SOCIAL FORESTRY

Defination

Social forestry is the management and protection of forest and afforestation of barren and deforested lands with the purpose of helping environmental, social and rural development.

For the first time the word "Social Forestry" was coined by the **Forest Scientist Westoby** who gave some lectures in the Ninth Common wealth Forestry Congress during 1968 in Delhi. He defined that "Social Forestry is a forestry which aims at producing flow of protection and recreation benefits for the community".

The term social forestry was first used in 1976 by The National Commission on Agriculture, Government of India. It was then that India embarked upon the social forestry project with the aim of taking the pressure off currently existing forests by planting trees on all **unused and fallow land**. Social forestry is basically a "**for the people, by the people and of the people**" approach. It is therefore a democratic approach of forest conservation and usage.

The Indian government is trying to increase forest areas that are close to human settlement and have degraded over the years due to human activities. Trees were to be planted in and around agricultural fields. Planting of trees along railway lines, roadsides, rivers and canal banks were carried out. They were planted in village common land, government wasteland, and Panchayat land. The social forestry scheme was initiated in India to increase fuel availability in rural areas and to prevent soil erosion.

History / Evolution of Social Forestry

The story of Jambhoji – The Bishnoi Community

The Bishnois, a Vaishnavite sect, living in western Rajasthan on the fringe of the Thar desert, have for centuries, been conserving the flora and fauna to the extent of sacrificing their lives to protect the environment. For these nature-loving people, protection of the environment, wildlife, and plants is a part and parcel of their sacred traditions. The basic philosophy of this religion is that all living things have a right to survive and share all resources.

In the fifteenth century, Jambhoji, a resident of a village near Jodhpur, had a vision that the cause of the drought that had hit the area and hardship that followed was caused by people's interference with nature. Thereafter, he became a sanyasi or

a holy man and came to be known as Swami Jambeshwar Maharaj. This was the beginning of the Bishnoi sect. He laid down 29 tenets for his followers which included a ban on killing animals, a ban to the felling of trees – especially the khejri – which grows extensively in these areas, and using material other than wood for cremations. Nature protection was given foremost importance in these tenets. Since then, the sect has religiously followed these tenets.

There are many stories about how the Bishnois have beaten up hunters and poachers for intruding in their area. The sacrifice made by Amrita Devi and over 350 others is a heart-rending example of their devotion. The Maharaja of Jodhpur wanted to build a new palace and required wood for it. To procure this his men went to the area around the village of Jalnadi to fell the trees. When Amrita Devi saw this she rushed out to prevent the men and hugged the first tree, but the axe fell on her and she died on the spot. Before dying she uttered the now famous couplet of the Bishnois, 'A chopped head is cheaper than a felled tree'. People from 83 surrounding villages rushed to prevent the men from felling the trees and by the end of the day more than 350 had lost their lives.

When the king heard about this, he was filled with remorse and came to the village to personally apologize to the people. He promised them that they would never again be asked to provide timber to the ruler, no khejri tree would ever be cut, and hunting would be banned near the Bishnoi villages. The village of Jalnadi thus came to be called Khejarli.

The Bishnois will go to any extent to protect the wildlife and the forests around them.Recently this sect was in the news due to the activities of some Mumbai film group that had gone on a hunting spree in their area targeting the black buck. The Bishnois, in keeping to their tradition, prevented them from doing so and lodged a complaint against two of them in the local police station.

The heartland of the Bishnois in the forests near Jodhpur is abundant in trees and wildlife. The landscape around here is greener than elsewhere and the animals mainly antelopes, particularly the blackbuck and the chinkara, in these forests are not afraid of humans and are often seen near the villages eating out of the villagers' hands. The Bishnois have indeed proved that human lives are a small price to pay to protect the wildlife and the forests around them.

Though they are staunch Hindus they often do not cremate their dead but bury them, as they are not permitted to use wood for the cremation.

There is a saying that goes "*Sir santhe rooke rahe to bhi sasto jaan*" this means that if a tree is saved from felling at the cost of one's head, it should be considered as a good deed. It is for this environmental awareness and commitment that the Bishnois stand apart from other sects and communities in India

The **Chipko movement**, or **Chipko Andolan**, was a forest conservation movement in India. It began in 1970s in Uttarakhand, then a part of Uttar Pradesh(at the foothills of Himalayas) and went on to become a rallying point for many future environmental movements all over the world. It created a precedent for starting nonviolent protest in India, and its success meant that the world immediately took notice of this non-violent movement, which was to inspire in time many similar eco-groups by helping to slow down the rapid deforestation, expose vested interests,increase social awareness and the need to save trees , increase ecological awareness, and demonstrate the viability of people power. Above all, it stirred up the existing civil society in India, which began to address the issues of tribal and marginalised people. The Chipko Andolan or the Chipko movement is a movement that practiced methods of Satyagraha where both male and female activists from Uttarakhand played vital roles, including Gaura Devi, Suraksha Devi, Sudesha Devi, Bachni Devi and Chandi Prasad Bhatt, Virushka Devi and others. Today, beyond the eco-socialism hue, it is being seen increasingly as an ecofeminism movement. Although many of its leaders were men, women were not only its backbone, but also its mainstay, because they were the ones most affected by the rampant deforestation,which led to a lack of firewood and fodder as well as water for drinking and irrigation. Over the years they also became primary stakeholders in a majority of the afforestation work that happened under the Chipko movement. In 1987, the Chipko movement was awarded the Right Livelihood Award.

Soon villagers and women, began to organise themselves under several smaller groups, taking up local causes with the authorities, and standing up against commercial logging operations that threatened their livelihoods. In October 1971, the Sangha workers held a demonstration in Gopeshwar to protest against the policies of the Forest Department. More rallies and marches were held in late 1972, but to little effect, until a decision to take direct action was taken. The first such occasion occurred when the Forest Department turned down the Sangh's annual request for ten ash trees for its farm tools workshop, and instead awarded a contract for 300 trees to Simon Company, a sporting goods manufacturer in distant Allahabad, to make tennis racquets. In March 1973, the lumbermen arrived at Gopeshwar, and after a couple of weeks, they were confronted at village Mandal on 24 April 1973,

where about hundred villagers and DGSS workers were beating drums and shouting slogans, thus forcing the contractors and their lumbermen to retreat.

This was the first confrontation of the movement, The contract was eventually cancelled and awarded to the Sangh instead. By now, the issue had grown beyond the mere procurement of an annual quota of the ash trees, and encompassed a growing concern over commercial logging and the government's forest policy, which the villagers saw as unfavorable towards them. The Sangh also decided to resort to tree-hugging, or Chipko, as a means of non-violent protest.

But the struggle was far from over, as the same company was awarded more ash trees, in the Phata forest, 80 km away from Gopeshwar. Here again, due to local opposition, starting on 20 June 1973, the contractors retreated after a stand-off that lasted a few days. Thereafter, the villagers of Phata and Tarsali formed a vigil group and watched over the trees until December, when they had another successful stand-off, when the activists reached the site in time. The lumbermen retreated leaving behind the five ash trees felled.

The final flash point began a few months later, when the government announced an auction scheduled in January 1974, for 2,500 trees near Reni village, overlooking the Alaknanda River. Bhatt set out for the villages in the Reni area, and incited the villagers, who decided to protest against the actions of the government by hugging the trees. Over the next few weeks, rallies and meetings continued in the Reni area.

On 25 March 1974, the day the lumbermen were to cut the trees, the men of Reni village and DGSS workers were in Chamoli, diverted by state government and contractors to a fictional compensation payment site, while back home labourers arrived by the truckload to start logging operations. A local girl, on seeing them, rushed to inform Gaura Devi, the head of the village *Mahila Mangal Dal*, at Reni village (Laata was her ancestral home and Reni adopted home). Gaura Devi led 27 of the village women to the site and confronted the loggers. When all talking failed, and the loggers started to shout and abuse the women, threatening them with guns, the women resorted to hugging the trees to stop them from being felled. This went on into late hours. The women kept an all-night vigil guarding their trees from the cutters until a few of them relented and left the village. The next day, when the men and leaders returned, the news of the movement spread to the neighbouring Laata and others villages including Henwalghati, and more people joined in. Eventually, after a four-day stand-off, the contractors left.

Women's participation in the Chipko agitation was a very novel aspect of the movement. The forest contractors of the region usually doubled up as suppliers of alcohol to men. Women held sustained agitations against the habit of alcoholism and broadened the agenda of the movement to cover other social issues. The movement achieved a victory when the government issued a ban on felling of trees in the Himalayan regions for fifteen years in 1980 by then Prime Minister Indira Gandhi, until the green cover was fully restored. One of the prominent Chipko leaders, Gandhian Sunderlal Bahuguna, took a 5,000 kilometre trans-Himalaya foot march in 1981–83, spreading the Chipko message to a far greater area. Gradually, women set up cooperatives to guard local forests, and also organized fodder production at rates conducive to local environment. Next, they joined in land rotation schemes for fodder collection, helped replant degraded land, and established and ran nurseries stocked with species they selected.

Jadav "**Molai**" **Payeng** (born 1963) is an environmental activist and forestry worker from Jorhat, popularly known as the *Forest Man of India*. Over the course of several decades, he has planted and tended trees on a sandbar of the river Brahmaputra turning it into a forest reserve. The forest, called Molai forest after him,[4] is located near Kokilamukh of Jorhat, Assam, India and encompasses an area of about 1,360 acres / 550 hectares.. He was born in the indigenous Mising tribe of Assam. The forest, which came to be known as Molai forest, now houses Bengal tigers, Indian rhinoceros, and over 100 deer and rabbits. Molai forest is also home to monkeys and several varieties of birds, including a large number of vultures. There are several thousand trees, including valcol, arjun (*Terminalia arjuna*), ejar (*Lagerstroemia speciosa*), goldmohur (*Delonix regia*), koroi (*Albizia procera*), moj (*Archidendron bigeminum*) and himolu (*Bombax ceiba*). Bamboo covers an area of over 300 hectares. In 2015, he was honoured with Padma Shri, the fourth highest civilian award in India

Saalumarada Thimmakka, also known as **Aalada Marada Timakka**, is an Indian environmentalist from the state of Karnataka, noted for her work in planting and tending to 385 banyan trees along a four-kilometre stretch of highway between Hulikal and Kudur. She has also planted nearly 8000 other trees. With the support of her husband, she found solace in planting trees.

She received no formal education and worked as a casual laborer in a nearby quarry. Her work has been honoured with the National Citizen's Award of India. Her

work was recognized by the Government of India and she was conferred with Padma Shri in 2019.

A U.S. environmental organisation based in Los Angeles and Oakland, California called *Thimmakka's Resources for Environmental Education* is named after her.

Thimmakka was born in Gubbi Taluk, Tumukuru District in Karnataka. She was married to Chikkaiah, a native of Hulikal village in the Magadi taluk of Ramanagar district in Karnataka.

Daripalli Ramaiah known as **Chetla (trees) Ramaiah** also **Vanajeevi (forest being) Ramaiah** (born 1937) is an Indian social worker known for his social forestry initiatives. He is the recipient of the Padma Shri award for the year 2017, for his invaluable contribution to extending tree cover. He is locally known as 'Chetla Ramaiah', trees Ramaiah. On a mission to bring back the green cover, he is estimated to have planted more than 100 million saplings in and around Khammam district with a thrust on trees that provide shade, fruit-bearing plants, and Biodiesel plants with assured benefit to future generations. As a relentless campaigner of social forestry for more than 5 decades, Ramaiah himself cannot recall when it all exactly started. He remembers vaguely that as a child he often saw his mother saving the seeds of vegetable plants for the next Growing season. Ever since he was a child, he has been collecting seeds of native trees such as Sandalwood, Albizia saman, Ficus religiosa, Aegle marmelos, Neolamarckia cadamba and many more in his mission to cover every barren land with trees Ramaiah believes in seed as the solution to human well being. "Of all the species that consider the Earth as their home, the most exalted is the human being. He supposedly has intellect, can think, can do and can get things done. Nature has bestowed her choicest blessings on this form of life. Therefore, we have a duty towards nature. Protect the nature; protect everything created by God, for the posterity", says Daripalli Ramaiah.

URBAN FORESTRY

Urban forestry has been described as the management of public and privately owned in and adjacent to urban centres. One distinguishing feature between urban and rural forestry is that urban forests and trees have more aesthetic value than rural trees.

Urban forests include a number of forest envirous such as green belts, parks, reserved lands, industrial and c ommerical green jones etc. The management of these environments is coordinated with the management of the cities. Urban forests serve two main purposes:

(1) Maintenance of narural process (water, and nutrient cycle; and support of flora and fauna).
(2) Provision of economic and social benefits.

AIMS OF URBAN FORESTRY

Wegner (1984) has classified the following aims of urban social forestry:

Economic concerns	**Opportunities**
Declining retail trade	Downtown area revitalization
Stagnating property values	Reforestation; Landscaping Wood
Rising fuel costs	utilization, firewood site planning,
Rising energy costs	landscaping for energy conservation
	Meaningful job opportunities
Employment	Landscape development of community
Declining tourism	entry ways and other significant areas.
Socio Cultural concern	**Opporunities**
Isolation of urbanities from natural environments	Education, awareness and project participation
Neighbourhood decline	Neighbourhood revitalization open space management
Limitied recreational opportunities	
Loss of important cultural and historical resources	Protection of community and intergrity of vegetation resources
Environmental & Resource Concern	**Opportunities**
Loss of prime land to urban development	Resource protection, conservation and
Air pollution	open space zoning
	Improved air quality, wind channeling

Desclining urban wildlife	Wildlife habitat management
Loss or decline of vegetative resource	Reforestation, integrated pest management.
Declining water quantity/ quality	Watershed management
Urban blight	Visual resource enhancement
Increasing fire hazard	Fire prevention / fuel management
Noise Pollution	Vegetative noise abatment
Soil erosion	Soil stabilization conservation.

Choice of Species

There are four consideration which are to be taken into account before species for urban planting are selected. These are:

1) List of trees hardy in the environment in which they must grow.
2) Diversification of species by restricting a species to not more than 15% of the total.
3) Selection and location of trees species based on the spce available. A well located tree will create the least interference with the objects and functioning of the society while providing maximum environmental enchancement.
4) Promoting spatial variety by using a blend of colour texture, for and size. Too diversity leads to the onset of monotony whereas too much leads to disorder.

