportation service. These vehicles are frequent targets of accidents and breakdowns due to not being assessed timely. These contribute to air pollution. Employing workers having lack of knowledge on the safety of the goods being transported also provides contribution to the air pollution indirectly. Unnecessarily coloring of vehicles causes the release of chemicals to the atmosphere.

The lack of a proper air quality monitoring system to track human exposure is a major limitation. There is still very limited capacity to address air pollution and manage the air quality in districts outside Colombo. Air quality monitoring is routinely conducted only in Colombo and on an *ad hoc* basis in other areas.

2.3 The differences between Sri Lankan and international transportation systems

International service providers and their workforce are well-trained, knowledgeable and are under a set of rules and regulations and rigorous conditions. Inter-organizational coordination is a critical part of planning because most planning involves multiple interacting organizations. There is no such inter organizational coordination among the land, water and air transportation sectors in Sri Lanka, whereas it is contrary to the rest of the world. In international goods transportation, there is a well-established methodology to follow from the acceptance of goods, loading, transporting, storing and handing over to ensure the safety and responsibility, whereas such a methodology is absent in Sri Lanka. This has damaged the faith of the general public on common transportation, and it leads for selection of individual private transportation facilities. This has created unnecessary congestion leading to enhanced pollution such as emissions.

Air pollution in the Colombo city

3. Strategic approach to solve the air pollution issues due to transportation

3.1 Methods applied worldwide and their shortcomings

Modification of existing engines or the development of new engine types could reduce pollution from individual engines. Lead can be emitted from petrol and the same octane rating can be maintained by alternative means. More general measures that can be used to reduce exhaust pollution include: the use of smaller engines and vehicles in congested urban areas; the use of electrically driven vehicles; the improvement of vehicle flow or ease traffic congestion; restriction on the use of private vehicles in the central areas of cities. The smoke pollution can simply be fixed during the routine maintenance of vehicles. The exhaust gas recirculation in engines is also a way of preventing emissions.

In order to reduce urban air pollution, the regulatory agencies have set limits for the maximum amount of pollution that can be emitted from vehicles. To be driven in anywhere in the world, vehicles must meet these standards. Vehicles are therefore tested in a laboratory before it can be initially sold to ensure compliance. In control of ambient air quality in Sri Lanka, it is mandatory to control source emissions as well as non-source emissions. As a strategy for source emission control, the Central Environmental Authority (CEA) has finalized source emission control standards for Sri Lanka. However, emissions in real-life driving are much higher than emissions measured in the tests carried out in a laboratory. There is a gap between the emissions measured in the laboratory and the emissions in real-life driving conditions of around 50 %. Therefore, emissions measured are usually in non-compliance with emission limits in the real world. It has been revealed that car makers cheat by fitting devices that give different emission values between testing and driving on roads.

An island wide mobile ambient air quality monitoring program was initiated by the CEA by using automated ambient air quality monitoring station provided by Vehicle Emission Test Trust fund. Hence, the government is supposed to pay particular attention to the alarming deterioration of the environmental quality caused by transport activities. It is supposed to take steps to minimize the damage to the environment, especially with respect to air quality. It is also supposed to systematically upgrade the existing system of transport technologies that are less polluting.

3.2. Possible solutions to the air pollution due to transportation in Sri Lanka

In order to tackle air pollution by road vehicles, a number of steps can be followed at the national level. An improved laboratory test cycle has to be introduced. The only way to avoid optimizing and cheating the test cycle is to test vehicles on the road in real-world driving conditions. The real-world driving emissions tests should be implemented using portable emissions measurement systems to ensure that vehicles meet the standards on the road. A framework should be created to help cities implement non-technical measures, low emission zones, congestion charges, etc to reduce road vehicle pollution.

Following simple activities can also reduce the air pollution to a great degree To understand the nature of the goods being transported and the suitability of the packing material of the goods being transported; to control the temperature to suit the goods being transported; to provide high safety when transporting chemicals and explosive materials; to control the pressure in the surrounding environment as well as inside the packing material of the goods being transported; to provide measures to protect goods being transported from impacts due to the vibration; to store the goods inside the vehicle to suit its capacity; to select trained drivers accordingly; and to update the maintenances of the motor vehicles. Sharing schemes is a simple method to control air pollution from motor vehicles. They cause a net reduction in car use, and thereby leading to the reduction of air pollution. A multi-modal, sustainable transport, which utilizes both public and active forms of transport (cycling and walking), should be encouraged.

Establishing a modern ambient air quality monitoring network covering the busy cities in the country, is important. Enactment of new laws and enforcing existing laws will require reliable baseline data on indoor and outdoor air quality and health impact. Modifying existing regulatory practices and strict adherence to regulations at community and household levels and identifying new mitigation strategies are vital.

According to a research study, to achieve 2035 climate goals, transport emissions should be reduced by 95 %. Further, to reach this goal, passenger cars must be zero carbon by 2050 as aviation is more difficult to be decarbonized. Hence, the replacement of the conventionally fueled vehicles by the electric vehicles should gradually take place within the next two decades.

4. Concluding Remark

In Sri Lanka, oil-based road transportation system is the major contributor to the air pollution, whereas Particulate Matter is the primary pollutant. The poorly-conditioned road network, and the absence of a well-planned public transportation network, well-established monitoring network and the improper traffic control system are the major causes of the environmental issues. Establishing a proper monitoring network to identify the problematic areas is one of the most pressing needs to upgrade the system and decrease the emissions. Changing the peoples' attitudes toward adopting to sharing schemes and the modes of transportation like cycling and walking for short distances, is also a promising approach. Revising the national transport policy towards a 'sustainable transportation system' is a timely need. A sustainable transport system can be achieved only by integrating economic development with the protection of the environment.

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Technological Advances and Electromagnetic Pollution

Dr K. Ahilan

In recent times, the level of electromagnetic pollution is seen to increase due to technological advances. Radio and TV broadcasting towers, cellular towers, microwave transmission links, bluetooth devices, WiFi routers and electronic devices such as smartphones, tablets, microwave ovens act as electromagnetic pollution sources. Since the usage of electromagnetic pollution sources has increased, health concerns have also been raised. An electromagnetic field above a certain level may cause biological effects on the human body, and may lead to health implications. In response to these concerns, several organizations, including the World Health Organization, (WHO) the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the British Health Protection Agency, and the International Agency for Research on Cancer have been studying the health effects of electromagnetic pollution over the last two decades. This article investigates how electromagnetic pollution is seen to increase due to technological advances.

Electromagnetic radiation spreads out the energy as it moves. Electromagnetic pollution level is determined by the frequency and intensity of electromagnetic fields. The electromagnetic spectrum spans over a range of wavelengths and frequencies, and these can be divided into a number of regions: (1) radio waves, (2) microwaves, (3) infrared (IR), visible light, ultraviolet (UV), X-rays and gamma rays as shown in Figure 01.

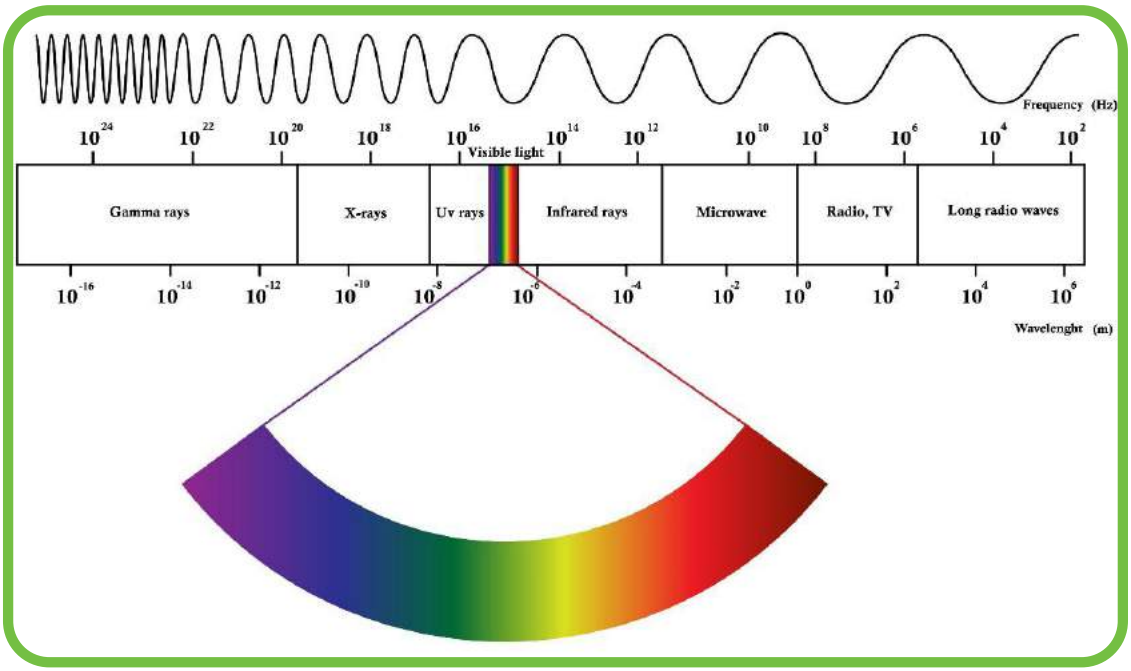
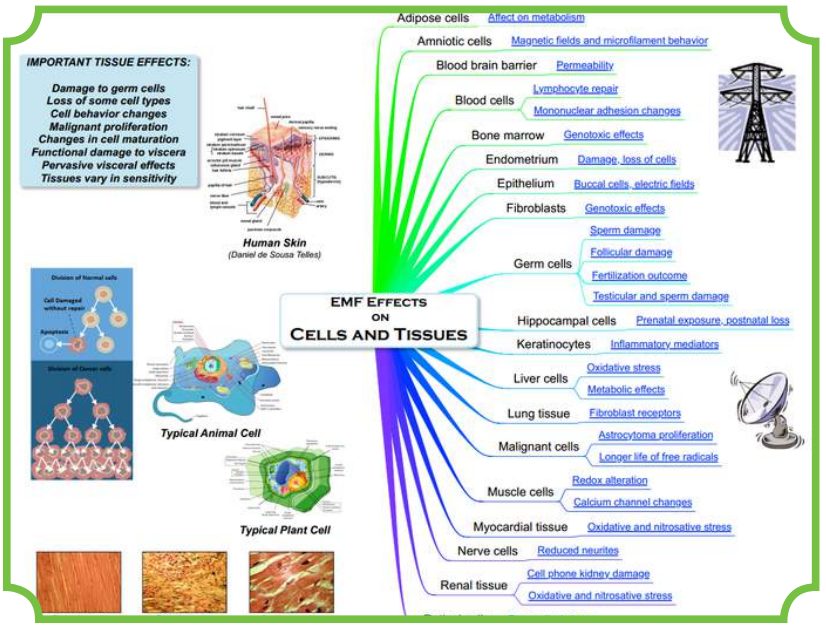
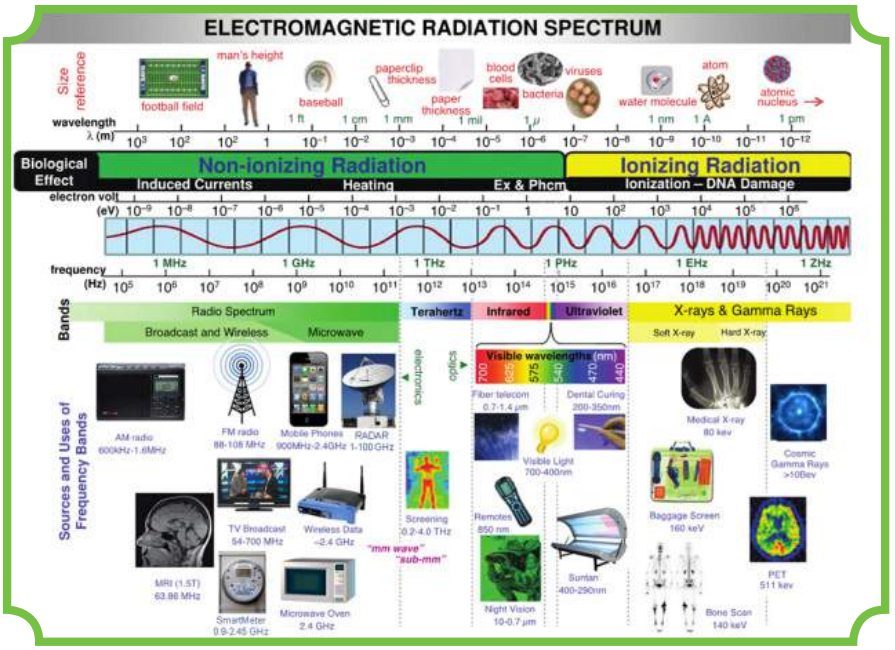


