ICPE Envis Eco-Echoes

INDIAN CENTRE FOR PLASTICS IN THE ENVIRONMENT

Management of Plastics, Polymer wastes and Biopolymers and impact of Plastics on the Eco-system

Sponsored by Ministry of Environment, Forests & Climate Change, Government of India

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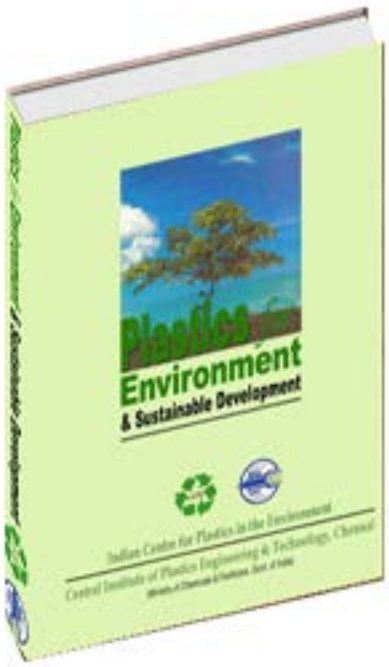

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Envis Eco-Echoes

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Editorial

NAME OF THE ENVIS CENTRE

INDIAN CENTRE FOR PLASTICS IN THE ENVIRONMENT

401, 4th Floor, Choksey Mansion
303, Shahid Bhagat Singh Road,
Fort, Mumbai - 400 001.
Tel.: +91 22 4002 2491, 2261 7137 / 7165
Fax: 2261 7168
E-mail: icpe@icpe.in, icpe@envis.nic.in

Web sites
www.icpeenvis.nic.in
www.icpe.in

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57 , LGF, WTC,
Babar Raod, New Delhi - 110 001.
Tel.: 011 4359 6329 • Telefax: 011 2332 6376
E-mail: icpedelhi@airtelmail.in

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Area of Activity

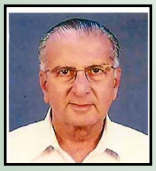
Capacity Enhancement Programme on Management of Plastics, Polymer Waste and Bio-Polymers, Impact of Plastics on Eco-System

Head of Institution

Mr. K. G. Ramanathan-
President - GC

Other Office Bearers

Mr. S. K. Ray
Hon. Secretary



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Hon. Treasurer /
Member - EC

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NGO - Project
Member - GC

ICPE-ENVIS Co-ordinator

Mr. T. K. Bandopadhyay
Technical Director

Designed By

Mr. Sudheer Khurana
Sr. Programme Officer

In this last edition of ICPE ENVIS Newsletter, we reproduce the FOREWORD written by Prof. M. M. Sharma (F.R.S.) and Dr. R. A. Mashelkar (F.R.S.) for the Monograph – "Plastics for Environment and Sustainable Development" published by ICPE in 2002-03. The scientific facts remain true even today except for the updates in consumption figure of plastics in the world today which is around 300 MMT.

We also reproduce the article titled "Plastics and Environmental Implications" published during the first year of induction of ICPE in the ENVIS structure. The scientific analysis made during January – February 2004 on the subject is relevant even today. Consumption of plastics world wide has gone up to around 300 MMT in 2016 – 17. The LCA study reports by various international bodies have been published now. All the studies clearly indicate that plastics save Green House Gas emissions saving the Earth from Global Warming caused by alternate materials. Waste management technologies have vastly improved in the country during the last 15 years. ICPE has conducted pioneering research work, in collaboration with cement major ACC Ltd, and Madhya Pradesh Pollution Control Board, to establish for the first time in India the protocol of co processing of plastics waste in cement kilns. ICPE has also contributed for establishing the scientific use of plastics waste for the construction of bitumen road. Solutions of plastics waste management has been demonstrated by ICPE in pilot projects in Mumbai and Delhi.

As a knowledge centre on plastics, ICPE was selected by the MoEF to host an ENVIS Node in 2003, which was later on upgraded to a full-fledged ENVIS Centre. The performance and achievements of the Centre during the period 2003 till date in fulfilling the agenda have been well acknowledged by all concerned including the MoEF & CC and other Ministries as well as various other Institutions / Organisations including educational institutions in India as well as various other countries. MoEF had recognized the performance of the ICPE ENVIS Centre by accrediting 'A' Grade to the Centre continuously for four years since 2011-12. Very few subject-specific ENVIS Centres achieved such high-performance record. ICPE ENVIS Centre has disseminated and shared the knowledge on importance of segregation of dry and wet waste at the source to achieve the desired results of proper waste management system. Field study results were also shared. To be precise, real ground study on plastics waste management system for the country has been described by ICPE ENVIS Centre with examples. Various myths and realities on plastics, issues and challenges and solutions have been described by the Centre

All these information and data were disseminated by ICPE ENVIS Centre through its Newsletter and websites. As a consequence of MoEF & CC's decision to discontinue the ENVIS Centre at ICPE with effect from 1st October 2017, no further edition of the newsletter ICPE ENVIS Eco-Echoes Newsletter would be published after this current edition. Readers may however like to visit ICPE website www.icpe.in to preview all the information related to Plastics in the Environment. ICPE Newsletter: Echo-Echoes will continue to bring out relevant information on the subject. Readers may send their comments.

Subscription Information:

ICPE ENVIS Newsletter is sent free of cost to all those interested in the information on Plastics and Environment.

