

- Climate change is increasing vector population:
  - » Mosquitoes are now able to breed throughout the year.
  - » Breeding behaviours of mosquitoes have also changed over the years. Now, they can lay eggs in dirty waters too. There is evidence that Aedes mosquitoes can breed in brackish water too.
  - » Artificial lights have increased the feeding period of Aedes mosquitoes.
- Other factors
  - » Aedes aegypti has also developed resistance to common insecticide permethrin.

## 16) WORLD MOSQUITOE PROGRAM (WMP)

- Intro
  - » WMP is a not-for profit initiative that works to protect the global community from mosquito-borne diseases such as Zika, Dengue, Chikungunya.
  - » Pioneered by Australian researchers, the WMP uses safe and natural bacteria called Wolbachia to reduce the ability of mosquitoes to transmit these viruses.
  - » WMP was first launched in Australia in 2011 and has expanded rapidly since then.
- About Wolbachia
  - » Wolbachia is a natural bacteria present in upto 60% of insect species, including some mosquitoes. It is one of the most common parasitic microbes and is possibly the most common reproductive parasite in the biosphere.
  - » However, they are naturally not found in Aedes aegypti mosquito.
- WMP research has shown that when introduced in Aedes aegypti mosquito, Wolbachia can help reduce the transmission of these virus in people. When introduced into this mosquito's cells, this parasite competes successfully against other parasites such as the viruses that cause dengue, chikungunya, yellow fever, Zika etc. Thus, it can be used to fight life-threatening diseases.
  - In a study in Djakarta, the number of cases saw a decline of 77% in the number of cases and a decline of 86% in hospitalizations due to dengue.
  - » Video link: [World Mosquito Program - Our Wolbachia method](#)

## 17) KYASANUR FOREST DISEASE (KFD) / MONKEY FEVER

- **Introduction**
  - » KFD is caused by KFDV, a member of virus family **Flaviviridae**. It was first identified in 1957 when it was isolated from a sick monkey in Kyasanur Forest in Karnataka state India.
  - » Since then, about 400-500 cases are reported every year from the state.
- **Reservoirs for Virus**
  - » **Hard Ticks** (*Hemaphysalis spinigera*) are the reservoir of the KFD virus and once infected, remain so for life.
  - » **Monkeys, shrews, and Rodents** are common hosts for KFDV after being bitten by an infected tick.
- **KFDV can cause epizootics** with high fatality in primates.
- **Transmission**
  - » Infected tick bite or contact with an infected animal (monkey, shrew etc.). No person-to-person transmission has been known so far.
  - » Transmission from other infected animals like goats, cows etc is extremely rare.
- **Symptoms**
  - » Chills, fever, headache, muscle pain, low platelet, low RBCs and WBCs.
- **Treatment:** No specific treatment -> hospitalization and support therapy like hydration and usual precautions is important.
- **Vaccine:** Yes; Used in endemic areas of India.
- **Distribution** Historically limited to western and central district of Kar, India. However, some samples have also been found from Tamil Nadu and Kerala.

## 18) INFLUENZA

### A) INFLUENZA A VIRUS

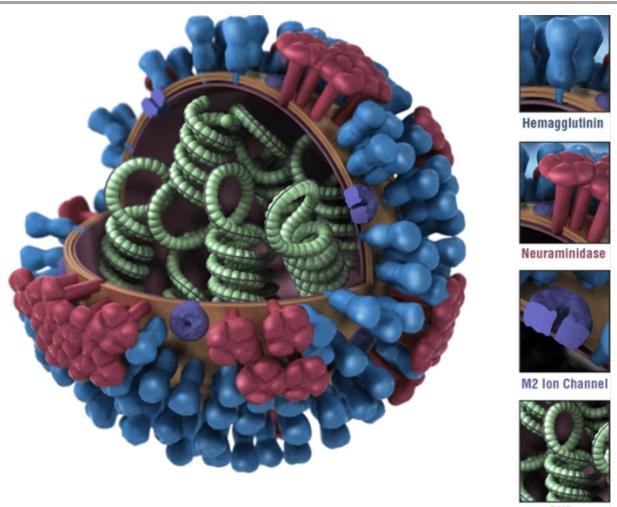
There are four types of Influenza viruses: A, B, C, and D. Influenza A and B viruses cause seasonal epidemics of diseases.

Influenza A viruses are the only influenza viruses known to cause flu pandemics (i.e. global epidemics of flu diseases)

Influenza A virus is the only species of the genus *Alphainfluenzavirus*. It is an RNA virus.

Influenza A viruses are divided into subtypes based on two proteins on the surface of the virus: hemagglutinin (H) and neuraminidase (N).

- There are 18 hemagglutinin subtypes (H1 - H18) and 11 different neuraminidase subtypes (N1 - N11)



More than **130 influenza A subtype combinations** have been identified in nature, primarily from birds, there are potentially many more influenza A subtypes combinations given the propensity of virus "**reassortment**".

**Reassortment** is a process by which influenza viruses swap gene segments. It can occur when two influenza viruses infect a host at the same time and swap genetic information.

- The influenza A virus subtypes that have been confirmed in humans, ordered by the number of known human pandemic deaths, are:
  - » **H1N1** caused Spanish Flu in 1918 and the 2009 swine flu pandemic.
    - A variant of H1N1 was responsible for the Spanish Flu pandemic that killed some 50 million to 100 million people worldwide in 1918 and 1919.
  - » **H2N2** caused "Asian Flu" in the late 1950s.
  - » **H3N2** caused "Hongkong Flu" in the late 1960s.

## B) SWINE FLU

- **Swine Flu** is a respiratory disease caused by **influenza A viruses** that infects respiratory tract of pigs and result in barking cough, decreased appetite, nasal secretion, and restless behavior; the virus can be transmitted to human.
- **The first case of influenza A H1N1** was reported in Mexico in **April 2009**. Since then, this infection has affected almost all the countries of the world.
  - » **The Virus**
    - Most common virus causing swine flu is H1N1 but the flu virus can sometimes also come from other subtypes such as **H1N2, H3N1, and H3N2**. Since 2017, H3N2 is becoming a dominant strain.
  - » **Cross Species infections** (swine to humans, humans to swine) etc. have **mostly remained local and haven't caused national or worldwide infections** in either pig or humans.
  - » **Transmission to humans:**
    - Most common way for humans to catch swine flu is through contact with an infected pig (not through properly cooked pork)
    - Swine flu is transmitted from person to person by inhalation or ingestion of droplets containing virus from people sneezing or coughing.
  - » **Symptoms**
    - Similar to most influenza infections: - fever, cough, nasal secretion, fatigue and headache.
  - » **Prevention and cure**
    - **Vaccination** is the best way to prevent or reduce the chances of becoming infected with influenza virus.

- Two antiviral agents, **zanamivir (Relenza)** and **oseltamivir (Tamiflu)**, have been reported to help prevent or reduce the effects of swine flu if taken within 48 hours of the onset of symptoms.

### C) AVIAN INFLUENZA: BIRD FLU

- **Intro**
  - Bird flu (Avian Influenza) is caused by influenza A viruses.
    - Only viruses of the H5 and H7 subtypes are known to cause the highly pathogenic form of the bird diseases.
      - Most avian influenza virus don't infect humans; however, some such as A(H5N1) and A(H7N9), have caused serious infections in people.
    - Recently, China reported that H10N3 has also infected humans.
- **There are several subtypes of Avian Influenza**
  - **AH5N1** is the most common virus causing bird flu, or avian influenza. It is largely restricted to birds, and often fatal (**high pathogenicity**) to them. it can sometimes cross over to other animals, as well as human.
    - According to WHO, the H5N1 was first discovered in humans in 1997 and has killed almost 60% of those infected. Though, it is not known to transmit easily among humans, the risk remains.
  - **A-H7N9**: It was reported in China in 2013. An outbreak of H7N9 strain killed around 300 people in 2016 and 2017.
- **Risk Factors for human infections**
  - The primary risk factor for human infection appears to be direct or indirect exposure to infected live or dead poultry or contaminated environments, such as live bird markets.
- **Impacts**
  - Outbreaks of AI in poultry may raise global public health concerns due to their effect on poultry population, their potential to cause serious disease in people and their pandemic potential.
  - Can impact local and global economies and international trade.
- **Note**
  - There is no evidence to suggest that the virus can be transmitted to humans through properly prepared poultry or eggs.

### D) THE EUROPEAN UNION IS EXPERIENCING THE LARGEST BIRD FLU OUTBREAK IN EUROPE: REPORT BY EUROPEAN FOOD SAFETY AUTHORITY (EFSA) (2022 AND 2023)

More than 50 million birds culled between Oct 2021 to Sep 2022

### E) FIRST CASE OF AVIAN FLU FOUND IN ANTARCTIC REGION (OCT 2023 )

- Avian flu has been detected for the first time in Antarctic region and has raised concerns for birds and mammals which feed on these bids.
- **Which type?**
  - Highly Pathogenic Avian Influenza (HPAI) was detected in brown skua (a predatory seabird) populations on Bird Island, South Georgia, making it the first known case in the Antarctic region.
- **Risk Assessment:**
  - Sea-Gulls and Skuas are the most threatened avian group. They are followed by bird's prey such as hawks and carcasses, terns and shorebirds.
  - Among marine mammals, fur seals and sea lions are reportedly most vulnerable, followed by southern elephant seals and dolphins.

## 19) NIPAH

### A) NIPAH

- **Why in news?**
  - » There has been an outbreak of the deadly Nipah virus in Kerala which have infected five people and killed two of them (Sep 2023)
- **Introduction**
  - » According to WHO Nipah Virus (NiV) infection is a newly emerging zoonosis (a disease that can be transmitted from animals to humans) that can infect both humans and animals.
    - It is classified as a "highly pathogenic paramyxovirus" and handling it requires the highest grade of facilities called BS-4.
  - » The natural host of the virus are fruit bats of the Pteropodidae family, Pteropus genus. Humans are generally infected by fruit bat or pigs. Human to human transmission is also known including in the hospital setting.
- **First identification**
  - » First identified during the outbreak of disease that took place in Kampung Sungai Nipah, Malaysia in 1998. In this case pigs were intermediate hosts. Since, then there have been several outbreaks even without intermediate hosts.
  - » In India it was first detected in Siliguri in 2001 and Nadia in 2007. This was a spillover of the outbreak in Bangladesh.
  - » Later in 2018, 19, 21 and again in 2023 it appeared in Kerala.
    - **Why?**
      - Kerala has several fruit plantations that host several species of bats.
      - Better health facilities in Kerala may be leading to better detection, surveillance etc., whereas in other states the cases may go undetected.
- **Symptoms** of NiV can be **neurological, respiratory and pulmonary**. They include:
  - i. **Encephalitis (brain swelling) due to Inflammation of the brain**
  - ii. Confusion, disorientation and even persistent drowsiness
  - iii. Headache, fever, nausea and dizziness (flu like symptoms)

- **Fatality:** Around 40-70% depending on the local capability for epidemiological surveillance and clinical management.
- **Prevention** (Avoid date palm sap; avoid close contact with NiV Patient; avoid direct contact with pigs/bats in endemic area)
- **Treatment / Vaccine**
  - » **Intensive Support care (no treatment or vaccine is available)**

According to NCDC (National Centre for Disease Control), Ribavirin, an antiviral, may have a role in reducing mortality among patients with encephalitis caused by NIPAH virus disease.

## B) WHY ZOONOTIC DISEASES ARE INFECTING HUMANS MORE AND MORE

- » **Dramatic increase in population and mobility** -> Environmental changes, Deforestation etc. -> increase human contact with pathogens.
- » **Increased demand for animal protein**
  - Livestock production is moving closer to towns in the form of poultry farms etc.
- » **Rise in intense and unsustainable farming**
- » **Increased use and exploitation of wildlife**
- » **Unsustainable utilization of natural resources**
- » **Many Indian villages are located within or around forests**
  - Thus, significant number of people interact with forests in their day-to-day lives
- » **Global Warming**
  - Increases the population of insects like ticks that harbour and transfer the virus
- » **Poor Preparation in terms of infra and human resource**
  - Zoonotic diseases become more problematic in countries where health infrastructure is poor (e.g., Ebola in Africa, Zika in South America, Nipah in Asia etc.)
- » **Lack of awareness** especially in rural areas also

## 20) HEPATITIS

- **About Hepatitis**
  - Hepatitis refers to inflammatory condition of liver. It's commonly caused by viral infections, but there can be other causes too (e.g., auto-immune hepatitis that occurs as a secondary result of medication, drugs, toxins etc.)
- **5 Types of Viral Hepatitis**
  - Hepatitis A, B, C, D, and E.
    - A different virus is responsible for each of these types.
  - » **Hepatitis A** by Hepatitis A Virus (HAV)
    - Transmitted by consuming food or water contaminated by faeces from a person infected with hepatitis A.
  - » **Hepatitis B** (HBV) is transmitted through contact with infectious body fluids, such as blood, vaginal secretion, semen etc.
  - » **Hepatitis C** (HCV) is transmitted through direct contact with infected blood fluids typically through injection drug use and sexual contact.

- Injecting drug use is a major contributor to the number of people newly infected with Hepatitis C globally.
- » **Hepatitis D (HDV)**, also called Delta Hepatitis is transmitted through direct contact with infected blood.
- » **Hepatitis E (HEV)**, is mostly found in areas with poor sanitation and typically results from injecting fecal matter that contaminates the water supply.
- **Hepatitis B and C** are responsible for more than 96% of cases.
  - » Vaccine for Hepatitis B is available
  - » Vaccine for Hepatitis C is not available
- **National Viral Hepatitis Control Program** (launched in July 2018)
  - » By MoH&FW
  - » It is aimed at eliminating the deadly condition by 2030.
  - » It has been launched in collaboration with WHO.
  - » Under the program, government will be providing free drugs and diagnosis for **Hepatitis B and C**.
  - » **Key strategies under the program include** - Preventive and promotive intervention through awareness generation; safe injection practices; sanitation and hygiene; safe drinking water; infection control and immunization; collaboration and coordination among different ministries; access to testing and management; building capacities at district, state, and national levels.
- **World Hepatitis Day - 28th July**
  - » Aims at raising awareness of hepatitis (A,B,C,D,E) and encourage prevention, diagnosis and treatment.
  - » World Hepatitis Day is one of the 8 global public health campaigns marked by WHO, along with World Health Day (7th April), World Blood Donor Day (14th June), World Immunization Week (last week of April), World Tuberculosis Day (24th March), World No tobacco day (31st May), World Malaria Day (25th April), and World Aids Day (1st December)

## 21) NOROVIRUS

- **Norovirus:**
  - » Norovirus is thought to be the most common cause of acute gastroenteritis (diarrhea and vomiting illness) around the world. It spreads easily through food and drink and can have a big impact on people's health.
  - » Noroviruses also are sometimes called food poisoning because they can be transmitted through contaminated food. They aren't always the result of food contamination.
- » **Transmission of Norovirus:**
  - Having direct contact with an infected person.
  - Consuming contaminated food or water or touching contaminated surface.
- » **Symptoms:** Diarrhea, Vomiting, Nausea, and Stomach Pain.
- » **Prevention:**

- **General Hygiene:** Regular hand wash; rinse fruits and vegetables etc.
- » **Treatment:** Not available - generally goes away on its own within 1 to 3 days.

## 12. NON- VIRAL DISEASES

### 1) MALARIA

- **Cause of Malaria:** It is caused by plasmodium pathogens.
  - » There are five human malaria parasites: Plasmodium falciparum (deadliest of the five) and Plasmodium vivax are the most common causes. The list also includes P. ovale, P. malarie, and P. knowlesi.
  - » **Mosquitoes inject sporozoite (Spore-like) stage** of the parasite into the skin when they bite, and the sporozoites travel to the liver. The parasite multiply in liver, and then infect the red blood cells.
- **Mosquito Vector:** Female Anopheles Mosquito (e.g. A. gambiae, A. culicifacies, A. fluviatilis etc.)
- **Note:** Malaria is the largest parasitic killer in the world.
- **Key Interventions to control Malaria:**
  - » Prompt and effective treatment with artemisinin-based combination therapies.
  - » **Reducing Mosquitoes** and Mosquito bites (female Anopheles Mosquito (e.g. A. gambiae, A. culicifacies, A. fluviatilis etc.)