Figure 01: Electromagnetic spectrum

Radio waves up to 3GHz and radio frequencies, are used in mobile base transceiver stations, wireless LAN, radio and television, mobile phones, tablets and computers. Microwaves have frequencies ranging from 3 GHz to 300 GHz. It is used for high bandwidth point to point transmission, radar communication and 5G. Visible light comes in the range of around 430THz to 770THz, and the frequency ranges of x-rays and gamma rays are very high.





in some parts of the Sri Lanka, landline connections are not available, and consequently, mobile phones are used for communication. Mobile phones have low-power transmitters. The Telecommunications Regulatory Commission of Sri Lanka (TRCL) grants approval for frequency allocations. In Sri Lanka, 900MHz and 1800MHz are being used for 2G mobile communications, and 2100MHz is used for 3G mobile communication, while 1800MHz and 2300MHz are used for 4G mobile communication. Microwave ovens operate at the frequency of 2.45GHz, and microwave ovens are limited to 5mW/cm^2 at approximately 2 inches from the oven surface.

The 5G technology has evolved from the previous generation of 3G and 4G technologies. The 5G network frequency band comes in two sets. Frequency range 1 (or sub-6 GHz) is from 450 MHz to 6 GHz, and frequency range 2 (or mm Wave) is from 24.25 GHz to 52.6 GHz. TRCSL has granted 3.5GHz band for pilot trials of pre-commercial 5G services. TRCSL will be awarding the initial 5G spectrum band slots to mobile service providers by the end of this year.

The microwave link uses up to 80 GHz for point-to-point communications. Service providers are using higher frequency for high capacity links, and such high powers are transmitted in long distance communications, as the power of electromagnetic radiation goes down at an increasing rate with the distance. The point-to-point microwave links produce higher electromagnetic pollution, as high frequencies are used and higher powers are transmitted. The microwave link parabolic antennas are usually placed at the top of the tower. In some places, the microwave link parabolic antennas are fixed at the top of the high-rise building, and it can be very harmful

Table 1 : The reference levels for exposure of the general public for over 30 minutes

Frequency range	Incident power density; S_{inc} (W/m^2)
400 MHz to 2 GHz	$\frac{f}{200} W/m^2$; where f is frequency in MHz
2 GHz to 300 GHz	$10\ W/m^2$

to walk across such links.
For all radio and microwave frequencies (0 to 300 GHz), maximum power levels are designed to avoid any adverse health effects. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has released new guidelines for limiting electromagnetic fields in the rage of 100kHz to 300GHz in 2020. These guidelines cover many applications including 5G technologies.

The reference levels for exposure of the general public for over 30 minutes and the whole body, to electromagnetic fields is given in Table 1, which were taken from ICNIRP's new guidelines.

The Table 2, specifies the electromagnetic radiation limits for the general public, to local exposures for over 6 minutes. These were also taken from ICNIRP's new guidelines.

In Sri Lanka, TRCSL has adopted the ICNIRP guidelines on limiting exposure to electromagnetic radiation. Telecommunication service providers are expected to make sure that power density of electromagnetic waves are within the limits as defined by ICNIRP guidelines.
The frequencies of radio and microwave are much lower than ionizing radiations such as x-ray and gamma rays, and the transmitting of power is also limited by regulation bodies. Therefore, they do not have enough energy to break molecular bonds or ionizing of atoms in the human body. There is no conclusive evidence yet to suggest that electromagnetic radiation causes adverse health effects including cancer, electro hypersensitivity, and infertility. However, heating effects occur from 100kHz onwards. Studies on the possible effects of non-ionizing radiation are being conducted, which indicate mixed results, and it may take a while to clearly understand its health consequences, and consequently develop appropriate guidelines and standards. It would be prudent to develop innovative solutions to cut down unnecessary exposure, while ensuring technological benefits. Such solutions would be attractive to both Telecommunication service providers and to users.

Table 2 : The electromagnetic radiation limits for the general public, to local exposures for over 6 minutes

Frequency range	Incident power density S_{inc} (W/m^2)
400 MHz -2 GHz	$0.058f^{0.86}$; where f is frequency in MHz
2 GHz – 6 GHz	$40\ W/m^2$
6 GHz – 300 GHz	$\frac{55}{f^{0.177}}$; where f is frequency in GHz
300 GHz	$20\ W/m^2$

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Visual Pollution : Another Eyesore

Dr Chamila Dias

We gather information from our surroundings through interaction of our sensory organs. The main sensory organ which has contacts with the surrounding environment is our eye. If someone's view or vista is covered by any unsightly elements or scenes that interfere, clutter, or intrude the beauty, it would become an eyesore. It is considered as a kind of pollution. We are all very much sensitive to water pollution, air pollution, soil pollution and sound pollution, but have you ever been concerned about visual pollution in your surrounding?

Let us focus on this special phenomenon of environmental pollution known as "visual pollution" in this article. Visual pollution is found both natural and built environment. The unsightly elements or scenes include natural factors such as smoke emitted from forest fires or windblown dust as well as man-made factors such as billboards to promote business interests, mobile towers and antennas used in telecommunication, above ground power lines distributing electricity, industrial smog released from large factories, and open garbage dumps etc.

Variations and the diversity in our environment are determined by the location of various objects. For an example, unplanned public transport stations, open garbage dumps, large panels and stores, poorly planned buildings and transportation systems could create visual pollution. The increase high-rise buildings creates negative effects to the visual and physical characteristics of a city, which reduces the readability of the city, and destroys its natural environment. These are regarded as visual pollution objects, referring to all kinds of man-made features that affect the visual quality of urban surroundings. Similar to the other types of pollution, visual pollution is also largely man-made. The upswing of advertisements and improvements in communication technologies initiate huge and unattractive modules, such as billboards and mobile towers, that came to dominate the skylines of the urban areas. Human actions like littering, vandalism and improper waste disposal, also contribute significantly towards the presence of unpleasant elements in the streets. Additionally, the construction of tall buildings in modern cities adds to the visual clutter, if they are not well planned before considering the overall city planning. The other main cause for visual pollution is the expansion of industries and high population density. Visual pollution destructs attraction of all objects in the environment. It may cause stress or depression to a person. Visual pollution may also reduce tourist attraction. Moreover, studies have revealed that the areas with high visual pollution are largely used for criminal activities.

Visual pollution is largely found in developing countries compared to that of developed countries. For instance, according to a group of scientists, billboards and outdoor advertisements contribute to 20.6% of visual pollution in a typical urban area of a developing country.

We know that songs or poems have basic characteristics or composition such as melody, harmony, and rhythm. In a similar manner, visual composition also has characteristics such as unity, rhythm, balance,

and harmony etc. Composition of visual environment is the arrangement of parts or elements to produce a conceptual whole. Visual environment is considered as having a three-dimensional composition. The basic elements could be in the form of lines, colours, shapes, sounds, words, etc., which give birth to different types of compositions. To understand it easily, colours can be taken as an example. Colours affect people psychologically. There are different physiological responses generated by different colours, or in other words certain colours are likely to produce certain feelings. Dark colours or luminous colours mostly cause visual pollution. However, some mental reactions are individual and subjective to each colour. Examples of generally accepted colour responses such as blue and green colours have a soothing effect, while red in contrast, give signs of danger and warning. Yellow has a cheering and stimulating effect, whereas purple stands for richness and importance.

Similarly, breach of rhythm in a certain system also causes visual pollution. Moreover, if shapes or volumes that do not suit the existing shapes and volumes of buildings in certain areas, these will obstruct ones' sight. The pictures given below show some situations and examples of visual pollution which occur in several ways.

Figure 1: Open dumping of garbage in a water body.

Open garbage dumping

Open dumping of garbage must be banned in developing countries, and effective environmental legislation such as the implementation of the "polluter pay principle" for offenders, could be a vital mitigation exercise to curtail curbside waste disposal. Figure 1 shows how a water body is polluted in such a manner, though the birds feeding on garbage is not clearly visible to the naked eye. Figure 2, shows how the beauty of elephants is obscured due to the thrash that they are feeding on?

Man-made structures and constructions

Visual pollution, observed in urban areas makes human beings suffer indirectly from mental stress and illnesses in the long term. High rise buildings, while camouflaging the natural greenery in the surrounding areas, cause heavy visual pollution.

Figure2:A herd of elephants foraging for meals in the middle of a trash dump in Sri Lanka

Unplanned constructions and man-made structures spoil the landscape and natural beauty of the surrounding environment and one such example is shown in figure 3 which was taken near Sigiriya by Sulochana Ramiah Mohan early this year.

Figure 3: High rise building construction near to world heritage Sigiriya in Sri Lanka

Air pollution

When we hear the word, air pollution, it brings the visions of smokestacks and flowing black clouds to the mind. Air pollution comes in many forms such as burning of fossil fuels, industrial processes emitting particulate matter, such as sulfur dioxide, carbon monoxide and other noxious gases. Indoor areas can become polluted by emissions from smoking and cooking. Some of these chemicals, when released into the air, contribute to smog and acid rain. Short term exposure to air pollution can irritate the eyes, nose and throat, and cause upper respiratory infections, headaches, nausea, and allergic reactions. Long-term exposures can lead to chronic respiratory diseases, lung cancers, and heart diseases. Long-term exposures also can lead to significant climatic changes that can have far reaching negative impacts on food, water and ecosystems. Apart from all these detrimental effects, smoke can cause visual pollution to our eyes.

Advertising and display material

Hanging wires, unsystematic display of billboards and unplanned buildings, as well as the display of banners for campaigning is a normal practice in major cities in developing countries including Sri Lanka. Figure 5 shows the heavy visual pollution in the city of Lahore, Pakistan. This practice remains uncontrolled, as there is no law to check the menace of visual pollution.