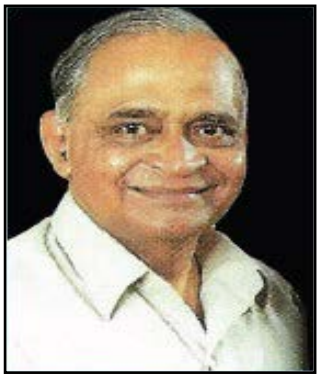
Readers are welcome to send their suggestions, contributions, articles, case studies, and new developments for publication in the Newsletter to the ICPE-ENVIS address.

Editor : Mr. T. K. Bandopadhyay

Plastics for Environment & Sustainable Development

We reproduce the FOREWORD written by Prof. M. M. Sharma (F.R.S.) and Dr. R. A. Mashelkar (F.R.S.) for the Monograph – "Plastics for Environment and Sustainable Development" published by ICPE in 2002-03. The scientific facts remain true even today except for some changes in consumption figure of plastics in the world today which is around 300 MMT.

FOREWORD



Prof. M.M. Sharma (F.R.S.)
Padma Vibhushan

Dr. R.A. Mashelkar (F.R.S.)
Padma Vibhushan

Plastics have moulded the modern world and transformed the quality of life. There is no human activity where plastics do not play a key role, from clothing to shelter, from transportation to communication and from entertainment to health care. Plastics, because of its many attractive properties, such as lightweight, high strength and ease of processing, meet a large share of the materials needs of man. From practically zero in the fifties, human kind today consumes greater than one hundred and fifty million tons of plastics. We truly live in a 'Plastics Age'. Our daily lives would be very much poorer without these benign and environmentally friendly materials. Plastics possess a unique combination of properties. Plastics can be super tough, rigid as well as flexible, transparent as well as opaque and can allow selective permeation or act as a barrier material.

Nature has produced 'plastic' like materials for centuries. Silk and cellulose are example of natural polymers. Reference to Shellac, a thermoplastic can be found even in Mahabharatha !

Growing population and consumption in India has put severe pressure on our natural resources and fragile eco-systems. The material needs of our population are growing and plastics offer a cost effective alternative.

Plastics are employed in myriad applications where they actually conserve natural resources. For example, asceptic packaging of food in barrier packaging films will render refrigeration unnecessary, saving capital and energy. Edible oils and milk are packaged in flexible packages eliminating the use of tin and glass containers. Rigid HDPE barrels are used for bulk chemical storage instead of steel drums. Apart from conserving natural resources, use of plastics in these applications saves transportation fuel as plastics are substantially lighter than tin, glass or steel.

Safe drinking water packaged in PET bottles are a very common sight now-a-days. They provide confidence to consumer on the quality of water and help reduce water-borne diseases. Advanced polymeric membranes help purify water from viruses and bacteria. They also provide potable drinking water from sea and brackish water through a process of desalination.

The fact that plastics are made from hydrocarbons derived from petroleum, which is non-renewable, has raised questions concerning its sustainability. Nevertheless, the consumption of petroleum hydrocarbon for the production of plastics is less than 5%, the balance being consumed as fuels and energy source. Consequently, the concerns about

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sustainability of plastic materials is somewhat exaggerated. On the contrary, processing of many natural materials (glass, paper, wood, metals0 consume far more energy and thus lead to greater consumption of fossil fuels. Additionally, research and development work currently in progress globally will provide future opportunities to make some of the plastics from biomass and other renewable resources. Thus, plastic manufacture will become even more sustainable in the years to come. It is fair to say that plastics replace several natural materials, which are either scarce, consume more energy for processing or cause damage to the eco-systems during their production. Thus use of plastics makes a positive contribution to the sustainability of earth's resources.

Another issue that is often discussed is whether because of their non-biodegradibility, plastics will cause damage to our eco systems. The signature of all natural materials made by biological processes is that they are biodegradable and bio-assimilable. The long life and desirability of plastics, which have made them, a material of choice for many applications is seemingly a disadvantage when it comes to their disposal. However, when handled properly, plastics do little damage to our environment. Plastics

Have the advantage that they can be easily reprocessed and recycled. In some cases, one can recover even the raw materials that were originally used in their manufacture. Plastics offer the unique advantage that one can recover the fuel value contained in the hydrocarbon polymer after its use. Plastics can also be made environmentally degradable, especially for packaging applications. There are expectations that in the near future plastics will be made even biodegradable and compostable so that waste plastics can be handled the same way as wet food waste and agricultural waste. The overall eco-friendliness of plastics become apparent when one evaluates the total 'life cycle' namely, an analysis of raw materials, energy, effluents, methods of disposal etc. of a material from its origin to its final disposal.

It is, therefore, very appropriate that the Indian Centre for Plastics in the Environment and Central Institute of Plastics Engineering and Technology are bringing about a monograph titled "Plastics for Environment and Sustainable Development". This monograph, which has chapters authored by several distinguished scientists and technologists from some of our leading R & D institutes will comprehensively address all issues concerning sustainability of plastics as materials and an assessment of the impact on environment. We do believe that the monograph will set to rest any lingering doubts about the sustainability of plastics as materials or their adverse impact on our environment and will lead to more enlightened discussion on the role of plastics in the armoury of materials used by men.

(Prof. M.M. Sharma)
Kothari Research Professor,

Jawaharlal Nehru Centre for Advanced Research
Former Professor of Chemical Engineering
& Director UDCT, Mumbai (India)

(Dr. R.A. Mashelkar)
Director General, CSIR

& Secretary, Department of
Scientific & Industrial Research
(Govt. of India)

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"World Bank Aided Program on Environmental Management Capacity Building Technical Assistance Project" and Sponsored by Ministry of Environment and Forests, Government of India.