The following table shows the relative susceptibility of north American trees to urban pollutants and stresses (Bases on report of the society of Americal Foresters, 1984).

Genus & Species	**Ozone**	**SO2**	**Salt**	**Flooding**	**Lighting**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
ABIES Abies amanbilis		L			
A Balsamila	L	M	M	H	
A Concolor	L	L			
ACER Acer galbrum		M			
A Negundo		H			
A Psevdoplantanus			M		
A rubrum	L	M	H		M
AESCULUS Aeculus Hippocatanum			L		
AILANTHUS Ailanthus altissima	H		L		
ALNUS Alnus incana			H		
A Rugosa			H		
A Taxifolia		M			
BETULA Betula spp		M			

Genus & Species	Ozone	SO2	Salt	Flooding	Lighting
(1)	(2)	(3)	(4)	(5)	(6)
B Lanta		H	L		
B Papyrifera		H	LM		H
B Pendula	L	H	M		H
CARPINUS Carpinus betulus			H		
C. Caroliniana			H		
C Japonica					L
CARYA Carya spp			H		
C Ovata		M	H		
CELTIS Celtis occidentalis		L	M		
CORNUS Cornus alba					H
C Florida	L				H
C Sanquinea					M
C Stolonifera					H
FRAXINUS Fraxinus Americana	H	L	M		
F. Pennsyl vanica	H	H	M	M	
JUGLANS Juglans nigra	L	H	M		
J Regia	H	H			
JUNIPIRERUS J Occidentalis	L	L			
J Osteosperma		L			
J Scopulorum		L	M		
J Virginiana		L	M		
LARIX Larix deciduas	H				
L Leplotepsis	M				
L. occidentalis		H			
MALUS Malus bacceta			M		
M Sargentii					L
MORUS Morus alba			L		
PICEA Picea abies	L		M		
P. asperata			M		
P. engelmannii		M			
PINUS Pinus banksiana	H	H	H		L
P. Contorata	M	M			
P. edulis		L			
P Monticola		M	L		
P Nigra	H	M	M		
P Sylvestris	M		L	L	
POPULUS Populus alba			M		
P angustifolia		M	L		
P candensis		L			

Genus & Species	Ozone	SO2	Salt	Flooding	Lighting
(1)	(2)	(3)	(4)	(5)	(6)
P deltoids		L	L	M	L
P Nigra	H	H	M		
P trichocarpa		M			
QUERCUS Quercus Alba	H	M	L		
Q. bicolor		M			
Q. imbricaria	L		M		
Q. Robour	L		L	L	L
Q Rubra	L	L	L		

SCOPE OF URBAN FORESTRY

Urban forestry has a very wide scope. These include the creation of avenues, shelter belts, aprks, camping sities, wildlife parks etc.

1) **Avenue:** Plantation are usually raised along roads in urban area. This helps in establishment of a green belt and also adds to the aesthetic value. Trees are alsi raised along traffic round abouts and traffic islands, Most of the trees species raised in such avenues have an ornamental and aesthetic value.
2) **Industrial shelter belts:** Plantations are raised around induatries so as to act as buffer belt between the insudarial complex and other urban areas. A number of industrial shelter belts have been raised in Gandhinagar and Ahmedabad towns of Gujarat. The most prominent one has been raised between the Gandhinagar thermal power station and other residential areas. Species hardy to the effect of pollutant should be raised such shelter belts.
3) **Urban parks:** Recreational parks are often set up in urban areas with a view to:-
    (i) Provide a source of recreation to the city dwellers
    (ii) Given an idea about plant life to the people.
    (iii) Serve as a green zone and help to keep the city air clean and free from pollution.
4) **Wildlife parks:** (Negi 1983) writes "The modern world is faced with the twin problem over population and poverty. The population of the world is increasing very rapidily and the exisiting resources of the earth are gradually getting depleted. The land and resource are limited but mouths to feed are innumerable and yet increasing. Under these circumstances of stress and strains, we are striving for a place for the wildlife. Thus, if we realize the conditions and dimensions of the various sectors of our geography social, economic life, the concept of management of wild life should strictly be guided by the doctrine of efficient and intensive land use. We can start propogating the concept of preservation and protection of wildlife through various ways so

as to ensure a viable public opinion on the one hand and on the other simultaneously should take steps for harnessing the economic benefits of this renewable natural resource for the benefits of the common man….

Developed countries have already taken steps in this direction and wildlife is viewed as a land use and most of the wildlife in these countries is seen in the individual farms, trade centers and national parks, zoos and sanctuaries.

With this end in view a large number of urban wildlife parks have been set up. The main aims are:

a) To give the city dweller of our rich heritage of wildlife.
b) To provide a source of recreation for the city dwellers.
c) To help in conservation of wildlife.
d) To serve to spread the message of conservation of nature and natural resources.

The Nandan Kalan park, set up near Bhuneshwar (capital of Orissa) is one of the best examples of such parks in India. Covering a sprawling campus, this park houses a wide variety of birds and animals under as near natural conditions as possible. A large artificial take serve as the home for aquatic fauna and avifauna.

Nepal has also taken rapid strides in urban forestry. A wildlife park has been set up at Gokasna, about 9 Kms to the northwest of the National capital Kathmandu. This park is famous for a wide variety of birds and animals such as the peacock, jungle fowl, partridge, spotted dear, monkeys, langur, panher, antelopes etc. This park is visited by thousands of visitors from Kathmandu city.

Many such areas have been created all over the world.

5) **Urban camp sites:** Special areas have been set aside for serving as urban camp sites in almost all modern well planned cities. Such areas are planted with the tree species of ornamental and aesthetic value. Lawns, specially planted with good grass are raised in these areas. Camp sites serve the following purposes:

(i) To provide a camping ground for tourists.
(ii) To serve as a recreational site for city dwellers
(iii) To act as green belt.

New Delhi has taken the lead in developing such farm of urban camp sites.

6) **Wilderness trails:** The idea of wilderness trails was developed for the first time in the USA. Wilderness trails are forest areas which are set aside exclusively for conservation and recreation purposes. Such areas are usually selected in the vicinity if urban centers, so that the city people may visit them and derive maximum benefits. Wilderness trails serve the following main purposes:

    1) To serve as a recreational spot for city dwellers.
    2) To help in conserving nature and natural resources.

    Urban forestry, has a major role to play in modern cities. As a matter of fact, this has become an integral part of all town planning processes. During town planning, adequate provision is made for urban forestry schemes and suitable areas set aside for raising avenues recreational parks, shelterbelts, camping sites etc. Urban forestry schemes act as:

    1) Green belts in a city full of pollution, garbage and dirt.
    2) Recreational areas for the tension filled lives of the urban dwellers.
    3) Help man in having a better understanding a nature and its resources.

Urban Forest Block Development Strategy in Telangana State

VISION

Urban Forestry for a greener, healthier and happier telangana state.

MISSION

Creating sustainable, healthy and bio-diverse urban forests that improve the ecosystem of the City and provide unwinding spaces to the City dwellers

OBJECTIVE

- To protect forest blocks from biotic interference, weeds, and forest fires
- To develop resilient forests by improving the forest density and enhancing biodiversity
- To secure and replenish all the water bodies
- To engage and involve communities in sustenance of the forest blocks
- To improve the ecosystem and livability index of the Hyderabad City by providing outdoor avenues for interactions, recreation and destressing
- To create ecosystem consciousness among the citizens and encourage them towards conservation and sustainability
- Contribute to the State and National sustainable development goals

SOCIAL BENEFIT

- ❑ Revitalized neighbourhood
- ❑ Social equity and environmental justice through inclusion
- ❑ Health and well-being
- ❑ Space for solace and spiritual sustenance

ENVIRONMENTAL BENEFIT

- ❑ Carbon sequestration
- ❑ Reduce heat island effect
- ❑ Promoting biodiversity and improving the forest resilience
- ❑ Manage storm water, reduce flooding and improved water quality
- ❑ Filtering pollutants resulting in a better air quality

ECONOMIC BENEFIT

- ❑ Liveability index of the City improved
- ❑ Increased revenue through ticketing for entry
- ❑ Real estate adjoining the parks are commanding higher property prices
- ❑ Reduced spend on air conditioning and water tankers

Forest Block Categorization

Criteria	Conservation Block	Ecotourism Site	Urban Forest Park
Population density	Low	Low	High
Adj to Public drawing places	Far	Far	Near
Natural Attraction (Cultural / History/ Rocks / Water bodies)	No	Yes	
Road Access	No	Yes	Yes
Distribution		Proximity to other tourist sites	Covers maximum citizens

S. No.	Category	No. of Locations	Area in Ha.	Amount Rs. In Crores
1	Urban Parks	52	21834	300.42
2	Eco-tourism spots	7	2264	32.96
3	Conservation blocks	70	39955	160.3
	TOTAL	**129**	**64053**	**493.68**

GOVERNMENT

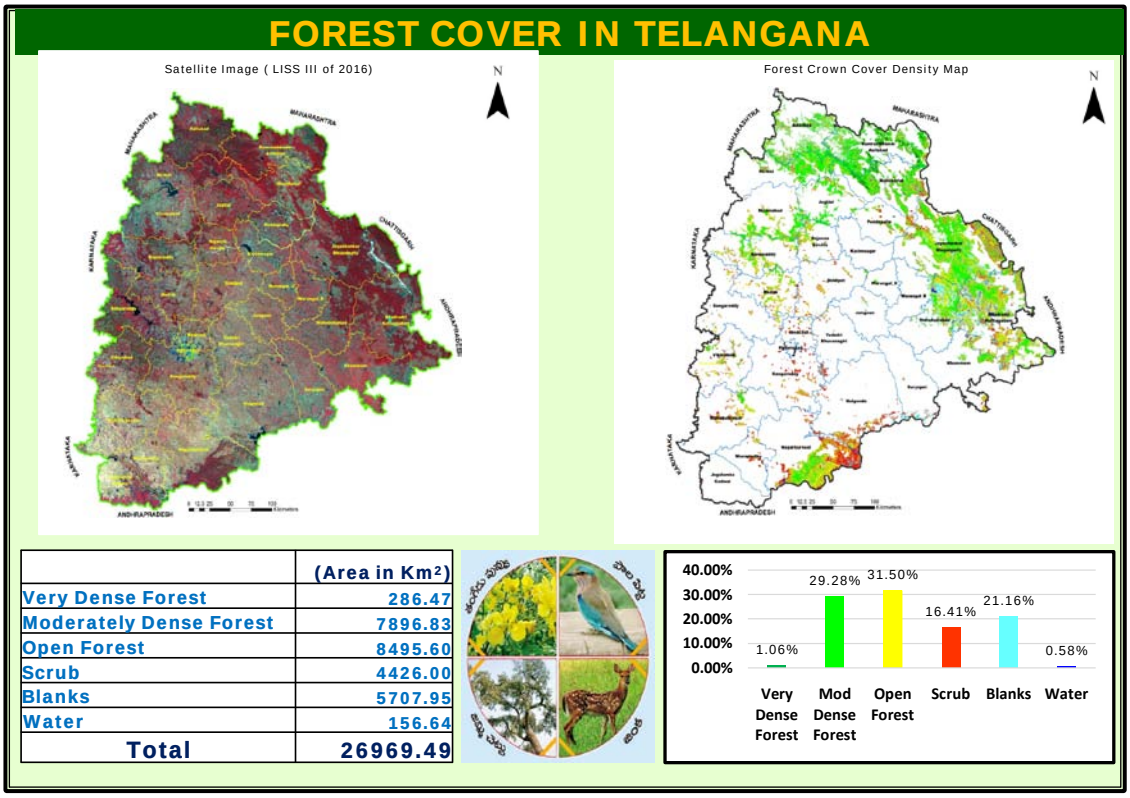
- National Funds for Green Mission
- Nagar Vana Udyan Yojana (Rs. 2 crore / Forest Block)
- Telangana State Government
- Hyderabad Metropolitan Development Authority (HMDA)
- Greater Hyderabad Municipal Corporation (GHMC)
- International Tree Funds

NON-GOVERNMENT

- Corporate CSR Initiatives
- Non-Governmental Organizations working on Climate Change
- Research Bodies
- Universities
- Traditional Medicines Researchers

PUBLIC

- Neighbourhoods
- Walkers Associations / Fitness Enthusiasts
- Bird Watching Clubs / Nature Clubs
- Travellers
- Schools / Educational Institutions



S. No.	Circle	District	Name of the Park	RF Block	Remarks	Opened for Public (Yes/No)
1	2	3	4	5	6	7
1	Hyderabad	**Hyderabad**	KBR	Jublile e Hills	Develop ed	**Yes**
2	**Medchal**	BhagyanagarNandan Vanam	Chengicherla, Medpally -I, Narepally -I & II Cluster	Developed. Fencing work in Chengicheralaand Narepally-I & II going on.		**Yes**
3	Shanti Vanam	Medpally-II		Developed		**Yes**
4	Prashanti Vanam	Dulapally		Developed		**Yes**
5	Oxygen Park	Kandlakoi		Developed		**Yes**
6		Nagaram		Developed		**Yes**
7	**Yadadri**	Tangeduvanam	Lakkaram II (UnNotified)	Developed		**Yes**
8		Somajipalli	Fencing work in progress			**No**

S. No.	Circle	District	Name of the Park	RF Block	Remarks	Opened for Public (Yes/No)
1	2	3	4	5	6	7
		(UnNotified)				
9		Raigiri-II (UnNotified)		Developed		**Yes**
10		Raigiri -I (UnNotified)		Developed		**Yes**

Activities taken up in Urban Forestry Blocks

1) Creating walking paths
2) Construction of children parks and playgrounds
3) Creating butterfly parks and birds aviaries
4) Rides and games for visitors
5) Providing Picnic areas
6) Recreation and awareness zones

PM Nagarvan Udyanvan Yojana

A Nagar Van-Udyan is a forested area in the vicinity of a city accessible to the city dwellers suitably managed for providing wholesome natural environment for recreation, conservation education, biodiversity conservation and supported services like water and soil conservation, pollution abatement, reduction of heat islands effect of the city with the essential elements for regular use. Nagar Van-Udyan Yojana is a Pilot scheme for implementation for a period of five Years (beginning 2015-16) by the the Ministry of Environment, Forests & Climate Change.