Figure 4: Smoke emission from an industry causing air pollution and at the same time visual pollution

Artificial lighting

The light bulb is the most transformative invention human beings have introduced to the planet. By flicking a switch or pushing a button, we can push back the mask that would naturally blanket our lives each night. We can work long after the sun sinks below the horizon. We can enjoy and roam in the cities until the hours stretch to late night. However, the dark side of light bulbs is that the city's lighting system affects animal behavior as well as human health, and consequently the ecosystem. The biggest disadvantage is that it obscures the band of the milky-way, our home galaxy. According to "The New World Atlas of Artificial Night Sky Brightness", the inhabitants of Chad, Central African Republic, and Madagascar, are the least

affected by light pollution. In these areas, the band of our home galaxy - the "Milky Way, is clearly visible.

Light pollution is one of the two highest sources of mortality for hatching sea turtles along our coastlines. Light is an important navigation tool for sea turtles. According to the Florida Fish and Wildlife Conservation Commission, when newborn sea turtles first hatch out on the beach they stay beneath the sand and wait to emerge until nighttime, after the temperature has cooled down and moonlight appears. But human interference through artificial light threatens to distort the sea turtles' ability to navigate and survive. Hatchlings will unconsciously move towards the brightest area, which would naturally be the ocean, glowing from the reflection of the night sky. Due to artificial lighting, turtles may mistakenly follow the light shining from streetlights and buildings in huge numbers. When the sun comes up, a disoriented, land-locked turtle is dehydrated, overheated and are at an increased risk of mortality from fatigue, predation, and collision with vehicles. A recent study has shown that less than one-third of the world's key biodiversity areas have completely unspoiled night skies, while around one-half lie entirely under artificially bright skies. According to National Geographic (2019), 83% of the worlds population live under light polluted skies.

Figure 5: Visual pollution in a street in Lahore, Pakistan

Curbside begging

Curbside begging is an eyesore to the public. Nevertheless, curbside "role plays" such as playing a guitar, street dancing and fancy dressing, can be encouraged for collection of money without causing a nuisance to the public.

Visual pollution related health problems

Rapid urbanization has enhanced visual pollution, deteriorating the quality of life in urban centres. Effects of exposure to visual pollution include, distraction, eye fatigue, decreases in opinion diversity, and loss of identity. Continuous exposure to visual pollution is believed to cause lack of sleep, mental irritability, and psychological

Figure 6: A hatchling sea turtle turns inland following manmade lights instead of seaward

Figure 7: Street beggars in India

disturbances in children as well as adults. Distracting advertisements and bright lights on billboards can cause traffic accidents or lead to an increase in stress levels among drivers. Visual pollution can intensify or generate stress and create an uncomfortable human occupation environment. Researchers have started exploring various dimensions of this new form of pollution.

How do we reduce the visual pollution ?

Many countries have enacted new laws to prevent visual pollution. For an example, in 1965 the first lady of the US, Lady Bird Johnson pioneered action against visual pollution on roadways. The "Highway Beautification Act of 1965" was implemented in USA because of her efforts. The US government also introduced the "Intermodal Surface Transportation Efficiency Act of 1991" which reduced visual clutter, providing funds for the creation, preservation and conservation of scenic byways and biking trails.

Similarly, the city of São Paulo in Brazil also passed the Clean City Law (Cidade Limpa) in 2006 which banned the use of all types of outdoor advertisements, including billboards, transport systems etc.

All these measures have proven to work with a certain degree of success. They can serve as examples for other countries like Sri Lanka to address the issue of visual pollution. Although various regulations have been enacted to protect the environment, there seems to be no implementation strategy for such laws, for prevention of visual pollution in Sri Lanka.
We feel and recognize water, air and sound pollution, and act immediately on them. However, visual pollution is not felt in such a manner. Nevertheless, it has impacts on our mind. Unpolluted visual environments help to create a person with a healthy mind. Hence let us commit ourselves to create a good visual environment to protect the beauty and peacefulness of our environment. Visual pollution is still to receive attention on a global level. The key to solving visual pollution lies in proper urban and suburban planning, thereby improving the environment and quality of life around us. Therefore, as individuals we should think of ways and means to contribute towards creating a visual pollution free Sri Lanka.

"Public space is a public property and we cannot pollute it with our personal intention".

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Silent Pollution due to Sodium in Irrigation Agriculture

Prof. H.D. Gunawardhana

Irrigation Water Quality

The largest user of water in Sri Lanka is irrigation agriculture. The irrigation water flows through a system of tunnels, streams, reservoirs (Wewa), canals etc. before it reaches the field where a crop is grown. During this flow some soluble salts are always dissolved in, and the water becomes saline containing high dissolved salts. Man's activities in industries, deforestation etc. in and around water sources **enhance dissolution of salts.** In the fields, the water will undergo evapo-transpiration resulting in the accumulation of dissolved salts, which will affect soil properties, especially soil permeability and subsequently crop growth. It has been reported that in countries such as Afghanistan, Pakistan, Egypt etc. **millions of hectares** of irrigated lands have been abandoned due to loss of soil permeability which affects the crop growth.

The ancient concept of availability of water for economic prosperity does not hold true today. **The 'quantity'** of available water along with **the 'quality'** plays an important role. In ancient times, available sources of water undoubtedly was suitable for the purpose of its use such as drinking, agriculture etc. Therefore, the need to check the 'suitability' for use did not arise, and also was not a factor to be considered. It is also obvious that the re-use of irrigation water was done only to a limited extent, and was not given any priority. The water once used for irrigation was allowed to drain off to the sea. The availability of irrigation water of suitable quality in ancient times made this possible. In addition, the judgment on the quality of water was not possible prior to reuse. It was based on strict abidance to the myth ***'respect water'***, which undoubtedly assisted in preventing water becoming unsuitable for irrigation. **"Respect water"** was the concept introduced to me by our teachers in the village school in the early 1950's. This can be considered as the wisdom from the past relating to sustainable development - an "Unwritten Science". The term "respect" excluded spitting or urinating on water i.e. not to pollute water. This system was practiced in Sri Lanka during the past 2,500 years in the domestic and agricultural use of water. In ancient times toilets were designed on the concept "respect water", thus preventing pollution of water in the past. Is there any such respect for water today in our domestic usage? Today, the quantity but also the suitability of water for the purpose i.e. quality would be significant. For example, if water containing injurious chemicals is available in large quantities, the people who drink such water will become sick, thus affecting the economy. Even if there is a plenty of water of poor quality for irrigation, it would lead to a crop failure, and consequently affecting the economy.

A knowledge of the quality of irrigation water is important in judging its suitability for irrigation. Suitability of a source of irrigation water depends upon several factors which include, soil, plant, and climate, and it can be expressed by the following relationship.

$$SI = f\ (QSPDC)$$

Where

SI = Suitability of irrigation water,
Q = Quality of water i.e. the total salt concentration, cationic and anionic composition,

S =Physico – chemical properties of the soil profile,
P =Salt tolerance characteristics of the crop plant at different stages of growth,
D = Drainage conditions,
C = Climatic parameter.
It is difficult to suggest a single water quality criterion **(Q)** because of the interaction of several factors. The degree of adverse effects on soil properties is mainly related to the chemical composition of water. The adverse effects of a particular quality water on soil-plant system depends upon the total salt concentration, relative proportion of sodium to other cations, boron concentration and bicarbonate content. Water with low electrical conductivity contain mostly sodium and chloride ions. The relative proportions of sodium to other cations is determined by the sodium adsorption ratio (SAR).

$$\textbf{SAR} = \frac{Na^{+}}{\sqrt{Ca^{2+} + Mg^{2+}}}$$

where ionic concentration of each is in mmol L^{-1}.

Any increase in the SAR of irrigation water increases the SAR of the soil solution, which ultimately increases the exchangeable sodium by the soil. Therefore, Exchangeable Sodium Percentage (ESP) or the adj.SAR has a wider role to play in the judgment on the suitability of water-for irrigation.

The degree of adverse effects on soil properties and crop growth are mainly related to the composition of irrigation water. Food and Agriculture Organization of the United Nations **(FAO)** has put forward the guidelines shown in Table 2, to evaluate water quality for irrigation using the problem approach. The Exchangeable Sodium Percentage (ESP) or the adj. SAR is expressed as follows:

$$\textbf{adj SAR or ESP} = \frac{Na^{+}}{\sqrt{Ca^{2+} + Mg^{2+}}} \quad (1 + (8.4 - pH_C))$$

where pHc is the theoretical,

calculated pH of irrigation water in contact with lime and is in equilibrium with soil carbon dioxide.

Since there are several factors associated with the soil-water system, the calculated pH of irrigation water in contact with lime, in equilibrium with soil carbon dioxide (pHC), plays an important role in assessing the value of ESP, which is directly responsible for the possible loss of soil permeability on continuous irrigation with poor quality waters. The pHC is expressed as:

$pH_C = pK'_{sp} - pK'_{sp} + p[Ca^{2+} + Mg^{2+}] + p(Alk.)$ K_{a2} = Conditional second dissociation constant of carbonic acid. K'_{sp} = Conditional solubility product of calcium carbonate (magnesium carbonate). $p(Ca^{2+} + Mg^{2+}) = -\log_{10}$ the sum of the concentrations of magnesium and calcium in $cmol.dm^{-3}$. $p(Alk) = -\log_{10}$ the sum of the concentrations of carbonate and bicarbonate in cmol. dm^{-3}. In recent reports, journal articles, the adj. SAR is more and more frequently being reported as Adjusted R_{Na}. The terms are synonymous. The SAR procedure encompasses the infiltration problems due to an excess of sodium in relation to calcium and magnesium. It does not take into account changes in calcium in the soil water that take place because of changes of solubility of calcium resulting from precipitation or dissolution during or following irrigation. Sodium, and important part of salinity, remains soluble and in equilibrium with exchangeable soil sodium at all times. Whether concentrated from withdrawal of water by the crop between a long irrigation interval, diluted with applied water, or leached away in drainage, outside influences have little effect on sodium solubility or precipitation. Calcium, however, does not remain completely soluble in constant supply, but is constantly changing until an equilibrium is established. Calcium changes occur due to dissolution of soil minerals into soil-water, thus raising its calcium content, or precipitation from soil-water, usually as calcium carbonate, thus reducing the calcium. Dissolution is encouraged by dilution and by carbon dioxide dissolve in the soil water; while precipitation may take place because of the presence of sufficient calcium along with enough carbonate, bicarbonate or sulphates exceeding the solubility of calcium carbonate (limestone) or calcium sulphate (gypsum). Soon after an irrigation activity, dissolution precipitation may occur, changing the supply of calcium, and establishing an equilibrium at a new calcium concentration, different to that in the applied water. The SAR equation, since it does not account for these changes, is therefore somewhat in error. However, the SAR equation and procedure is still considered an

$$CaCO_3(s) + H_2O(l) + CO_2(aq)(HCO_3^-) \underset{\text{Precipitation}}{\overset{\text{Dissolution}}{\rightleftharpoons}} Ca^{2+}(aq) + 2HCO_3^-(aq)$$

acceptable evaluation procedure for most of the irrigation water encountered in irrigated agriculture. Water from an irrigation water tank

(wewa or vari) was used to irrigate about a 100 hectare paddy field for over 1000 years. About 50 years ago a canal with poor water quality (Adj. SAR 55.9) was diverted to this tank to increase the quantity of water.(Fig. 1) The farmers were happy with the availability of plenty of water for a few years. Subsequently, a crop failure was observed and now the farmers lost their paddy fields. This is the consequence of increasing the quantity without quality.