Plastics and Environmental Implications

Excerpts from presentation by
T. K. Bandopadhyay, Technical Manager, ICPE

In 12,000 BC, first deliberate man- made fire was created. That was the real beginning of civilization. As the civilization progressed, so were the needs of the human race. Civilization brought about industrialization. Great inventions changed the world and brought comfort to our life style. These inventions have made a vast difference between the way of life as a human being and that of an animal. Industrialization has been rapid since the middle of the 19th century. The environmental effects of many inventions were far reaching. The development of industries have created enormous impact on the environment to such an extent that it has become a concern to the very existence of the civilization.

MAJOR REASONS

If we analyse different reasons for environmental pollution, we note that the following are the major ones:

- Air pollution due to various types of gaseous emissions and Suspended Particulate Materials (SPM).
- Water & soil pollution due to various types of effluents and disposal of other waste materials.
- Global warming due to industrial emissions, especially carbon dioxide.
- Depletion of Ozone layer resulting in penetration of harmful UV rays on the Earth's surface.

We will attempt to examine the role of plastics in each of these environmental issues:

First of all let us discuss about plastics materials. Carbon atom is the backbone of the chemical compounds that make up all living things. Carbon atoms can build up chain links to form a large molecular structure. The most abundantly naturally occur ring life process, plants, have this structure in the form of cellulose. And this cellulose was the mother of invention of plastics. In 1862, Alexander Parkes in Britain modified cellulose nitrate with camphor to produce the first man- made plastic material.

Since then, various types of plastics have been invented involving many chemicals organics as well as inorganic. Present annual consumption of plastics in the world is about 130 million tons which has almost doubled in last 30 years.

We will first try to analyse the impact of these plastics on environmental management. While analysing the impact/effect of material on the environment one should consider the Life Cycle Assessment (LCA) which includes the following aspects:

1. Production
2. Storage
3. Transportation/Delivery
4. Usage/ reusage
5. Disposal, up to final disintegration

Life Cycle Assessment is an important environmental management tool to know the impact of a product on environment from its manufacturing stage to its final disposal/ disintegration. However, LCA requires basic research to build up the data over a period of time. Some international organizations are con- ducting LCIA (Life Cycle Impact Assessment) on many products. LCIA on plastics products will be an important tool to compare plastics with other products in terms of pollution nature.

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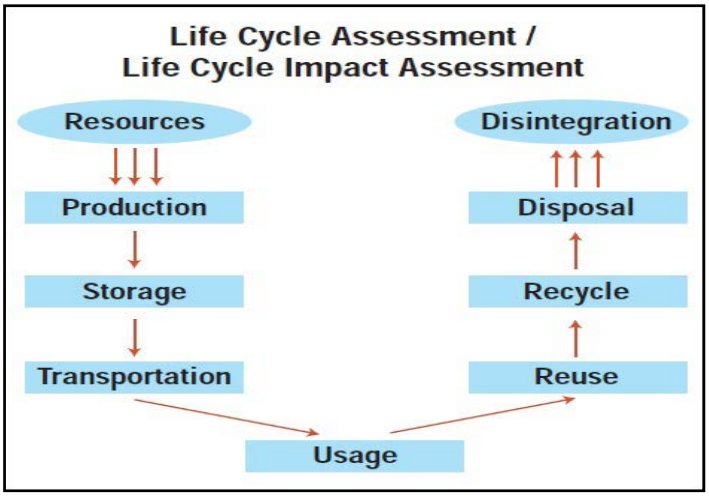
Till such time LCIA studies are re- leased and those results accepted by different countries, we may assess the issue of environmental pollution as per existing norms and rules.



AIR POLLUTION

Air Pollution is considered the most serious concern, mainly in the highly populated/industrial areas.

Table shows the major air pollutants and type of industries/sources responsible for such pollutions. The industries which have been identified as major sources of air pollution under this by Central Pollution Control Board (CPCB) are:

- Thermal Power Plants
- Brick Kilns
- Potteries
- Steel rolling plants and
- Induction furnaces

Plastics processing has been kept under non-polluting (Green) category. During production of commodity plastics raw materials, mainly four chemicals are involved which attract attention of critics. These are:

- Ethylene
- Propylene
- Chlorine / Vinyl Chloride Monomer (VCM), and
- Benzene

Critical characteristics and safety limits,TLV (Threshold Limit Value), IDLH (Immediately Dangerous to Life or Health) limit etc. are available.

PVC is the most controversial plastic material which attracts the attention and criticism of the environmentalists lobby and hence it is the most researched material all over the world. The topic is vast and calls for elaborate discussion. The major issues concerning PVC are:

Issue-1: PVC contains VCM - which is carcinogenic:
Most manufacturers are today offering PVC containing Residual Vinyl Chloride Monomer (RVCM) less than 5 ppm level - a safe limit for the environment. Some of the new plants can even boast of RVCM level of 1 ppm and below.