#### A) DEVELOPMENT OF DRUG RESISTANCE:

A study from Africa has found that P. falciparum has developed resistance to the primary drug used to treat the disease i.e. Artemisinin and Artemisinin based combination therapies.

- Resistance was earlier shown in Asia, but experts are more worried about the development of resistance in Africa as it has 90% of the world's Malaria cases

#### B) 2023 WORLD MALARIA REPORT – PUBLISHED BY WHO (DEC 2023)

- **India:**
  - » In 2022, India accounted for 66% of the cases in the WHO South-East Asia region. This region accounted for only 2% of the global cases.
    - Plasmodium vivax was responsible for almost 46% of all cases in the region.
- **WHO Africa region** accounts for around 95% of the cases.
- **Crucial milestone of the WHO Global Technical Strategy for Malaria 2016-2030** have been missed in 2020.
- **Key factors** impacting fight against Malaria:
  - » Covid-19 disruptions; Drug and Pesticide Resistance; Humanitarian Crisis; climate change response; delays in program implementation.

#### C) GLOBAL TECHNICAL STRATEGY FOR MALARIA 2016-2030: WHO

- Aimed at dramatically lowering the global malaria burden over the 15 year period

#### D) VACCINATIONS

As of Dec 2023, RTS/AS01 and R21/Matrix-M vaccines are recommended by WHO to prevent malaria in Children. Malaria vaccines should be provided to children in a schedule of 4 doses from around 5 months

of age. These malaria vaccines act against P. falciparum, the deadliest malaria parasite globally and the most prevalent in Africa.

## RTS,S

- The WHO has recommended widespread use of the RTS,S/AS01 (RTS,S) malaria vaccine (Commercial name: Mosquirix) among Children in regions of moderate to high P. falciparum malaria transmission.
- RTS, S has been developed by PATH Malaria Vaccine Initiative (MVI) and GlaxoSmithKline (GSK) with support from Bill and Melinda Gates foundation.
  - » It is a **recombinant vaccine**. It consists of the P.falciparum circumsporozoite protein (CSP) from the pre-erythrocytic stage (i.e. the CSP is secreted at the sporozoite stage of this plasmodium). The CSP antigen causes the production of antibodies capable of preventing the invasion of hepatocytes and additionally elicits a cellular response enabling the destruction of infected hepatocytes.
  - » **Note:** Mosquito bites transfer the CSP and sporozoites into the human bloodstream, and the CSP nudges the parasite towards the liver, where it enters liver cells, matures and proliferates. The release of mature merozoites marks the onset of the symptoms of malaria

## R21 MALARIA VACCINE

- **Why in news?**
  - » A malaria vaccine manufactured by the biotechnology company Serum Institute of Technology of India and University of Oxford have passed the next round of regulatory approval by the WHO (Dec 2023)
    - R21/Matrix-M meets the WHO standards for vaccine quality, safety, and efficacy.
- **Details about the vaccine:**
  - » R21 is a modified form of a vaccine called RTS,S or Mosquirix.
  - » Vaccine is highly effective and can reduce malaria cases by 75% over a year.
  - » It is the second malaria shot approved by WHO, following the RTS,S/AS01 one, which was approved in July 2022.
  - » R21 is designed to be both more potent and cheaper to produce than Mosquirix. .
    - **Note1:** R21 and Mosquirix both target the malaria parasite in the sporozoite phase of its life cycle - the phase in which it enters the human body from its mosquito host. The vaccines include a protein (Circumsporozoite Protein (CSP)) secreted by the parasite at that stage, in the hope of stimulating an antibody response against it. R21 includes a higher concentration of these proteins.
    - **Note2:** Each of the vaccine is administered with a chemical called an adjuvant, which boosts immune responses to the inoculation. But the Adjuvant used with R21 is easier to make than that used with Mosquirix, raising hopes that it could be cheaper as well.
- **WHO's Approval:**
  - WHO has added the vaccine to the WHO's list of prequalified vaccines.

- This was also recommended for use for the prevention of malaria in Children by the global health agency on 2nd Oct 2023.
- **How is a vaccine added in the WHO list of pre-qualified vaccine?**
  - If a vaccine has undergone through evaluation of relevant data, testing of samples and WHO inspection of relevant manufacturing sites - and the outcome is positive - it is included in the WHO list of Prequalified Vaccines.
  - Pre-qualification is also a pre-requisite for vaccine procurement by UNICEF and fuding support for development y Gavi, the Vaccine alliance.

#### E) MALARIA'S COMBACK IN USA

- **USA** has recorded its first homegrown malaria cases in decades. In the year 2023, 9 indigenous cases have been reported (7 in Florida, one in Texas, and one in Maryland)
- **How?**
  - » Anopheles mosquitoes capable of carrying malaria are still very much present in the USA they've just had very few opportunities to transmit the parasite because there are so few infected people to feed on.
    - **Experts believe that** a person infected with Malaria traveled to the USA from a malaria-endemic area and was bitten by a local Anopheles mosquito, which picked up the parasite and then bit someone else, passing on the parasite.
  - » **Climate change** is making environment more suitable for Malaria. Higher temperature also enhance the growth rate and transmissibility of the parasites responsible for malaria. Higher rainfall and sea level rise may also make the situation more suitable for malaria.

## 2) IMPORTANT INTERNATIONAL INITIATIVES RELATED TO MALARIA

### A) E-2025 INITIATIVE

- Under this initiative WHO has identified 25 countries, including 3 from Africa, with the potential to eradicate malaria by 2025.
  - » The WHO will provide specialized support and technical guidance to these countries under the initiative.
- The initiative is built on the foundation of the E-2020 initiative. The countries were identified by WHO across four key criterias:
  1. The generation of government endorsed elimination plan
  2. Meeting a defined threshold of Malaria case reductions in recent years
  3. A designated government agency for Malaria elimination and the capacity to confirm 100% of suspected malaria cases in a laboratory
  4. Selected by the Malaria Elimination Oversight Committee

- Countries selected for the E-2025 initiative:

| Automatically Nominated  | Newly Added  |
|--|--|
| 1- Mexico<br>2- Costa Rica<br>3- Ecuador<br>4- Suriname<br>5- Belize<br>6- Cabo Verde<br>7- Saudi Arabia<br>8- Islamic Republic of Iran<br>9- Nepal<br>10- Bhutan<br>11- Republic of Korea<br>12- Malaysia<br>13- Comoros<br>14- Botswana<br>15- Eswatini<br>16- South Africa<br>17- Timor-Leste | 1- Panama<br>2- Vanuatu<br>3- Honduras<br>4- Thailand<br>5- Guatemala<br>6- Dominican Republic<br>7- Sao Tome And Principe<br>8- Democratic People's Republic of Korea |

#### B) CHINA CERTIFIED MALARIA FREE AFTER 70 YEARS OF FLIGHT: WHO (JUNE 2021)

- In 1940s, China used to report 30 million cases annually. Now, it has gone for four consecutive years without an indigenous case.
- **Requirement of WHO's Malaria Free status:** 3 Consecutive years of zero indigenous cases. The country must also present rigorous evidence and demonstrate the capacity to prevent transmission re-emergence.
- **China** has become the 40th territory to be certified malaria free. The other recent countries to get Malaria free status include - El Salvador (2021), Algeria and Argentina (2019), and Paraguay and Uzbekistan (2018).
  - China is also the first country in WHO's Western Pacific region to be awarded a malaria-free certification in more than three decades. The only others with certified status are Australia (1981), Singapore (1982) and Brunei (1987).
- **Key initiatives by China** which has made this possible?
  - Discovery of Artemisinin in 1970s -> most effective anti-malarial drug.
  - Among the first countries to test the use of insecticide treated net to prevent Malaria and China distributed millions of nets

#### C) MAJOR NATIONAL INITIATIVES

- **National Framework for Malaria Elimination (2016-2030)**
  - Released by MoH&FW and aims to make India Malaria free by 2030.

### 3) KALA AZAR (VISCERAL LEISHMANIASIS, BLACK FEVER, AND DUMDUM FEVER)

- As per WHO, there are three main forms of Leishmaniases of which Kala-azar is the most serious form.
- **Basics of Kala Azar (Black Fever)**
  - **Parasite:** Protozoan parasite called '**leishmania donovani**'. (Genus: Leishmania)
  - **Vector:** female Sand fly.
    - » The parasite is spread to humans by bites from infected female sand flies.
  - **Second largest parasite killer** in the world (after malaria)
  - It is one of the most neglected Tropical Diseases (NTD).
  - The parasite migrates to the internal organs such as liver, spleen (hence visceral), and bone marrow, and, if left untreated, will almost always result in the death of the host.
  - **Other factors:**
    - » The disease affects some of the poorest people in the world and is linked to malnutrition, population displacement, poor housing, a weak immune system and a lack of financial resources.
    - » It is also linked to environmental changes such as deforestation etc.
  - **Symptoms:** Irregular fever, weight loss, anaemia, and swelling of the spleen and liver.
  - **Only infects humans** (no other animal known to harbour the infection in Asia), and **humans are considered the only reservoir of the parasite**.
  - **Treatment:** Anti-leishmanial medicines are available for treatment. Vector control is another aspect.
- **Cases of Visceral Leishmaniasis or Kala Azar in India (Jan 2023)**
  - **Kala Azar cases in India fell to 834 in 2022 from 44,533 in 2007 - a 98.7% decline**: Union health Ministry.
  - After missing deadlines thrice, India is poised to achieve the elimination target for visceral leishmaniasis or Kala Azar this year with no block in the country reporting more than 1 case per 10,000 people. (Dec 2023)
    - India needs to sustain the momentum over the next 3 years in order to receive the WHO certification.
  - India contributes to 11.5% of total cases reported globally.
  - 89% of the cases were reported from eight countries - Brazil, Eritrea, Ethiopia, India, Kenya, Somalia, South Sudan and Sudan.
- In October 2023, Bangladesh became the first country in the world to be officially validated by the WHO for elimination of Kala Azar as a public health problem
- **National Kala Azar Elimination Program (NKEP)**
  - Though the initial 2015 deadline has been missed, the numbers have been brought down significantly.
  - **Key steps taken:**

- India has also expanded vector control interventions:
    - Indoor residual spraying to control the population of sandflies.
  - Since sandflies have developed resistance to DDT, the NVBDCP introduced a synthetic pyrethroid for indoor residual spraying in 2015.
  - Reducing Crevices in 'Kuccha' walls to reduce breeding areas.
  - ASHA (Accredited Social Health Activist) network was tasked with ensuring that people with PKDL complete treatment.
- Note:
- Since 2003, National Vector Borne Disease Control Programme (NVBDCP) is in charge of coordinating with endemic states to eliminate disease.
    - NVBDCP now funds consultants at state and district level and Kala-Azar Technical Supervisors (KTS) at the State's blocks (or clusters of village panchayats) to conduct surveillance.
- International efforts to control Kala Azar
- An initiative was launched by WHO to eliminate VL as a public health problem from SE Asia region by 2020. The deadline has now been extended to 2023.

### **POST KALA-AZAR DERMAL LEISHMANIASIS (PKDL)**

- » It is a complication of Kala-Azar, in which the disease-causing protozoan invades the patient's skin cells. These cases act as reservoirs of the pathogens.
- » **PKDL treatment is a bigger problem**
  - **Diagnostic is difficult**
    - PKDL cannot be diagnosed by the trademark rapid diagnostic kits. So, a skin snip examination is required. But not all PHCs are equipped with such tools.
- » **Longer dose and greater quantity of drugs**
  - PKDL requires a longer dose and greater quantity of drugs than primary Kala Azar.
- » **Why treating PKDL is important?**
  - It is not life threatening but can act as a source for Kala Azar infection to others.

### **A) OTHER TWO FORM OF LEISHMANIASIS**

#### **CUTANEOUS LEISHMANIASIS (CL)**

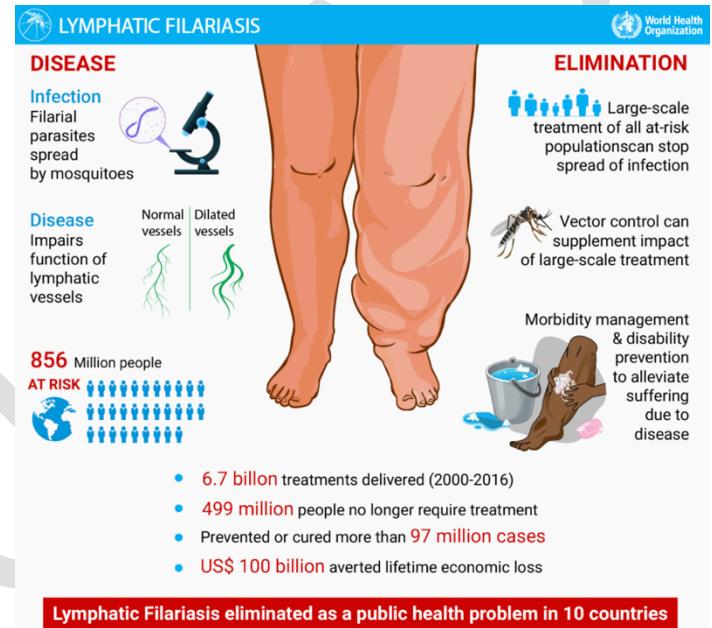
- It is the most common form of leishmaniasis.
- It is caused by 15 different species of the protozoan parasite Leishmania, transmitted by infected female sandflies.
- They are not life threatening, but can cause skin lesions, mainly ulcers, on exposed parts of the body, leaving life-long scars and serious disability or stigma.
  - » About 95% of CL cases occur in the Americas, the Mediterranean basin, the Middle East and Central Asia.

## MUCOCUTANEOUS LEISHMANIASIS

It leads to partial or destruction of mucous membranes of the nose, mouth, and throat. More than 90% of the cases come from Bolivia, Brazil, Peru, and Ethiopia.

## 4) FILARIASIS

- **Basics:**
  - » It is a parasitic disease caused by infection with roundworms of the **Filarioidea** type.
  - » **Lymphatic Filariasis** impairs the lymphatic system and can lead to the abnormal enlargement of the body parts, causing pain, severe disability, and social stigma. It is also known as elephantiasis and is a Neglected Tropical Disease.
- **Vectors: Mosquitoes** are infected with microfilariae (immature larvae) when biting an infected host. This larva matures in the mosquito and when the mosquitoes bite people, people are infected with mature parasite larvae. The larvae then migrate into lymphatic vessels where they develop into adult worms.
  - » It may be transmitted by different types of mosquitoes including the Culex Mosquito.
- The disease is prevalent in more than 50 countries.



## 5) NEUROCYSTICERCOSIS

- **Details**
  - » Neurocysticercosis (NCC) is caused when a human consumes meat from (or is indirectly in contact with) - a pig infected with tapeworm.
    - The eggs of tapeworms invade muscles of the human body to make cysts. Sometimes these cysts get into human brains, triggering epileptic seizures, headaches, difficulty with balance and excess fluid around the brain.
  - » A study published in the ***Nature journal*** in 2021 reported higher prevalence (42.2%) of NCC among patients with active epilepsy in the tea gardens of Assam. These findings were in sync with the older findings that NCC was one of the leading causes of seizures in developing countries, particularly in areas without proper sanitation and where pig rearing was widespread.