The previous example was the abandoning of about100 hectares of paddy fields in Sri Lanka due to the loss of soil permeability. This may be a possibility in all the other irrigation schemes if priority is given only for the quantity rather than the quality. Therefore, it is essential to take adequate precautionary measures, especially in the areas irrigated by Mahaweli waters, in order to prevent any such salt danger caused by the increased utilization of irrigation water resources.

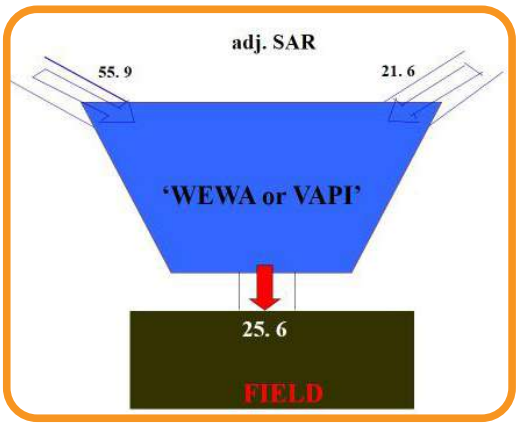

Fig.1 (Above) Schematic representation of silent sodium pollution of irrigation waters in Sri Lanka

Prevention is better and less expensive than the cure.

The Mahaweli irrigation project involves utilization of water of the Mahaweli Ganga to irrigate an **extensive area of the dry zone. When completed, the Mahaweli Development Project is expected to supply water** for the irrigation need of 900,000 acres for two crops a year. The master plan also envisages the generation of 2,037 million kilowatt hours of hydroelectric energy. The phase 1 of the project, (Kala Oya, Abanganga) covers 132,000 acres of existing lands and 91,000 acres of new lands. A monitoring programme was initiated in 1978 to check the quality of irrigation waters in the system H of the Mahaweli diversion scheme. The block 302 of the system H of the Mahaweli development scheme was selected for this purpose. It was reported that there is a remarkable increase of the Sodium Adsorption Ratio(SAR) and Residual Sodium Carbonate (RSC) values especially in the drainage waters in April, and in November. This coincides with the Maha and Yala harvesting seasons of the system H. Usually, a heavy rainfall leads to the decrease of these values significantly. BalaluWewa is the reservoir which supplies irrigation water to Block 302 through the Left Bank Canal (L.B.C.). Seasonal variation of the filterable residue and total residual contents of waters from BalaluWewa, Left Bank Canal, and at the beginning of D1 Channel of Block 302 shows similar trends. It was seen that there was an increase in the filterable residue as well as the total residue of the irrigation waters in April 1978 and 1979. The Maha harvest starts in March and ends in April. During this period the water supply to the field being completely cut off and consequently, as a result of rapid evaporation of existing water, the filterable residual content increases.

$$= \frac{Na^{+}}{\sqrt{Ca^{2+} + Mg^{2+}}}$$

where ionic concentration of each is in mmol L^{-1}.

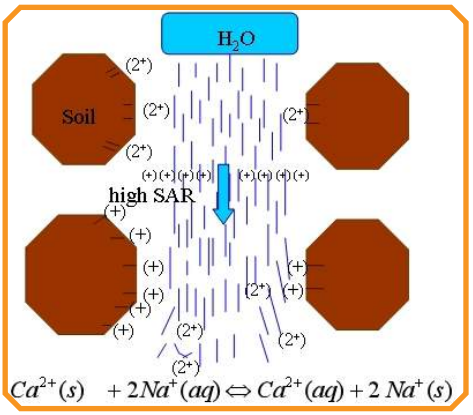

Figure 2: Illustration of the loss of soil permeability when waters of high SAR values are used for irrigation.

The history of conservation of water in Sri Lanka could be traced to the reign of King Pandukabhaya (380 – 310 B.C.), who constructed the first reservoir (Wewa) at Anuradhapura. Thereafter, several hundreds of reservoirs have been constructed mainly to conserve rainwater. Very little evidence could be gathered on the construction of reservoirs by building dams across flowing streams or rivers. In such instances a **forest cover** was maintained in and around the streams carrying water to the reservoirs and also the canals which supplied water to paddy fields. The belief was that such divine beings living in trees assisted to preserve the forest cover. In addition, powerful dictatorship and good governance prevented people from clearing a forest. One method of **achieving sustainability** in the ancient irrigation projects,

is to maintain the forest cover. According to modern science clearing of forests increases the sodium ion concentration of irrigation waters, thus causing water unsuitable for irrigation, which ultimately leads to a loss of soil permeability. Ancient water management was based on this type of ancient scientific views (unwritten science).

Kalawewa is one such reservoir constructed by King Dathusena (6th Century A.D.) by building a dam across a stream (presently Dambulu Oya – Kala Oya). He may have constructed this to fulfill his wishes, and may have gone against the opinion of his advisors in making the decision. Three or four hundred years later, the continuous use of Kala Wewa waters for irrigation, resulted in the Anuradhapura kingdom getting shifted to Polonnaruwa. One could attribute this change to crop failure due to the loss of soil permeability. This administrative failure during the period 6th to the 9th century resulted in poor water management, which ultimately led to crop failures. Continuous irrigation with poor quality water and consequent crop – failure affected the agricultural economy in the Anuradhapura area, ultimately resulting in the shift of the kingdom to Polonnaruwa in the 10th century.

Table.1: FAO Guidelines for interpretation of water quality for irrigation.

IRRIGATION PROBLEM	DEGREE OF PROBLEM		
	No Problem	Increasing Problem	Severe Problem
Salinity (affects crop water availability) ECw (mmhos/cm)	< 0.75	0.75 – 3.0	> 3.0
Permeability (affects infiltration rate into soil) ECw (mmhos/cm) adj. SAR (or ESP) Montmorillonite (2:1 crystal lattice) Illite – vermiculite (2:1 crystal lattice) Kaolinite – sesquioxides (1:1 crystal lattice)	 > 0.5 < 6 < 8 <16	 0.5 – 0.2 6 – 9 8 –16 16 - 24	 < 0.2 > 9 > 16 > 24
Specific toxicity (affect sensitive crops) Sodium (adj. SAR) Chloride (meq/dm-3) Boron (mg/dm-3)	 < 3 < 4 < 0.75	 3 – 9 4 – 10 0.75 – 2.0	 > 9 > 10 > 2.0

The recurrence of large scale crop–failures cannot be ruled out today. However, it is now impossible to shift the population in the affected areas unlike in the 10th century. A possible crop failure today will lead to disaster, and destruction of the developments achieved during the last two decades. A proper water management programme guided by the results of a continuous monitoring programme and water quality criteria, will undoubtedly prevent such disasters.

In the case of a natural resource such as water, it has been revealed that the per capita availability has declined to alarming levels affecting the future generations. To maintain sustainability without curtailing the current human needs, it is essential to develop technologies on the reuse or recycling of water, effluent treatment processes etc. The development of such technology is impossible without the necessary scientific knowledge on the water bodies. The immediate requirement is to assess the water quality and its seasonal variation by monitoring programmes, and the subsequent use of scientific principles, to monitor sustainability without a decrease in the per capita availability.

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Microplastics Pollution: A Silent Killer that Leads to the Next Global Environmental Disaster

Ms J. Bimali Koongolla

Consumption of plastic products within the society has increased exponentially in recent years. Many favorable properties of plastics including durability and low-cost make plastics the obvious choice in many situations. Unfortunately, society has been slow to expect the need for dealing adequately to prevent plastics entering the marine environment. Consequently, plastic pollution has become a pressing environmental problem, and is the most widespread problem affecting the marine environment since society uses the ocean as a convenient place to dispose of litter and waste products.

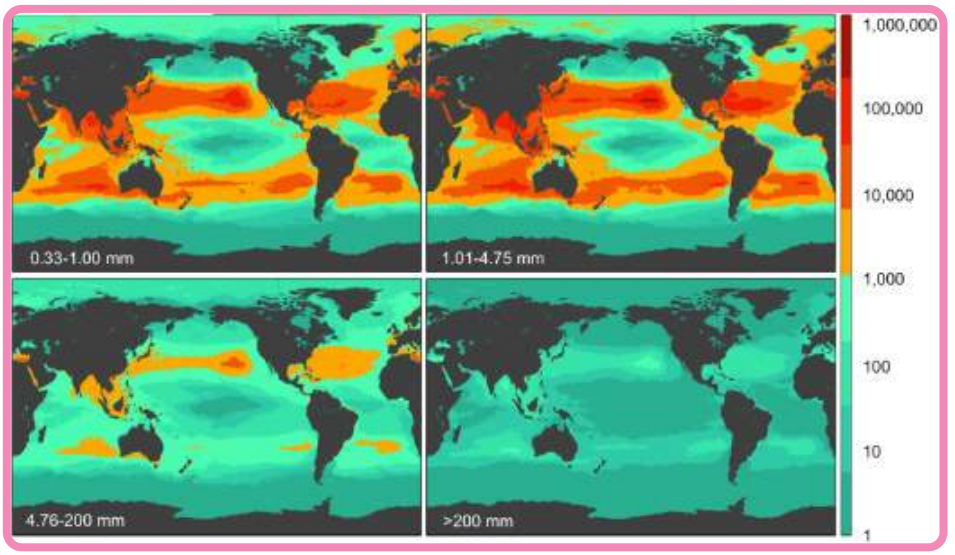

Figure 1: Model results for global count density in four size classes of plastics

Figure 2: Widespread of Microplastics in the environment

What are microplastics?

Plastic particles are in different shapes and sizes, but those that are less than five millimeters in length are called "microplastics". These microplastics in the environment represent one of the most serious environmental threats of present day. It is a great issue at the moment in the media, and rightly so. Unfortunately, there is no other way to discuss the issue of

microplastics other than through experiencing a global catastrophe. It appears that every corner of the planet is now contaminated with microplastics as they are in the air we breathe, the water we drink, seafood we eat and even in extremely remote regions such as on the tops of mountain peaks, and in the deepest trenches of the ocean. However, microplastics now appear to be a ubiquitous pollutant of the beaches, surface waters and the marine sediment worldwide.

The origin of microplastics can be shown through two main pathways such as primary and secondary. The distinction between primary and secondary microplastics depends on whether the particles were originally manufactured to be that size or whether they have occurred due to the breakdown or fragmentation of larger debris. Primary microplastics include micro-beads used in cosmetic formulation, plastic powders used in molding, and several types of virgin pellets of spherical or cylindrical shaped particles typically around 5 mm in diameters that are widely used in industrial process. Secondary microplastics are created due to the fragmentation of larger macroplastic items into smaller microplastics. This type of microplastics can also be released into the environment during the use of products such as textiles, paint, and tyres. With high UV irradiation and physical abrasion by waves, microplastics production due to the fragmentation of larger plastic items is most effective on beaches. Even if we were able to stop the discharge of macroplastic litter into the sea today, there is an issue with the ongoing degradation of the plastic particles which can result in a sustained increase in microplastics for many years to come.

Sources of microplastics

The sources depend on where the litter entered the sea, either land-based or sea-based. Land-based sources include domestic, agricultural and industrial activities that result in plastic debris being washed out from land, and aggregation in the ocean during storms via rivers, streams and sewage treatment plants. Recreational activities along the coast, general public litter, harbors and unprotected landfills, as well as dumps located near the coast are also identified as sources. Sea-based sources are fisheries, recreational boats, energy production systems, shipping, research, and legal and illegal dumping activities.