Issue-2: PVC evolves Chlorine and Hydrochloric Acid

Table : AIR POLLUTANTS AND THEIR EFFECTS ON ENVIRONMENT

Sno.	POLLUTANT	TYPE OF INDUSTRY/ SOURCE RESPONSIBLE	EFFECTS ON ENVIRONMENT
1	Suspended Particulate Matter (SPM)	Fuel burning, stacks of boilers, dust storm, volcanic eruptions, explosions, cement, mining	Deposition of leaves and hence reduced photosynthesis, respiratory diseases and pulmonary tuberculosis and bronchial asthma.
2	Sulphur Dioxide (SO_2)	Fuel burning, sulphuric acid, incineration of city's solid wastes, chemical industries, smelting, refinery.	Acid rains, leaf burn, chlorophyll destruction, corrosion of stones, and monuments, damage of testicles, irritation to membranes and lachrymal, reduced visibility, asthma.
3	Oxide of Nitrogen (Nox)	Petroleum operations, industrial and automobile combustion, lightning.	Irritation to mucous membranes, chlorotic mot premature needle drops, rymation.
4	Carbon Monoxide (CO)	Incomplete combustion of fuels and hydro carbons in industry and automobiles.	Asphyxiating gas in enclosed places, headache, loss of visu-al acuity, loss of a lity to accurately estimate time intervals, decrease in muscular co-ordination, loss of oxygen from blood, disruption of nitrogen fixation free living bacteria and nitrogen fixers.

* Plastics are not considered as sources of these pollutions.

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(HCl) during processing, which are hazardous: If enough HCl is evolved from PVC during processing, then the product degrades which is indicated by yellowing, browning and ultimately blackening of the product. In reality, HCl is not allowed to evolve from PVC during processing by the action of stabilizers which fix the HCl inside the compound itself, thus preserving loss of the basic property of the product.

Issue-3: PVC uses many heavy metals as stabilizers - which are hazardous:

Yes, one of the earliest and most efficient stabilizers for PVC was Lead and its salts. However, the development of newest stabilizers/ additives have already started replacing many controversial stabilizers' cost. For food contact applications safe additives/stabilizers are already being used. In India, Bureau of Indian Standard (BIS) have laid down these limits and any PVC product bearing 'ISI' mark comply with these.

Issue-4: PVC evolves Dioxin during incineration:

The American Society of Mechanical Engineers (ASME) has concluded in a recent study that there is no correlation between the amount and type of chlorine in the waste stream and the amount of Dioxin emitted by waste incinerators. It is now widely believed that, incinerator design and operating conditions are the keys to control Dioxin. As per the draft report of US EPA, Dioxin in the atmosphere in 2000 has reduced by 1/3rd as compared to that in the seventies, whereas the production of plastics raw materials has tripled during the same time. This proves that Dioxin and plastics are not correlated.

Issue-5: Fire situation in building emit toxic gases due to burning of PVC items:

PVC is generally fire resistant. It does not catch fire by itself. Moreover in fire situation the types of gases emitted from other building materials cause same or a more severe type of hazardous situation as done by PVC. PVC cannot be singled out as the only reason for fatal injury to human lives during fire situation. PVC does not have any additional toxicity risks under fire situation. During fire situation, PVC, like all organic materials, releases gases which are toxic. Hydrochloric acid, a product released during PVC fire, is not a killer gas in the amounts normally released. A study report shows that it would require about 30 minutes exposure to hydrogen chloride released from the PVC present in a typical room fire to inhale a lethal dose. Long before that, a person trapped in a room fire would have died from the carbon monoxide released by all other organic materials (wood, clothes, etc.) in the room, or from heat and flame exposure. While hydrogen chloride has a characteristic pungent odour to give signals of danger to the people, carbon monoxide, being odourless, does not give any indication of the impending danger.

WATER AND SOIL POLLUTION

Plastics do not pollute water. In fact most plastics materials may be used in contact with food products. Potable water is stored and delivered through plastics. Plastics processing industries do not generally have scope of releasing any effluent except water itself which is used as cooling agent.

DISPOSAL

There are options for disposal of plastics items. These are - Reuse, Recycle, Disintegration through incineration and Land filling. Biodegradable and Photodegradable plastics also have been developed. In any of these options, plastics by themselves do not pose any problem. Civic awareness and strict control of methods of disposal are the keys to the treatment of plastic wastes required. There is a general concern that plastic carry bags often choke the municipal drainage system. Here, it may be mentioned that, there are many other things which may choke the drainage system. There should be a social awareness that plastics items (any item for that matter) should be disposed off in a correct manner. If we want to live in the comfort of an urban life style and if we want to take advantage of technological developments in our lives, we must behave ourselves.

USAGE/REUSAGE

Plastics are used in:

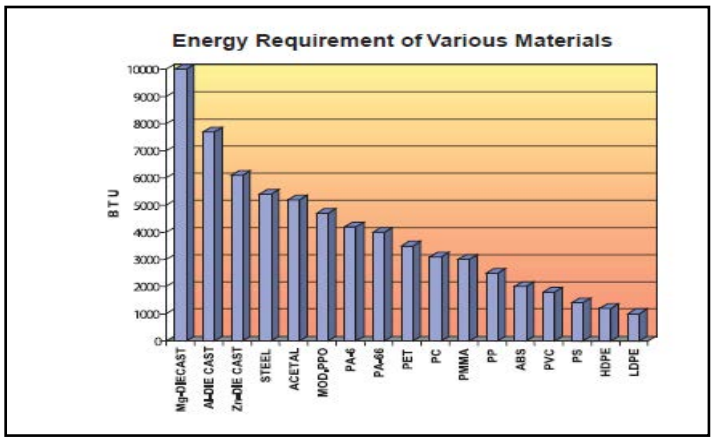
- Packaging
- Buildings including furniture
- Pipes
- Cables
- Electronics & Electricals
- Automobiles and Aviations
- Medical including population control systems
- Agriculture and water management
- Appliances and household products
- Many other applications

In all the above cases plastics always preserve the natural resources/ energy and help to keep the environment clean. In some cases plastics are the only material for

use. Reuse/Recycle of plastics is very much possible for which detailed procedures are well developed.