## 6) TUBERCULOSIS

- **Introduction**
  - » TB is an infectious **bacterial disease** caused by bacillus Mycobacterium tuberculosis, which most commonly affects the lungs (pulmonary TB) but can affect other sites as well (extra pulmonary TB)
- **Symptoms:**
  - » Healthy people -> often no symptoms (immune system wall off the bacteria)
  - » **Symptoms of active TB of the lung** include coughing (sometimes with sputum or blood), chest pains, weakness, weight loss, fever, night sweats etc.
- **Diagnosis**
  - » **Sputum Smear Microscopy** - used since more than 100 years.
  - » **Rapid Molecular Test** - developed recently - uses polymerase chain reaction (**PCR**)
  - » **Culture Methods** - needs developed laboratory capacity.
- **Treatment**
  - » The effective drug treatments were **first developed in the 1940s**.
    - The most effective first-line anti-TB drug, rifampicin, became available in the 1960s.
    - The currently recommended treatment for new cases of drug-susceptible TB is a six month regimen of four first line drugs: rifampicin, isoniazid, ethambutol and pyrazinamide. Treatment success rates of 85% or more for new cases are regularly reported to WHO by its member states.
  - » Additionally, social determinants of TB such as under-nutrition, overcrowding and poor ventilation in slums and clinical risk factors such as diabetes mellitus, smoking etc. should be addressed simultaneously.
  - Treatment for **Multi drug resistant TB (MDR-TB)**, defined as resistance to isoniazid, rifampicin (the two most powerful anti TB drugs) is longer, and requires more expensive and more toxic drugs. For most patients with MDR-TB, the current regimens recommended by WHO last 20 months, and treatment success rates are much lower.
- **Vaccine**
  - » Not yet (BCG is not effective in tropical countries)
- **Steps Taken**
  - i. **For Detection**
    - **National Policy of Mandatory Reporting** of detected cases since 2012
    - Launch of **Nikshay Platform** - a nation wide web-based and case-based reporting system that facilitates reporting of detected cases by care providers in public and private hospitals.
  - ii. **National Strategic Plan for Tuberculosis Elimination (2017-2025)**



- **Goal**
  - » Achieving rapid decline in the burden of TB, morbidity and mortality while working towards elimination of TB by 2025
- **100% case finding by 2020**
- **Elimination of TB 2025 (< 1 per 1,00,000 population)**
  
- **Updated MDR-TB Recommendations from WHO (Aug 2018)**
  - Replace all injectable with oral regime for MDR-TB patients.
    - Injectables have been found to be less effective
  - Prioritize newer drugs like **Bedaquiline** in the fully oral regime.
    - Data has shown that newer drugs show greater success in treatment and lower mortality rate.
  
- **24 March: World Tuberculosis Day**
  
- **New Vaccines and Medicines**
  - i. New BCG based TB vaccine, VPM1002 has shown promise in animal and small-scale human trials. It is to be supplied by Pune based Serum Institute of India.
  - ii. **Bedaquiline** - a new drug for drug resistant TB - launched by Union Health Ministry on 24th March 2016 (Worth TB Day)

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#### A) WHO'S GLOBAL TB REPORT

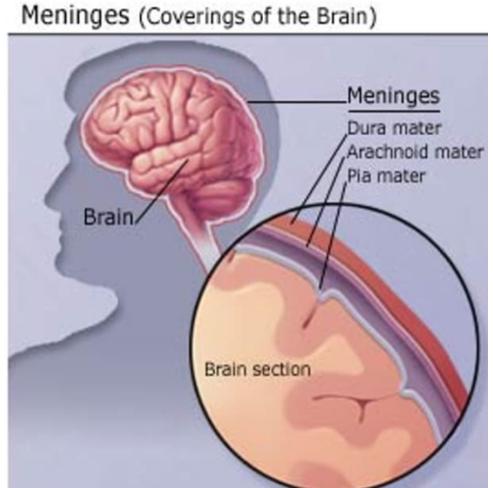
## 7) LEPROSY

- **Introduction**
  - » Leprosy, also known as Hansen's disease, is a chronic infectious disease caused by *Mycobacterium leprae*. It is one of the oldest diseases known to humans and despite advances in all spheres of medical science, continues to be a public health challenge in India.
  - » The disease mainly affects the skin, the peripheral nerves, mucosal surfaces of the upper respiratory tract and the eyes. The deadening of hands and feet leaves patients prone to kinds of disabling injuries that have become stigmatizing symbol of leprosy.
  - » Leprosy is known to occur at all ages. Leprosy is a leading cause of permanent physical disability.
  - » It is included under the list of Neglected Tropical Diseases of WHO.
  - » India, Indonesia and Brazil constitute around 81% of the cases with India contributing to more than 50% of the cases.
- **Transmission**
  - » The exact mechanism of transmission of leprosy is not known.
  - » Till recently, most widely held belief was that the disease was transmitted by **contact** between cases of leprosy and healthy persons.
  - » More recently, possibility of transmission by **respiratory route** is gaining ground. There are other possibilities like transmission through insects which can't be ruled out.
- **Treatment**
  - » Leprosy is curable with combination of drugs known as **multidrug therapy (MDT)** (to prevent drug resistance)

- » Treatment, before nerve damage occurs, is the most effective way of preventing disability due to leprosy.
- **Leprosy Situation in India**
- India currently accounts for 60% of the total new leprosy cases in the world. Though, technically, WHO declared India leprosy free in 2005(<1 case per 10,000 population), the disease is still widespread in the region where poverty and stigma have kept patients hidden and untreated.
    - Bihar, Jharkhand, Odisha, West Bengal, Madhya Pradesh, Chhattisgarh, Odisha and Maharashtra account for 76% of the new leprosy cases.
  - Further, another worrying trend is that Leprosy is impacting the marginalized population more. For e.g. an analysis by ORF indicates that Adivasis account for 18.8% of India's new cases and this percentage has been increasing over the last decade.
- **Steps taken by India towards eradicating Leprosy:**
- a. **National Leprosy Eradication Program (NLEP)**, running since 1983 - a centrally sponsored health scheme of MoH&FW, GoI.
    - NLEP is aimed at eradicating the disease from the country. India was able to eliminate leprosy (bring the number of cases to less than 1 per 10,000 population) by 2005, but complete eradication has not taken place yet.
  - b. **Sparsh Leprosy Awareness Campaign (SLAC)** under NLEP was launched in 2017.
  - c. **Personal Laws (Amendment) Act, 2019** is aimed at removing leprosy as a ground for divorce in India family laws.
    - The act amends five acts - The Divorce Act, 1869, the Dissolution of Muslim Marriage Act, 1939, the Special Marriage Act, 1954, the Hindu Marriage Act, 1955, and the Hindu Adoption and Maintenance Act, 1956 - on provisions related to marriage, divorce, and separation of Hindu and Muslim couples.

## 8) MENINGITIS (BOTH VIRAL AND BACTERIAL REASONS)

- **What is Meningitis?**
  - » It is inflammation of the meninges (three membranes that cover the brain and spinal cord). It occurs when fluid surrounding the meninges becomes infected.
- **Causes:** Viral and bacterial infections; Cancer; chemical irritation; fungi; and drug allergies.
  - » **Bacterial Meningitis:** It is an extremely serious illness. It can be caused by several bacteria including Streptococcus pneumoniae (pneumococcus), Neisseria meningitidis (meningococcus) etc.
    - **Meningococcal meningitis** (caused by the Neisseria meningitidis bacteria), is associated with high fatality rate. It primarily affects small children (though can infect everyone) and can cause severe brain damage if left untreated. It holds the potential to cause large epidemics as it has the potential to transfer from person to person through respiratory droplets.
      - This is vaccine preventable.



- *Haemophilus influenzae type b* (Hib) was a common cause of meningitis in babies and young children until the Hib vaccine became available for infants.
- » **Viral Meningitis** is more common but generally less serious than bacterial meningitis.
- » **Fungal Meningitis** is very rare. Generally, people with weak immune system are vulnerable to it.
- » **Parasitic and Amoebic meningitis** are also rare.
- » **Noninfectious meningitis** is caused by diseases like cancer or in case of injury due to accident, surgery or reactions to medications.
- **Contagious?**
  - » Some viral and bacterial meningitis are contagious. They can be transmitted by coughing, sneezing, or close contact.
- **Symptoms:** In the beginning the viral and bacterial meningitis have similar symptoms. However, bacterial meningitis symptoms are usually more severe. These symptoms also vary depending on your age.
- **Regions most affected:** Meningitis epidemics have occurred in the last decade in all regions of the world. But it is most common in the 'Meningitis Belt', which spans 26 countries across sub-Saharan Africa.
- **Vaccines:**
  - » Several vaccines protect against meningitis, including meningococcal, Haemophilus Influenza type b and Pneumococcal vaccines.
- **"The Global Roadmap to Defeat Meningitis by 2030" by WHO (Sep 2021)**
  - » It aims to eliminate the epidemic of bacterial meningitis - the deadliest form of the disease - and to reduce deaths by 70 percent and halve the number of cases.
  - » Focus on urgently expanding access to existing tools like vaccines, spearheading new research to prevent, detect, and treat the various causes of the disease and improving the rehabilitation for the affected.

## 13. NEGLECTED TROPICAL DISEASES (NTDS)

- **WHO Definition:**
  - NTDs are a diverse group of 20 conditions that are mainly prevalent in tropical areas, where they mostly affect impoverished communities and disproportionately affect women and Children.
    - The epidemiology of NTDs is complex and often related to environmental conditions.
    - They are caused by variety of pathogens - viruses, bacteria, protozoa, and parasitic worms (helminths).
- **Which are the diseases included in NTDs:**

- Buruli Ulcer, Chagas Disease, Dengue & Chikungunya, dracunculiasis (Guinea-worm disease), echinococcosis, foodborne trematodiases, human African trypanosomiasis (sleeping sickness), leishmaniasis, leprosy (Hansen's disease), lymphatic filariasis, mycetoma, chromoblastomycosis and other deep mycoses, onchocerciasis (river blindness), podoconiosis, rabies, scabies, and other ectoparasitoses, schistosomiasis, soil-transmitted helminthiases, snakebite envenoming, taeniasis/cysticercosis, trachoma, and yaws and other endemic treponematoses.

- **Note:**
  - 'Noma' is the latest addition to WHO's list of neglected tropical diseases (Dec 2023)
- These diseases are **contrasted with the "big three" infectious diseases** (HIV/AIDS, tuberculosis, and malaria), which generally receive greater treatment and research funding.
- **Jan 30: World NTD Day**
  - In May 2021, the delegates at the 74th World Health Assembly unanimously adopted a proposal to declare Jan 30 as 'World NTD Day.'
- **WHO's new roadmap for 2021-2030 calls for three strategic shifts to end NTDs:**
  - From measuring process to measuring impact.
  - From disease-specific planning and programming to collaborative work across sectors.
  - From externally driven agendas reliant to programmes that are country-owned and country-financed

#### A) INCLUSION OF NOMA ON THE WHO'S LIST OF NTD

It is a severe gangrenous disease of the mouth and face. It primarily affects young children (between the ages of 2 years to 6 years) in regions of extreme poverty.

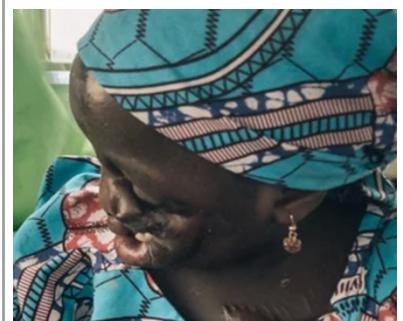
It starts as an inflammation of gums, which, if not treated early, spreads quickly to destroy facial tissues and bones.

**Cause:** Evidence indicate that NOMA is caused by bacteria found in the mouth. There are multiple risk factors associated with the disease. It includes malnutrition, weakened immune system, infections, and extreme poverty. If the child is malnourished and has recently been sick with an infectious disease, such as measles or chickenpox, they are at more risk for developing noma.

It is not contagious but tends to strike when the body's immune system is weak.

**Impact:** It can be fatal and may also cause severe disfigurement for survivors.

**Treatment:** It involves antibiotics, advice and support on practices to improve oral hygiene with disinfectant mouth wash and nutritional supplements. In case of early diagnosis, proper wound healing without long-term consequences may take place. In severe cases, surgery may be necessary.



NOMA is sometimes called the 'Face of Poverty' as it is a social marker of extreme poverty and malnutrition.

**Significance of Including NOMA in the NTD's list:**

- Amplify global awareness.
- Catalyze research, stimulate funding and boost efforts to control

**Cases** are mostly found in sub-Saharan Africa. Some cases are also reported from Americas and Asia.

the disease through multisectoral and multi-pronged approaches.

**Accurate estimation** of the number of noma cases is challenging due to rapid progression of the disease and the associated stigma.

## 14. NON-COMMUNICABLE DISEASES

### 1) HYPERTENSION (HIGH BLOOD PRESSURE)

- **Why in news?**
  - » Who releases its first-ever report on global impact of high BP, states approximately four in every five not treated adequately (Sep 2023)
- **What is Blood Pressure?**
  - » **Blood pressure** is a measure of how much the blood moving through your arteries pushes against the vessel walls. According to medical standards, the reading on a doctor's BP monitor going above 140/90 accounts for hypertension. **High Blood Pressure (Hypertension)** is a serious medical condition that significantly increase the risks of heart, brain, kidney and other diseases.
  - » A large number of people who suffer from hypertension are unaware of this, therefore it is also sometimes referred as a silent killer.
  - » It is a condition that knows no boundaries affecting people of every age and different socio-economic conditions. It can't be cured but can be managed through lifestyle changes, medication, and regular monitoring.
- **WHO Report on Global Impact of High BP (Sep 2023)**
  - » Hypertension affects 1 in 3 adults worldwide and around 1/3rd of the adults with hypertension are unaware of their conditions. Nearly 4/5 people with hypertension are inadequately treated. Scaling up coverage can avert 76 million deaths between 2023-2050.
- The number of people living with hypertension (blood pressure of 140/90 mmHg or higher or taking medication for hypertension) doubled between 1990 and 2019, from 650 million to 1.3 billion.
- **Hypertension Situation in India:**
  - » **As per a paper published in *The Lancet*:**
    - Hyper Tension is the most important risk factor for death and disability in India.
      - Less than 1/4th of hypertensive patients in India had their blood pressure under control during 2016-2020.
      - There is a growing prevalence of hypertension amongst younger adults and those from lower socioeconomic backgrounds.
  - » **NFHS-5** reported a hypertension prevalence of 24% in men and 21% among women, an increase from 19% and 17% respectively from the previous round (NFHS-4)

- **Key Issues with Hypertension situation in India:**
  - Lack of Awareness:** As per WHO, 1/3rd of the hypertension patients don't even know that they are suffering from hypertension.
  - Limited Access to healthcare services**
  - Inadequate adherence** to medication and lifestyle modifications

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#### A) BENEFITS OF REDUCING SALT INTAKE (DEC 2022)

- Adding less salt to food -> Fewer heart attacks and strokes.
  - This was found to be true even in participants who were following DASH diet (Dietary Approaches to Stop Hypertension).
  - **DASH** is the best recommended diet to prevent cardiovascular events. It involves eating fruits, vegetables, lean meat, poultry, nuts, whole grains, and reducing intake of saturated fats, cholesterol, and sugar.
  - WHO recommends only 5 gm of salt per day.
- **Other key things to know:**
  - **Sodium** intake from processed and restaurant food contributes to high rates of high blood pressure, heart attack, and stroke. Reducing sodium intake could prevent thousands of deaths annually.
  - **How does salt raise blood pressure** -> Class discussion?

## 2) DIABETES AND INSULIN

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#### A) WHAT IS DIABETES?

- A medical condition when person's blood sugar level is too high.
- It is classified in **two types**:
  - » **Type 1 diabetes:** This type of diabetes appears in childhood where body can't make insulin or make insufficient Insulin, a hormone that regulates blood sugar level. It helps glucose get into cell. This condition occurs because body's immune system attacks the cells in the pancreas that make insulin.
  - » **Type 2 diabetes:** The body doesn't make enough insulin or when cells are not responding to insulin. This type of diabetes is associated with **obesity** and can lead to blindness, strokes, heart disease and even death.

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#### B) TYPE 1 DIABETES LEADING CAUSE OF DIABETES DEATHS IN THOSE BELOW 25, EASILY PREVENTABLE: STUDY PUBLISHED IN LANCET

- » **Type 1** diabetes in those below 25 years accounted for at least 73.7% of the overall 16,300 diabetes deaths in this age group in 2019. This is despite fatalities from this condition being largely curable.
- » The **death rate** varied based on the Socio-demographic index (SDI) of a country.
  - Countries on the higher end of the SDI spectrum recorded 0.13 deaths per 100,000 people.