Vision

To create/ develop at least one CITY FOREST in each City having Municipal Corporation/ Class I Cities for providing wholesome healthy living environment, and contributing to growth of Smart, Clean, Green, Sustainable and Healthy Cities.

Objectives

- To create 200 City Forests in the Country. A City Forest will be developed in each City with Municipal Council.
- To create awareness on plants and biodiversity.
- Conservation education on important flora and fauna of the region including threat perception.
- Ecological rejuvenation of the cities-Forests the green lungs will contribute to Environmental improvement of cities by pollution mitigation, cleaner air, noise reduction, water harvesting and reduction of heat islands effect.

- In-situ Biodiversity conservation.
- Health benefits to citizens.
- Making cities climate resilient.

Components of City forests

- Fencing as appropriate.
- Wooded blocks with emphasis on locally appropriate species.
- Plants to include shrubs, climbers, medicinal plants, seasonal flowering plants etc. to represent floral biodiversity.
- Irrigation/ rain water harvesting facility.
- Open Air Conservation education displays, signages, brochures etc.
- Public convenience, drinking water facilities, benches etc.
- Walkways/ footpath, Jogging and cycle track.

Strategy

The Ministry supports one time development and non-recurring expenditure to the concerned agency of the concerned cities for creation of a City Forest. Cities' authorities will be encouraged to have a City Forest comprising area upto 100 ha. in forest areas within their jurisdiction for deriving maximum ecological and environmental benefits. The minimum area should not be less than 20 ha.

Budgetary provision

- The assistance is shared with concerned State in the ratio of 80:20.
- The Ministry provides one time grant to the concerned State government/ City Local Authority/ land owning agency based on the work requirement subject to the maximum Grant of Rs. 2.00 crores per City Forest.

The grant is made in two installments, first of 50% of the sanctioned amount after the approval of the project and remaining in second installment after 3/4th utilization of the first installment. The Concerned State Government/ Project Proponent is mandated to confirm availability of their share of 20% of the cost before submitting their proposal.

Greenbelt Development: Purpose, Advantage and Design

Greenbelt Development: Purpose, Advantage and Design!

Purpose of Greenbelt Development:

The purpose of a green belt around the industrial site is to capture the fugitive emissions, attenuate the noise generated and improve the aesthetics.

For example, if the industry has been proposed in an area of about 1.2265 hectares that is 12265 sq. m. Out of 12265 sq. m of total land available about 4019.5 sq. m

for built up area like production blocks, raw material stores, finished goods godowns, utilities, R&D, QC, administrative block and pollution control facilities. About 1550 Sq. m for Roads, 2395.5 Sq. m for Vacant area and 4300 sq. m greenbelt area.

The proposed green belt at the .project site will form an effective barrier between the plant and the surroundings. Open spaces, where tree plantation may not be possible, will be covered with shrubs and grass to prevent erosion of topsoil. Adequate attention has been paid to plantation of trees, their maintenance and protection based on the geology, soil condition and topography of the site area.

Green belt will be developed around the plant site, whatever space is available around the periphery of the plant will be planned to be utilized for green belt. Other open spaces within the factory will be converted to green areas in the form of lawns or flowering plants.

A wide range of plant species wilt be planted in and around the premises to help capture the fugitive emissions and noise levels from the plant premises. This wide range covers plants of fast growing type with thick canopy cover, perennial green nature, native origin and a large leaf area index. A specialist in horticulture may be appointed to identify any other native species and also supervise greenbelt development.

Advantage of Green Belt Development:

1. The biological activity of the particles at various locations necessarily vary because of difference of pollutant source profiles. These variations are expressions of both quantitative and qualitative differences, as for instance the relative amount of sulfuric acid mist, sulfates, or other reactive substances in the particulate mix or the relative amounts of specific carcinogenic compounds in the organic fraction of airborne particulate.

2. It, therefore, can be seen that the evaluation of biological activity ascribable to “particulate” is complex and depends not only on the total quantity, size range and intrinsic physical or chemical properties, but also on their chance for interaction in the polluted air. The opportunity for variation in biological activity is enormous.

3. Stomata are microscopic pores on the underside (abaxial) of the leaf. These stomata allow the plant leaves takes in Carbon Dioxide (C02) and lets out Oxygen (02), and also allows water vapor out in the process of transpiration. As air passes

through the stomata, most of the airborne particles will not pass through the stomata but will rather land on the' leafs outer surface.

This is similar to a filter, where air is pulled through the filter by an air pump and the airborne particles deposit on the filter surface. If this air flow is the major cause of particles depositing on the leaf, the result will be that the concentration of particles on the abaxial surface of the leaf will be higher than that of the top surface (adaxial) because the airflow through the stomata will be pulling more particles onto the bottom surface.

4. There is a certain amount of force needed for particles to stick to a surface. This amount is greater depending on the size of the particles. Because the airflow through the stomata is not very powerful, only the smaller particles will stick to the bottom surface. The particles on the top surface of the leaves will mainly be from the settling of dust. Because settled particles are mostly larger ones, those found on the top surface will be mostly larger. Therefore, analysis of the particle sizes on the leaves will show that particles on the tops of leaves are on average, larger than those on the bottom of leaves.

5. Different types of leaves tend to have differences in several aspects of their surfaces. Some types of leaves have greater surface rigidity or roughness than other leaves, which may affect their stickiness or particle solubility. Stickier leaves would be better for collecting particles because more particles would stick to their surface. Therefore, some types of leaves may be better for use in this type of analysis than others.

6. It has been derived that trees can delimit the fine particulate pollution and have tremendous potential for improved air quality with substantial cost savings. This study will help to quantify the relative ability of individual tree species for removing fine particulates such as PM25. The plantation of urban trees can be evaluated in terms of money saved vis-a-vis expenditure involved in implantation of fine particulate strategies.

7. Trees can act as efficient biological filters, removing significant amounts of particulate pollution from urban atmospheres. The study indicated that there has been significant difference in interception of particulate matter (PM2.5) by different tree species.

8. It is recommended based on the studies that Green cover /areas of Highly Dust capturing plant species should be developed around residential areas / industrial area, since dust capturing plants species can act as efficient biological filters, removing significant amounts of particulate pollution from urban atmospheres. The dust capturing phenomenon of plant species is a cost effective technology for reduction of particulate load in urban agglomerations.

The geographical, environmental, morphological, anatomical & physiological aspects of plants species have been found influencing the dust capture by plant species, therefore following criteria should be adopted for selection of plant species for green belt development in urban areas:

a. The species should be adapt to site and should be able to produce optimum harvest on a sustained basis for example tree like Ficus religiosa (Peepal), Ficus bengalensis (Banyan), Ficus elastica (Indian Rubber) and Artocarpus integrifolia (Jack Fruit).

b. The leaf litter should decompose quickly thus adding organic matter to the soil tree like Acacia farmesiana (Vilayati kikar), Delonix regiosa (Gulmohar), Accacia nelotica (Babul), Azadirachta indica (Neem) Melia azadirachta (Melia) are suitable for the purpose.

c. The species should preferably be capable of enriching soil, through nitrogen fixation or any other mechanism tree like members of Leguminaceare family such as Luceana leucophloea (Shoe babool), Acacia farmesiana (Vilayati kikar) are better nitrogen fixing capabilities.

d. The morphological characters of the species must suit the objectives of plantation and the cultivation practice; e.g. a wide crown may be preferred for dust capturing and fuel wood plantation but small-narrow crown with minimum effect on agriculture crop and providing valuable wood.

e. Multi-purpose tree plant species have a special significance in fulfilling the objectives of environment as well as needs of the people. The combination of species to address the local needs are more beneficial. The trees like Quaking Aspen (Populus tremuloides); Blue Gum (Eucalyptus globules: Acacia farmesiana (Vilayati kicker), Delonix regiosa (Gulmohar), Accacia nelotica (Babul), Azadirachta indica (Neem) melia Azadirachta (Melia) are more valuable.

f. The tree products should have acceptable characteristics to suit local customs and traditions flowering Herbs & shrubs species like Grape Jasmine (Gardenia jasminoides) Crown Daisy (Chrysanthamum species) Lily (Lillium species); Sunflower (Helianthus annuus) etc;

Environment

Defination

The environment is defined as the whole physical and biological system surrounding man and other organisms along with various factors influencing them. The factors are soil, air, water, light, temperature etc. These are called Abiotic factors. Besides the abiotic factors, the environment is very much influenced by biotic factors which include all forms of life like plants, animals, microorganisms etc.

Man is thus an inseparable part of the environment. Man and Environment have very close relationship with each other. The social life of man is affected by environment. This is the reason for various types of social and cultural activities around the world. The hilly people have different life styles than people in the plain area. Similarly people around the world differ in their food, cloth, festivals etc. All these are influenced by the factors around him.

Environment and Its Components

The environment has three important constituents. These are:

a) Physical
b) Biological
c) Social

(a) The Physical Constituent of environment includes soil, water, air, climate, temperature, light etc. These are also called abiotic constituents of the environment. This part of the environment mainly determines the type of the habitat or living conditions of the human population. This physical constituent of the environment is again divided into three parts.

These are:

(i) Atmosphere (gas)

(ii) Hydrosphere (liquid)

(iii) Lithosphere (solid)

These three parts represent the three important states of matter constituting the environment. This physical component of environment only consists of non-living things like air, water and soil. All these nonliving things influence much to all living organisms including man. Water and temperature are the most important abiotic

components affecting living beings. Larger proportion of body's weight is due to water.

All living organisms require water for their survival. Besides water is the main vital fluid to keep optimum temperature of the body. All life activates work in a particular range of temperature. When temperature will be in excess of necessity, living beings will die.

Air is main physical component which provides oxygen for respiration. All living beings including plants & animals require oxygen for their existence. Oxygen is taken into the body by respiration process and comes out in from of carbon dioxide. Plants, on the other hand takes in carbon dioxide for food preparation during photosynthesis and gives out oxygen to the surrounding.

Soil is the most important for all living beings to create their habitat. It is the soil in which plant grows and man constructs houses to live in. It is the ground water present in the soil which provides for drinking and other farming activities.

(b) The biological constituent of environment is also called biotic component of environment. This component consists of all living things like plants, animals and small micro-organisms like bacteria. This component interacts with the abiotic component of the environment. This interaction of two components forms various ecosystems like pond ecosystem, marine ecosystem, desert ecosystem etc.

The self sufficient large ecosystem of the earth is called Biosphere. All ecosystems consist of three different types of living organisms.

These three types are named as:

(a) Producers

(b) Consumers

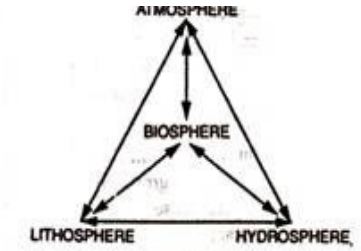
(c) Decomposers.

Producers are generally green plants and other photosynthetic bacteria which produces various organic substances such as carbohydrates, proteins etc. with the help of water, soil and light energy. Consumers depend for their nutrition on the organic food produced by the green plants Decomposers bring about the decomposition of dead plants and animals and return various important minerals for the running of the biogeochemical cycles.

(c) The social constituent of environment mainly consists of various groups of population of different living organisms like birds, animals etc. Man is the most

intelligent living organism. Like other living creatures, man builds house, prepares food and releases waste materials to the environment. Man is a social animal as told by Greek philosopher, Aristotle. He makes various laws, policies for the proper functioning of the society.

The three components of the environment give rise to four important zones. These are Atmosphere, Hydrosphere, Lithosphere and Biosphere. There is continuous interaction among these four zones. These interactions involve the transport of various elements, compounds and energy forms. These zones are explained as follows. [Fig. 1 (A).l]



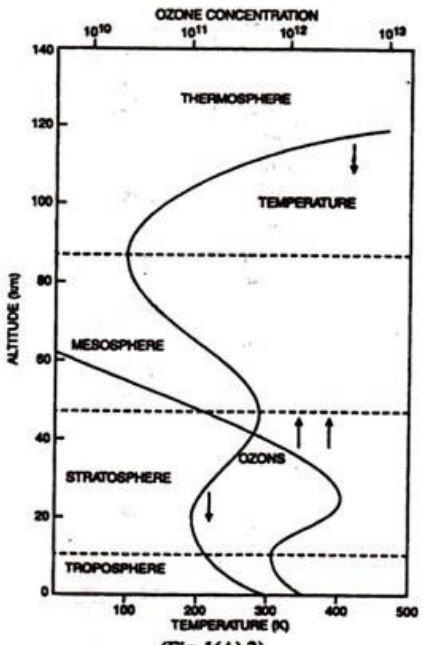
(Fig. 1(A).1)
Interaction of environmental components

Atmosphere:

The earth's atmosphere, a complex fluid system of gases and suspended particles, did not have its origin in the beginning of the planet. The atmosphere as of today has been derived from the Earth itself by chemical and biochemical reactions. Although the fluid system forms a gaseous envelope around the Earth, its boundaries are not easily defined. They can be arbitrarily defined as the Earth's atmosphere interface and space interface.

The gases like Nitrogen. Oxygen, Argon, Carbon dioxide and water vapour etc. together make up the total volume of atmosphere. Together with suspended particulates, viz. dust and soot constitute the gaseous turbidity particularly in troposphere. However, the composition of atmosphere and so also the structure is variable in time and space.

The vertical structure of atmosphere is very much related to radiant energy absorption and this can be described in terms of variable of temperature [Fig. 1(A) 2]. Below 60 km. there are two main zones of absorption at the Earth's surface and in the Ozone layer. The absorbed energy is redistributed by radiation, conduction and convection.



(Fig. 1(A).2)
(Temperature profile of atmospheric layers)

There are, therefore, two temperature maxima: at the Earth's surface and at an elevation of 50 km. above each of these maxima there is mainly convectional

mixing. Temperature in these mixing layers decreases with height above the heat source. The lower of these two zones is referred to as troposphere and the upper is the mesosphere.

These are separated by a layer of little mixing in which the atmosphere tends towards a layered structure referred as the stratosphere. Between the ionosphere and the stratosphere is the tropopause which marks the approximate upper limit of mixing in the lower atmosphere. The average height of this is usually given as 11 km., but this varies over the earth.