Transport and distribution

Day by day the number of microplastics in the ocean are growing due to the inescapable rise of plastics consumption, as well as inadequacy in re-use, recycling and waste management practices in many parts of the world which has led to this pathetic situation. We still know relatively little of the fate of microplastics, e.g. whether particles are more limited to the shelf and the coastline, or whether they are being deposited in deep-sea sediments. The vertical movement depends on the types and sizes of particles, e.g. plastic fragments that are heavily bio-fouled tend to sink, but once the fouling species has been removed by grazing or deterioration, it may become buoyant again. Therefore, the behavior of different sized particles and the density of the plastic itself may also play a role. Further information such as the locations where macro plastic debris accumulates and where

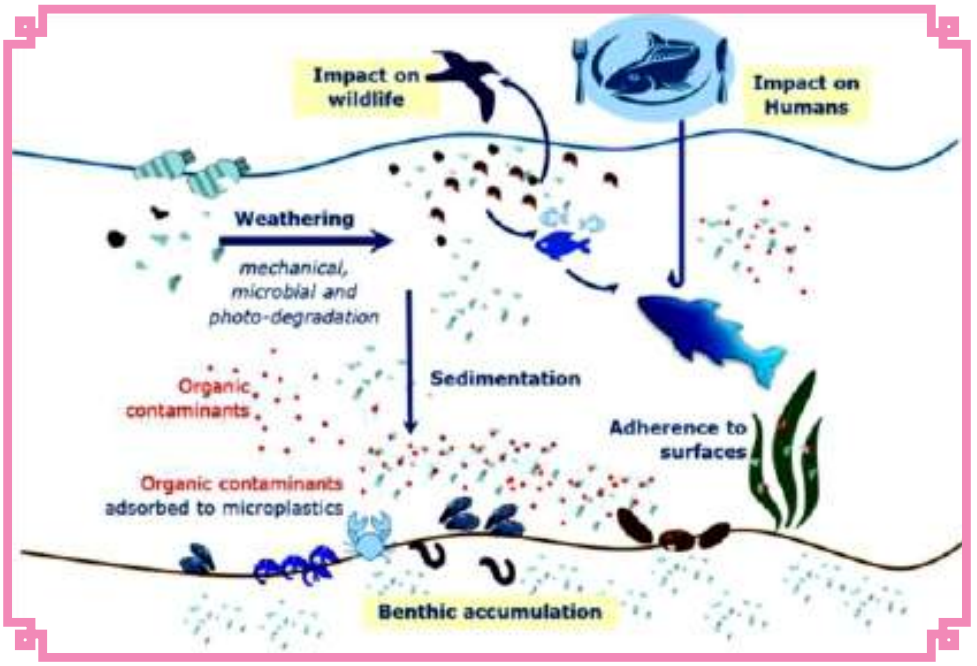

Figure 3: Potential transport pathways of microplastics and their interaction with the biota

microplastics are expected to be deposited in sinks needs to be gathered.

What are the impacts of microplastics?

As mentioned before, microplastics accumulating in the marine environment may be one of the greatest threats facing the planet. Commonly, plastics are light and durable. Thus discarded objects can easily be transported long distances from their source. A large quantity of microplastics normally float on the surface, being less dense than seawater, whereas microplastics with a density that exceeds that of seawater (>1.02 g.cm-^{3}) will sink and accumulate in the sediment. However, the buoyancy and density of plastics depend on the polymer type, and may change during their residence at sea due to processes such as weathering and bio-fouling. Therefore, habitat degradation due to microplastics and marine debris have extensive impacts on biodiversity, since many critical areas such as coral reefs, mangroves, marshes, and sea grass that serve as breeding grounds or nurseries for the majority of marine species are affected. It not only damages habitats directly via physical and chemical impacts, but it can also lead to reduced recruitment and reproduction for certain species, which may indirectly alter or degrade critical nurseries and other fragile ecosystems. Microplastics may also have the capacity to modify the population structure with potential impacts on ecosystem dynamics. This can also negatively effect photosynthesis of primary producers, and on the growth and reproduction of secondary producers, ultimately giving reduced results of productivity of the whole ecosystem, and hence represent a primary concern.

Plastics also carry other chemical compounds called additives in addition to the polymer resin. Even though polymers are generally non-toxic, the additives can have serious impacts on the health of marine organisms. Besides additives, they may also contain adsorbed chemicals from the surrounding water. Since plastics are hydrophobic, other hydrophobic (or lipophilic) chemicals present in seawater may have an affinity to the polymer. In addition, insecticides and pesticides are hydrophobic and have a tendency to accumulate on the plastic surfaces.

Furthermore, these microplastics overlap with the size range of food items for many creatures and animals that are at the base of the marine food web. Hence, the polluter does not always have to deal with consequences. But it is reasonable for marine wildlife to come into contact with these materials. Very often the smaller fragments (nano size) can pass through the gut without hurting the organism. But larger fragment can cause damage, or induce starvation if it remains trapped inside the stomach or digestive tract. Generally, this can occur due to a misidentification of the litter or may be ingested accidently during feeding. Likewise, microplastics in the water column may also be mistaken for planktonic prey by filter feeders and suspension feeders. Nevertheless, a range of marine biota including seabirds, crustaceans and fish can ingest microplastics. Such accumulation of ingested chemicals in the body tissue of the organism is called "bioaccumulation". Organisms from a higher trophic level contain higher concentrations of contaminants via their prey. The rate of contaminants (bio magnification) accumulating through the food web depends on the trophic levels of the particular organism.

Figure 4: Potential risk of microplastics for human through food chain

Furthermore, it is predictable that human beings are exposed

Figure 5: Solutions for minimize microplastic pollution

to microplastics at different levels due to high seafood consumption worldwide. Majority of earlier studies had obtained microplastics in the guts of organisms, an organ that is not generally consumed directly by man. But shellfish such as mussels, clams and some shrimps are eaten whole or with their gut. However, a recent study suggest that ingested microplastics can get translocated from the gut, and into the muscular tissue in small amounts in tiny sizes that potentially make such plastic available to anything that eats that muscle tissue, whether it be larger fish or potentially human beings that occupy a high trophic level in the marine food chain.

Solutions for microplastics pollution

Trillions of microplastics that have already entered the oceans will be the next immense challenge in ocean conservation, and it would be sensible to attempt the elimination of these foreign particles from the natural environment at this stage. One of the credible solutions to the global disaster of plastic pollution is to minimize production. After that, it is essential to ensure that all plastic waste are captured before it escapes into the environment. We can manage the waste volumes that currently exist by not adding to this problem the expected increase in plastics production. It is like, when you come home to find that the house is flooded, you do not try to reach the mop, but merely turn off the tap. However, the consequences are clearly worse for less developed and developing countries like Sri Lanka where waste management systems and infrastructure are not capable of capturing plastic waste.

It is the general view, that the world has to take three primary steps to get the microplastics problem under control. In the short-term, society needs to significantly restrict unnecessary single-use plastic items such as water bottles, plastic shopping bags, straws and utensils. Also, governments need to strengthen waste management and recycling systems to prevent waste from leaking into the environment through the domestic trash collection and landfills, and improve recycling rates as mitigation measures. Eventually, as a long term process, scientists need to devise ways to breakdown plastics into its most basic units which can be recast into new plastics or other materials, and also find alternatives that can be used in place of plastics.

Therefore, policy-makers and other decision-makers in the public and private sectors need guidance now on how best to target the microplastics issue. If not, microplastics pollution would be the next environmental catastrophe that Sri Lanka will face in the next decade.

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An overview of Laws in Sri Lanka Relating to Marine Environmental Pollution Prevention

Mr Ranil Kavindra Asela Kularatne

1.Introduction

Sri Lanka is a tropical island country located in the Indian Ocean with 45 estuaries and 40 lagoons (with a total extent of 1580.17 km^2) with mangroves and several Marine Protected Areas (MPAs) having sensitive ecosystems such as coral reefs. However, due its unique position in the Indian Ocean, Sri Lanka connects the East-West shipping route with an estimated 300,000,000 to 550,000,000 MT of oil per annum transported from the Middle East to the Far East, passing through its Exclusive Economic Zone (EEZ), while it is reported that about 300 vessels per day are passing through the offshore southern part of Sri Lanka, often utilizing services such as ship channeling, supply of water, fuel and crew changes for international shipping from Sri Lankan ports/harbors.

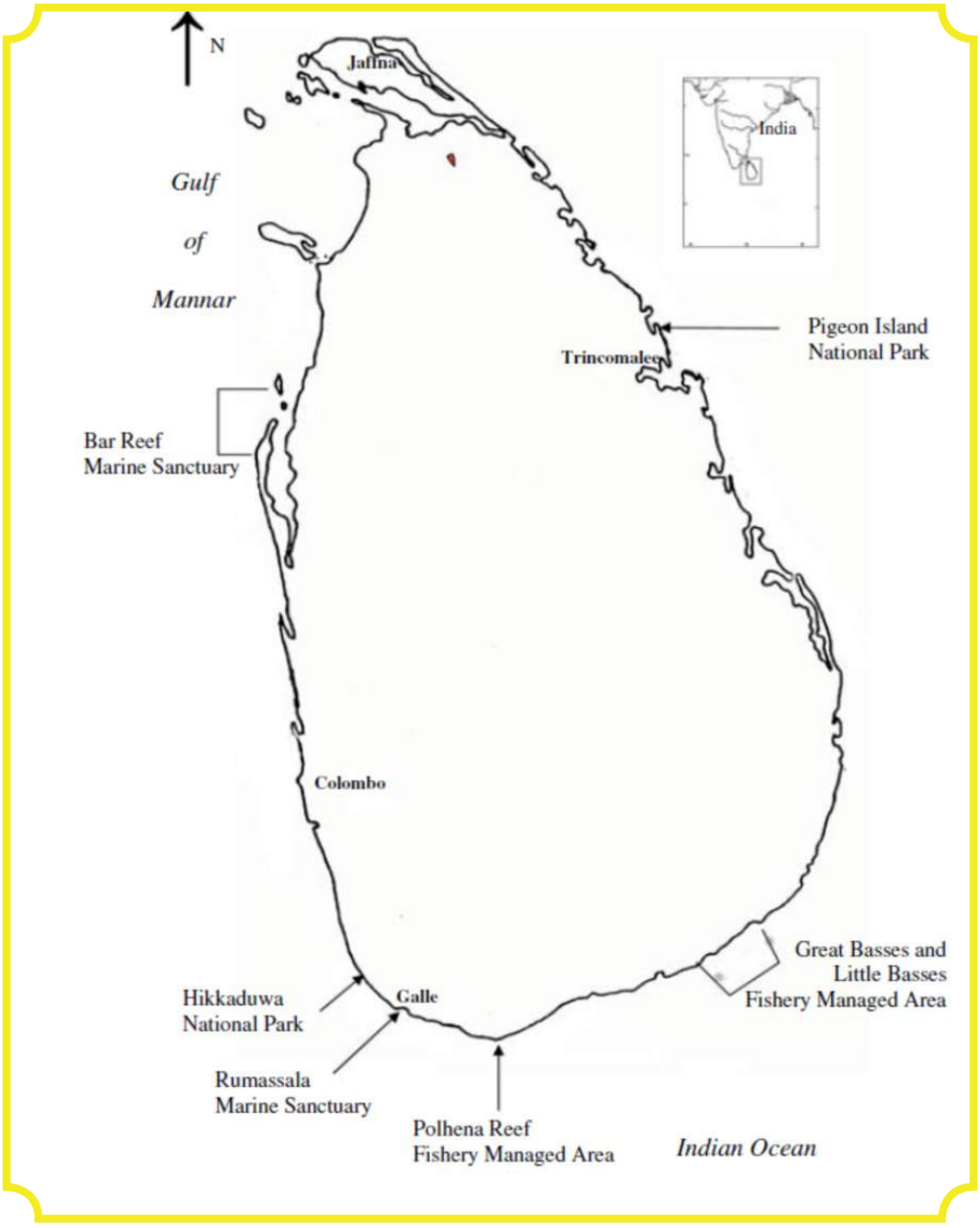
Furthermore, since the cessation of the ethnic conflict in May 2009, Sri Lanka has experienced an economic boom with an increased flux of tourists and goods, for which there has been a rehabilitation of the commercial harbors, which are all owned by Sri Lanka Ports Authority/SLPA, in Colombo (Western Province), Oluvil (Eastern Province), Galle (Southern Province), Point Pedro and Kankesunthurai (Northern Province), and the new Hambantota Port (Southern Province) opened in November 2010. Due to projected increase in shipping activity, enhancing the capacity of all the harbors/ports has been envisioned. However, many of these commercial ports, and, a majority of fishing ports/ anchorages are located near sensitive marine environments. This includes MPAs controlled by the Department of Wildlife Conversation (DWC) under their Fauna and Flora Protection Ordinance No. 2 of 1937 (FFPO) and its amendments. MPAs also include Fisheries Management Areas (FMAs) managed by the Department of Fisheries and Aquatic Resources (DFAR) of the Ministry of Fisheries and Aquatic Resources / MFAR, under their Fisheries and Aquatic Resources Act No.2 of 1996 (FARA), such as the Great and Little Basses in Kirinda, Southern Coast.