GLOBAL WARMING

Global warming-up is a major concern today. Temperature on earth is increasing. However, plastics cannot be considered as the cause of global warming.



In fact, plastics consume less energy for conversion compared to many other materials (Graph). Lesser consumption of energy means lesser requirement of electricity or other energy resources most of which pollute the environment. Imbalance in carbon dioxide generation, which is the major cause of global war ming-up is caused by many reasons. Contribution of plastics in causing imbalance in carbon dioxide generation is negligible.

DEPLETION OF OZONE LAYER

There are certain chemicals which have been identified as Ozone Depleting Substances (ODS's). They cause depletion of Ozone layer. CFC (Chloro Fluoro Carbon) is one of them. CFC-11 is used as blowing agent in certain plastics to give foamy structure. Hydro carbons, specifically cyclopentane is reported to have replaced CFC-11 blowing agent. Other ODS substances are Halons, Carbon, Tetrachloride (CTC) and Methyl Chloroform (MCF). These do not find applications in the manufacture of commodity plastics.

STORAGE & TRANSPORTATION

Storage and Transportation of plastics products do not create any environmental pollution. In fact, transportation of various products in plastics containers/ pack- ages save enormous amounts of fuel due to the very low density of plastics materials. The positive contributions of plastics in maintaining the ecological balance are many: One MT of plastics product replaces the wooden products derived out of 5 matured trees. Considering at least 10 years for a tree to mature (which is much more in case of many trees) we may analyse the benefit we derive by using plastics for manufacturing furniture/building materials, packaging materials, etc. Afforestation is a prime factor for preserving the earth's environment. Plastic nursery bags help in the social forestry programme. Geo textiles, plastic films help in restricting soil erosion and water seepage in canals and other areas. Plastics mulching increases agricultural production. Plastics drip laterals are employed for proper water management and to achieve higher agricultural yield. Green Houses made of plastics films enable agricultural products to be grown in places where otherwise it is not possible.

CONCLUSION

In conclusion it is clear that plastics protect the environment by con- serving precious natural resources and energy. While policy makers in the Government have already taken decisions to use plastics in various applications, more such decisions may be taken to make use of plastics mandatory in areas where it replaces wood and other natural resources and where it prevents use of many environmentally hazardous substances.

Editor's comments:

In this last edition of ICPE ENVIS Newsletter we reproduce the article titled "Plastics and Environmental Implications" published during the first year of induction of ICPE in the ENVIS structure. The scientific analysis made during January – February 2004 on the subject is true even today. Consumption of plastics world wide has gone up to around 300 MMT. The LCA study reports by various international bodies have been published now. All the studies indicate that plastics save GHG emissions. Waste management technologies have vastly improved in the country during the last 15 years. We are confident, that the Plastic Waste issues can be resolved scientifically in the near future.

Awareness Campaign For Science Express by ICPE ENVIS Centre from 19th July to 21st July, 2017 at Chhatrapati Shivaji Maharaj Terminus Railway Station, Mumbai

Science Express Climate Action Special (SECAS) is an innovative mobile science exhibition mounted on a 16 coach AC train which has been custom-built for Department of Science & Technology (DST) by Indian Railway. It aims to create awareness among various sections of society, especially students, as to how Climate Change can be combated through mitigation and adaptation. The train travels through a pre-decided rout of stations covering the entire country. The SECAS was scheduled to visit Chhatrapati Sivaji Maharaj Station during 19th to 21st July, 2017. ICPE ENVIS Centre, as per direction of MoEF & CC, had participated in the Science Express Climate Special event at CSTM Station during this period by way of organizing awareness programmes among the students at the location where the SECAS train was parked. About 50, 000 students visited the event.

The awareness programme comprised of display of panels, distribution of pamphlets and organising of Quiz Programmes. Display panels included:

- Why Plastics? - benefits of plastics compared to alternatives,
- Issues on environmental pollution created by human actions & inaction littering and improper waste management
- Technical solutions for plastics recycling / recovery.

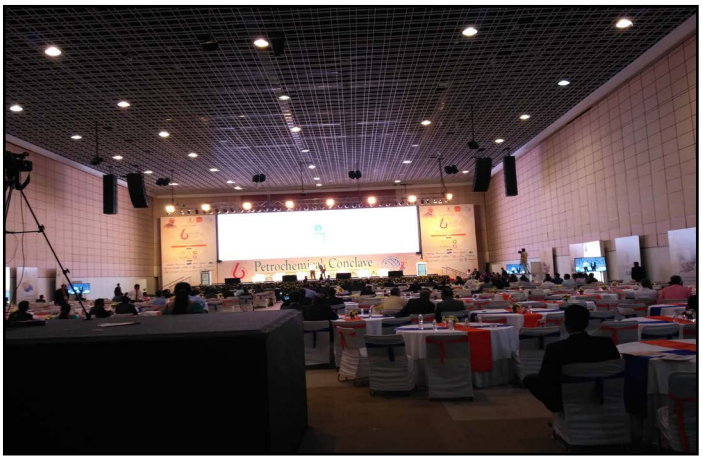
Although space was available in the railway platform, however not enough space was allotted to ENVIS Centre for displaying all panels (due to security reasons). To establish direct interaction with the students, special Quiz Programme was organized for the students wherein the students were encouraged to answer 10 questions printed in one page. Emphasis was given on segregation of waste: Dry and Wet, at source and its recycling / composting etc. scientifically. Students who answered correctly 5 or more questions were given chocolates as prize. The teachers accompanying students were approached for allowing their students to take part in the contest and the students voluntarily took part in the same. About 1000 students took part in the contest. All the filled-up answer sheets have been preserved for any future reference. Detail information of the students have been preserved. About 80% participating students successfully answered 5 or more questions however there was lack of awareness about what were Dry and Wet waste. Students were appraised about the correct answers.