In tropical latitude its average height is 16 km. and in polar latitude it is only 10 km. There is one further zone of heating, above the mesosphere and more than 90 km. from the Earth's surface where shortwave ultraviolet radiation is absorbed by many oxygen molecules present at this height. This is referred to as thermosphere. Within this layer, ionization occurs which produces charged ions and free electrons. Beyond the thermosphere, at a height of approximately 700 km, lies the exosphere where the atmosphere has an extremely low density. At this level there are increasing numbers of ionization particles which are concentrated into bands referred to as the Van Allen radiation belts.

However, this simple model of vertical structure can be simplified to provide a model of the atmosphere as two concentric shells the boundaries of which are defined by the stratopause at approximately 50 km. above the Earth's surface and a hypothetical outer limit of the atmosphere, at approximately 80,000 km.

Below the stratopause, in the stratosphere and troposphere, there is 99% of the total mass of the atmosphere and it is at this level that atmospheric circulatory systems operate. Beyond the stratopause a layer of nearly 80,000 km. thick contains only 1 % of total atmospheric mass and experiences ionization by high-energy, short wavelength solar radiation. The temperature profiles of atmospheric layer are given in

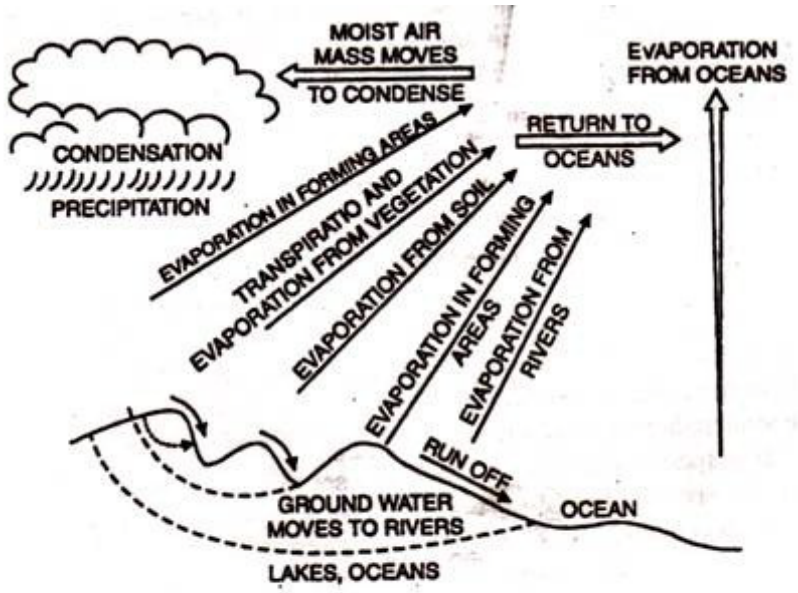
Hydrosphere:

It includes the surface water and its surrounding interface. It is vital for life molecule to survive. Water possesses a number of physical and chemical properties that help the molecule to act as best suited medium for life activities. The movement of water from earth surface to atmosphere through hydrological cycle appears to be a close system.

Water is the most abundant substance on the Earth's surface. The oceans cover approximately 71% water of the planet, glaciers and ice caps cover additional areas. Water is also found in lakes and streams, in soils and underground reservoirs, in the atmosphere, and in the bodies of all living organism. Thus, water in all its forms- ice, liquid, water and water vapour- is very familiar to us.

there is need to make precious use of pure fresh water and their fruitful storage and conservation We use water at home, in industry, in agriculture, and for recreation. These applications differ widely in the quantity and quality of the water that they require. In one way or another we use all available sources- inland waters, ground water, and even oceanic water.

The demand for global water resources increasing day-by-day though availability pure fresh water has been decreasing severely. Thus. A simplified outline of hydrological cycle is given in Fig. 1(A).3.



(Fig. 1(A).3)
(A simplified outline of hydrological cycle)

Lithosphere:

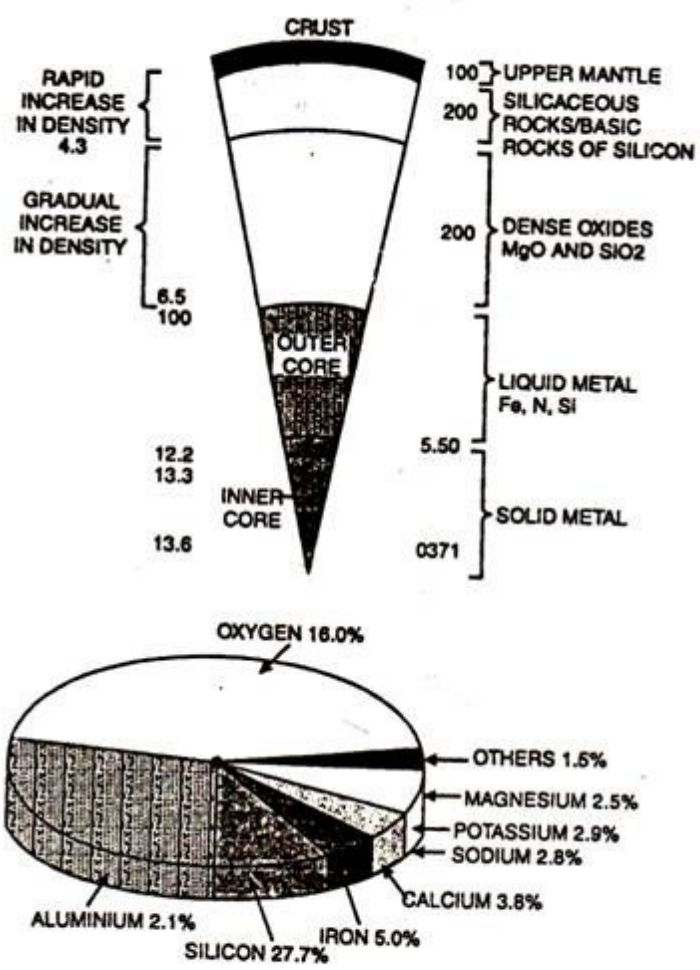
It is the outer boundary layer of solid earth and the discontinuity within the mantle. The outer boundary forms a complex interface with the atmosphere and hydrosphere and is also the environment in which life has evolved. The inner boundary is adjacent to rock, which is near its melting point and is capable of motion relative to the lithosphere above.

Basically lithosphere is nothing but a crustal system composed of various layers: Core, mantle and outer crust. Various elements constitute such crustal layer in mixture of different proportions. In general, the earth curst is composed of three major classes of rocks (as classified on the basis of their mode of origin):

Igneous rocks, sedimentary rocks and metamorphosed rocks. There are two types of crusts – continental crust which is composed of granitic rocks in silicon aluminium and with a mean density of 2.8; the other oceanic crust which is basaltic

in composition consisting of more basic minerals and has a mean density of 3.0. Overall, the average density of the earth is 5.5 gm/c.c.

Interaction between the crustal system of the lithosphere, atmosphere and biosphere takes place where continental crust is exposed above sea-level. At the land/air interface crustal material becomes exposed to inputs of solar radiant energy, precipitation and atmospheric gases. These inputs are often modified by or operate through the effects of the living systems of the biosphere. Under the influence of these inputs, crustal rocks are broken down by weathering process and are transferred to fine porus crustal layers called soil.



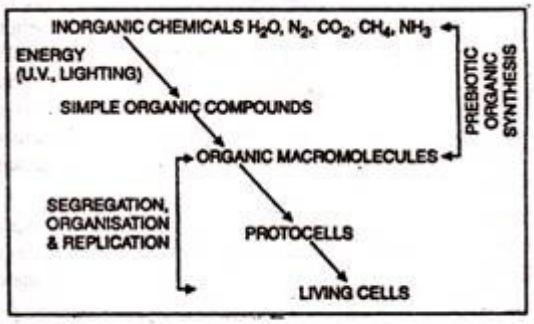
(Fig. 1(A).4.)
(An outline of earth layers and composition of materials)

An outline of earth layers and composition of crustal materials is given in Fig. 1(A).4.

Biosphere:

The biosphere encompasses all the zones on the Earth in which life is present, i.e. entire bio-resources of the earth. It develops on earth since 4.5 billion year through evolutionary process. At the top of the lithosphere, throughout the hydrosphere and into the lower atmosphere, life of diverse type exists. These bio-resources and their surrounding constitute the “Biosphere” where mankind acts as the most evolved creature.

The steps involved in the origin of life on earth is very complex and require several centuries. Considerable uncertainty surrounds the details of atmospheric composition, the processes involved and even the sequence of some events leading to formation of living cells. The conventional view held that the earliest organism on the plant were heterotrophic prokaryotic bacteria. Subsequently, autotrophic prokaryotes & eukaryotes start appearing as stepwise evolutionary changes. The major steps of origin of life in primitive earth are depicted in Fig. 1(A).5.



(Fig. 1(A).5.)
(Steps to origin of life)

Life on Earth requires water, a source of energy (sun light) and various nutrients found in the soil, water and air. Suitable combinations of these essentials cannot be found high in the upper atmosphere or deep underground. These exists only in a narrow layer near the surface of the Earth.

ENVIRONMENTAL POLLUTION AND CONTROL

Introduction

For normal and healthy living a conducive environment is required by all living beings, including humans, livestock, plants, micro – organisms and whildlife, The favourable unpolluted environemnta has a specific composition. When this composition gets changed by addition of harmful substance, the environment is called polluted environment and the substance polluting it are called pollutants. Environmental pollution canm therefore, be defined as any undesirable change in the physical, chemical or biological characteristics of any components of the environment (air, water soil), which can ciause harmful effects on various forms of life or property. Environment pollution could be of the following types:

(i) Air pollution and noise pollution
(ii) Water Pollution
(iii) Soil or Land Pollution
(iv) Thermal pollution
(v) Nuclear pollution

The pollutants which cause environmental pollution can be chemical, physical or biological in nature. There is a variey of chemical pollutants in the environment. Thses may include gases and particulate matter, toxic metals, agrochemicals (pesticides and fertilizers), toxic and hazardous chemicals etc. The physical pollutants include, odours, heat, sound waves, radiations, radioactive substances while the biological pollutants may be pathogenic organisms, pollen grains etc. The causes, effect and control technologies are given in details in the relevant category of environemtal pollution.

Air Pollution

It is an atmospheric condition in which certain substances (including the normal constituents in excess) are present in concentrations which can cause undersirable effects on man and his environment. These substances include gases, particulate matter, radioactive substance etc.

Gaseous pollutants include oxides of sulphur (mostly SO_2, SO_3) oxides of nitrogen (mostly NO and NO_2 or NO_x), carbon monoxide (CO), volatile organic compounds (mostly hydrocarbons) etc. Particulate pollutants include smoke, dust, soot, fumes, aerosols, liquid droplets pollen grains etc.

Radioactive pollutants include radon -222, iodine -131, strontium – 90 plutonium – 239 etc.

Classification of air pollutnats: Primary and Secondary Pollutants

Air pollutants may occur in gaseous or particulate form and may be organic or inorganic in nature. On the basis of origin of pollutants, these can be classified as primary or secondary pollutnats.

a) **Primary Pollutants**: These are emitted directly from the point sourc (identifiable source) eg. Carbon monoxide (CO), oxides of nitrogen (NO_x), oxide of sulphur (SO_x), hydrocarbons, radioactive substances etc.

b) **Secondary Pollutants**: Thses are formed by interaction of primary pollutants (s) with other primary pollutants (s) or with some natural constituents of atmosphere, eg. Ozone (O_3), peroxyacetyl nitrate (PAN), Photochemical smog etc.

Causes / Sources of Air Pollutants

The sources of air pollutants are natural and man – made (anthropogenic).

a) Natural source: The natural source of air pollution are volcanic eruptions, forest fires, sea salt sprays, biological decay, photochemical oxidation of terpenes, marshes, extra terrestrial bodies, pollen grains of flowers, spores etc. Radioactive minerals present in the earth crust are the source of radioactivity in the atmosphere.

b) Man- Made: Man- made source include thermal power plants induatrial units, vehicular emissions, fossils fuel burning, agricultural activities etc. Thermal power plants have become the major sources for generating electricity in India as the nuclear power plants couldn`t be installed as planned. The main pollutants emitted are fly ash and SO2 Metallurgical plants also consume coal and produce similar pollutants. Fertilizers plants, smelters, textile mills, tanneries, refineries, chemical induatries, paper and pulp mills are other source of air pollutions.

Effects of Air Pollution

Air pollution has adverse effects on living organisms and materials.

a) **Effects on human health:** Human respiratory systems has a number of mechanisms for protection from air pollution. Bigger particles (>10um) can be trapped by the hairs and stickly mucus in the linning of the nose.

Smaller particles can be reach tracheobronchial system and there get trapped in mucus. They are sent back to throat by beating of hair like cilia from where they can be removed by spitting or swallowing. Years of exposure to air pollutants (including cigarette smoke) adersely affect these natural defences and can result in lung cancer,asthama, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acure shortness of breath). Suspended particulates can damage to lung tissue and diseases like asthama, bronchitis and cancer especially when they bring with them cancer, causing or toxic pollutants attached on their surface. SUlphur dioxide (SO2) causes contriction of respiratory passage and can cause bronchitis like condition. In the presence of supended particulates, SO2 can form acid sulphate particles which can go deep into the lungs and affect them severely.

Oxides of nitrogen especially NO2 can irritate the lungs and cause Conditions like chronic bronchitis and emphysema. Carbon monoxide (CO) reaches lungs and combines with haemoglobin of blood to form carboxyhaemoglobin. Haemoglobin has affinity for CO 210 tomes more than that for oxygen. Haemoglobin is , therefore, unable to transport oxygen to various parts of the body. This causes suufocation. Long exposure to CO may cause dizziness, unconsciousness and ven death.

Many other air pollutants like benzene (from unleaded petrol), formaldehyde and particulates like polychlorinated bipheyls (PCBs) toxic metals and dioxins (from burning of polythene) can cause mutations, reproductive problems or even cancer.