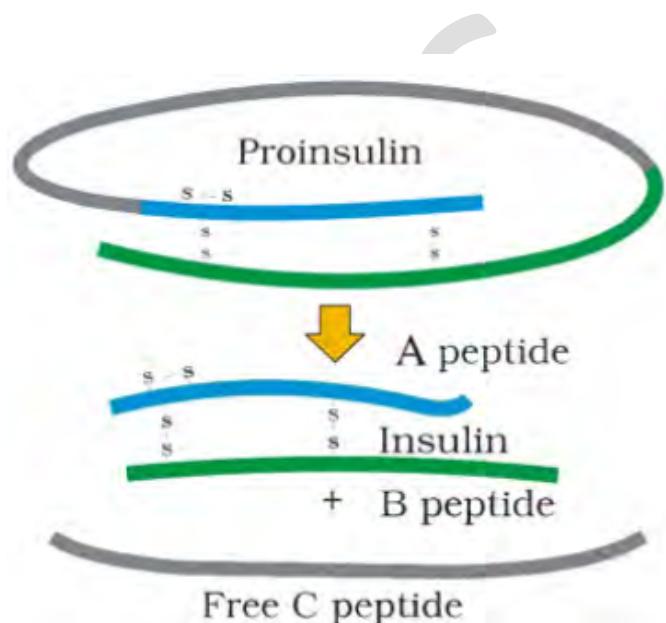
- Countries on the low middle SDI spectrum recorded 0.6 deaths per 100,000 people.
- Countries on low SDI spectrum recorded a 0.71 per 100,000 population death rate.
  - Myanmar (1.93/1,00,000 population), Papua New Guinea (1.78 per 100,000 population) and Haiti (1.57 per 100,000 population) had the highest age-standardized death rates for diabetes.

### C) INSULIN

- **Details**
  - » Insulin is a peptide hormone produced by pancreas. Inside the pancreas, the hormone insulin is made in the beta cells, which are part of islets of Langerhans. With each meal, beta cells release insulin to help the body use or store the blood sugar it gets from the food.
  - » In the beta cells, insulin is first created as a big molecule called "proinsulin". Proinsulin is broken into two pieces: Insulin and C-Peptides.
  - » **Note:** Insulin cannot be taken as pill as it would be broken down during digestion just like the protein in food. It must be injected into the fat under your skin for it to get into your blood.
- **Discovery of Insulin:**
  - » Insulin was discovered in 1921 by **Sir Frederick G Banting**, Charles H Best, and JJR Macleod at the University of Toronto in 1921 - after which it was purified by James B Collip for safer testing on humans. It was the **greatest medical breakthrough of the 20th century** and remains the go-to treatment for type-1 diabetes globally today.
    - **Note:** Back in the 19th century, those suffering from type-1 diabetes were rarely expected to live longer than a year or two after detection. This happens because type-1 diabetes is an autoimmune disease where the body destroys the cluster of cells in the pancreas
  - » In **Jan 1922**, Leonard Thompson was administered first dose. **Banting and Macleod** went on to win the **Nobel prize in Physiology** or Medicine on Oct 25, 1923.
  - » **Important Video:** 100 years of insulin use: How it was discovered and where we stand today
- **Situation today:**
  - » Globally, 15/1 lakh people suffer from type-1 diabetes. The international diabetes federation have estimated that 451 million adult suffered from diabetes worldwide in 2017. This would increase to 693 million by 2026 if not effective prevention methods are adopted.

### D) NON SUGAR SWEETNERS

- **What are non-Sugar Sweeteners?**



- » Non-Sugar Sweeteners (NSS) or Non-Nutritive Sweeteners (NNS) are substances used in place of sweeteners that have sugar (sucrose) or sugar alcohols. They have negligible or zero calories because, unlike sugar, they don't get broken down by the body into products that provide energy or calories.
- » They are used as tabletop sweeteners as well as in food items marked as 'Sugar Free', 'Diet' etc.
- » They are of primary two types - i) Artificial, ii) Natural
  - **Artificial:** These NSS are prepared in laboratories. Examples include Aspartame, Saccharine, Acesulfame-potassium, Sucratose, Neotame (derived from aspartame), Advantame (derived from aspartame) etc.
  - **Natural:** These are extracted from plants (e.g. Stavia, Thaumatin, Monk Fruit etc.)
- » All the six artificial NSS and 3 natural NSS are approved by the US Food and Drug Administration. India's FSSAI has also approved all of them (except Advantame, and Monk Fruit).

- **Why are they used?**
  - » **TO reduce consumption of sugar** (which has led to global rise in diabetes and obesity).
- **Market:**
  - » As per a report by global market consultancy The Business Research Company the market for these NSS was worth \$20 billion in 2022 and it is expected to reach about \$30 billion by 2027.
- **Criticisms:**
  - Little Evidence to substantiate the benefits of NSS** in controlling diabetes and obesity.
  - Growing body of research** says that these NSS may lead to cardiovascular diseases, cancers, and type-2 diabetes.
    - For e.g. WHO in its July 2023 guidelines have classified Aspartame as "possibly carcinogenic to humans".

#### D) PRELIMS FACTS: ASPARTAME:

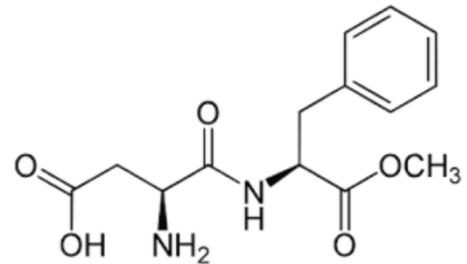
Aspartame is an artificial sweetener which was invented in 1965 and has been in use in USA since early 1980s.

It is a compound of carbon, hydrogen, nitrogen, and oxygen with chemical formula  $C_{14}H_{18}N_2O_5$ .

It is among the most popular sugar substitute used in the world.

**Several Studies have highlighted problems associated with Aspartame:**

- The **WHO** analyzed some 1,300 studies, and cited the following three, to declare aspartame "possibly carcinogenic to humans" -> European Journal of Nutrition, 2016; Cancer Epidemiology, 2022; Cancer Epidemiology, Biomarkers & Prevention, 2022;



- **WHO has placed aspartame in Group 2B.** This group consist of those substances which are possibly carcinogenic.
- **Details about various Groups:**

- » **Group-1: Carcinogenic:** These substances have shown sufficient evidence in humans and animals to be treated as carcinogenic. It includes tobacco smoking, alcohol consumption, Solar Radiation, ionizing radiation.
- » **Group-2A: Probably Carcinogenic:** Limited evidence in humans but sufficient evidence in animals. It includes insecticide DDT, Red Meat, Night Shift Work, Emission from high temperature frying etc.
- » **Group-2B: Possibly Carcinogenic:** Limited evidence in humans or sufficient evidence in animals. It includes aspartame, gasoline engine exhaust, heavy metal lead;
- » **Group-3: Not classified as carcinogen:** Inadequate evidence in humans and in animals. It includes coffee, Mercury, Paracetamol, crude oil etc.

## 15. RARE GENETIC DISEASES

- **Introduction**
  - » A rare disease is a health condition of low prevalence that affects a small number of people compared with other prevalent diseases in general population.
    - They generally include genetic diseases, rare cancers, infectious tropical diseases, degenerative diseases etc.
  - » The most common rare diseases recorded in India are Haemophilia, Thalassemia, sickle cell anaemia, primary immuno-deficiency in children, auto-immune diseases, Lysosomal storage disorders such as Pompe disease, Hirschsprung disease, Gacher's disease, Cystic fibrosis etc. These diseases may be impacting around 70 million people from India, 50% of which are children.
- **Why special focus is needed for rare diseases / Need of a separate policy on Rare Diseases**
  - » **High cost of treatment** or no treatment -> not affordable for most of the citizens -> health insurance generally excludes rare diseases.
    - Available are primarily expensive because pharma companies are not interested in R&D as the number of patients for each disease is very less (Orphan Drugs)
    - As per WHO, only 5% of the identified rare diseases have treatment.
  - » **Difficult to diagnose.**
  - » **Early screening generally doesn't happen** because of lack of awareness among primary care physicians, lack of adequate screening and diagnostic facilities etc. There are very few medical professionals who can deal with these diseases
  - » Currently there is inadequate insurance cover and treating practitioners are lacking management practices.

### 1) NATIONAL POLICY FOR RARE DISEASES, 2021

- MoH&FW came up with the policy in March 2021.
- It aims to lower the high cost of treatment for rare diseases with increased focus on indigenous research with the help of a National Consortium to be set up by Department of Health Research, MoH&FW as convenor.

- It envisages creation of a national hospital based registry of rare diseases so that adequate data is available for definition of rare diseases and for R&D.
- It focuses on **early screening and prevention** through primary and secondary healthcare infrastructure such as H&W Centres and District Early Intervention Centres (DEICs) and through counselling of high risk parents.
  - Screening will also be supported by NIDAN Kendras set up by the DBT.
- The policy aims to strengthen tertiary health care facilities for prevention and treatment of rare diseases through designating 8 health facilities as Centre of Excellence and these CoEs will also be provided one-time financial support of upto Rs 5 crores for upgradation of diagnostic facilities.
- **Provision for financial support:** The policy was amended in May 2022. It now provides a financial assistance of upto Rs 50 lakh for treatment of rare diseases of all categories.
- The policy also envisages a **crowd funding mechanism** in which corporates and individuals will be encouraged to extend financial support through a robust IT platform for treatment of rare diseases.
  - Funds so collected will be utilized by CoEs for treatment of all three categories of rare diseases as first charge and then the balance financial research could also be used for research.
- **Performance of the policy (Critical Analysis)** (Jan 2023)
  - LS MP Varun Gandhi have written to Union Health Minister and have said that more than 4,000 identified patients of rare diseases - mostly children - are yet to receive the Rs 50 lakh financial assistance for treatment guaranteed by the Union Government under the National Policy for Rare diseases, 2021.
    - More than 10 children who were awaiting treatment have already lost their lives.
  - The 10 CoEs constituted under the policy are yet to seek financial assistance (crowdfunding) for patients with rare diseases.

## 2) SOME RARE GENETIC DISEASES IN MORE DETAILS

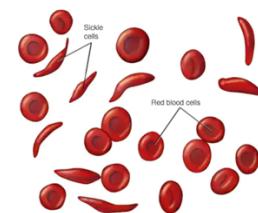
### A) SICKLE CELL ANAEMIA

- **Why in news?**
  - » The first therapy based on gene editing technology Crispr-Cas9 for Sickle cell disease and thalassemia has been approved in UK (Nov 2023)

#### About Sickle Cell Anaemia:

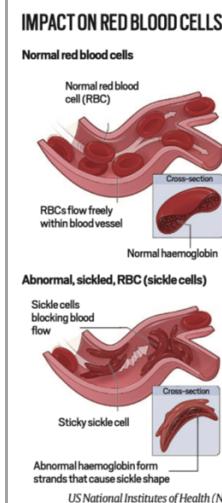
It is one of a group of inherited disorders known as Sickle Cell Diseases. It affects shape of the red blood cells which carry oxygen to all parts of the body.

RBCs are usually round and flexible so that they move easily through the blood vessels. But, in sickle cell Anaemia, some of the RBCs are shaped like sickle and also become rigid and sticky. This slows or blocks blood flow.



**Note:** Both Sickle Cell Anaemia and thalassemia are caused by errors in the gene for haemoglobin, a protein in the red blood cells that carry oxygen to organs and tissues.

**Symptoms:** Anaemia -> fatigue; Episodes of extreme pain called pain crises; Swelling of hands and feet; delayed growth and puberty; Vision problems etc.



## THE UK DRUG REGULATOR, IN A LANDMARK BREAKTHROUGH, IN NOV 2023 APPROVED A GENE THERAPY FOR THE CURE OF SICKLE CELL DISEASE AND THALASSEMIA.

- This therapy is called **Casgevy**. It is the first licensed therapy in the world based on gene editing technology CRISPR-CAS9. This therapy edits the faulty gene that leads to these blood disorder, potentially curing person for life.
- **How does the therapy work?**
  - » The therapy uses the patient's own blood stem cells, which are precisely edited using Crispr-Cas9. A gene called BCL11A, which is crucial for switching from foetal to adult is targeted in the therapy.
  - » Foetal haemoglobin, which is naturally present in everyone at birth, doesn't carry the same abnormalities as adult haemoglobin. The therapy uses the body's own mechanisms to start producing more of this foetal haemoglobin, alleviating the symptoms of the two conditions.
- **How is the therapy prepared and given:**
  - » **Casgevy** is one time treatment for which the doctor has to first collect blood stem cells from the bone marrow using a process called apheresis - used to filter out the blood for different components. The cells are then sent to the manufacturing site where it takes about six months for them to be edited and tested.
  - » **Then the edited cells are then transplanted**. Before this doctor gives a conditioning medicine for a few days to clear the bone marrow of other cells that will be replaced by modified cells.
  - » **The patient has to stay in hospital for at least one month** so that the edited cells take up the residence in bone marrow and start making RBCs with normal haemoglobin.
- **Side effects** from the treatment are similar to those associated with autologous stem cell transplants, including nausea, fatigue, fever and increased risk of infection.
- **Key challenges of the treatment:**
  - » **Very Costly**: it is estimated that the therapy will cause around \$2 million per patient, which is in line with other gene therapies.

- » **Absence of local manufacturing technology:** This means that the harvested blood stem cells have to be sent across countries.
- » **Preventing the misuse of CRISPR-CAS9:**

- **Situation in India:**

- An estimated 30,000 - 40,000 children in India are born with this disorder every year. Thus, India has one of the highest burdens of sickle cell anaemia in the world.

- **Steps taken by India:**

- In Budget 2023-24, a Mission to Eliminate Sickle Cell Anaemia by 2047 was announced. It entails awareness creation, universal screening of 7 crore people in the age group of 0-40 years in affected tribal areas, and counselling through collaborative efforts.

## B) THALASSEMIA:

- Thalassemia is an inherited blood disorder in which the body makes an abnormal form of hemoglobin.

- If both of your parents are carriers of thalassemia, you have a greater chance of inheriting a more serious form of disease.

- The disorder results in excessive destruction of RBCs, which leads to anemia.

- **Treatment Option**

- Blood Transfusion
- Bone Marrow transplantation
- Medication and supplements
- Possible surgery to remove spleen or gallbladder.

- **Situation in India**

- India is the thalassemia capital of the world with 40 million carriers (highest in the world) and over 1,00,000 patients (Majors) under blood transfusion every month. It is the most common genetic blood disorder that is prevalent in India.
- People suffering from the disease are unknowingly transferring on this genetic disorder to their children.

- Around 10,000 births of Thalassemia major are taking place every year.

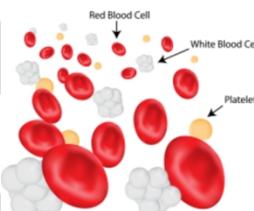
- Most of the thalassemia treatment takes place in private sector with out-of-pocket expenses.
- The 2021 policy and associated benefits haven't been operationalized yet.

- **World Thalassemia Day**

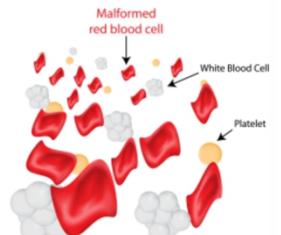
- It is observed on May 8 every year to commemorate Thalassemia victims and to encourage those who struggle to live with the disease.
- The day was created by Thalassemia International Federation (TIF) in 1994.
- **Theme for 2023:** "Strengthening Education to Bridge the Thalassemia Care gap"

**Thalassemia**

**Normal**



**Thalassemia**



### C) HUNTER SYNDROME OR MPS-II

1. It is a very rare inherited, genetic disorder caused by a missing or malfunctioning enzyme iduronate 2-sulfatase. This enzyme's job is to break down certain molecules (large sugar molecules called glycosaminoglycans), and without enough of this enzyme, the molecule build up in harmful amounts.
2. The buildup of massive amounts of these harmful substances eventually causes permanent, progressive damage affecting appearance, mental development, organ function and physical disabilities.
3. The condition is one type of a group of inherited metabolic disorders called mucopolysaccharidoses (MPSs). Hunter syndrome is also known as MPS II.
4. **Cure:** There is no cure for hunter syndrome. Treatment involves managing symptoms and complications.
5. **It mainly affects males.**
  - It is caused by a defective X chromosome. For females, even if one X chromosome is defective, the other may provide the correct gene. But males have only one X chromosome and hence the defective X chromosome would lead to Hunter Syndrome.