Awareness Campaign For 6th Petrochemical Conclave on 29th July, at Mahatma Mandir, Gandhinagar, Gujarat

The global chemical and petrochemical demand is currently estimated to be around 590 MMT and is expected to reach 700 MMT by 2020. China is expected to contribute almost 40% of this rise in demand while rest of Asia including India is expected to contribute 15-16%. The world average per capita consumption of Polymers is currently about 35 Kg/person.

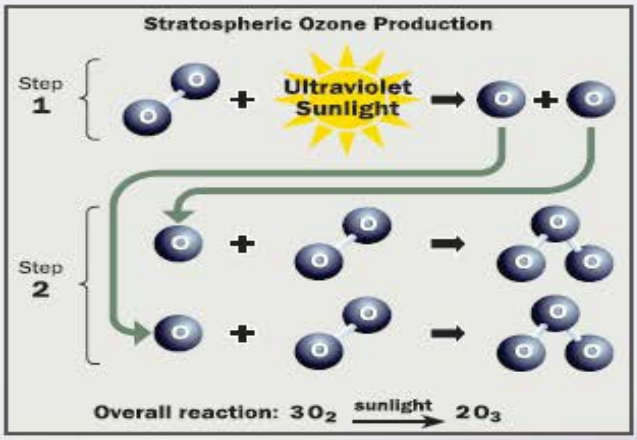
The Indian chemical and petrochemical industry demand growth has consistently outperformed the GDP growth rates of India – growing at around 1.5 times the GDP growth rate. Major chemical and petrochemical demand in India is currently estimated to be around 30 MMT and growing at a CAGR of 9%. The total chemical and petrochemical market in India is currently valued at approximately $50 billion and had registered a growth of 11% per annum during the FY11-FY15 period. Despite this high growth, average domestic per capita consumption of Polymers is only about 10 Kg/person (~12 Kgs in 2016-17) compared to about 40 Kgs for China. Therefore, India is expected to witness a high growth trajectory in chemicals and petrochemicals consumption, driven by high GDP growth and low per capita consumption. ***(Source: IOCL)***

In this context, Indian Oil Corporation Limited, under the aegis of Minister of Petroleum & Natural Gas, Government of India, organised the 6th edition of the Petrochemical Conclave at Gandhinagar, Gujarat, India on 29th of July 2017. The theme of the Conclave was "India Petrochemicals 2030 - Opportunities and Challenges". The Conclave was inaugurated by Shri Dharmendra Pradhan, Hon'ble Minister of State (In Charge), Ministry Of Petroleum & Natural Gas, Govt. of India. Other Ministers and dignitaries from the Ministry were also present in the event.
On invitation ICPE ENVIS Centre had participated in the exhibition organised during the Conclave showcasing the impotence of plastics in our day to day life, various environmental issues on plastics including the waste management and scientific solutions thereof. Using Display Panels, Screening of Short Awareness Films and distribution of Pamphlets ICPE ENVIS Centre had disseminated the scientific information on the subject.

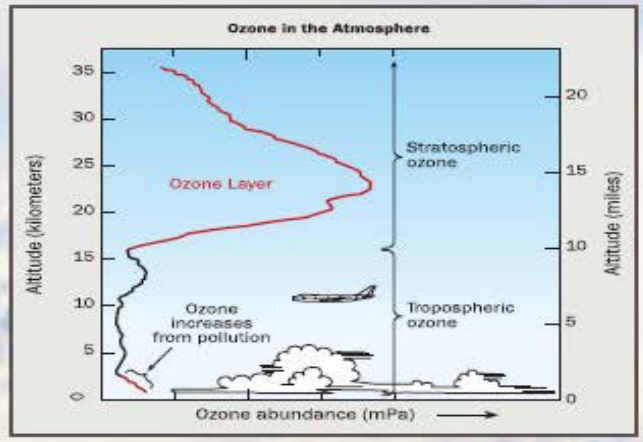


DATA SHEET

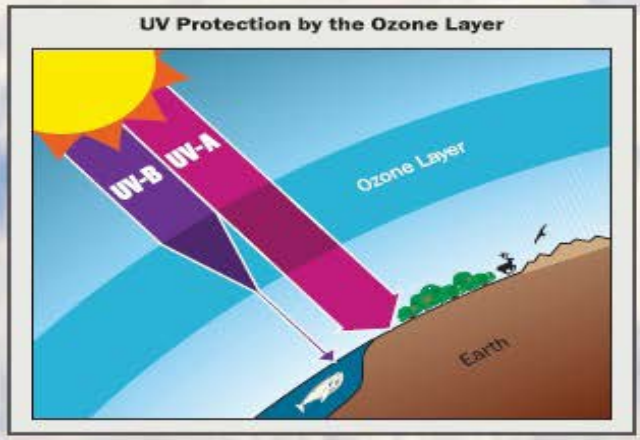
Stratospheric Ozone Layer



- Ozone is a tri-atomic molecule of oxygen
- Formed naturally in the upper level of the Earth's atmosphere
- Three molecules of oxygen in the presence of sunlight form two molecules of Ozone in the stratosphere



- Stratosphere extends between 10-50 kilometeres above the earth surface
- 90% of ozone formed in the atmosphere is present in the Stratosphere, hence called Stratosphere Ozone Layer



- Stratospheric Ozone Layer absorbs a large part of the Sun's biologically harmful UV-B ultraviolet radiation

Source (figures):
Michaela I. Hegglin (Lead Author), David W. Fahey, Mack McFarland, Stephen A. Montzka, and Eric R. Nash, Twenty Questions and Answers About the Ozone Layer: 2014 Update, Scientific Assessment of Ozone Depletion: 2014, 84 pp., World Meteorological Organization, Geneva, Switzerland, 2015.