Many other hazardous maerials like Asbesos, Beryllium Mercury, Arsenic and radioactive substances cause lung disease and / or affect other vital organs like kidney, liver, splee, brain and some may also cause cancer.

b) **Effects on plants:** Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis. During the day time the stomata are wide open to facilitate photosynthesis. Air pollutants during day time affect plants by entering the leaf through these stomata more than during night. Pollutants also erode waxy coating of the leaves called cuticle. Cuticle prevents excessive water loss and damge from diseases, pests drought and frost. Damage t leaf structure causes necrosis (dead areas of leaf), chorosis (loss

or reduction of chlorophyll causing yellowing of leaf) or epinasty (downward curling of leaf), and abscission (dropping of leaves). Particulates deposited on leaves can form encrustations and plug the stomata and also reduce the availability of sunlight. The damage can result in death of the plant.

SO2 causes bleaching of leaves, chlorosis, injury and necrosis of leaves. NO2 results in increased abscission and suppressed growth O3 causes flecks on leaf surface, premature ageing, necrosis and bleaching Perixyacetyl nitrate (PAN) causes silvering of lower surface of leaf, damage to young and more sensitive leaves and suppressed growth. Fluorides cause necrosis of leaf – tip while ethylene results in epinasty leaf abscission and dropping of flowers.

c) **Effects on aquatic life:** Air pollutants mixing up with rain can cause high acidity (lower pH) in fresh water lakes. Thid affects aquatic life especially fish. Some of the fresh water lakes have experience total fish death.

d) **Effects on materials:** Because of their corrosiveness, particulates can cause damage to exposed surfaces. Presence of SO2 and moisture can accelerate corrosion of metallic surfaces due to formation of sulfuric acid. Metal parts of buildings, vehicles bridges, wires and metallic railway tracks are affected. Sulfuric acid also damages buildings and cause disfigurement of statues made up of marble and limestone. Sulfuric acid formed by atmospheric SO2 and water vapours damages the leather binding of books. The pages of the books also become brittle. SO2 can affect fabric, leather paint and paper. Ozone in the atmosphere can cracking of rubber. Nylon sticking are weakened and ultilmately damged. Tyres of various vehicles are also damaged. These days chemical are added to prevent damage to tyre rubber by zone. Oxides of nitrogen and zone can also fading of cotton and rayon fibres.

Control of Air Pollution

Air pollution can be minimized by the following methods.

- Siting of industries after proper Enviromental Impact Assesment studies.
- By dulition of emission. This cane be done by increasing the stack height (Though up to permissible height), beyond inversion layer. Wind currents will disperse the pollutnats.

- But this results in interstate dispute and is not considered to be solution for air pollution problem.
- Minimize activities which cause pollution like transportation and enery production.
- Modification of process and or equipments.
- Use of appropriation material.
- Using low sulpur coal in induatries,
- Removing sulphur from coal (by washing or with the help of bacteria).
- Removing NOx during the combustion process and controlling the flow of air and fuel in industrial boilers.
- Vehicular pollution can be checked by regular tune-up of engines; replacement of more polluting old vehicles; installing catalytic converters; by engine modification to have fuel efficient (lean) mixtures to reduce CO and hydrocarbon emissions; and slow and cooler burning of fuels to reduce NOx emission (Honda Technology).
- Using mass transport system, bicycles etc.
- Shifting to less polluting (clean) fuels (Hydrogen gas).
- Using non – conventional sources of energy
- Using biological filters and bio- srubbers.
- Planting more trees.
- Reduction of pollution at source.

WATER POLLUTION

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state.

1) Source of water pollution

Water is an essential commodity for survival. We need water for drinking, cooking, bathing, washing, irrigation, and for industrial operations. Most of water for such uses comes from rivers, lakes or ground water sources. Water has the property to dissolve many substance on it, therefore, is can easily get polluted. Pollution of water can be caused by point source or non – point sources. Point source are specific sites near water which directly discharge effluents into them. Major point source of water pollution are industries, sewage treatment plants, power plants, underground coal mines, offshore oil wells, oil tankers etc. It is easy to control water pollution by point source. Many advanced countries have stricter legislation for the same. However, such control is not effective in most of the developing nations. The discharge from non-point source is not at any particular site, rather these source are scattered which individually or collectively pollute water. Surface run – off from agriculture fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc. are the non –point source of water pollution. It is diffuclt to control water pollution by non point source because of the heigh cost and difficulty in identifying and treating the pollutants from diffused source.

Major Pollutants of water and their sources

The major pollutants and source of surface water pollution are:

1) **Sewage:** Emptying the drains and sewers in fresh water bodies causes water pollution. The problem is serve in cities.
2) **Induatrial effluents:** Industrial wastes containing toxic chemicals, acids, alkalis, heavy metals, phenols, cyanides, ammonia, radioactive substances, ect are source of water pollution. They also cause thermal (heat) pollution of water.
3) **Synthetic detergents:** Synthetic detergents used in washing and cleaning produce foam and pollute water.
4) **Agrochemicals;** Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fundicides, herbicides etc) washed by rain- water and surface run – off pollute water.
5) **Oil:** Oil spillage into sea water during drilling and shipment pollute it.

6) **Waste heat:** Waste heat from industrial discharges increase the temperature of water bodies and affects distributions and survival of sensitive species.

There are a number of potential source of ground water pollution also. Septic tanks, undustry (textile, chemical, tanneries), deep well injection, mining etc are mainly responsible for ground water pollution which is irreversible.Ground water pollution with arsenic fluoride and nitrate are posing serious helath hazards.

a) The major sources of ground water arsenic are
   Weathering of minerals and ores having arsenic
   Infiltration or runoff from sites of mining activities in the past.
b) Source od nitrates in ground water are:
   Use of synthetic nitrogen fertilizers
   Relatively thin soil or soils with poor buffering capacity.
c) Source of fluoride in ground water are:
   Sediments of maribne origin of mountainous area
   Volcanic rock
   Igneous and metamorphic rock.
   India, high concentration of fluoride in villages in Andhra Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Tamil Nadu, and Gujarat have been reported.

Effects of water Pollution

Following are some important effects of various types of water pollutants:

a) **Oxygen demanding wastes:** Organic matter wich reaches water bodies is decomposed by micro – organisms presnt in water. For this degradation oxygen dissolved in water is consumed. Dissoved oxygen (DO) is the amount of oxygen dissolved in a given quantity of water at a particular temperature and atmospheric pressure. Amount of dissolved oxygen depends on aeration, photosynthetic acticity in water, respiration of animals and plants and ambient temperature.

   The saturation value of DO varies from 8-15 mg / L. for active fish species (trout and Salmon) 5-8 mg /L. of DO is required whereas less desirable species like carp can survive at 3.0 mg .L of DO.

   Lower DO may be harmful to animals especially fish population. Oxygen depletion (deoxygenation) helps in release of phosphates from bottom sediments and cause eutrophication.

b) **Nitrogen and Phosphorus compounds (nutrients):** Addition of compounds containing nitrogen and phosphorus helps in the growth of algae and other

plnats which when die and decay consume ixygen of water. Under anaerobic conditions foul smelling gases are produced. Excess growth or decomposition of plant material will change the concentration of CO2 which will further change pH of water. Changes in pH, oxygen and temperature will change many physic – chemical characteristics of water.

c) **Pathogens:** Many wastewaters especially sewage contain many pathogenic (disease causing) and non- pathogenic micro – organisms and many viruses. Water borne disease like cholera, dysentery, typhoid, jaundice etc are spread by water contaminated with sewage.

d) **Toxic compounds:** Pollutants such as heavy metals, pesticides cyanides and many other organic and inorganic compounds are harmful to aquatic organisms.

Control of Water Pollution

It is easy to reduce water pollution from point source by legislation. However, due to absence of defined strategies it becomes difficult to prevent water pollution from non – point source. The following points may help in reducing water pollution from non- point sources.

(i) Judicious use of their urface like pesticides and fertilizers which will reduce their surface run – off and leaching. Avoid use of these on sloped lands.

(ii) Use of nitrogen fixing plants to supplement the use of fertilizers.

(iii) Adopting integrated pest management to reduce reliance on peaticides.

(iv) Prevent run – off of manure. Divert such run off to bain for settlement. The nutrient rich water can be used as fertilizers in the fields.

(v) Separate drainage of sewage and rain water should be provided to prevent overflow od sewage with rain water.

(vi) Planting trees would reduce pollution by sediments and will also prevent soil erosion.

For controlling water pollution water pollution from point source, treatment of wastewaters is essentiola before being discharged. Parameters which are considered for reduction in such water are:

Total solids, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrate and phosphates oil and grease, toxic metals etc.

Wastewaters should be properly treated by primary amdsecondary treatments to reduce the BOD, COD levels up to the permissible levels for discharge.

SOIL POLLUTION

Source of soil Pollution

Soil is the upper layer of earth crust which is formed by weathering of rocks. Organic matter in the soil makes it suitable for living organisms. Dumping of various types of amterials especially domestic and industrial wastes causes soil pollution. Domestic wastes include garbage, rubbish material like glass, plastic metallic cans paper, fibres, cloth rags, containers, paintsm varnishes etc. LEachates from dumping sites and sewage tanks are harmful and toxic, ehci pollution the soil.

Industrial wastes are the effluents discharged from chemical industries, paper and pulp mills tanneries, textiles millsm steel industrial distillers, refineries, pesticides and fertilizers industries, pharmaceutical induatries, food processing industries, cement induatries, thermal and nyclear power p;nts, mining unsudtries etc. Thermal power plants generate a alarge quanity of Fly ash'. Huge quantities of these wastes are dumped on soils, thus contaminating them.

Industrial wastes also contain some organic and inorganic compounds that are refractory and non- biodegradable. Industrial sludge may contain various slats, toxic substance, metals like mercury, lead cadium, arsenic etc. Agrochemicals released with the wastes of pesticides and fertilizers factories or during agriculture practice also reach the soil and pollute it.

Pesticides are used to kill pests that damage crops. These pesticides ultimately reach the soil and perist there for a long time. Pesticides which are persistent in nature are chlorinated hydrocarbon insecticides e.g DDT, HCH, endrin, Indance, heptachlor, endodulfan etc. Residues of these pesticides in the soils have long – term effects especially under the temperate conditions.

Soil also received excreta from animals and humans. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms whci cause pollution in the soil.

The sources of radioactive substances in soil are explosion of radioactive devices, radioactive wastes discharges from industries and laboratories, aerial fall out etc. Isotopes of radium, uranium, thorium strontium, iodine, cesium and of many elements reach the soil and persist there for a long time and keep on emitting radiations.

Effects of Soil Pollution

Sewage and unsudtrial effluents which pollute the soil ultimately effect human health. Varoious types of chemicals like acids, alkalis, pesticides, insecticides, weedicides, fungicides, heavy metals etc. in the industrial discharges affect soil fertilizers byc causing changes in physical, chemical and biological properties.

Some of the persistent toxic chemicals inhibit the non- target organisms, soil flora and funa and reduce soil productivity. These chemicals accumalte in food chain and ultimalety affect human health. Indiscrimante use of pesticides specially is a matter of concern.

Sewage sludge has many types of pathogenic bacteria, viruses and intestinal worms hcih may cause various types of disease. Decomposing organic matter in soil also produces toxic vapours.

Radioactive fallout on vegetation is the source of radio – isotopes which enter the food chain in the grazing animals. Some of these radio isotopes replace essential elements in the body and cause abnormalities e.g. strontium – 90 instead of calcium gets deposited in the bones and tissues. The bones become brittle and prone to fracture.

Radioisotopes which attach with he clay become a source of radiations in the environment.

Nitrogen and phosphorus from the fertilizers in soil reach nearby water bodies with agriculture run – fff and cause eutrophication. Chemicals or their degradation products from soil may percolate and contaminate ground water resources.

Control of Soil Pollution

(i) Ellfuents should be properly treated before dischating them on the soil.
(ii) Solid wastes should be properly collected and disposed off by appropriate method.
(iii) From the wastes, recovery of useful products should be done.
(iv) Biodegradable organic waste sould be used for generation of biogas.
(v) Cattle dung should be ised for methane generation. Night – soil (human faces) can also be used in the biogas plant to produce inflammable methance gas.
(vi) Microbial degradation of biodegradable substances is also one of the scienctifc approached for reducing soil pollution.

NOISE POLLUTION

We hear various types of sounds everyday. Sound is mechanical energy from a vibrating source. A type of sound may be pleasant to some and at the same time unpleasant to others. The unpleasant and unwanted sound is called noise.

Sound can propogate through a medium like air, liquid or solid, sound wave is a pressure perturbation in the medium through which sound travels. Sound pressure alternately causes compression and rarefaction. The number of compressions and rarefactions of the molecules of the medium (for example air) in a unit time is described as frequently. It is expressed in Hertz (Hz) and is equal to the number of cycles per second.

There is a wide range of sound pressures, which encounter human ear. Increase in sound pressure does not invoke linear response of human ear. A meaningful logarithmic scale has been devised. The noise measurements are espressed as sound pressure level (SPL) which is logarithmic ratio of the sound pressure to a reference pressure. It is expressed as dimesionless unit, decibel (db). The international a healthy ear. Decibel scale is a measure of loudness. Noise can affect human ear because of its loudness and frequency. (pitch).

Source of Noise Pollution

The main source of noise are various modes of transportation (like air, road, rail transportation), industrial operations, construction activities and celebrations (Social / religious functions, elections ect) electric home appliance. Various sources of noise and their associated sound levels on decibel scale are given in table 4.3.

High levels of noise have been recorded in some of the cities of the worls. In Nanjing (China) noise level of 105 dB has been recorded, while in some other cities of the world these levels are: Rome 90dB, New York 88 dB, Kolkata 85 dB, Mumbai 82 dB, Delhi 80 dB Kathmandu 75 dB.

	Sound level (dB)	Source of sound
	180- 170 160	Rocjket engine
Threshold of pain	150- 140	Jet plane take off

	130-	Maximum recrded rock music
	120-	Thunder cap
	110-	Autohorn 1m away
	100-	Jet fly over at 300m, construction work, Newspaper press
	90-	Motor cycle /8 m away, food blender
	80	Vaccum cleaner, ordinary conservation
	70-	
	60	Air conditioning unit, 6m away, light traffic noise, 30 m away
	50-	
	40	Library, soft whisper
	30-	Boardcasting studio
	20-	Rustling leaf
	10-	
Thresold of heating	0	

Effects of Noise

Noise causes the following effects.