### D) HAEMOPHILIA A AND HAEMOPHILIA B (ALREADY DISCUSSED WITH BIOTECHNOLOGY)

## 16. OTHER DISEASES

### 1) DEMENTIA

- **Details**
  - **What is dementia?**
    - It is the loss of cognitive functioning - thinking, remembering, and reasoning - to such an extent that it interferes with a person's daily life and activities.
    - Dementia is more common as people grow older (about 1/3rd of all the people aged 85 or older may have some form of dementia) but it is not a normal part of aging. Many people live in 90s and beyond without any sign of dementia.
    - There are different forms of dementia including Alzheimer's disease which is responsible for 70% of the cases.
  - **Situation in India:**
    - According to a 2020 report published by the Alzheimer's and Related Disorder Society of India, there are 5 million people in India living with dementia.
  - **Cause:** When healthy neurons, or nerve cells, in the brain stop working; sometimes genetic mutation may also be responsible.
    - The exact causes of Alzheimer's are still unknown, but a classical feature of the disease is the build up of two proteins in the brain: beta amyloid and tau.

- In people with Alzheimer's, **beta-amyloid** is usually found in large quantities outside of neurons (brain cells), and tau "tangles" are found inside axons, the long, slender projection of neurons.
- Three genes have been linked to Alzheimer's disease in the young: **amyloid precursor protein (APP)**, **presenilin 1 (PSEN1)** and **presenilin 2 (PSEN2)**.
  - These genes are involved in producing a protein fragment called **beta-amyloid peptide**, a precursor to the previously mentioned beta-amyloid. If the gene is faulty, it can lead to an abnormal build-up (plaques) of beta-amyloid in the brain – a hallmark of Alzheimer's disease and a target for treatments such as the recently approved drug **lecanemab**.
  - People only need **one of APP, PSEN1 or PSEN2** to be faulty to develop **Alzheimer's disease**.
- Prevention of Dementia:
  - No proven prevention
  - In general, **leading a healthy lifestyle** may help reduce the risk factors that have been associated with these diseases.
- A 19-year-old from China is the youngest person to be diagnosed with Alzheimer's disease - the cause is a mystery (Feb 2023)
  - Nearly, all cases of Alzheimer's disease in people younger than 30 are due to **inherited faulty genes**. In fact, the previous youngest case - a 21-year-old - had a genetic cause.
  - But, in this case, **genetic cause was ruled out**.
- Lecanemab gains FDA approval for early Alzheimer Disease (Jan 2023)
  - This is a treatment that may **moderately slow mild cognitive decline and reduce amyloid-B plaques in the patients with early Alzheimer disease**. It gained **accelerated approval from the US FDA**.

## 17. MITOCHONDRIAL DISEASE

- Introduction
  - » Mitochondrial disease is a group of disorders **caused by dysfunctional mitochondria**, the organelles that generate energy for the cell.
  - » It is an **inherited chronic illness** that can be **present at birth or develop later in life**. It causes debilitating physical, developmental, and cognitive disabilities with symptoms including poor growth; loss of muscle coordination; muscle weakness and pain; seizures; vision and/or hearing loss; gastrointestinal issues; learning disabilities; and organ failures. About 1 in 2000 people have this disease in USA. It's **progressive and there is no cure**.
  - » There are many forms of mitochondrial disease, and it is inherited in a number of ways.
- What causes Mitochondrial diseases?
  - » For many patients, mitochondrial disease is an **inherited genetic condition**. Some percentage of patients **acquire symptoms** due to **other factors, including mitochondrial toxins**.
  - » The types of inherited mitochondrial diseases inherited include:
    - **DNA inheritance** (DNA contained in the nucleus of the cell). Also called autosomal inheritance

- **MtDNA Inheritance (DNA contained in mitochondria)**
  - There is **100% chance of trait occurring in other siblings, since all mitochondria are inherited from mother**, although symptoms might be more or less severe.
  - Note: Mitochondrial DNA is separate from DNA found in the cell nucleus and does not affect human characteristics such as hair or eye color, appearance or personality traits.
- » **Other causes**
  - Diseases specifically from deletions of large parts of mitochondrial DNA molecule are usually sporadic without affecting other family members.
  - Medicine or other toxic substances can trigger mitochondrial disease.
- **Treatment**
  - » The goal is to improve symptoms and slow the progression of diseases.
    - Use vitamin therapy.
    - Conserve energy
    - Pace activities
    - Maintain an ambient environmental temperature.
    - Avoid exposure to illness.
    - Ensure adequate nutrition and hydration.
- **Three Parent Babies**
  - » In 2015, Britain became the first country in the world to allow a three-parent baby to prevent some inherited incurable diseases.
  - » It is considered only hope for women who carry defective mitochondria to have healthy children. It is designed to help couples with mitochondrial disease, incurable condition passed down the maternal line that affect around one in 6500 children worldwide.
  - » The treatment is known as "three-parent" in vitro fertilization (IVF) because the babies, born from genetically modified embryos, would have DNA from mother, a father and from a female donor.
- In 2018, UK doctors selected first women to have 'three person babies'.
  - They carried genetic mutations which caused rare genetic disease.

How to make a three-person embryo



## 18. ANTI-MICROBIAL RESISTANCE

- **Why in news?**
  - » **Genes fuel antibiotic resistance in Yemen Cholera Epidemic (Sep 2023)**
    - The Cholera outbreak in Yemen, which began in 2016, is the largest in modern history and anti-biotic resistance has become widespread among V. cholerae bacteria since 2018.

- A study has found the presence of a new plasmid - a small, circular DNA molecule - in *V. cholerae* from late 2018 to the bacterial strain behind the epidemic. This plasmid introduced genes encoding resistance to multiple clinically used antibiotics, including macrolides (such as azithromycin).
- **Introduction:**
  - » Antibiotic resistance occurs when an antibiotic has lost its ability to effectively control or kill bacterial growth; in other words, the bacteria become "resistant" and continue to multiply in the presence of therapeutic levels of antibiotic.
- Why do bacteria become resistant to antibiotic?
  - » **Natural Phenomena: Evolution** - Selective pressure for the survival of resistant strains of bacteria.
  - » **Human Action:** Current higher levels of antibiotic resistant bacteria are attributed to the overuse and abuse of antibiotics.
- **How do bacteria become resistant?**
  - » Some bacteria are naturally resistant to certain type of antibiotics.
  - » However, bacteria may also become resistant in two ways:
    - By Genetic Mutation
    - By acquiring resistance from another bacterium.
- **Why Anti-biotic resistance is more prevalent in India: Key Factors**
  - » **India is the largest consumer of anti-microbials globally** and the use of **last resort antimicrobials like cephalosporins is soaring**.
    - **Easy availability and overuse** of anti-biotics is the most important factor: Over the Counter Availability; Irrational Use; over-prescription by doctors
  - » **Poor Health Sector** -> improper treatment -> Development of anti-biotic resistance
    - Further, exposure to subtherapeutic levels of anti-microbials or non-adherence to prescribed medications has also been cited as a driver of AMR
    - E.g.: in case of TB
  - » Increasing and completely unregulated use of antibiotic in Agriculture, live stocks and Poultry sector.
    - Amount of antibiotics used in the farm animal and food industry is three to four times more than those used by humans.
    - For instance, Colistin is extensively used in veterinary practices as a growth promoter. This leads to generation of colistin-resistant bacteria in poultry and fresh water fish.
  - » **Poor Sanitation conditions** -> More diseases -> More use of medicines -> More AMR development
  - » **Unchecked discharge of effluents by the pharmaceutical industries** -> high concentration of pharmaceutical substances are found in surface and ground water systems near production facilities -> anti-biotics cause development of anti-microbial resistance in environment.
- **Impact of increasing anti-microbial resistance**
  - » **Damage to Public Health:**

- In 2019, drug-resistant superbugs killed about 1.27 million people globally - a toll more than HIV/AIDs or malaria - and according to the UN estimates, the number could reach 10 million by 2050.
  - Demands complicated treatment pattern, with longer stay in hospitals -> increase in cost of treatment.
  - Stronger antibiotics which are used after the first line of drugs fail generally have toxic side effects
  - Resistance also emerging for second line of drugs (e.g. XDR-TB emerging)
  - Without functional anti-microbials to treat bacterial and fungal infections, even the most common surgical procedures, as well as cancer chemotherapy, will become fraught with the risk of untreatable infections.
  - All this is compounded by the fact that no new class of anti-biotics have made it to the market in the last three decades, largely on account of inadequate incentives for their development and production.
- » **Economic damages** due to AMR can be equivalent to what 2008-09 economic shocks resulted into: UN Report
- » **Environmental Damages**
  - Extensive amount of anti-biotics lead to development of AMR in some micro-organisms. It impacts the microbial biodiversity and thus the environmental balance needed.
- **Steps that government has taken:**
  - **National Policy** for Containment of Antimicrobial Resistance, 2011
  - Guidelines for appropriate antibiotic usage which have revised Schedule H drugs to make over-the-counter availability of certain antibiotics nearly impossible
  - Programs such as Red Line Campaign
  - Sanitation campaigns such as Swatch Bharat Mission etc.
  - National Surveillance system for AMR (April 2017)
  - **National Action Plan on Antimicrobial Resistance (April 2017):** Focused on enhancing awareness, strengthening surveillance, improving rational use, promoting research and supporting neighboring countries.

## 19. SMOKING/DRINKING ETC.

### 1) SPURIOUS LIQUOR/ HOOCH TRAGEDIES/ METHYL ALCOHOL

- **Why do spurious drinks become poisonous sometime?**
  - » **Excess Methanol:** Illicit brewing is unscientific, hooch brewers inadvertently mix excessive amounts of methanol in their liquor every once in a while, leading to mass death.
  - » **Why is Methyl Alcohol (Methanol) used?**
    - It is similar in appearance and test to Ethyl Alcohol
    - It is easily available.
      - In Industry it is used as antifreeze, solvent, fuel, and ethanol denaturant.
  - » The potential lethal dose of methanol is variable, adverse effects has reportedly occurred at 30 ml. The toxicity of methyl alcohol manifests as permanent blindness or ultimately death due to respiratory failure.
  - » **Why is Methanol poisonous?**

- Due to accumulation of formic acid, a metabolite of methanol metabolism.
- Why do people go for this kind of drink?
  - » Cheap Price:
  - » Availability
  - » Strong effect
- Other reasons Spurious liquor prosper-> Corruption

## 20. INTERNATIONAL INITIATIVES

### 2) THE LANCET

- Details about the Lancet:
  - » The Lancet is a weekly peer-reviewed general medical journal and one of the oldest of its kind. It is also world's highest-impact academic journal. It was founded in 1823.
  - » It publishes original research articles, review articles, editorials, book reviews etc.
  - » The journal has editorial offices in London, New York City, and Beijing.
- The Lancet announced a new commission on Dec 15, 2022, to address public health threats.
  - » The scope of work by The Lancet Commission on 21st-Century Global Health Threats includes demographic changes and inverted population pyramids, high body mass index, anti-microbial resistance, eroding sexual and reproductive rights for women, food security, and fraying multilateralism.
  - » In 2024, the body will release its report after detailed study of 2 years.

## 21. FOOD SAFETY

### 1) LAWS AND INSTITUTIONS

#### A) FOOD SAFETY AND STANDARDS ACT, 2006

- Came into force in 2011.
- Key Provisions
  - i. **Consolidation of existing mechanisms**
    - The FSS Act consolidated a number of food legislations, rules, orders etc and established a single law for all matters relating to food safety and standards.
    - It subsumes acts like Prevention of Food Adulteration Act, 1954, The Fruit Product Order, 1955 etc.
  - ii. **Classification into standardized and non-standardized**
    - **Standardized Food products** - Standards are prescribed and do not require product approval prior to manufacture, sale distribution, or import. The first time manufacturer or importer only requires an FSSAI license to begin a food business.
    - **Non-standardized food products** - don't have standards as their safety parameters are either not known or either not yet ascertained.

- iii. **Statutory Authority: Food Safety and Standards Authority of India (FSSAI) and State Food Safety Authorities**
  - FSSAI is the apex body for food quality regulation in the country. It is responsible for setting standards and regulate, manufacture, storage, distribution, sale and import of food items to ensure food safety.
- iv. **Commissioner of Food Safety of state**
  - Appointed by respective state governments.
  - For efficient implementation of the Food Safety Act and various rules and regulations regarding food safety
  - Commissioner also responsible for appointing Food Safety Officers for various local areas
- v. **Graded Punishment and penalties** for contravention of the Act
- vi. **Adjudicating and Appellate Tribunal**

## B) FOOD SAFETY AND IPC

- **Section 272 of IPC** prescribed punishment for adulteration of food or drink intended for sale.
- **Section 273 of IPC** punishes sale of noxious food or drink.
  - These two sections provides for imprisonment (upto six months) and/or fine (upto 1,000 rupees)

## C) STATE FOOD SAFETY INDEX (FSI)

- **Details**
  - SFSI is an index developed by FSSAI. It aims to measure the performance of states and UTs on selected parameters of food safety.
  - It is aimed at encouraging states and Uts to improve their performance and work towards establishing a proper od safety ecosystem in their jurisdiction.
  - It is an annual report which has been released since 2018-19.
  - **Key Parameters used:**
    - » **Human Resources and Institutional Data (20%):**
    - » **Compliance (30%)**
    - » **Food Testing - Infrastructure and Surveillance (20%):**
    - » **Training and Capacity Building (10%)**
    - » **Consumer Empowerment (20%)**

## 22. MAKING MEDICINES AFFORDABLE

### 1) GENERIC MEDICINES:

- **Why in news recently?**
  - » On Aug 2023, the National Medical Council (NMC) directed all doctors to prescribe only generic names and not brand names which led to protest. Following the Indian Medical Association's protest, the NMC has withdrawn the order on 'generic prescribing' since Aug 23, 2023.
    - **Why the protest?**

- Doctors trust certain brands
- The control over which brands to take will go to chemist shops.
- **What is a generic drug?**
  - Generic drug is a low cost version of pharmaceutical drug that is equivalent to a brand-name product in dosage, strength, route of administration, quality, performance and intended use.
  - They usually enter market after patent protection of the original drug expires.
- **Note:** Broadly Medicines can be of three types:
  - **Branded:** These are still on patent
  - **Branded Generic:** Off-Patent and Generic, but nonetheless produced by a reputed company, with a brand.
  - **Generic:** Off Patent, and unbranded.
- **Advantages**
  1. Affordable healthcare
  2. Breaks the doctor-pharma nexus
    - Reduce unnecessary prescription
  3. Promotes domestic pharma companies.
  4. Difficult for quacks to function
- **Limitations**
  1. Quality concerns
  2. Erode doctor-patient relationship
  3. Low profit margins for retailers
  4. Shortage
  5. Difficult for common person to understand, especially the multiple salt names in a FDC.
  6. May discourage big pharma companies to launch their new medicines in India

## 2) JAN AUSHADHI KENDRAS

- **Intro:**
  - » Pradhan Mantri Bhartiya Janaushadhi Pariyojna (PMBJP) was launched by Department of Pharmaceuticals, Ministry of Chemical and Fertilizers, Government of India as a direct market intervention scheme in 2008.
- It aims to make quality generic medicines available to all at affordable prices through Jan Aushadhi Stores (JAS) opened in each district of the states.
  - » First Jan Aushadhi Store (JAS) was opened at Amritsar Civil Hospital in 2008.
- Other key focus of the scheme is to create awareness and demand for generic medicine.
- **Incentives given:**
  - » The scheme provides an excellent opportunity of self-employment with suitable and regular earnings.