Therefore, in view of the afore-mentioned reasons Sri Lankan marine environment is highly vulnerable for pollution from ships (due to oil and garbage discharges) and also from land-based sources especially from the Coastal Zone. The Coastal Zone is a zone of high human activity in Sri Lanka having 32% of the total population and 65% of the urban population inhabits the coastal zone and also economically crucial where > 90% of industrial units and 80% of the tourism infrastructure are located and hence the coastal zone is a recipient of pollutants from various anthropogenic activities within and beyond the Coastal Zone.

Due to the conflict between environmental protection and economic development in Sri Lanka, enforcement of environmental laws present special challenges and hence needs serious consideration. This article provides a brief overview of national laws dealing with marine environmental pollution prevention.

2.National Environmental Act No. 47 of 1980 and its amendments

The National Environmental Act



No. 47 of 1980 (NEA) and its amendments (1988, 1995, 1999 & 2000) is the main National Legislation for regulating all activities that affect the environment (marine, aquatic, terrestrial and atmospheric environment) in Sri Lanka, except in the North-western Province (Kurunegala and Puttalam Districts) where the North Western Provincial Environmental Statute No. 12 of 1990 is applicable. The NEA is enforced by the Central Environmental Authority (CEA), which functions under the Ministry of Environment (MEA). The scope of this law virtually covers all aspects necessary to safeguard the environment and natural resources in Sri Lanka. To achieve the objectives of protection, management and enhancement of the environment, for the regulation, maintenance and control of the quality of the environment; for the prevention, abatement and control of pollution, the NEA uses the two protective

Name	Year of declaration	Area / ha	Responsible agency	Governing legislation	Selection criteria	Permitted activities	Prohibited activities	Major habitats
Hikkaduwa National Park	1979*	104	DWC	FFPO	Biologically diverse and important marine habitat	Recreational activities	Fishing and extraction of other natural resources	Coral reef
Pigeon Island National Park	2003	471.4	DWC	FFPO	As above	As above	As above	Coral reef
Bar Reef Marine Sanctuary	1992	30,670	DWC	FFPO	As above	As above artisanal fisheries	Commercial fishing and other resource extraction	Coral reef, sandstone reef
Rumassala Marine Sanctuary	2003	1707	DWC	FFPO	As above	As above	As above	Coral reef
Great and Little Basses FMA	2001	Unclear†	DFAR	FARA	Management of commercially important fishery resources	Recreational activities, fishing with permit	Fishing without a licence from the DFAR	Rocky reefs
Polhena FMA	2001	Unclear†	DFAR	FARA	As above	As above	As above	Coral reef

* Upgraded to the status of national park in 2002

† Boundary of FMA has been demarcated, but area is not included in declaration

Fig. 1. Locations of MPAs in Sri Lanka

mechanism to safeguard the environment form developmental activities. Firstly, the environmental protection licenses (EPLs) issued under the provisions of the Act and the Gazette Notification No. 1534/18 dated 01.02.2008 prescribes certain activities which will require an environmental protections license in order to permnt a person to carry on with such an activity legally. This is aimed at safeguarding the environment from the excessive adverse impacts caused by small and medium scale activities. The same gazette also mandates a facility to posses a scheduled waste management license (SWML) if the facility is to generate, collect, transport, store, recover, recycle or dispose hazardous wastes known as scheduled wastes. Secondly, the Environmental Impact Assessments (more commonly known EIAs) or Initial Environmental Examinations (IEEs) are required to be carried out regarding major development projects in order to analyze the relative costs and benefits of a project; Under Part IV C of the NEA (amended by Act No. 56 of 1988 and No: 53 of 2000), "Prescribed Projects" (PP), have been published under Gazette Extra-Ordinary No. 772/22 of 24th June 1993 amended by the Gazette Extra Ordinary No. 1104/22 of 05th November 1999, as projects that must undergo the EIA procedure if such projects are totally or partially located outside the Coastal Zone as defined by the Coast Conservation Act No. 57 of 1981 (as amended) or within or close to an Environmentally Sensitive Area (ESA).

3.North Western Provincial Environmental Statute No. 12 of 1990

This legislation applicable to the North-western Province (NWP) is implemented by the Provincial Environmental Authority (PEA) of the NWP. This law came into effect in 1995. Like the NEA, this legislation prescribes certain activities to possess an EPL and where necessary a SWML as per Gazette Notification No. 1685/11 dated 2010.12.21. This legislation also utilizes the two-tier IEE and EIA system and is compulsory for developments to be located in ESAs and for prescribed developments (according to Gazette Extraordinary 1020/21 of 27th March, 1998).

4.Marine Environmental Pollution Prevention Act No. 35 of 2008

Marine Pollution Prevention Act No. 59 of 1981 (certified on September 16th, 1981) was established by the Marine Pollution Prevention Authority (MPPA) under the Ministry of Environment and Natural Resources to protect the coastal / marine waters of Sri Lanka from pollution. However, this Act was repealed to pass the Marine Pollution Prevention Act No. 35 of 2008 (while renaming the Marine Pollution Prevention Authority as the Marine Environmental Protection Authority known as MEPA) with a view to strengthen the legal authority vested with this authority to deal with marine pollution incidents and to implement United Nations International Maritime Organization (IMO), United Nations adopted international conventions (relating to marine pollution prevention) ratified by the Government of Sri Lanka.

Therefore, the Marine Pollution Prevention Act No. 35 of 2008 is currently the national legislation to prevent and control marine pollution exclusively in Sri Lanka (implemented by MEPA under the MEA) considering the international instruments ratified by Sri Lanka namely the United Nations Convention on the Law of Sea (UNCLOS) 1982 and the following conventions adopted by the IMO.

•International Convention for the Prevention of Pollution from ships 1973 (MARPOL 73/78)
•International Convention on Civil Liability on Oil Pollution Damage 1969 (CLC Convention)
•International Convention relating to Intervention on the High Seas in cases of Oil Pollution Casualties 1969
•International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1971 (Fund Convention).

4.1.Scope of the Act

This Act comprises 11 Parts (comprising a total of 62 Sections or Articles) as follows.

- Part I (Sections 2-5) – Establishment of the Marine Protection Authority
- Part II (Sections 6-13) – Functions of the Authority
- Part III (Sections 14 and 15) – Establishment of Marine Environmental Council
- Part IV (Sections 16 and 17) – Staff of the Authority
- Part V (Sections 18-20) – Finance

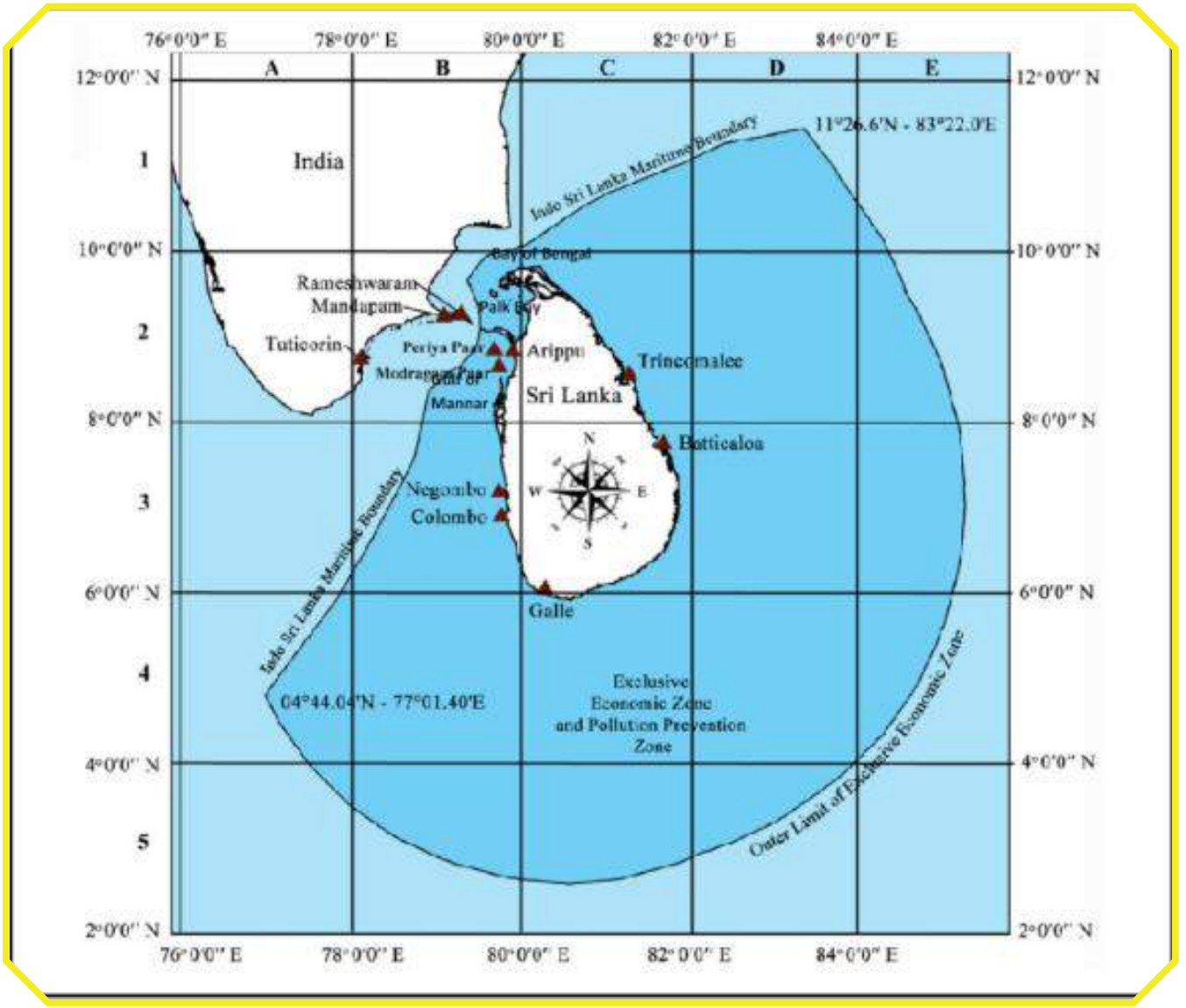


Fig. 2. Map of Sri Lankan EEZ, which is 200 nautical miles (except at the maritime boundaries with India)