Ministry of Environment, Forest & Climate Change

For further information
Ozone Cell, Ministry of Environment,
Forest and Climate Change
Government of India
Core-4B, 2nd Floor, India Habitat Centre,
Lodhi Road, New Delhi-110 003
Tel: 011-24642176; Fax: 011-24642175
Email: pmucfc-mef@nic.in, Website: www.ozonecell.com

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Science of Ozone Layer Depletion

Principal Steps in the Depletion of Stratospheric Ozone

1 Emissions

Human and natural processes emit Halogen source gases, which contain chlorine and/or bromine, at earth's surface. Halogen source gases are often referred to as Ozone Depleting Substances (ODSs). Human activities generate major proportion of ODSs as compared to natural sources.

2 Accumulation

ODSs accumulate in the atmosphere and are globally distributed throughout the lower atmosphere by winds and other air motions.

3 Transport

ODSs are transported to the stratosphere by air motions.

4 Conversion

Most ODSs are converted in the stratosphere to reactive halogen gases in chemical reactions involving ultraviolet radiation from the sun.

5 Chemical reaction

Reactive halogen gases cause chemical depletion of stratospheric ozone over the globe.

Low temperature surface reactions on polar stratospheric clouds (PSCs) significantly increase reactive halogen gases and thereby cause severe ozone loss in polar regions in late winter and early spring.

6 Removal

Air containing reactive halogen gases returns to the troposphere where the gases are removed by moisture in clouds and rain.

Source:
Michaela I. Hegglin (Lead Author), David W. Fahey, Mack McFarland, Stephen A. Montzka, and Eric R. Nash, Twenty Questions and Answers About the Ozone Layer: 2014 Update, Scientific Assessment of Ozone Depletion: 2014, 84 pp., World Meteorological Organization, Geneva, Switzerland, 2015.

Ministry of Environment, Forest & Climate Change

For further information
Ozone Cell, Ministry of Environment,
Forest and Climate Change
Government of India
Core-4B, 2nd Floor, India Habitat Centre,
Lodhi Road, New Delhi-110 003
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Email: pmucfc-mef@nic.in, Website: www.ozonecell.com

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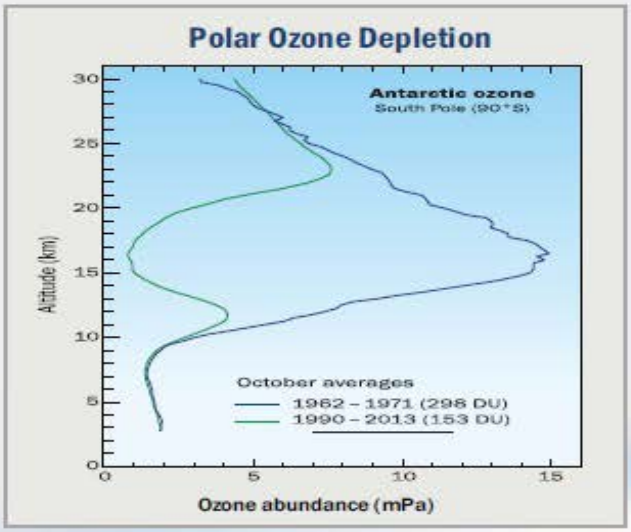
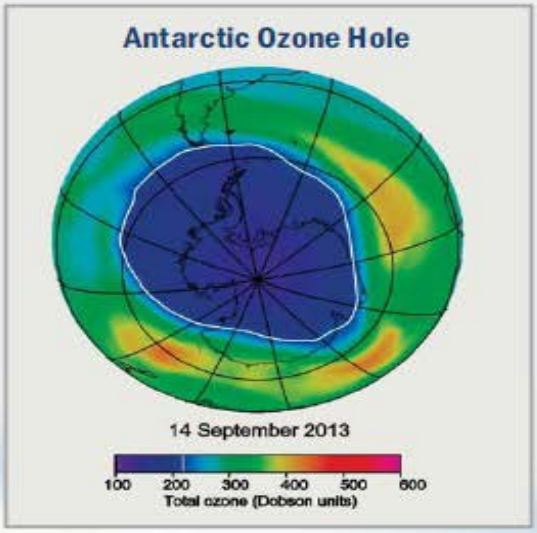
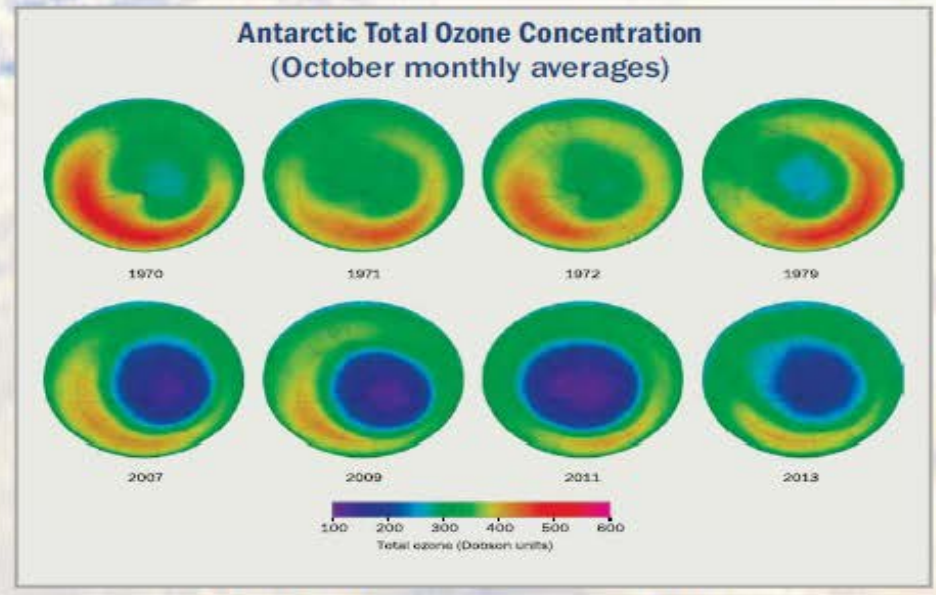
Antarctic Ozone Hole