(i) Interferes with mans communication: In a noisy area communication is severly affected.

(ii) Hearing damage: Noise can cause temporary or permanent hearing loss. It depends on intensity and duration of sound level. Auditory sensitivity is reduced with noise level of oer 90 dB in the mid – high frequency for more than a few minutes.

(iii) Physiological and psychological changes: Continous exposure to noise affects the functioning of various systems of the nody. It may result in hypertension, insomnia (sleepleness), gastro – intestinal and digestive disorders, peptic ulcers, blood pressure changes, behavioural changes, emotional changed etc.

Industrial Noise – Occupational Health Hazards.

Industrial noise is the noise which is created by the machines and process in the industries. It is of concern as it threatens safety and health of the industrial workers and common people in the insudtrial environment. Noise levele more tha 85 decibels can cause hearing impairment and such industrial environment is not a health environment for the workers. Noise Induced heaarng loss (NIHL) has

been observed in workers of heavy industries like ship – building, iron and steel industry , railway yards ect.

Besides hearing loss other occupational health hazards include:

(i) Increases stress

(ii) Fatigue

(iii) High blood pressure

(iv) Annoyance

(v) Headache

(vi) Vertigo

(vii) Speech problems Learinng impairment

(viii) Aggresion

(ix) Anxiety

(x) Stomach unclers

(xi) Depression.

Permissible noise levels for varying number of hours per day exposure have been given by occupational safety and health act.

Generally 90 dB (A) sound levels are persmissble for 8 hours a day exposure. However, it has been observed that over a period of 10 years exposure to these levels of noise a significant number of employees would suffer noise – induced hearing loss, suggesting that occupational noise levels ofr 8 nours per day exposure be reduced to 85 dB (A).

Occupational noise environment is not acceptable if after 10 years of 8 hour per day exposure, the average employee has suffered a permanent workinduced hearing loss of 10 decibels at 1000 Hertz, 15 decibels at 2000 Hertz, or 20 decibels at 3000 Hertz or above.

STANDARDS

Central Pollution Board (CPCB) Committee has recommended permissible noise levels for different locatons as given in Table

Ambient air quality standards in respect of noise.

Area code	**Category of area / zone**	**Limits in dB (A) Leq***	
		Day time	**Night Time**
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone	50	40

Notes:

1) Day time mean from 6.00 am to 10.00 pm
2) Night time shall mean from 10.00 pm to 6.00 am
3) Silence zone is an area comprising not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4) Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

dB (A) Leq denoted the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

"A"" decibel" is a unit in which noise is measured.

"A", in dB (A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specifies period.

Methods of Control of Noise

1) Reduction in source of noise: Source of noise pollution like heavy vehicles and old vehicles may not be allowed to ply in the populated areas.
2) Machine noise can be reduced by proper machine design involving process modification, chages in shape and material.
3) Noise making machine should be kept in containers with sound absorbing media. The noise path witll be in interrupted and will not reach the workers.
4) Proper oiling will reduce the noise from the machinery.
5) Noise levele can b reduced by reducing the noise radiating surfaces.
6) Heavy machines transmit vibrations to the hard surface in touch which in turn radiate noise. This type of secondary noise can be reduced by providing pads of suitable material (rubber, felt, cork, etc) to absorb and reduce noise transmission.
7) Hugh frequency noise which gets reflected like beam of kught or heat can be reduced by providing sound absorbing acoustical barriers or shields between the noise sourec and workplace. Porous materials absorbent – fibres, glass wool, etc are sound absorbing materials which can absorb upto 90% of sound energy falling on them depending on the angle of suvh incidence. Ceilings and walls may be provided with layers of such sound absorbing materials to reduce workplace noise.
8) Workers may be deployed in noisy ebvironemtn with maximum permissible noise levels and the relatively quieter areas in shifts so that the time of

exposure to high noise level doesn` exceed that recommende by the occupational safety and health act.

9) Workers may be provided with ear protectors to reduce noise reaching the eardrums.
10) Planting more tress having broad leaves.
11) Thriugh law: Legislation can ensure that sound production is minimized at various social functions. Unnecessary horn blowing should be restricted especially in vehicle – congested area.

Thermal Pollution

Thermal Pollution can be defined as presence waste heat in the water which can cause underirable changes in the natural environment.

A) **Causes of thermal pollution:** Heat producing industries i.e thermal power plants, nuclear power plants, refineries, steel mills etc. are the major source of thermal pollution. Power plants utilize only 1/3 of the energy provided by fossil fuels for their operations. Remaininng 2/3 is generally lost in the form of heat to the water ised for cooling. Cold water, generally, is drawn from some nearby water-body, passed through the plant and returned to the same water body, with temperature 10-16^{o} C higher than the initial temperature. Excess of heat reaching such water bodies caused thermal pollution of water.

B) **Effects of thermal pollution**.

(i) The dissolved oxygen content of water is decreased as the solubility of oxygen in water is decreased at high temperature.

(ii) High temperature becomes a barrier for oxygen penetration into deep cold waters.

(iii) Toxicity of pesticides, detergent and chemicals in the ellfuents increases with increase in temperature.

(iv) The composition of flora and fauna changed because the speices sensitive to increased temperature due to thermal shock will be replaced by temperature tolerant species.

(v) Metabolic activities of aquatic organisms increase at high temperature and require more oxygen, whereas oxygen level falls under thermal pollution.

(vi) Discharged of hested water near the shores can disturb spawing and can even kill young fishes.

(vii) Fish migration is affecte due to formation of various thermal zones.

C) **Control of thermal pollution:** the following methods can be employed for control of thermal pollution.

(i) Cooling ponds

(ii) Spray ponds

(iii) Cooling towers.

Plastic pollution

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Plastic pollution in Ghana, 2018

Plastic pollution is the accumulation of plastic objects and particles (e.g.: plastic bottles and much more) in the Earth's environment that adversely affects wildlife, wildlife habitat, and humans. Plastics that act as pollutants are categorized into micro-, meso-, or macro debris, based on size. Plastics are inexpensive and durable, and as a result levels of plastic production by humans are high. However, the chemical structure of most plastics renders them resistant to many natural processes of degradation and as a result they are slow to degrade. Together, these two factors have led to a high prominence of plastic pollution in the environment.

Plastic pollution can afflict land, waterways and oceans. It is estimated that 1.1 to 8.8 million metric tons (MT) of plastic waste enters the ocean from coastal communities each year. Living organisms, particularly marine animals, can be harmed either by mechanical effects, such as entanglement in plastic objects, problems related to ingestion of plastic waste, or through exposure to chemicals within plastics that interfere with their physiology. Effects on humans include disruption of various hormonal mechanisms.

As of 2018, about 380 million tons of plastic is produced worldwide each year. From the 1950s up to 2018, an estimated 6.3 billion tons of plastic has been produced worldwide, of which an estimated 9% has been recycled and another 12% has been incinerated. This large amount of plastic waste enters the environment, with studies suggesting that the bodies of 90% of seabirds contain plastic debris. In some areas there have been significant efforts to reduce the prominence of free range plastic pollution, through reducing plastic consumption, litter cleanup, and promoting plastic recycling.

Some researchers suggest that by 2050 there could be more plastic than fish in the oceans by weight.

Effects on the environment

The distribution of plastic debris is highly variable as a result of certain factors such as wind and ocean currents, coastline geography, urban areas, and trade routes. Human population in certain areas also plays a large role in this. Plastics are more likely to be found in enclosed regions such as the Caribbean. It serves as a means of distribution of organisms to remote coasts that are not their native environments. This could potentially increase the variability and dispersal of organisms in specific areas that are less biologically diverse. Plastics can also be used as vectors for chemical contaminants such as persistent organic pollutants and heavy metals.

Plastic pollution as a cause of climate change

In 2019 a new report "Plastic and Climate" was published. According to the report, in 2019, plastic will contribute greenhouse gases in the equivalent of 850 million tons of carbon dioxide (CO_2) to the atmosphere. In current trend, annual emissions will grow to 1.34 billion tons by 2030. By 2050 plastic could emit 56 billion tons of Greenhouse gas emissions, as much as 14 percent of the earth's remaining carbon budget. By 2100 it will emit 260 billion tons, more than half of the carbon budget. Those are emission from production, transportation, incineration, but there are also effects on Phytoplankton

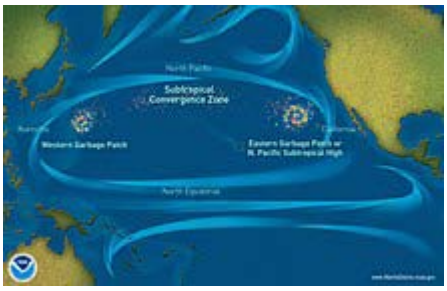
Effects of plastic on land

Plastic pollution on land poses a threat to the plants and animals – including humans who are based on the land. Estimates of the amount of plastic concentration on land are between four and twenty three times that of the ocean. The amount of plastic poisoned on the land is greater and more concentrated than that in the water. Mismanaged plastic waste ranges from 60 percent in East Asia and Pacific to one percent in North America. The percentage of mismanaged plastic waste reaching the ocean annually and thus becoming plastic marine debris is between one third and one half the total mismanaged waste for that year.

Chlorinated plastic can release harmful chemicals into the surrounding soil, which can then seep into groundwater or other surrounding water sources and also the ecosystem of the world. This can cause serious harm to the species that drink the water

Effects of plastic on oceans

See also: Marine pollution § Plastic debris



Pacific Ocean currents have created 3 "islands" of debris.

In 2012, it was estimated that there was approximately 165 million tons of plastic pollution in the world's oceans. The Ocean Conservancy reported that China, Indonesia, Philippines, Thailand, and Vietnam dump more plastic in the sea than all other countries combined.

One study estimated that there are more than 5 trillion plastic pieces (defined into the four classes of small microplastics, large microplastics, meso- and macroplastics) afloat at sea.

The litter that is being delivered into the oceans is toxic to marine life, and humans. The toxins that are components of plastic include diethylhexyl phthalate, which is a toxic carcinogen, as well as lead, cadmium, and mercury.

Plankton, fish, and ultimately the human race, through the food chain, ingest these highly toxic carcinogens and chemicals. Consuming the fish that contain these toxins can cause an increase in cancer, immune disorders, and birth defects.]

The majority of the litter near and in the ocean is made up of plastics and is a persistent pervasive source of marine pollution. According to Dr. Marcus Eriksen of The 5 Gyres Institute, there are 5.25 trillion particles of plastic pollution that weigh as much as 270,000 tons (2016). This plastic is taken by the ocean currents and accumulates in large vortexes known as ocean gyres. The majority of the gyres become pollution dumps filled with plastic.

Sources of ocean-based plastic pollution

In October 2019, when research revealed most ocean plastic pollution comes from Chinese cargo ships, an Ocean Cleanup spokesperson said: "Everyone talks about saving the oceans by stopping using plastic bags, straws and single use

packaging. That's important, but when we head out on the ocean, that's not necessarily what we find."

Almost 20% of plastic debris that pollutes ocean water, which translates to 5.6 million tons, comes from ocean-based sources. MARPOL, an international treaty, "imposes a complete ban on the at-sea disposal of plastics". Merchant ships expel cargo, sewage, used medical equipment, and other types of waste that contain plastic into the ocean. In the United States, the Marine Plastic Pollution Research and Control Act of 1987 prohibits discharge of plastics in the sea, including from naval vessels. Naval and research vessels eject waste and military equipment that are deemed unnecessary. Pleasure crafts release fishing gear and other types of waste, either accidentally or through negligent handling. The largest ocean-based source of plastic pollution is discarded fishing gear (including traps and nets), estimated to be up to 90% of plastic debris in some areas.

Continental plastic litter enters the ocean largely through storm-water runoff, flowing into watercourses or directly discharged into coastal waters. Plastic in the ocean has been shown to follow ocean currents which eventually form into what is known as Great Garbage Patches. Knowledge of the routes that plastic follows in ocean currents comes from accidental container drops from ship carriers. For example, in May 1990 The Hansa Carrier, sailing from Korea to the United States, broke apart due to a storm, ultimately resulting in thousands of dumped shoes; these eventually started showing up on the U.S western coast, and Hawaii.

Land-based sources of ocean plastic pollution

Estimates for the contribution of land-based plastic vary widely. While one study estimated that a little over 80% of plastic debris in ocean water comes from land-based sources, responsible for 0.8 million tonnes (790,000 long tons; 880,000 short tons) every year. In 2015, Jambeck et al. calculated that 275 million tonnes (271,000,000 long tons; 303,000,000 short tons) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million tonnes (12,500,000 long tons; 14,000,000 short tons) entering the ocean – a percentage of only up to 5%.

In a study published by *Science*, Jambeck *et al* (2015) estimated that the 10 largest emitters of oceanic plastic pollution worldwide are, from the most to the least, China, Indonesia, Philippines, Vietnam, Sri Lanka, Thailand, Egypt, Malaysia, Nigeria, and Bangladesh.

In a study published by *Environmental Science & Technology*, Schmidt *et al* (2017) calculated that the Yangtze, Indus, Yellow River, Hai River, Nile, Ganges, Pearl River, Amur, Niger, and the Mekong "transport 88–95% of the global [plastics] load into the sea.

A source that has caused concern is landfills. Most waste in the form of plastic in landfills are single-use items such as packaging. Discarding plastics this way leads to accumulation. Although disposing of plastic waste in landfills has less of a gas emission risk than disposal through incineration, the former has space limitations. Another concern is that the liners acting as protective layers between the landfill and environment can break, thus leaking toxins and contaminating the nearby soil and water. Landfills located near oceans often contribute to ocean debris because content is easily swept up and transported to the sea by wind or small waterways like rivers and streams. Marine debris can also result from sewage water that has not been efficiently treated, which is eventually transported to the ocean through rivers. Plastic items that have been improperly discarded can also be carried to oceans through storm waters.