- » An incentive of **Rs 5,00,000** is provided to the Jan Aushadhi Kendras as financial assistance and one-time additional incentive of Rs 1 lakh (as reimbursement for IT and infra expenditure) is provided to Jan Aushadhi Kendra opened in **North-Eastern India, Himalayan state, island territories, and backward areas identified by NITI Aayog as aspirational districts or if opened by women entrepreneurship, Ex-Serviceman, Divyangs, SCs and STs.**
- As of Jan 2023, **9,000 Jan Aushadhi Kendras** are functional across the country.
  - » The government has set up a target to increase the number of Jan Aushadhi Kendras to **10,000 by March 2024.**
    - It offers **1759 medicines, and 280 surgical devices** covering all major therapeutic groups.

| PYQs: |  |
|-------|--|
| 1     | <p>Living organisms require at least 27 elements, of which 15 are metals. Among these, those required in major quantities include: [Prelims 1995]</p> <p>(a) Potassium, manganese, molybdenum and calcium<br/>         (b) Potassium, molybdenum, copper and calcium<br/>         (c) Potassium, Sodium, Magnesium, and Calcium<br/>         (d) Sodium, Magnesium, Copper and manganese</p>   |
| 2     | <p>Which of the following hormones contains iodine? [1995]</p> <p>(a) Thyroxine<br/>         (b) Testosterone<br/>         (c) Insulin<br/>         (d) Adrenaline</p>   |
| 3     | <p>Which of the following are associated with <i>Diabetes mellitus</i>, a common disease in adults? [1996]</p> <ol style="list-style-type: none"> <li>1. Higher sugar level in blood</li> <li>2. Low sugar level in blood</li> <li>3. Lower insulin level in blood</li> <li>4. Higher insulin level in blood</li> </ol> <p>Select the correct answer by using the codes given below:</p> <p>A. 2 and 4<br/>         B. 1 and 2<br/>         C. 2 and 3<br/>         D. 1 and 3</p> |
| 4     | <p>Consider the following statements: [1996]</p> <p>AIDS is transmitted</p> <ol style="list-style-type: none"> <li>1. By sexual intercourse</li> <li>2. By Blood Transfusion</li> <li>3. By Mosquito and other blood sucking insects</li> <li>4. Across the placenta</li> </ol> <p>Select the correct answer using codes provided below:</p> <p>A. 1, 2 and 3<br/>         B. 1, 2 and 4</p>   |

|              | C. 1, 3 and 4<br>D. 1 and 3   |        |        |             |         |           |            |        |         |              |             |
|--------------|---|--------|--------|-------------|---------|-----------|------------|--------|---------|--------------|-------------|
| 5            | Which of the following leads to malnourishment? [1996]<br>1. Overnutrition<br>2. Undernutrition<br>3. Imbalance nutrition<br>Select the correct answer using the codes given below:<br>A. 2 only<br>B. 2 and 3 only<br>C. 1 and 3 only<br>D. 1, 2 and 3   |        |        |             |         |           |            |        |         |              |             |
| 6            | Antigen is a substance which: [1997]<br>(a) lowers body temperature<br>(b) destroys harmful bacteria<br>(c) triggers the immune response<br>(d) is used as an antidot to poison   |        |        |             |         |           |            |        |         |              |             |
| 7            | Consumption of fish is considered to be healthy when compared to flesh of other animals because fish contains: [1997]<br>(a) polyunsaturated fatty acids<br>(b) saturated fatty acids<br>(c) essential vitamins<br>(d) more carbohydrates and proteins  |        |        |             |         |           |            |        |         |              |             |
| 8            | Match List-I with List-II and select the answer using the codes given below: [1998]<br><table border="1" style="display: inline-table; vertical-align: middle;"> <thead> <tr> <th>List-1</th> <th>List-2</th> </tr> </thead> <tbody> <tr> <td>A - Malaria</td> <td>1 Fungi</td> </tr> <tr> <td>B - Polio</td> <td>2 Bacteria</td> </tr> <tr> <td>C - TB</td> <td>3 Virus</td> </tr> <tr> <td>D - Ringworm</td> <td>4 Protozoan</td> </tr> </tbody> </table><br>(a) A-4, B-3, C-2, D-1<br>(b) A-4, B-3, C-1, D-2<br>(c) A-3, B-4, C-1, D-2<br>(d) D-3, B-4, C-2, D-1 | List-1 | List-2 | A - Malaria | 1 Fungi | B - Polio | 2 Bacteria | C - TB | 3 Virus | D - Ringworm | 4 Protozoan |
| List-1       | List-2  |        |        |             |         |           |            |        |         |              |             |
| A - Malaria  | 1 Fungi   |        |        |             |         |           |            |        |         |              |             |
| B - Polio    | 2 Bacteria  |        |        |             |         |           |            |        |         |              |             |
| C - TB       | 3 Virus   |        |        |             |         |           |            |        |         |              |             |
| D - Ringworm | 4 Protozoan   |        |        |             |         |           |            |        |         |              |             |
| 9            | Haemophilia is a genetic disorder which leads to: [1998]<br>A. Decrease in haemoglobin level<br>B. Rheumatic Heart Disease<br>C. Decrease in WBC<br>D. Non-clotting of blood  |        |        |             |         |           |            |        |         |              |             |

|    |  |
|----|--|
| 10 | <p>Assertion (A): Unsaturated fats are more reactive compared to saturated fats<br/> Reason (R): Unsaturated fats have only single bonds in their structure</p> <p>(A) Both A and R are true and R is the correct explanation of A<br/> (B) Both A and R are individually true but R is not the correct explanation of A<br/> (C) A is true but R is false<br/> (D) A is false but R is true</p>   |
| 11 | <p>Consider the following statements about probiotic food: [2008]</p> <ol style="list-style-type: none"> <li>1. Probiotic food contains live bacteria which are considered beneficial to health</li> <li>2. Probiotic food help in maintaining gut flora</li> </ol> <p>Which of the statements given above is/are correct?</p> <ol style="list-style-type: none"> <li>A. 1 only</li> <li>B. 2 only</li> <li>C. Both 1 and 2</li> <li>D. Neither 1 nor 2</li> </ol>   |
| 12 | <p>Regular intake of fresh fruits and vegetables is recommended in the diet since they are good source of anti-oxidants. How do antioxidants help a person maintain health and promote longevity? [Prelims 2011]</p> <ol style="list-style-type: none"> <li>A. They activate the enzymes necessary for vitamin synthesis in the body and help prevent vitamin deficiency</li> <li>B. They prevent excessive oxidation of Carbohydrates, fats and proteins in the body and avoid unnecessary wastage of energy</li> <li>C. They neutralize the free radicals produced in the body during metabolism</li> <li>D. They activate certain genes in the cells of the body and help delay the ageing process</li> </ol> |
| 13 | <p>Which of the following is/are correct? [2013]</p> <ol style="list-style-type: none"> <li>1. Viruses lack enzymes necessary for the generation of energy</li> <li>2. Viruses can be cultured in the synthetic medium</li> <li>3. Viruses are transmitted from one organism to another by biological vectors only</li> </ol> <p>Select the correct answer using the codes given below:</p> <ol style="list-style-type: none"> <li>A. 1 only</li> <li>B. 2 and 3 only</li> <li>C. 1 and 3 only</li> <li>D. 1, 2 and 3</li> </ol>   |
| 14 | <p>Consider the following minerals [Prelims 2013]</p> <ol style="list-style-type: none"> <li>1. Calcium</li> <li>2. Iron</li> <li>3. Sodium</li> </ol>   |

|    |  |
|----|--|
|    | <p>Which of the minerals given above is/are required by human body for the contraction of muscles?</p> <ol style="list-style-type: none"> <li>1 only</li> <li>2 and 3 only</li> <li>1 and 3 only</li> <li>1, 2 and 3</li> </ol>  |
|    |  |
| 15 | <p>Which of the following diseases can be transmitted from one person to another through tattooing? [Prelims 2013]</p> <ol style="list-style-type: none"> <li>Chikungunya</li> <li>Hepatitis B</li> <li>HIV-AIDS</li> </ol> <p>Select the correct answer using the codes given below:</p> <ol style="list-style-type: none"> <li>1 only</li> <li>2 and 3 only</li> <li>1 and 3 only</li> <li>1, 2 and 3</li> </ol> |
| 16 | <p>Consider the following diseases: [Prelims 2014]</p> <ol style="list-style-type: none"> <li>Diphtheria</li> <li>Chickenpox</li> <li>Smallpox</li> </ol> <p>Which of the above diseases has/have been eradicated in India?</p> <ol style="list-style-type: none"> <li>1 and 2 only</li> <li>3 only</li> <li>1, 2 and 3</li> <li>None</li> </ol>   |
| 17 | <p>H1N1 virus is sometimes mentioned in news with reference to which one of the following diseases? [Prelims 2015]</p> <ol style="list-style-type: none"> <li>AIDS</li> <li>Bird Flu</li> <li>Dengue</li> <li>Swine Flu</li> </ol>   |
| 18 | <p>Which of the following statements is/are correct? (2016 Pre)</p> <p>Viruses can infect</p> <ol style="list-style-type: none"> <li>bacteria</li> <li>fungi</li> <li>plants</li> </ol> <p>Select the correct answer using the code given below.</p> <ol style="list-style-type: none"> <li>1 and 2 only</li> <li>3 only</li> <li>1 and 3 only</li> <li>1, 2 and 3</li> </ol>                                      |

|    |  |
|----|--|
| 19 | <p>'Mission Indradhanush' launched by the Government of India pertains to (Pre 2016)</p> <ul style="list-style-type: none"> <li>(a) immunization of children and pregnant women</li> <li>(b) construction of smart cities across the country</li> <li>(c) India's own search for the Earth-like planets in outer space</li> <li>(d) New Educational Policy</li> </ul>  |
| 20 | <p>Consider the following statements: (Pre 2017)</p> <ol style="list-style-type: none"> <li>1. In tropical regions, Zika virus disease is transmitted by the same mosquito that transmits dengue.</li> <li>2. Sexual transmission of Zika virus disease is possible.</li> </ol> <p>Which of the statements given above is/are correct?</p> <ul style="list-style-type: none"> <li>(a) 1 only</li> <li>(b) 2 only</li> <li>(c) Both 1 and 2</li> <li>(d) Neither 1 nor 2</li> </ul>   |
| 21 | <p>Which of the following statements is not correct? (Pre 2019)</p> <ul style="list-style-type: none"> <li>(a) Hepatitis B virus is transmitted much like HIV.</li> <li>(b) Hepatitis B, unlike Hepatitis C, does not have a vaccine.</li> <li>(c) Globally, the number of people infected with Hepatitis B and C viruses are several times more than those infected with HIV.</li> <li>(d) Some of those infected with Hepatitis B and C viruses do not show the symptoms for many years.</li> </ul>  |
| 22 | <p>Which of the followings are the reasons for the occurrence of multi-drug resistance in microbial pathogens in India? [Prelims 2019]</p> <ol style="list-style-type: none"> <li>1. Genetic predisposition of some people.</li> <li>2. Taking incorrect doses of antibiotics to cure diseases.</li> <li>3. Using antibiotics in livestock farming.</li> <li>4. Multiple chronic diseases in some people.</li> </ol> <p>Select the correct answer using the code given below.</p> <ul style="list-style-type: none"> <li>(a) 1 and 2</li> <li>(b) 2 and 3 only</li> <li>(c) 1,3 and 4</li> <li>(d) 2,3 and 4</li> </ul>    |
| 23 | <p>A company market food products advertises that its items don't contain trans-fats. What does this campaign signify to customers? [Prelims 2021]</p> <ol style="list-style-type: none"> <li>1. The food products are not made out of hydrogenated oils</li> <li>2. The food products are not made out of animal fats</li> <li>3. The oil used are not likely to damage the cardiovascular health of consumers</li> </ol> <p>Which of the statements given above is/are correct?</p> <ul style="list-style-type: none"> <li>A. 1 only</li> <li>B. 2 and 3 only</li> <li>C. 1 and 3 only</li> <li>D. 1, 2 and 3</li> </ul> |
| 24 | <p>The term ACE2 is talked about in the context of (Prelims 2021):</p> <ul style="list-style-type: none"> <li>A. genes introduced in the genetically modified plants</li> <li>B. development of India's own satellite navigation system</li> </ul>   |

|    |   |
|----|---|
|    | <p>C. radio collars for wildlife tracking<br/>D. spread of viral diseases</p>   |
| 25 | <p>In the context of hereditary diseases, consider the following statements: [Prelims 2021]</p> <ol style="list-style-type: none"> <li>1. Passing on mitochondrial diseases, from parent to child can be prevented by mitochondrial replacement therapy either before or after in vitro fertilization of egg</li> <li>2. A child inherits mitochondrial diseases entirely from mother and not from father</li> </ol> <p>Which of the statements given above is/are correct?</p> <ol style="list-style-type: none"> <li>A. 1 only</li> <li>B. 2 only</li> <li>C. Both 1 and 2</li> <li>D. Neither 1 nor 2</li> </ol> |
| 26 | <p>Consider the following statements in respect of probiotics: [Prelims 2022]</p> <ol style="list-style-type: none"> <li>1. Probiotics are made of both bacteria and yeast.</li> <li>2. The organisms in probiotics are found in foods we ingest but they do not naturally occur in our gut.</li> <li>3. Probiotics help in the digestion of milk sugars.</li> </ol> <p>Which of the statements given above is/are correct?</p> <ol style="list-style-type: none"> <li>A. 1 only</li> <li>B. 2 only</li> <li>C. 1 and 3</li> <li>D. 2 and 3</li> </ol>  |
| 27 | <p>'Wolbachia method' is sometimes talked about with reference to which one of the following?</p> <ol style="list-style-type: none"> <li>(a) Controlling the viral disease spread by mosquitoes</li> <li>(b) Converting crop residues into packing material</li> <li>(c) Producing biodegradable plastics</li> <li>(d) Producing biochar from thermochemical conversion of biomass</li> </ol>   |



# TARGET PRELIMS 2024

## BOOKLET-11; EB&CC-1

# ENVIRONMENTAL ECOLOGY - BASICS

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## 2. SOME BASIC FACTS

### 1) RAMDEO MISRA

- He is considered the **father of ecology in India**. He was born in 1908 and obtained **Ph.D. in Ecology (1937)**, from LEEDS University in UK.
- He **established teaching and research in ecology at the Department of Botany of the Banaras Hindu University (BHU)**.
- His research laid the **foundations for understanding of tropical communities and their succession**, environmental responses of plant populations and productivity and nutrient cycling in tropical forest and grassland ecosystems.
- He **formulated first post graduate course in ecology in India**.
- Due to his efforts, the GoI established the **National Committee for Environmental Planning and Coordination (1972)** which, in later years, paved the way for the **establishment of the Ministry of Environment and Forest (1984)**.

## 3. ORGANISMS, POPULATION, ECOSYSTEM AND ECOLOGY

- **Ecology** is the study of the **relationships of living organisms with the abiotic (physical-chemical factors) and biotic components (other species) of their environment**. It is concerned with **four levels of biological organization – Organisms, Populations, Communities and Biomes**.

### 1) ORGANISM AND ITS ENVIRONMENT; ECOLOGY AND ECOSYSTEM

- **Environment:** Everything that surrounds an organism is its environment.
  - » In simple terms, **environment of an organism refers to the physical, chemical, and biological conditions and factors** that surround and influence the life of an organism. It includes **all the living (biotic components)** and non-living things (**abiotic components**) that an organism interacts with, such as the air, water, soil, light, temperature, **other organisms**, and the physical structure in its surroundings.
  - » The environment of an organism is critical for its survival and protection as it affects many aspects of its life including metabolism, behaviour, growth and development.
  - » **Understanding Environment of organism** is very important because:
    - Environment is **critical for the survival and protection**.
    - Different organisms have **different environmental requirements** and adaptations. Some may be **more tolerant or adaptable to change in their environment than others**.

- By studying environment of an organism, scientists can gain insights into how it has evolved and adapted to its surroundings and how it may respond to future changes in environment.
- **Ecology** is the study of relationship between living organisms, including humans and their environment. It seeks to understand the vital connections between plants and animals and the world around them. It seeks to understand how organisms interact with each other and with their physical environment, and how these interactions affect the sustainability of the entire system.