❖ Part VI (Sections 21-23) – Reception facilities and preventive measures against pollution
❖ Part VII (Sections 24 and 25) – Maritime casualties
❖ Part VIII (Sections 26-33) – Prevention of pollution; criminal liability
❖ Part IX (Sections 34-39) – Prevention of pollution; civil liability
❖ Part X (Sections 40 and 41) – Prevention of pollution when engaged in exploration of natural resources including petroleum or any related activity
❖ Part XI (Sections 42-62) – Miscellaneous provisions

The Act is strictly and equally applicable to all local maritime zones (see below) declared under the Maritime Zones Law No. 22 of 1976 (enacted by the Parliament of Sri Lanka).

Maritime zones include the territorial waters, Contiguous Zone, the EEZ, the Continental Shelf and the Pollution Prevention Zone (PPZ) declared by Proclamation (Presidential Proclamation of 15th January 1977 in pursuance of Maritime Zones Law No. 22 of 1 September 1976) in terms of this Law and any other Zone which may be declared at a future date under the same law (Fig. 2).

However, the maritime boundary with India (Sri Lanka's nearest maritime neighbor) is different; after gaining independence from British occupation by both countries, a maritime agreement

was signed between the 2 countries (between Adam's Bridge and the Palk Strait) with handing over of Kachhatheevu Islands to Sri Lanka on 08.07.1976. The second agreement was signed on 23.03.1976 to define the maritime boundaries in the Gulf of Mannar and the Bay of Bengal and the maritime boundary in the Gulf of Mannar was extended in 22.11.1976. Presently, there are 3 different areas in the maritime borders between Sri Lanka and India, which is about 400 km wide (Bay of Bengal in the north, the Palk Bay and the Gulf of Mannar in the center and the Indian Ocean in the south). The distance in Palk Bay region varies between 8.6 nautical miles and 24.3 nautical miles between the coasts of the 2 countries, which means territorial waters of each country in some areas departs into the others if 12 nautical miles criteria of UNCLOS is rigorously applied.

The Act is also applicable to the entire Coastal Zone (Fig. 3) which is a part of the territorial waters. However, the coastal Zone, as per the Coast Conservation Act No. 57 of 1981 and its amendments (Act No. 64 of 1988 and Act No. 49 of 2011) (which is implemented by the Coast Conservation Department now known as the Department of Coast Conservation & Coastal Resource Management) also includes any rivers, streams, lagoons or any other waterbody connected to the sea either permanently or periodically when the landward boundary extends to a limit of 2 km measured perpendicular to the straight baseline drawn between the natural entrance points identified by the mean low water line thereof, and hence, include waters of such rivers, streams, and lagoons, etc. connected to the sea.

4.2.Provisions for pollution control

The most critical Chapter is Chapter VI dealing with waste management which includes oil, garbage and other harmful substances including bilge waters (as listed in Annex 1 of the MARPOL Convention along with oil) and any other pollutants including noxious liquids such as ballast waters (as described in MARPOL Convention Annex II). MEPA has the following powers.

❖ To provide reception facilities within or outside any harbour/port in Sri Lanka, in consultation with the Marine Environmental Council (whose function is to advise MEPA regarding its functions and powers) to enable any ship using such port or traversing Sri Lankan waters or any other maritime zone, its fore-shore and the coastal zone of Sri Lanka to discharge or deposit any residue of oil or other pollutants (MEPA has the power to seek the assistance of any other person for the provision of such facilities or arrange for the provision of such facilities by any other person); MEPA has the power to seek the assistance of any other person for the provision of such facilities or arrange for the provision of such facilities by any other person.

❖ To direct the person in charge of all ports, harbours, terminals, repair yards of ships, dry docks or any other marine related facility used by ships which have any residue of oil to discharge, to provide adequate reception facilities for the purpose of such discharge

❖ To direct the person in charge of all ports, harbours, terminals, repair yards of ships, dry docks or other marine related facilities used by ships which have any residue of oil discharge, to obtain the service of any such facility arranged by MEPA

❖ To direct the person in charge of all ports, harbours, terminals, repair yards of ships, dry docks or any other marine related facilities

❖ To direct the person in charge of all ports, harbours, terminals, repair yards of ships, dry docks or other marine related facilities used by ships to prepare a waste management plan which shall be approved by MEPA, to regularly update such plan with the approval of MEPA and to carry out at prescribed intervals, an EIA by a Classification Society approved by MEPA. Classification Society refers to organizations independent of commercial and state influences that determine and publish (a) the safety and construction standards for ships, marine craft and other off-shore installations; (b) operational procedures of ships, marine craft and other off-shore installations. The level of standards imposed is indicated by the classification number and letter.

Under section 22(1), there is a requirement for every ship (a task that is delegated to the master or the person in charge of the ship) that enters Sri Lankan waters to carry record books (a requirement under MARPOL Annex 1; the Oil Record Book helps crew members to log and keep track of oily wastewater discharges among other things) relating to oils, harmful substances or any other pollutants.

There is also a requirement under section 23(1) that every ship entering Sri Lankan waters to have equipment to prevent any discharge of oil, harmful substances or any other pollutant.

The other most crucial chapter is Part X, which address pollution control due to exploration of natural resources including petroleum. Under Section 40(1), there is a requirement for any person who intends to conduct or engage in exploration of such natural resources or any related activity

❖ To conform to the prescribed national standards and install and maintain prescribed anti-pollution equipment for the purpose of ensuring the control and prevention of pollution

❖ Dispose of all industrial garbage in bulk in accordance with the prescribed conditions in relation to marine dumping

❖ Ensure that the equipment utilized for oil storage installation and oil pipelines conforms to the required standards of MEPA

❖ Obtain the prior written approval of MEPA to utilize chemical dispersant in the prescribed manner

❖ Obtain a license in the prescribed manner for the purposes of using dynamite or similar harmful explosives; this requirement is made explicit in detail in Offshore Exploration for and Exploitation of Natural Resources including Petroleum (Marine Environment Protection) Regulation No. 1 of 2011 (Extraordinary Gazette No. 1709/15 dated June 7th, 2011). Furthermore, there is a requirement to prepare an Oil Spill Contingency Plan and enact it to the satisfaction of the MEPA in accordance to Oil Spill Contingency Plan Regulations No. 01 of 2012 (Extraordinary Gazette No. 1771/19 dated August 15th, 2012)

Under section 51 of Chapter XI, the Minster in charge of the Ministry of Mahaweli Development and Environment has provisions to make regulations to further strengthen the objectives of this Act. Hence with reference to oil and other pollution control, 3 Regulations have been gazetted by the Parliament of Sri Lanka as follows.

❖ Offshore Exploration for and Exploitation of Natural Resources including Petroleum (Marine Environment Protection) Regulation No. 1 of 2011 (Extraordinary Gazette No. 1709/15 dated June 7th, 2011) which is read with Section 40 of Part X of the Act. Under this Regulation, there is a requirement for any Project Proponent / party that engages in exploration of natural resources including petroleum to submit a Discharge Management Plan and an EIA to obtain a Marine Environmental Protection License (MEPL). Additionally, the owner or operators of any offshore

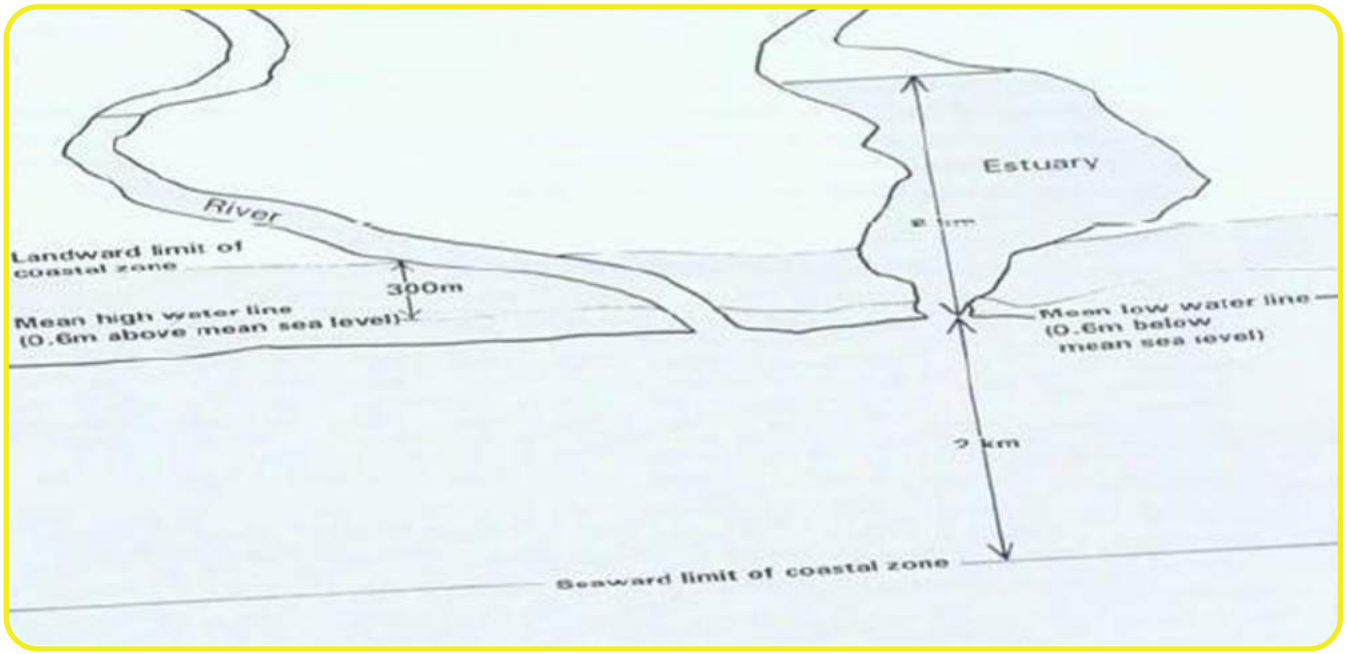


Fig.3. Illustration of the legal boundary of the Coastal Zone of Sri Lanka

installation are mandated to maintain an Oil Record Book and Garbage Record Book.