Effects on animals

Plastic pollution has the potential to poison animals, which can then adversely affect human food supplies. Plastic pollution has been described as being highly detrimental to large marine mammals, described in the book *Introduction to Marine Biology* as posing the "single greatest threat" to them.[1] Some marine species, such as sea turtles, have been found to contain large proportions of plastics in their stomach. When this occurs, the animal typically starves, because the plastic blocks the animal's digestive tract. Sometimes Marine mammals are entangled in plastic products such as nets, which can harm or kill them.

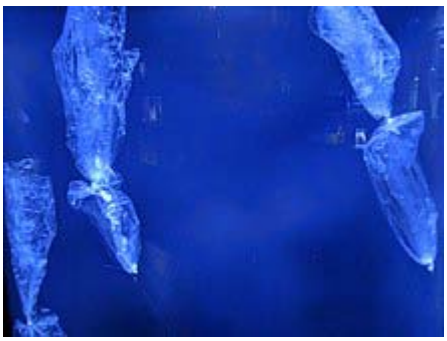
Entanglement

Sea turtle entangled in a ghost net

Entanglement in plastic debris has been responsible for the deaths of many marine organisms, such as fish, seals, turtles, and birds. These animals get caught in the debris and end up suffocating or drowning. Because they are unable to untangle themselves, they also die from starvation or from their inability to escape predators. Being entangled also often results in severe lacerations and ulcers. In a 2006 report known as *Plastic Debris in the World's Oceans*, it was estimated that at least 267 different animal species have suffered from entanglement and ingestion of plastic debris. It has been estimated that over 400,000 marine mammals perish annually due to plastic pollution in oceans. Marine organisms get caught in discarded fishing equipment, such as ghost nets. Ropes and nets used to fish are often made of synthetic materials such as nylon, making fishing equipment more durable and buoyant. These organisms can also get caught in circular plastic packaging materials, and if the animal continues to grow in size, the plastic can cut into their flesh. Equipment such as nets can also drag along the seabed, causing damage to coral reefs.

Ingestion

Marine animals



An exhibit at the Mote Marine Laboratory that displays plastic bags in the ocean that look similar to jellyfish.

Sea turtles are affected by plastic pollution. Some species are consumers of jelly fish, but often mistake plastic bags for their natural prey. This plastic debris can kill the sea turtle by obstructing the oesophagus.[63] Baby sea turtles are particularly vulnerable according to a 2018 study by Australian scientists.

So too are whales. Large amounts of plastics have been found in the stomachs of beached whales. Plastic debris started appearing in the stomach of the sperm whale since the 1970s, and has been noted to be the cause of death of several whales. In June 2018, more than 80 plastic bags were found inside a dying pilot whale that washed up on the shores of Thailand. In March 2019, a dead Cuvier's beaked whale washed up in the Philippines with 88 lbs of plastic in its

stomach.[68] In April 2019, following the discovery of a dead sperm whale off of Sardinia with 48 pounds of plastic in its stomach, the World Wildlife Foundation warned that plastic pollution is one of the most dangerous threats to sea life, noting that five whales have been killed by plastic over a two-year period.

Some of the tiniest bits of plastic are being consumed by small fish, in a part of the pelagic zone in the ocean called the *Mesopelagic zone*, which is 200 to 1000 metres below the ocean surface, and completely dark. Not much is known about these fish, other than that there are many of them. They hide in the darkness of the ocean, avoiding predators and then swimming to the ocean's surface at night to feed. Plastics found in the stomachs of these fish were collected during *Malaspina's circumnavigation*, a research project that studies the impact of global change on the oceans.

A study conducted by Scripps Institution of Oceanography showed that the average plastic content in the stomachs of 141 mesopelagic fish over 27 different species was 9.2%. Their estimate for the ingestion rate of plastic debris by these fish in the North Pacific was between 12000 and 24000 tons per year. The most popular mesopelagic fish is the lantern fish. It resides in the central ocean gyres, a large system of rotating ocean currents. Since lantern fish serve as a primary food source for the fish that consumers purchase, including tuna and swordfish, the plastics they ingest become part of the food chain. The lantern fish is one of the main bait fish in the ocean, and it eats large amounts of plastic fragments, which in turn will not make them nutritious enough for other fish to consume.

Another study found bits of plastic outnumber baby fish by seven to one in nursery waters off Hawaii. After dissecting hundreds of larval fish, the researchers discovered that many fish species ingested plastic particles. Plastics were also found in flying fish, which are eaten by top predators such as tunas and most Hawaiian seabirds.

Deep sea animals have been found with plastics in their stomachs.

Birds

Northern gannet on Helgoland, trapped in their own nests, build only of old nets and other plastic waste.

Plastic pollution does not only affect

animals that live solely in oceans. Seabirds are also greatly affected. In 2004, it was estimated that gulls in the North Sea had an average of thirty pieces of plastic in their stomachs. Seabirds often mistake trash floating on the ocean's surface as prey. Their food sources often has already ingested plastic debris, thus transferring the plastic from prey to predator. Ingested trash can obstruct and physically damage a bird's digestive system, reducing its digestive ability and can lead to malnutrition, starvation, and death. Toxic chemicals called *polychlorinated biphenyls* (PCBs) also become concentrated on the surface of plastics at sea and are released after seabirds eat them. These chemicals can accumulate in body tissues and have serious lethal effects on a bird's reproductive ability, immune system, and hormone balance. Floating plastic debris can produce ulcers, infections and lead to death. Marine plastic pollution can even reach birds that have never been at the sea. Parents may accidentally feed their nestlings plastic, mistaking it for food. Seabird chicks are the most vulnerable to plastic ingestion since they can't vomit up their food like the adult seabirds.

After the initial observation that many of the beaches in New Zealand had high concentrations of plastic pellets, further studies found that different species of prion ingest the plastic debris. Hungry prions mistook these pellets for food, and these particles were found intact within the birds' gizzards and proventriculi. Pecking marks similar to those made by northern fulmars in cuttlebones have been found in plastic debris, such as styrofoam, on the beaches on the Dutch coast, showing that this species of bird also mistake plastic debris for food.

An estimate of 1.5 million Laysan albatrosses, which inhabit Midway Atoll, all have plastics in their digestive system. Midway Atoll is halfway between Asia and North America and north of the Hawaiian archipelago. In this remote location, the plastic blockage has proven deadly to these birds. These seabirds choose red, pink, brown, and blue plastic pieces because of similarities to their natural food sources. As a result of plastic ingestion, the digestive tract can be blocked resulting in starvation. The windpipe can also be blocked, which results in suffocation. The debris can also accumulate in the animal's gut, and give them a false sense of fullness which would also result in starvation. On the shore, thousands of birds corpses can be seen with plastic remaining where the stomach once was. The durability of the plastics is visible among the remains. In some instances, the plastic piles are still present while the bird's corpse has decayed.

Similar to humans, animals exposed to plasticizers can experience developmental defects. Specifically, sheep have been found to have lower birth weights when prenatally exposed to bisphenol A. Exposure to BPA can shorten the distance between the eyes of a tadpole. It can also stall development in frogs and can result in a decrease in body length. In different species of fish, exposure can stall egg hatching and result in a decrease in body weight, tail length, and body length.

Effects on humans

Compounds that are used in manufacturing pollute the environment by releasing chemicals into the air and water. Some compounds that are used in plastics, such as phthalates, bisphenol A (BRA), polybrominated diphenyl ether (PBDE), are under close statute and might be very hurtful. Even though these compounds are unsafe, they have been used in the manufacturing of food packaging, medical devices, flooring materials, bottles, perfumes, cosmetics and much more. The large dosage of these compounds are hazardous to humans, destroying the endocrine system. BRA imitates the female's hormone called estrogen. PBD destroys and causes damage to thyroid hormones, which are vital hormone glands that play a major role in the metabolism, growth and development of the human body. Although the level of exposure to these chemicals varies depending on age and geography, most humans experience simultaneous exposure to many of these chemicals. Average levels of daily exposure are below the levels deemed to be unsafe, but more research needs to be done on the effects of low dose exposure on humans. A lot is unknown on how severely humans are physically affected by these chemicals. Some of the chemicals used in plastic production can cause dermatitis upon contact with human skin. In many plastics, these toxic chemicals are only used in trace amounts, but significant testing is often required to ensure that the toxic elements are contained within the plastic by inert material or polymer. Children and women during their reproduction age are at most at risk and more prone to damaging their immune as well as their reproductive system from these hormone-disrupting chemicals.

It can also affect humans because it may create an eyesore that interferes with enjoyment of the natural environment.

Clinical significance

Due to the pervasiveness of plastic products, most of the human population is constantly exposed to the chemical components of plastics. 95% of adults in the United States have had detectable levels of BPA in their urine. Exposure to

chemicals such as BPA have been correlated with disruptions in fertility, reproduction, sexual maturation, and other health effects. Specific phthalates have also resulted in similar biological effects.

Thyroid hormone axis

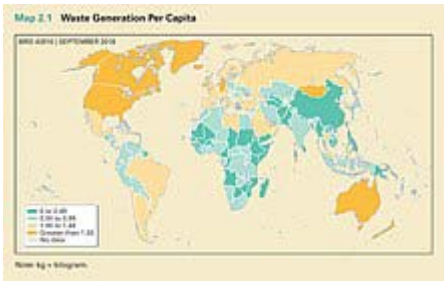
Bisphenol A affects gene expression related to the thyroid hormone axis, which affects biological functions such as metabolism and development. BPA can decrease thyroid hormone receptor (TR) activity by increasing TR transcriptional corepressor activity. This then decreases the level of thyroid hormone binding proteins that bind to triiodothyronine. By affecting the thyroid hormone axis, BPA exposure can lead to hypothyroidism.

Sex hormones

BPA can disrupt normal, physiological levels of sex hormones. It does this by binding to globulins that normally bind to sex hormones such as androgens and estrogens, leading to the disruption of the balance between the two. BPA can also affect the metabolism or the catabolism of sex hormones. It often acts as an antiandrogen or as an estrogen, which can cause disruptions in gonadal development and sperm production.

Reduction efforts

Household items made of various types of plastic.



Waste generation, measured in kilograms per person per day

Efforts to reduce the use of plastics and to promote plastic recycling have occurred. Some supermarkets charge their customers for plastic bags, and in some places more efficient reusable or biodegradable materials are being used in place of

plastics. Some communities and businesses have put a ban on some commonly used plastic items, such as bottled water and plastic bags.

In January 2019 a "Global Alliance to End Plastic Waste" was created. The alliance aims to clean the environment from existing waste and increase recycling, but it does not mention reduction in plastic production as one of its targets.

Biodegradable and degradable plastics

The use of biodegradable plastics has many advantages and disadvantages. Biodegradables are biopolymers that degrade in industrial composters. Biodegradables do not degrade as efficiently in domestic composters, and during this slower process, methane gas may be emitted.

There are also other types of degradable materials that are not considered to be biopolymers, because they are oil-based, similar to other conventional plastics. These plastics are made to be more degradable through the use of different additives, which help them degrade when exposed to UV rays or other physical stressors. yet, biodegradation-promoting additives for polymers have been shown not to significantly increase biodegradation.

Although biodegradable and degradable plastics have helped reduce plastic pollution, there are some drawbacks. One issue concerning both types of plastics is that they do not break down very efficiently in natural environments. There, degradable plastics that are oil-based may break down into smaller fractions, at which point they do not degrade further.

A Parliamentary committee in the United Kingdom also found that compostable and biodegradable plastics could add to marine pollution because there is a lack of infrastructure to deal with these new types of plastic, as well as a lack of understanding about them on the part of consumers. For example, these plastics need to be sent to industrial composting facilities to degrade properly, but no adequate system exists to make sure waste reaches these facilities. The committee thus recommended to reduce the amount of plastic used rather than introducing new types of it to the market.

Non-usage and reduction in usage

The Ministry of Drinking Water and Sanitation, Government of India, has requested various governmental departments to avoid the use of plastic bottles to provide drinking water during governmental meetings, etc., and to instead make arrangements for providing drinking water that do not generate plastic waste. The

state of Sikkim has restricted the usage of plastic water bottles (in government functions and meetings) and styrofoam products. The state of Bihar has banned the usage of plastic water bottles in governmental meetings.

The 2015 National Games of India, organised in Thiruvananthapuram, was associated with green protocols. This was initiated by Suchitwa Mission that aimed for "zero-waste" venues. To make the event "disposable-free", there was ban on the usage of disposable water bottles. The event witnessed the usage of reusable tableware and stainless steel tumblers. Athletes were provided with refillable steel flasks. It is estimated that these green practices stopped the generation of 120 metric tonnes of disposable waste.

The city of Bangalore in 2016 banned the plastic for all purpose other than for few special cases like milk delivery etc.

The state of Maharashtra, India effected the Maharashtra Plastic and Thermocol Products ban 23 June 2018, subjecting plastic users to fines and potential imprisonment for repeat offenders.

In July 2018, Albania became the first country in Europe to ban lightweight plastic bags. Albania's environment minister Blendi Klosi said that businesses importing, producing or trading plastic bags less than 35 microns in thickness risk facing fines between 1 million to 1.5 million lek (€7,900 to €11,800).

In January 2019, the Iceland supermarket chain, which specializes in frozen foods, pledged to "eliminate or drastically reduce all plastic packaging for its store-brand products by 2023."

In Bali, a pair of two sisters, Melati and Isabel Wijsen, have gone through efforts to ban plastic bags in 2019. Their organization Bye Bye Plastic Bags has spread to 28 locations around the world.

In 2019 The New York (state) banned single use plastic bags and introduced a 5-cent fee for using single use paper bags. The ban will enter into force in 2020. This will not only reduce plastic bag usage in New York state (23,000,000,000 every year until now), but also eliminate 12 million barrels of oil used to make plastic bags used by the state each year.

In 2019, The House of Representatives of Nigeria banned the production, import and usage of plastic bags in the country.

In Israel, 2 cities: Eilat and Herzliya, decided to ban the usage of single use plastic bags and cutlery on the beaches.

The government of India decided to ban single u e plastics and take a number of measures to recycle and reuse plastic, from 2 October 2019.

Action for creating awareness

Earth Day

In 2019, the Earth Day Network partnered with Keep America Beautiful and National Cleanup Day for the inaugural nationwide Earth Day CleanUp. Cleanups were held in all 50 states, five US territories, 5,300 sites and had more than 500,000 volunteers.