## 2) LEVEL OF ORGANISATIONS IN ECOSYSTEM

Ecosystems are complex and dynamic systems that can be studied at different levels of organization each provide a different perspective on the ecosystem. The level of organizations in ecosystem include:

- 1) **Individual Organisms:** The smallest unit of an ecosystem is the individual organism, such as a single plant, animal or microbe.
- 2) **Population:** A population is a group of individuals usually of the same species living in the same area and interacting with each other.
- 3) **Community:** It is a group of populations of different species living in the same area and interacting with each other. It consists of all the biotic factors of an area.
  - Communities in most cases are named after the dominant plant from (species). E.g. Grassland community is dominated by grasses. Though it may contain herbs, shrubs, some trees, and other animals. It is named after grasses.
  - **Communities can be classified into – Major Community vs Minor Communities**

| Features:                    | Major Community  | Minor Community  |
|------------------------------|--|--|
| <b>Definition:</b>           | These are <u>large sized, well organized, and relatively independent</u> ( <u>self-sustaining</u> ) and depend on only sun's energy and is independent of inputs and outputs from adjacent community. E.g. <u>Grasslands; Deserts; Evergreen rain forests etc.</u> | These are <u>smaller</u> and are <u>dependent on neighbouring communities</u> . These are <b>secondary congregation within a major community</b> and are <u>not therefore completely independent units</u> as far as energy and nutrient dynamics are concerned. E.g. ( <u>stream within a forest; mat of lichen on a cow dung pad</u> ) |
| <b>Size</b>                  | Large  | Small; localized area  |
| <b>Self-sustainability</b>   | Yes  | No; depends on resources from other neighbouring communities   |
| <b>Impact of disturbance</b> | More resilient due to larger size and diversity  | More vulnerable to disturbance due to smaller size and dependence on other community.  |
|                              |  |  |

- 4) **Ecosystem:** It includes all the biotic and abiotic components in the given area and the interactions between them.

- 5) **Biome:** A biome is a large geographical area characterized by a specific set of climatic conditions and plant and animal communities.
- 6) **Biosphere:** The biosphere is the portion of the Earth that supports life, including all of the ecosystems on the planet

Each level of organization in an ecosystem is interconnected and interdependent, and changes at one level can have cascading effects on the other levels. Understanding the different levels of organization in an ecosystem can help us better understand how ecosystem function, how they respond to disturbance, and how we can manage them for sustainability.

### 3) ECOSYSTEM AND VARIOUS COMPONENTS OF AN ECOSYSTEM

- An ecosystem is a community of living organisms (plants, animals, and microorganisms) that interact with each other and with the non-living components (such as air, water, and soil).
- Ecosystem can vary in size, from a small pond to a vast forest. Each ecosystem is a functioning unit of nature.
  - Every organism in an ecosystem is dependent on the other component of the ecosystem. Therefore, if some part of the ecosystem is damaged, it has an impact on other organisms living in that ecosystem.
- **Components of Ecosystem:**

#### A) ABIOTIC COMPONENTS

- Energy
- Water/Rainfall
- Temperature
- Atmosphere
- Substratum (soil and minerals)
- Latitude and Longitude

#### B) BIOTIC COMPONENT

- It consists of living organisms and are classified as per their functional attributes into **producers** and **consumers**:
  - a) **Primary Producers (Autotrophs):** These are organisms which are capable of making their own food using sunlight (photosynthesis) or inorganic compounds (chemosynthesis).
    - Examples include plants, algae, and some bacteria.
  - b) **Consumers (Heterotrophs or phagotrophs)**
    - They don't produce their own food and depend on food derived from other plants, animals and other species.
    - They can be divided into macro-consumers and micro-consumers.
      - **Macroconsumers:** They feed on both plants and animals and can be classified into **herbivores/primary consumers** (e.g. Deer) (feed mainly on plants);

- carnivores/secondary consumers** (e.g. wolves) (feed on primary consumers); **carnivores/tertiary consumers** (e.g. lion) (feed on secondary consumers) and **Omnivores** (e.g. humans, monkeys etc.) (feed on both plants and animals).
- **Micro consumers – Saprotrophs** (decomposers or osmotrophs): These are bacterias and fungi which derive their energy and nutrients by decomposing dead organic substances (detritus) of plant and animal origin. They release inorganic nutrients into environment which are used by primary producers and thus are recycled. Earthworms, and some soil organisms (such as nematodes and arthropods) are detritus feeders and help in decomposition of organic matter and are called **detrivores**.

#### 4) ECOTONE

**Ecotone** refers to the transitional zone or boundary where two different ecosystems or biomes meet and integrate with each other. It is characterized by a mix of vegetation, soil and animal species from both ecosystems, creating a unique habitat with its own set of ecological dynamics.

It can be found in various terrestrial and aquatic environments, such as where a forest meets a grassland, or where a river meets a lake.

##### Important Characteristics of ecotones:

- 1) **Transitional zone**
- 2) **High Species Diversity** compared to either of the adjacent ecosystem, as they contain species from both ecosystems and may offer greater range of resources for organisms.
  - a. **Edge Effect:** Sometimes number of species, and the population density of some of the species is much greater in this zone than either ecosystem. This is called edge effect.
  - b. **Edge Species:** Edge dwelling or ecotone dependent species are those that are particularly adapted to living in the transitional zone or boundary between two different ecosystems or biomes. These organisms occur primarily or most abundantly in the ecotone zone. In terrestrial ecosystem the edge effect is most applicable on birds. Density of birds is greater in the mixed habitat of ecotone between the forest and desert.
    - E.g., of edge species: Indian Spotted eagle; Indian rock python; Golden jackal etc.
- 3) **Unique Species Composition:** Ecotones may contain unique species that are specialized to the transitional habitat and not found in either adjacent ecosystem.
- 4) **Abiotic Gradient:** Ecotones may be characterized by abiotic gradient, such as changes in soil, water, temperature, or light conditions, which create different microhabitats and ecological niches for species.
  - a. This brings a linearity -> progressive increase in composition of one in coming community and a simultaneous decrease in species of the other outgoing adjoining community.

##### Significance of ecotone:

- **Support high level of biodiversity** due to greater range of resources (higher species richness and ecological resilience)

- Act as **important corridors for movement of species** between different ecosystems, allowing for a genetic exchange and maintaining population viability.
- **Important indicator of ecosystem health:** They can also be particularly sensitive to environmental changes and disturbances. Thus, they can inform conservationists about the required management efforts.

**Overall**, ecotones play a crucial role in maintaining the health and functioning of ecosystems, as well as providing important ecosystem services and biodiversity.

## 2) ECOLOGICAL NICHE

**Ecological Niche** refers to the role or position of a species within an ecosystem. It includes its interaction with biotic and abiotic factors of the ecosystem. It encompasses the species habitat requirements, food and water requirements, reproductive strategy and its relationship with other species in the ecosystem.

**Niche Differentiation:** Each species in an ecosystem occupies a unique ecological niche to minimize competition for resources. This allows different species to co-exist and allows for a greater biodiversity within an ecosystem.

- For example, some species may occupy a niche as primary producers, converting sunlight and inorganic nutrients into organic matter, while others may occupy a niche as herbivores or carnivores, feeding on the primary producers or other consumers in the ecosystem

**Competitive Exclusion Principle:** The two species competing for same limited resources cannot coexist in the same niche at a constant population level. If the needs are identical and resources limited than one will outcompete other leading to extinction or niche differentiation.

- **E.g.-1: Darwin Finches** (Galapagos Finches): On Galapagos island, different finch species have evolved different beak types so that they can depend on different kind of food sources. This allowed them to co-exist even within limited resources.
- **E.g.-1: Competitive Dominance:** An invasive species which has some competitive advantage can lead to extinction of native species.

### Fundamental vs Realized Niche:

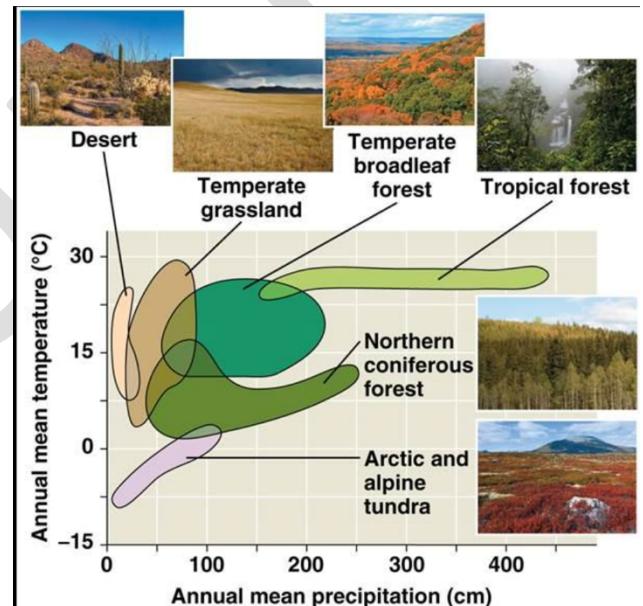
- **Fundamental niche** refers to range of environmental conditions which will allow a species to reproduce and survive successfully, if there was no competition or predators. It reflects species full ecological capabilities and adaptations, assuming ideal conditions.
- **Realized Niche:** It refers to actual set of conditions and resources a species utilizes in the presence of competition from other species. Competition, Predation, and limited resources restrict the species' access to some parts of its fundamental niche. The realized niche is always smaller than or equal to fundamental niche. The same species can have different realized niche in different locations, depending on the local community and environment.

The ecological niche of a species is not fixed, but rather can change over time due to changes in the environment, competition with other species, and other factors. In some cases, two or more species may occupy similar ecological niches, leading to competition for resources and potential changes in the niche of one or both species.

Understanding the ecological niche of a species is important for conservation and management efforts, as it can help to identify the key resources and environmental conditions that are necessary for the survival of the species. By protecting the ecological niche of a species, conservationists can help to maintain the biodiversity and functioning of the ecosystem as a whole.

### 3) BIOMES

- A biome is a large geographical area characterized by a specific set of climatic conditions and plant and animal communities. Variation in temperature, precipitation (both rain and snow) account for the formation of biomes.
- It can also be defined as a major life zone, that includes communities of plants and animals that have a common adaptation to that particular environment.
- **Biomes of the World:** For general understanding purpose we have divided the terrestrial biome into following types (based on NCERT). Please note that some other sources may make this division in many different ways, some going to the extent of 20 different biomes.



## C) VARIOUS TYPES OF TERRESTRIAL BIOMES AND KEY FEATURES:

### 1) Arctic and Alpine Tundra:

- It is characterized by cold, dry and windy conditions.
- Most of the region is under permafrost (a thick layer of ice lying just below the shallow soil). Because of this tree cant penetrate to anchor their roots.
- **Flora:** Lichens, Mosses, grasses, shrubs etc.
- **Fauna:** Polar bears, arctic foxes, migratory birds, reindeer etc. Here reptiles and amphibians are almost absent.



### 2) Taiga/ Northern Coniferous Forests/ Boreal Forests:

- Boreal forests are full of life that are adapted to withstand frigid temperatures year around (or very long cold winters). They are made up of conical evergreen trees with needle like trees. These trees are called conifers because their seeds are clumped into cones. They include spruce, fir, pine etc.
- **Fauna** includes birds, hawks, fur bearing carnivores, little mink, elks, puma etc.
  - During cold winters mammals hibernate and birds migrate. Some animals have evolved to grow dense feathers or fur to survive the winters.
- **Taiga** is the largest land (terrestrial) biome in the world.



### 3) Temperate Deciduous Forest:

- Characterized by moderate temperatures and rainfall
- Deciduous trees, shrubs, grasses
- Fauna: Deer, bears, squirrels, birds etc.

### 4) Tropical Rain Forests:

- High temperatures and rainfall, little seasonal change,
- **Fauna:** Broad leaf evergreen trees, lianas, epiphytes, orchids. Multiple storey of broad-leaved evergreen trees are in abundance.
- **Floras:** Most animals and epiphytes are concentrated in the canopy or tree top zones. They include monkeys, sloths, jaguars, snakes etc.

**Why tropical rain forests are not suitable for agriculture-> very less fertility:**

- Surface soil is heavier leached (nutrients washed away) by running water. Here, the inferior surface soil is the limiting factor that limits the germination of seeds.
- Germinated saplings may not survive due to lack of light because of the dense canopy. Here, the absence of light (shade of the forest) is the limiting factor.

## 5) Savannah Grasslands/ Tropical Grasslands:

- Most extensive in Africa
- Warm and hot conditions with distinct wet and dry seasons
- **Flora:** Grasses are the dominant vegetation in Savannah grasslands, with trees and shrubs scattered throughout the landscape.
  - **Acacia tree** is commonly found in African Savannahs and eucalyptus trees are found in Australian Savannahs.
  - **Enough seasonal rainfall** so that trees can grow in open groups or singly throughout.
- **Fauna:** Large herbivores like zebra, giraffes, antelopes, as well as predators like Lions, Cheetahs, and hyenas.
- **Fire:** It is a common characteristic of Savannah which help to maintain grassy landscapes by clearing away excess vegetation and promoting new growth.
- **Soil:** Soil is typically nutrient poor and shallow and thus it finds difficulty in supporting trees.



## 6) Temperate Grasslands:

- They are popularly known as prairies, steppes or pampas.
- **Climate:** Continent climate with hot summers cold winters. They receive moderate rainfalls.
- **Fauna:** Large herbivores such as bison, pronghorn, and deer as well as predators such as foxes, coyotes, wolves etc.
- **Fire:** they are also characterized by frequent forest fires.  
(The region is dry enough to cause fires and trees can't survive).
- **Soil:** Nutrient rich due to accumulation of organic matter from the grasses. The soil is often deep, and fertilize making it suitable for agriculture.



## 7) Desert:

- **Climate:** Low precipitation; extreme temperature fluctuations
- **Flora:** Cacti, Succulents scrubby bushes
- **Fauna:** Lizards, snakes, scorpions, coyotes, kangaroo rats etc.

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## D) VARIOUS TYPES OF AQUATIC BIOMES AND THEIR KEY FEATURES:

The aquatic biomes are divided into fresh water and marine regions.

### 1) Fresh Water Biomes:

- a. **Rivers and Lakes:** Fast moving, flowing water that originates from mountains and has high oxygen levels.
- b. **Lakes and Ponds:** Standing bodies of water with varying depths, temperatures, and oxygen level
- c. **Wetlands:** Low lying area with standing water, such as marshes, swamps.

### 2) Marine Biomes:

- a. **Oceans:** The largest biome on earth, oceans are divided into zones based on depth and receive varying amount of sunlight, affecting the types of organisms that can survive in each zone
- b. **Coral Reefs:** Warm, shallow waters where diverse species of corals thrive
- c. **Estuaries:** Areas where freshwater meets saltwater, creating unique habitats for species adapted to changing salinity levels.

**Please note:** This is not an exhaustive list of terrestrial and aquatic biomes.

## 4) BIOSPHERE

- The biosphere is the part of the earth where life exists, which includes all living organisms and their interactions with the environment. It extends from the deepest ocean depths to the highest altitudes in the atmosphere and includes all terrestrial and aquatic ecosystems.
- The biosphere is composed of various biomes.
- The biosphere is a complex system, with numerous ecological interactions and feedback loops. It consists of various food chains and food webs.

## 5) HABITAT AND HOW ORGANISMS HAVE EVOLVED TO ADAPT TO OPTIMIZE ITS SURVIVAL AND REPRODUCTION IN ITS HABITAT

- **Regional and local variations** with each biome leads to formation of habitat.
  - » Over a period of time, the organism had evolved to adapt to optimize its survival and reproduction in its habitat.

### A) MAJOR ABIOTIC FACTORS/ ABIOTIC COMPONENTS

- **Temperature:** It is the most important ecologically relevant environmental factor. It affects the kinetics of enzymes and through it the metabolic activity and other physiological functions of the organism. The levels of thermal tolerance of different species determine to a large extent their geographical distribution.
  - » A few organisms can tolerate and thrive in wide range of temperatures (they are called euthermal). (e.g., Humans, Cows, Monkeys, Sheep, Goats etc.)
  - » A vast majority of organism are restricted to a narrow range of temperatures (they are called stenothermal). (e.g. penguins, crustaceans etc.)