❖ Bunkering (Marine Environmental Protection) Regulations No. 02 of 2011 (Extraordinary Gazette No. No. 1741/19 dated January 19th, 2012) which is read with Section 7 of Part II and section 21 of Part VI of the Act. The Provisions of these regulations and the International Safety Guide for Oil Tankers and Terminals (ISGOTT) shall apply to all bunker oil supply facilities, afloat and ashore. This Regulation mandates to have a valid bunkering license issued by the MEPA for any person carrying out a bunkering activity in the territorial waters of Sri Lanka or any other Maritime Zone, its foreshore and the coastal zone of Sri Lanka.

❖ Oil Spill Contingency Plan Regulations No. 01 of 2012 (Extraordinary Gazette No. 1771/19 dated August 15th, 2012). This is applicable to every owner, operator, master or their agents or any other person in charge of ports, harbour terminals, repair yards of ships, dry docks, offshore installations, Pipe lines or any other apparatus used for transferring of oil to and from ships in territorial waters of Sri Lanka and any Maritime Zone declared under Maritime Zones Law, No. 22 of 1976. There is a requirement to prepare and possess an Oil Spill Contingency Plan (which is subjected to approval by MEPA) in accordance with the National Oil Spill Contingency Plan (NOSCOP) prepared and revised from time to time by MEPA; NOSCOP outlines the national arrangements for responding to oil spills in the marine environment and the first NOSCOP was prepared in 1995 by MEPA. It also establishes a mechanism to coordinate and integrate all resources to respond effectively under MEPA.

Under section 24 (1) – Part VII, MEPA has the power to direct the owner of any ship, the charterer of any ship or to any other person in possession of the ship to take urgent and immediate measures if there has been a pollution incident or if there is an imminent danger of pollution. The directions issued may include the following (Section 24(2)).

❖ The ship to be moved to a specified place, or to be removed from a specified area or locality

❖ The ship not to be moved to a specified place or area or locality or by way of a specified route

❖ Any oil or other cargo to be either loaded or not to be loaded, unloaded or discharged as the case may be

❖ That specified salvage measures are to be or are not to be so taken

If the directions issued under Section 24(2) is ineffective or inadequate to prevent, mitigate or eliminate pollution or there are potential threats, then MEPA has the power to do any of the following (Section 24(3)) and the MEPA or any MEPA authorized person are not liable for any damages when taken in any Court of Law (Section 24(4)).

❖ Undertake operations for the sinking or destruction of the ship or any part of it;

❖ Undertake operations which may necessarily involve the taking over of control of the ship

❖ Undertake operations which may involve the loading, unloading or discharging of any oil.

Section 36(1) under Part IX mandates the owner or the operator of any ship carrying more than 2000 MT of oil in bulk as cargo (which enters or leaves a port in Sri Lanka or enters or leaves the territorial waters of Sri Lanka or any other maritime zone, its fore-shore and the coastal zone of Sri Lanka or a terminal in such waters) to possess a valid Certificate of Insurance or other financial security (example, a bank guarantee or a certificate issued by an international fund, in respect of such ship). If the ship is registered in a State which is a party to the CLC Convention, a Certificate issued by the appropriate authority of that State is required by MEPA.

The Act also has provisions (section 37(1) under Part XI of the Act) restricting transfer of oil (port to ship, ship to ship and / or ship to port transfers) between 6 pm and 6 am on any day to prevent oil spills. This is applicable for any owner, operator, master or agent of any ship, any occupier of any place or from a vessel in any harbour in Sri Lanka (unless prior notice has been given to the Harbour Master and prior consent of the Fire Department of the port/harbour has been obtained).

4.3.Provisions for penalties due to violations of the Act

There are provisions in the Act to apply penalties for any form of marine pollution that damages

marine resources and marine biodiversity which are covered under Part VIII (Sections 26-33) and Part IX (Sections 34-39) of the Act (taking into consideration of the "Polluter Pays Principle" - Principle 16 of the Rio Declaration on Environment and Development 1992 and the principles of CLC Convention).

According to Section 26, if any oil, harmful substance or other pollutant is discharged or escapes into the territorial waters, any other maritime zone, its fore-shore and the coastal zone, the owner of the ship, owner of the off-shore installation or the owner of the pipeline will be guilty of an offence and subjected to a fine of Sri Lankan Rs 4,000,000-15,000,000 (unless the discharge is in accordance with the terms and conditions of a permit granted by the MEPA as per Section 27). Furthermore, any offender will be liable for the costs of any measures to be taken for preventing, reducing or removing any damage caused or any interests (this includes (a) marine, coastal, port or estuarine activities including fisheries activities; (b) the promotion of tourism and the preservation and development of tourist attractions in the territorial waters of Sri Lanka or any other maritime zone or on the fore-shore including beaches and coral reefs; (c) the health of the coastal population and their wellbeing; and (d) the protection and conservation of living marine resources and wildlife) related thereto; this means any pollution abatement costs and compensation costs are to be borne by the offender considering the "Polluter Pays Principle". A good example has been the Turkish vessel MT GRANBA incident in April 2009, which spilled ~ 6250 MT H_2SO_4 acid at a distance of 50 nautical miles off the Trincomalee coast (East of Sri Lanka). As per Section 50 (Part XI) of the Act, Attorney-General (instructed by the Legal Division of MEPA) appeared for MEPA and the judgment was delivered in May, 2010 ordering the Accused to pay a fine of Sri Lankan Rs 10,000,000 under Section 26 of the Act. Furthermore, a sum of $ 50,000 (Sri Lankan Rs 5,600,000) was received by MEPA from the Accused in Civil Liability (Section 34 of the Act) as an outcome of Court settlement.

Additionally, Sections 25(2), 39(2), 41(1), 41(2), 42(1), 45(2), 45(3), 53 and 55(3) have provisions for penalties / fines.

The "Polluter Pays Principle" is also embodied into permits (MEPLs and bunkering licenses are included) for violations.

5. Conclusions

In Sri Lanka, the Marine Pollution Prevention Act No. 35 of 2008 (implemented by MEPA) sets the legal background to national jurisdiction for the enforcement of UNCLOS and MARPOL at large and the Act mentions that it is for prevention, control and reduction of pollution of the marine environment of Sri Lanka, thereby making it clear that there is a legal mechanism in Sri Lanka to address marine pollution control. This Act considers the Precautionary Principle and it has strong provisions to control pollution caused by ships (except the ships/vessels owned by the Sri Lankan military and underwater vessels), ports/harbors, any facility used by ships (e.g., repair yards) and offshore petroleum exploration projects. Also, there are provisions in this Act (considering the "Polluter Pays Principle") to deal with criminal offenses and civil liabilities. Many provisions of the Act tally largely with those of the UNCLOS and its provisions dealing with pollution caused by ships tally with the MARPOL too.

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What have you learnt from the Vidurava 2021 April - June Q_2 Issue? Scan your own memory!

1] Air Pollution due to Transportation: A Case Study for Sri Lanka

True or False?

1.All motor vehicles in the world consume large amounts of fuel, and emit large amounts of pollutants.

2.Smog formation is not affected by bright sunlight and the topography of the region.

3.The tiny airborne particles emitted by motor vehicles get into the lungs, and are small enough to pass through tissues and enter the blood.

4.Sri Lanka's land transport system is predominantly road transport (93%), which is based mainly on a road network centered in Colombo.

5.According to a research study, to achieve 2035 climate goals, transport emissions should be increased by 95 %.

2] Technological Advances and Electromagnetic Pollution

True or False?

1.Radio and TV broadcasting towers, cellular towers, microwave transmission links, Bluetooth devices, WiFi routers and Electronic devices such as smartphones, tablets, microwave ovens act as electromagnetic pollution sources.

2.The 5G technology has evolved from the previous generation of 3G and 4G technologies.

3.The point-to-point microwave links produce lower electromagnetic pollution, as high frequencies are used and higher powers are transmitted.

4.The frequencies of radio and microwave are much higher than ionizing radiations such as x-ray and gamma rays, and the transmitting of power is also limited by regulation bodies.

5.For all radio and microwave frequencies (0 to 300 GHz), maximum power levels are designed to avoid any adverse health effects.

3] Visual Pollution : Another Eyesore

True or False?

1.Visual pollution is found both in the natural and built environment.

2.The increase in high-rise buildings creates positive effects to the visual and physical characteristics of a city.

3.The basic elements of visual environment could be in the form of lines, colours, shapes, sounds, words, etc., which give birth to different types of compositions.

4.According to "The New World Atlas of Artificial Night Sky Brightness", the inhabitants of Chad, Central African Republic, and Madagascar, are the most affected by light pollution.

5.Curbside "role plays" such as playing a guitar, street dancing and fancy dressing, can be encouraged for collection of money without causing a nuisance to the public.

4] Silent Pollution due to Sodium in Irrigation Agriculture

True or False?

1.In ancient times, available sources of water undoubtedly were suitable for the purpose of its use such as drinking, agriculture etc.

2.Suitability of a source of irrigation water depends upon several factors which include, soil, plant, and climate, and it can be expressed by a special expression.

3.Whether concentrated from withdrawal of water by the crop between a long irrigation interval, diluted with applied water, or leached away in drainage, any outside influences will have little effect on sodium solubility or precipitation.

4.Calcium remains completely soluble in water, and in constant supply, but is constantly changing until an equilibrium is established.

5.In the case of a natural resource such as water, it has been revealed that the per capita availability has increased to alarming levels, thereby affecting future generations.

5] Microplastics Pollution: A Silent Killer that Leads to the Next Global Environmental Disaster

True or False?

1.Plastic particles are in different shapes and sizes, but those that are less than five millimeters in length are called "microplastics".

2.The distinction between primary and secondary microplastics depends on whether the particles were originally manufactured to be that size or whether they have occurred due to the breakdown or fragmentation of larger debris.

3.With high UV irradiation and physical abrasion by waves, microplastics production due to the fragmentation of larger plastic items is the least effective on beaches.

4.Day by day the number of microplastics in the ocean are growing due to the inescapable rise of plastics consumption, as well as inadequacy in re-use, recycling and waste management practices.

5.A recent study suggests that ingested microplastics cannot get translocated from the gut.

6] An overview of Laws in Sri Lanka relating to Marine Environmental Pollution Prevention

True or False?

1.Due to the tension between environmental protection and economic development in Sri Lanka, enforcement of environmental laws presents special challenges and are given serious consideration.

2.The National Environmental Act No. 47 of 1980 (NEA) and its amendments (1988, 1995, 1999 & 2000) constitue the main National Legislation for regulating all activities that affect the environment (marine, aquatic, terrestrial and atmospheric environment) in Sri Lanka.

3.Environmental Impact Assessments (more commonly known EIAs) or Initial Environmental Examinations (IEEs) are required to be carried out regarding minor development projects in order to analyze the relative costs and benefits of a project.

4.Marine Pollution Prevention Act No. 59 of 1981 (certified on September 16th, 1981) was established by the Marine Pollution Prevention Authority.

5.The "Polluter Pays Principle" is not embodied into permits (MEPLs and bunkering licenses are included) for recording of violations.

Answers

01) 1. True, 2. False, 3. True, 4. True, 5. False
02) 1. True, 2. True,, 3. False, 4. False, 5. True
03) 1. True, 2. False, 3. True, 4. False, 5. True
04) 1. True, 2. True, 3. True, 4. False, 5. False
05) 1. True, 2. True, 3. False, 4. True, 5. False
06) 1. True, 2. True, 3. False, 4. True, 5. False

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