Earth Day 2020 is the 50th Anniversary of Earth Day. Celebrations will include activities such as the Great Global CleanUp, Citizen Science, Advocacy, Education, and art. This Earth Day aims to educate and mobilize more than one billion people to grow and support the next generation of environmental activists, with a major focus on plastic waste.

World Environment Day

Every year, 5 June is observed as World Environment Day to raise awareness and increase government action on the pressing issue. In 2018, India was host to the 43rd World Environment Day and the theme was "Beat Plastic Pollution", with a focus on single-use or disposable plastic. The Ministry of Environment, Forest and Climate Change of India invited people to take care of their social responsibility and urged them to take up green good deeds in everyday life. Several states presented plans to ban plastic or drastically reduce thei use.

Other actions

On 11 April 2013 in order to create awareness, artist Maria Cristina Finucci founded The Garbage Patch State at UNESCO[121] headquarters in Paris, France, in front of Director General Irina Bokova. This was the first of a series of events under the patronage of UNESCO and of the Italian Ministry of the Environment.

ECOSYSTEMS

Introduction

We have a variety of life – supporting systems like lakes, ponds, crop-lands, grasslands, forests, deserts, oceans and estuaries on this earth that support different types of flora, fauna and micro – organisms. Structurally and functionally these systems may look very different, yet thst all have some basic similarities as they all have biotic (living) and aboitic (non-living) components interacting closely with each other and exchanging matter and energy. How such diverse types of communities live and sustain themselves, how do they influence each other, how do they derive their energy and nutrients are the issue dealt within Ecology. The term Ecology derived from the Greek works Oikos (home) + logos (study) was coined by Earnst Haeckel in 1869.

Ecology deals with study organisms in their natural home interacting with their surroundings.

The surroundings of an organism may be living organisms (biotic) or physical components like air, water or soil (abiotic). Ecosystem is one such basic unit and ecology is now often defined as **'the study of ecosystems'**.

Definination

An ecosystem is a self – regulating group of biotic communities of species interacting with one another and wih their non- living environment exchanging energy and matter.

Scope and importance

(i) Ecosystem of different types provide natural home to different types of flora and fauna.

(ii) Ecosystems are of enormous value from the biodiversity point of view, providing various commercial products, medicines and drugs for human welfare.

(iii) Ecosystems regulate the flow of water and nutrients.

(iv) Ecosystems help conserve soil and build soil organic matter.

(v) Ecosystem help purify air and water.

(vi) Ecosystems are systems or units, hence we can apply modeling to understand their behavior, make predictions for future and plan management in view of changing environmental conditions.

Classification of Ecosytems

Ecosystems may be classified in different manners:

(a) Based on exchange of matter and energy they can be of two types:

(i) Open ecosystems: When there is free exchange of matter and energy.

(ii) Closed ecosystem: When there is no exchange of nutrients from outside.

b) Based on their creation ecosystems are of two types:

(i) Natural ecosystems that are of natural origin e,g. Forest ecosystem, grassland ecosystem, marine ecosystem, river ecosystem.

(ii) Man – made ecosystems that are created by human beings e.g. agro – ecosystem, rural ecosystem, urban ecosystem.

c) Based on habitat ecosystems can be classified as follows:

(i) Terrestrial ecosystems that occupy land portion of the biosphere. There ecosystems characterized by a distinct climate and species compositions are reffered to as biomass. Some important terrestrial ecosystems are forests, grasslands and desert ecosystems.

(ii) Aquatic ecosystems are the ecosystems present on fresh water or marine, habitats. Pond, lake ecosystems, river ecosystems, marine and estuarine ecosystem are some examples of aquatic ecosystems. A brief description of salient features of the important terrestrial and aquatic ecosystems is given below:.

Structural Components

1) Biotic structure: The plants, animals and microorganisms presnt in an ecosystem form the biotic component. These organisms have different nutritional behavior and status in the ecosystems and are accordingly known as Producers or Consumers, based on how do they get their food.

a) Producers: They are mainly the green plants, which can synthesize their food themselves by making use of carbon dioxide present in the air and water in the presence of sunlight by involving chlorophyll, the green pigment present in the leaves, through the process of photosynthesis.

b) Consumers: All organisms which get their organic food by feeding upon other organisms are called consumers, which are of the following types:

(i) Herbivores (Plant eaters): They feed directly on producers and hence also known as primary consumers (e.g. rabbit, insects, many birds).

(ii) Carnivores (meat eaters): They feed on other consumers, IF they feed on herbivores they are called secondary consumers (eg. Frog) and if they feed on other carnivores, they are known as tertiary carnivores / consumers (e.g snakes, big fishes, wolf).

(iii) Omnivores: They feed on both plants and animals (e.g humans, rat fox, many birds).

(iv) Detritivires (Detritus feeders or Saprotrohs): They feed on the parts of dead organisims, wastes of living organisms, their cast – offs and partially decomposed matter (e.g beetles, termites, ants crabs, earthworms etc.)

c) Decomposers: They derive their nutrition by braking down the complex organic molecules to simpler organic compounds and ultimately into inorganic nutrients. Varoius bacteria and fungi are decomposers.

2) Aboitic structure: They physical and chemical components of an ecosystem constitute its abiotic system structure. It includes climate factors, edaphic (soil) factors, geographical factors, energy, nutrients and toxic sunstances.

a) Physical factor: The sunlight and shade, intensity of solar flux, duration of sun hours, average temperature, maximum – minimum tempaerature, annual rainfall, wind, latitude and altitude, soil type, water availability, water currents etc are some of the important physical features which have a strong influence on the ecosystem.

b) Chemical factors: Availabiltiy of major essential nutrients like carbon, nitrogen, phosphorus, potassium, hydrogen, oxygen and sulphur, level of toxic substances, salts and various organic substance present in the soil or water largely influence the functioning of the ecosystem.

Functions of Ecosystems

The major functional attributes of an ecosystems are as follows:-

Food chain, Food Pyramid, Energy Pyramids, food weds and trophic structure.

1) **Food chains:** The sequence of eating nad being eaten in an ecosystem is known as food chain. All organisms, living or dead, ae potential food for some other organism and thusm there is essentially no waste in the functioning of a natural ecosystem. A caterpillar eats a plant leaf, a sparrow eats the caterpillar, a cat or a hawk eats the sparrow and when they all die, they are all consumed by microorganisms like bacteria or fundgi (decomposers) which break down the organic matter and convert it into simple inorganic substances that can again be used by the plants the primary producers. Some common examples of single food chains are:

- Grass – Grasshopper – Frog – Snake – Hawk (Grassland ecosystem)
- Phytoplanktons- water fleas – small fish – Tuna (Pond ecosystem)
- Lichens – reinder – Man (Arctic tundra).

2) **Food Web:** Food chains in ecosystem are rarely found to operate as isolated linear sequences. Rather, they are found to be interconnected and usally form a complex network with several linkages and are known as food webs. Thus, food web is a network of food chains where different types of irganisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level.

Illustrates an examples of a food web in he unique Antarctic Ecosystem. This is representing the total ecosystem including the Antarctic sea and the continental land. The land does not show any higher life forms of plants. The only species are that of some algae, lichens and mosses. The animals include penguins and and snow petrel which depend upon the aquatic chain for their food energy.

In a tropical region, on the otherhand, the ecosystems are much more complex. They have a rich species diversity and therefore, the food webs are much more complex.

Why nature has evolved food webs in ecosystems instead of simple linear food chains? This is because food webs give greater stabliltiy or one species suffers then the species in the subsequent trophic levels are also affected. In a food web, on the other hand, there are a number of options available at each trophic level. SO if one species is affected, it does not affect other trophic levels so seriously.

Just consider the simple food chains of Arctic Tundra ecosystem.

Cladonia – Reindeer – Man

Grass _ Caribou – Wolf

IF due to some stree, the population of reindeer or Caribou falls it will leave little option for man or wolf to eat from the ecosystem. Had there been more biodiversity, it would have led to complex food web gicing ecosystem more stability.

Sugnificance of food chains and food webs

- Food chains and food webs play a very significant role in the ecosystem because the two most important functions of energy flow and nutrient cycling take place through them.
- The food chains also help in maintaining and regulationg the population size of different animals and thus, help maintain the ecological balance.

Ecological Pyramids

Graphics representation of trophic structure and function of an ecosystem, staring with produces at the base snd successive trophic levels forming the apex is known as an ecological pyramid. Ecological pyramids are of three types:

1) **Pyramid of numbers:** It represents the number of individual organisms at each trophic level. WE may have upright or inverted pyramid of numbers, depending upon the type of ecosystem and food chain as shown in fig. A grass land ecosystem and a pond ecosystem show an upright pyramid of numbers. The producers in the grasslands are grasses and that in a pond are phytoplanktons (algae etc.,) which are small in size and very large in number. So the producers form a board base. The herbivores in a grassland are insects while tertiary carnivores are hawks or other birds which are gradually less and leess in number and hence the pyramid apex becomes gradually narrower forming an upright pyramids. Similar is the case with the herbivores, carnivores and top carnivores in pond which decrease in number at higher trophic levels.

In a forest ecosystem, big trees are the producers, which are less in number and hence form a narrow base. A large number of herbivores including birds, insetc and several species of animals feed upon the trees (on leaves, fruits, flowers bark, etc.) and form a much broader middle level. The secondary consumers like fox, snakes, lizards etc. are less number than herbivores while top carnivores like lion, tiger etc. are still smaller in number. SO the pyramids is narrow on both sides and broader in the middle.

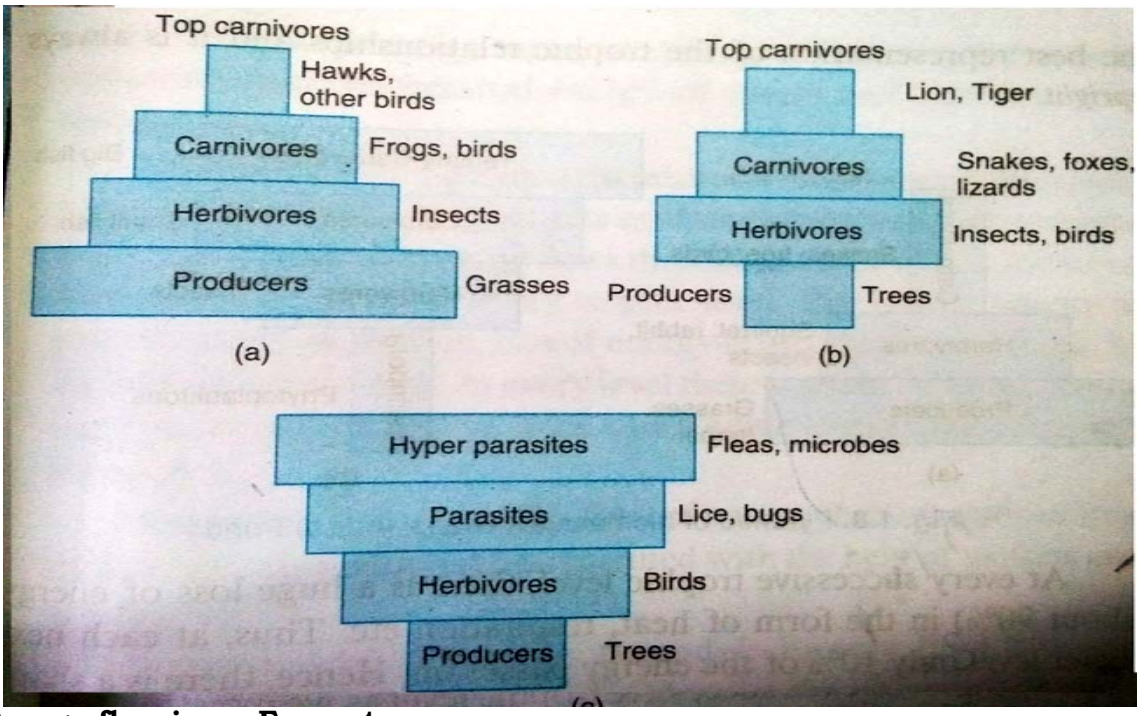
Parasitic food chain shows an inverted pyramid of number. The producers like a few big trees harbor fruit eating birds acting like herbivores which are larger in number. A much higher number of lice, bugs etc, grow as parasites on these birds while a still greater number of hyperparasites like bugs, fleas and microbes feed upon them, thus making an inverted pyramid.

2) **Pyramid of biomass:** It is based upon the total biomass (dry matter) at each trophic level in a food chain. The pyramid of biomass can also be upright or inverted. Show pyramids of biomass in a forest and an aquatic ecosystem. The pyramid of biomass in a forest is upright in contrast to its pyramid of numbers. This is because the producers (trees0 accumulate a huge biomass while the sonsumers total biomass feeding on them declined at higher trophic levels, resulting in broad base and narrowing top.

The pond ecosystem shows an inverted pyramid of biomass. The totak biomass of producers (phytoplansktons) is much less as compared to herbivores (zooplanktons, insects, carnivores (small fish) and tertiary carnivores (big fish). Thus the pyramid takes an inverted shape with narrow base and broad apex.

3) **Pyramid of Energy:** The amount of energy present at each trophic level is considered for this type of pyramid. Pyramid of energy gives the best representationof the trophic relationship and it is always upright.

At every successive trophic level, there is a huge loss of energy (about 90%) in the form of heat, respiration etc. this, at each next higher level only 10 % of the energy passes on. Hence, there is a sharp decline in energy level of each successive trophic level as we move from producers to top carnivores. Therefore, the pyramid of energy is always upright.



Energy flow in an Ecosystem

Flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the ecosystem going. The most important features of this energy flow is that it is unidirectrional or one – way flow. Unlike the nutrients (like carbon, nitrogen, phosphorus ect) which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain. Also, the flow of energy follows the two laws of Thermodynamics:

First Law of Thermodynamics states that energy can neither be created nor be destroyed but it can be transformed from one form to another. The solar energy

captures by the green plants (producers) gets converted into biochemical energy of plants and later into that of consumers.

Second Law of Thermodynamics states that energy dissipates as it is used or in other words, it gets converted from a more concentrated to dispersed form. As energy flows through the food chain, there occurs dissipation of energy at every trophics level. The loss of energy takes place through respiration, loss of energy in locomotion, running, hunting and other activities. At every level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only about 10%.