Vertical distribution of Ozone in Stratosphere over Antarctica



Antarctica Ozone Hole in 2013
(Blue region depicts extremely low concentration of ozone over Antarctica)



Changes in Ozone concentrations over Antarctica
(1970-2013)

Source:
Michaela I. Hegglin (Lead Author), David W. Fahey, Mack McFarland, Stephen A. Montzka, and Eric R. Nash, Twenty Questions and Answers About the Ozone Layer: 2014 Update, Scientific Assessment of Ozone Depletion: 2014, 84 pp., World Meteorological Organization, Geneva, Switzerland, 2015.

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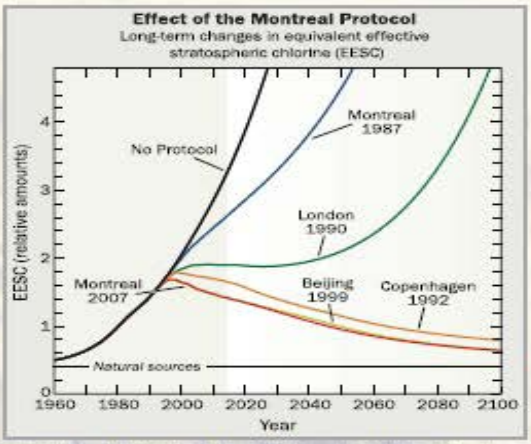
International Actions for Protection of the Ozone Layer

- Vienna Convention for the protection of Ozone Layer – 22nd March, 1985
- Montreal Protocol on substances that Deplete the Ozone Layer - 16th September, 1987

  Amendments to the Montreal Protocol
  - Montreal - 1987
  - London - 1990
  - Copenhagen - 1992
  - Beijing - 1999
  - Kigali - 2016
- Implementation of the Montreal Protocol has led to phase-out of major Ozone Depleting Substances such chlorofluorocarbons (CFCs), Halons, carbon tetrachloride (CTC) and methyl bromide globally, Hydrochlorofluorocarbons (HCFCs) are still being phased-out.
- Montreal Protocol is the only environment treaty having universal ratification of 197 UN member countries.
- Montreal Protocol has not only phased-out Ozone Depleting Substances, but has also provided significant climate co-benefits by avoiding 135 billion tonnes of CO_2 equivalent emissions in the atmosphere.
- As per estimates, Montreal Protocol has led to reduction is two million skin cancer cases per year globally by 2030.
- Ozone Depleting Substances not only have Ozone Depleting Potential, but also have high global warming potential.



Source (graphic):
Michaela I. Hegglin (Lead Author), David W. Fahey, Mack McFarland, Stephen A. Montzka, and Eric R. Nash, Twenty Questions and Answers About the Ozone Layer: 2014 Update, Scientific Assessment of Ozone Depletion: 2014, 84 pp., World Meteorological Organization, Geneva, Switzerland, 2015.

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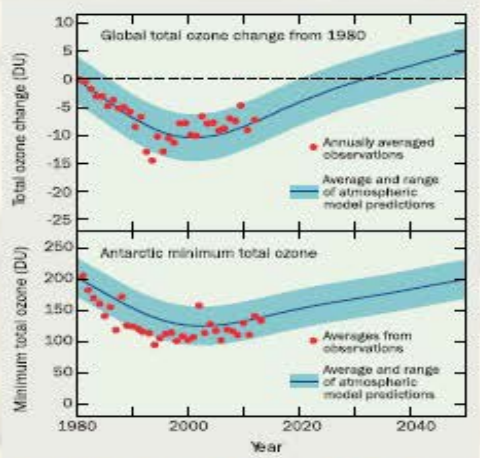
How can you help protect the Ozone layer

- Dispose of old air conditioners and refrigerators containing Ozone Depleting Substances (ODSs) responsibly. Refrigerants should be removed from an appliance before it is discarded.
- Old portable Halon fire extinguisher should be returned for cycling
- Use ozone friendly products. Replace old ODS based equipment with non-ODS equipment
- Buy products (refrigerators, air-conditioners, fire extinguishers, etc.) that do not have ODSs
- Spread awareness about protection of Ozone Layer, and ozone depleting substances

Collective global action has led to the signs of recovery of ozone layer

Simulation results showing trend towards recovery of ozone layer



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Do Not Litter
Keep Your Environment Clean

- Segregate and Throw Waste Only in Waste Bins.
- Use Two Bins - One for Wet Waste, One for Dry Waste

Plastics, Metals, Paper ...
Can be recycled into useful products

Waste Food and other Biodegradable Waste
Can be composted into manure

Indian Centre for Plastics in the Environment