- **Water:** Life on earth originated in water and can't sustain without water. In limited water conditions like deserts, special adaptations techniques are needed for organisms to live there. The productivity and distribution of plants are also dependent on water. Even aquatic organisms face water related issues as sometimes the quality, pH etc. becomes problematic. The salt concentration of water is also an important factor. Many freshwater species can't survive in ocean water for long because of the osmotic pressure that they face.
  - » Some organisms may tolerate a wide range of salinities (euryhaline), but others are restricted to narrow range (stenohaline).
- **Light:** Autotrophs who form the first level of any food chain depend on light for generating food. Thus, light is important for all living organisms.
  - » **Some organisms** survive in less light conditions (e.g., herbs and shrubs growing in tropical rain forests have adapted to do photosynthesis optimally under very low light conditions because they are constantly overshadowed by tall, canopied trees).
  - » **Many plants** are dependent on sunlight to meet their photoperiodic requirement for flowering.
    - Most angiosperms (flowering plants) use photoperiodism to determine when to flower. To do that they use one of the photoreceptor protein present in their body such as cryptochrome or photochrome.
  - » **For many animals too, light is important** in that they use diurnal and seasonal variation in light intensity as cues for timing their foraging, reproductive and migratory activities.
  - » **Note:** How do deep sea organisms get their energy (since light doesn't reach there)?
    - **Three major methods** – Marine Snow; Whale Falls; Chemosynthesis.
    - **Marine Snow:** It refers to biological debris that originate from the top layers of the ocean and drift to the seafloor, providing primary source of energy for animals in the deep ocean. It primarily consists of phytoplankton produced through photosynthesis and as they sink, it collects other floating debris, including fecal material, dead or decaying animals, suspended sediments etc.
    - **Whale Fall:** When whales die and sink, the whale carcasses, or whale falls provide a sudden concentrated food source and a bonanza for organisms in the deep sea. Useful video: [https://youtu.be/LUFKzP8ql\\_A?si=aSWIQtOw2u1xeAsi](https://youtu.be/LUFKzP8ql_A?si=aSWIQtOw2u1xeAsi)
  - » **Among the red, green and brown algae** that inhabits the sea, which is likely to be found deepest in water?
    - **How sunlight penetration varies with depth of ocean? Short wavelength/high frequency** light can penetrate sea water more easily. Thus, as depth increases, blue light reaches, green reaches less, Yellow further lesser and Red reaches the least.

- Red algae at the depth of the ocean thus absorbs blue green wavelength and survive at deeper layer. They have more quantity of the pigment **phycoerythrin**. It absorbs the blue-green spectrum of the visible light.
- **Soil:** Characteristics of soil such as soil composition, grain size, and aggregation determine the percolation and water holding capacity of the soils. These characteristics along with other parameters like pH, mineral composition, and topography determine to a large extent the vegetation in any area. This in turn dictates the type of animals that can be supported. Similarly, the aquatic environment, the sediment-characteristics often determine the type of benthic animals that can thrive in the soil.

## B) RESPONSES TO ABIOTIC FACTOR

- **Abiotic components** of a habitat may vary drastically with time.
  - » But most species have evolved to have a relatively constant internal (within the body) environment. This constant environment provides maximal efficiency for all biochemical and physiological functions and thus enhances the overall fitness of the organisms. This may be in terms of optimal temperature and osmotic concentration of the body fluid.
  - » **Ideally then**, the organism should try to maintain the constancy of its internal environment (a state called homeostasis) despite varying external conditions that tends to upset its homeostasis.
    - **Note:** Homeostasis is the state of steady internal, physical, and chemical conditions maintained by living environment.
- How do organisms living in such habitats cope or manage with such stressful conditions?
  - » **Regulate:** Some organisms are able to maintain homeostasis by physiological means (sometimes behavioral means also).
    - **All birds and mammals**, and a very few lower vertebrates and invertebrates are capable of such regulation (thermoregulation and osmoregulation).
    - Evolutionary biologists believe that success of Mammals is largely due to their ability to maintain a constant body temperature and thrive weather they live in Antarctica or Sahara Desert
      - **For e.g.: Human** maintain the body temperature at 37-degree C. In summers, we sweat to produce evaporating cooling and in winters, we shiver to produce heat and raise the body temperature.
    - **Regulation is energetically expensive.** This is particularly true for small animals like shrews and hummingbirds. Small animals have large surface area relative to their volume, they tend to lose their body heat very fast when it's cold outside; and they would need a lot of energy to maintain the body temperature. This is the reason why very small animals are rarely found in Polar region.
  - » **Conform:** Conformers are organisms that lack the ability to regulate their internal body temperature (endothermy) and instead rely on their environment to dictate their internal

temperature (ectothermy). This means that they experience significant changes in their body temperature along with the fluctuations in their surrounding environment.

- In aquatic animals, the osmotic concentration of body fluids changes with that of the ambient air, water osmotic concentration. These animals and plants are conformers.
- **E.g. of conformers:**
  - » **Fish:** Many fish are conformers, meaning that their body temperature matches to their surrounding water. They adjust metabolic rates and activity levels based on the outside temperature. Some fish species like trots which prefer colder waters will migrate to deeper or cooler oceans during warmer seasons.
  - » **Reptiles** are classic examples of conformers. They rely on external source of heat such as sunlight to regulate their body temperature. Basking in the sun helps them warm up, while seeking shade or burrowing underground helps them cool down.
  - » **Amphibians** – most are conformers. Basking in sun, shelter in cooler areas to avoid overheating etc.
  - » **Ectothermic Plants** – The metabolic activities and growth of plants are influenced by ambient temperature. For e.g., the rate of photosynthesis in plants increase at higher temperature and decreases with low temperature.
- **Why didn't these animals and plants become regulators?**
  - » Thermoregulation is energetically expensive for many organisms.
  - » During evolution, the cost and benefit of maintaining a constant internal environment are taken into consideration. Some species have evolved the ability to regulate, but only over a limited range of environment, beyond which they simply conform.
- » **Migrate:** If the stressful external condition is localized or remain only for short duration, the organisms have two other alternatives for survival Migration or Suspension.
  - **Migration:** In migration, organism move temporarily from the stressful habitat to a more hospital area and return when stressful period is over. (E.g., Siberian crane coming to Rajasthan in winters)
  - **Suspension:**
    - In bacteria, fungi and lower plants, various kinds of thick-walled spores are formed which help them to survive unfavorable conditions – these germinate on availability of suitable environment.
    - In higher plants, seeds and some other vegetative reproductive structures serve as means to tide over periods of stress besides dispersal – they germinate to form new plants under favorable moisture and temperature condition. They do so by reducing their metabolic activity and going into a state of 'dormancy'.

- **Animals** which are unable to migrate, may escape in time (i.e., **hibernate** during winters). Some animals go into **deep sleep** for extended period of time, while **others will just slow down** but **remain active**. Some will go into a combination of both, known as **Torpor**.
  - » Animals like bats, Squirrels, Marmot, Lemurs, Hedgehog, Earthworms, Toads, Bees, bears etc. **hibernate in a warm place during winters**.
  - » **Bears** living in cold climate hibernate during winters – when the food is scarce, but the bear in warmer climate can find plenty of food all year long so they don't have any reason to hibernate. **Bears** are **true hibernators** and sleep heavily never to wake up again till the spring arrives. Only the Mama Bear wakes up in Jan/Feb to give birth to the new cubs, and the babies will be happy nestling with Mamma until she can take them out on their first adventure.
  - » **Bats also hibernate** (again the once in warmer areas don't).
  - » **Some snakes** also hibernate.
- **Some snails and fish** go into aestivation to avoid summer-related problems-heat and desiccation.
  - » **Note:** Aestivation or estivation is a state of dormancy that some animals enter during hot and dry periods. It is similar to hibernation, which is a state of dormancy during cold and harsh conditions.
- Under unfavorable conditions, many zooplankton's species in lakes and ponds are known to enter diapause, a stage of suspended development.
- **Dieback:** It refers to the progressive dying, usually backwards from the tip of any portion of the plant. This is one of the adaptive mechanisms to avoid adverse conditions like droughts. In this mechanism, the root remains alive for years together, but the shoots die. E.g., Sal, Red Sanders, Silk-Cotton etc.

### C) ADAPTATION

- Adaptation is any attribute of the organism (morphological, physiological, behavioral) that enable the organism to survive and reproduce in its habitat.

Many adaptations have evolved over long evolutionary time and are genetically fixed. In the absence of external source of water, the **Kangaroo rat**, in North American deserts is capable of meeting all its water requirements through its internal fat oxidation (in which water is a byproduct). It also has the ability to concentrate its urine so that less water is lost



- **Desert plants** have adapted to following features to survive in water scarce conditions:

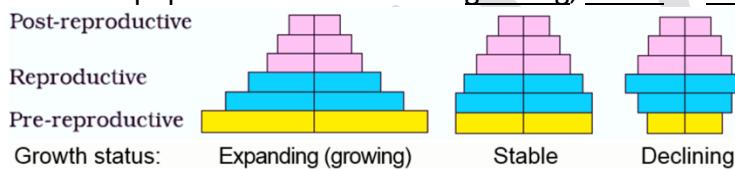
- » **Reduced Leaf Size:** Smaller leaves minimize water loss through transpiration.
  - » **Thick Cuticles:** Desert plants have a thick waxy layer on the surface of their leaves and steps to reduce water loss.
  - » **CAM Photosynthesis:** Some desert plants, such as cacti and succulents, use a special type of photosynthesis called Crassulacean Acid Metabolism (CAM), which allows them to conserve water during photosynthesis.
    - In this system, CO<sub>2</sub> is fixed at night when temperature is cooler, and stomata (pores in leaves) can remain open without excessive water loss. Here CO<sub>2</sub> is converted into malate (a four carbon acid) which will be used during day time for photosynthesis.
    - E.g. of CAM mechanisms: Succulents like aloe-vera and Jade plant; some orchids; Crassula, a genus of flowering plants giving CAM its name.
  - » **Deep Roots:** To access water from deep underground.
  - » **Efficient Water Use:** Desert plants have adapted to use water efficiently by closing their stomata during the day and opening them at night to reduce water loss.
  - » **Succulent Tissues:** Some desert plants have fleshy, water storing tissues that allow them to survive for long periods without water.
  - » **Spines or Thorns:** To deter herbivores and to reduce water loss from leaf surface.
- **Allen's Rule:** Mammals from colder climate, generally have shorter ears and limbs to minimize heat loss (This is called Allen's Rule).
- In the **polar seas**, aquatic mammals like **seals**, have a thick layer of fat (blubber) below their skin that acts as insulator and reduces loss of body heat.
- **Tribes living in high altitude region**, normally have higher RBC count (or total hemoglobin) than people living in plains. Why?
- **Some microbes** (archaeabacteria) flourish in hot springs and deep-sea hydrothermal vents where temperature far exceeds 100-degree C.
  - » Microbes which can live at such high temperature are called **thermophiles**. They are able to survive in such high temperatures because their bodies have adapted to such environmental conditions. They contain specialized thermo resistant enzymes, which carry out metabolic functions that don't get destroyed at such high temperatures.
- **How do fish in Antarctic water prevent their body fluids from freezing?**
  - They have developed proteins that act as **anti-freeze**. These anti-freeze proteins are a group of unique macromolecules that help some polar and subpolar marine bony fishes avoid freezing in their icy habitat. These **proteins bind to and inhibit growth of ice crystals** within body fluids through an absorption-inhibition process. These proteins attach to small ice crystals stemming their growth.
- **How do deep sea organisms live under high pressure?**
  - Most living things in the deep sea are largely water and water is incompressible. **Without gas filled spaces** like lungs or bladders, organisms in the great deep are less affected by pressure than we imagine. Further, they have "**piezolytes**" – small, organic molecules which have only recently been discovered. These piezolytes stop the other molecules in the creatures' bodies, such as membranes and proteins, from being crushed by the pressure.

## 5) POPULATIONS

- Majority of organisms live in groups in a well-defined geographical area, share or compete for similar resource, **potentially interbreed (same species)**, and thus constitute a **population**.
- Although the term interbreeding may imply **sexual production**, a group of individuals resulting from **even asexual reproduction** is also generally considered a population.
  - » E.g.: Rats in an abandoned dwelling; bacteria in a culture plate, lotus plants in a pond etc.
- So far, we had studied that Individual organism is the one that has to cope with a changed environment, it is at population level that **natural selection operates to evolve the desired traits**. Population ecology is, therefore, an important area because it links ecology to population genetics and evolution.

| Individual                                   | Population  |
|--|---|
| Individuals don't show attributes            | Population has certain attributes                 |
| Individual may have <u>births and deaths</u> | Population has <u>birth rates and death rates</u> |
| Individual may be male/female etc.           | Population can have <u>sex ratio</u> .            |

- **Age distribution of a population** forms what is called **Age Pyramid**. The shape of the pyramid reflects the growth status of population. Whether it is growing, stable or declining.



- The size of the population tells us a lot about the habitat.

### A) POPULATION GROWTH

- The density of a population in a given habitat during a given period, fluctuates due to changes in four basic processes: **Natality and Immigration** contribute to an increase in population. **And Mortality and Emigration** contribute to decrease in population.

### B) LIFE HISTORY VARIATION

- Populations evolves to maximize their reproductive fitness, also called **Darwinian fitness** (high r value), in the habitat in which they live. Life history traits of organisms have evolved in relation to the constraints imposed by the abiotic and biotic components of the habitat in which they live. They develop the most efficient reproductive strategy.

For e.g. – Some organisms breed only once (for e.g., Pacific Salmon fish, Bamboo); while others breed many times during their lifetime (most birds and mammals)

### C) POPULATION INTERACTION:

- In nature, animals, plants and microbes don't and cannot live in isolation but interact in various ways to form a biological community. Even in minimal communities, many interactive linkages exist, although all may not be readily apparent.
- Interspecific interactions arise from the interaction of population of two different species. This interaction could be beneficial (+), neutral (0) or detrimental (-) to one of the species or both. All possibilities are given below:

| Species A | Species B | Name of Interaction |
|-----------|-----------|---------------------|
| +         | +         | Mutualism           |
| -         | -         | Competition         |
| +         | -         | Predation           |
| +         | -         | Parasitism          |
| +         | 0         | Commensalism        |
| -         | 0         | Amensalism          |
|           |           |                     |

- In parasitism and predation only one species benefits (parasite and predator, respectively) and the interaction are detrimental to other species (host and prey, respectively).
- Mutualism, Predation, Parasitism, and Commensalism share a common characteristic, the interacting species live closely together.

#### MUTUALISM

- The interaction confers benefits to both the interacting species.
- E.g.
  - » Lichens (intimate mutualistic relationship between fungus and photosynthesizing algae or cyanobacteria)
  - » Mycorrhizae are associations between fungi and the roots of higher plants. The fungi help the plant in the absorption of essential nutrients from the soil, while the plant in turn provides the fungi with energy yielding carbohydrates.
  - » Plant Animal Relationship: Plants need animals for pollinating their flowers and dispersing the seeds, whereas plants given them in return, honey fruits etc.
  - » Now you can see why plant-animal interactions often involve co-evolution of the mutualists, that is, the evolutions of the flower and its pollinator species are tightly linked with one another.
  - » In many species of fig trees, there is a tight one-to-one relationship with the pollinator species of wasp. It means that a given fig species can be pollinated only by its 'partner' wasp species and no other species. The female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds within the fruit for nourishing its larvae. The wasp pollinates the fig inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination the fig offers the wasp some of its developing seeds, as food for the developing wasp larvae

#### COMPETITION

- Competition occurs when closely related species compete for the same resources that are limiting.
  - » But totally unrelated species may also compete (for e.g., visiting flamingoes and resident fishes compete for their common food, the zooplanktons in a lake).
  - » Even in case of abundant resources, competition may occur, in **interference competition**, the feeding efficiency of one species might be reduced due to interfering and inhibitory presence of the other species.
- Therefore, competition is best defined as “a process in which **fitness of one species**, is significantly lower in the presence of another species”.
- E.g., **Abingdon tortoise in Galapagos Islands** became extinct within decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.
- Species facing competition might also evolve mechanisms that promote co-existence rather than exclusion. One such mechanism is “**resource partitioning**”. Here species avoid competition by choosing for instance, different time for feeding on different foraging patterns.

#### PREDATION:

- » **Significance:** Transferring the energy to higher trophic levels; Keeping prey population under control and contribute to ecosystem stability; they also help in promoting species biodiversity in a community, by reducing the intensity of competition among competing prey species.
  - In the absence of predator, a prey may become invasive and damage the ecosystem. E.g., when prickly pear cactus was introduced in Australia in the early 1920s, they caused havoc by spreading rapidly to millions of hectares. It was only when a cactus feeding predator (a moth) was introduced, the population could be controlled and damaged could be reduced.
  - **Predators by nature are prudent.** Because if the overexploit and prey population reduces drastically, predators would also suffer.
  - **Prey species** have also evolved various mechanisms to protect themselves from predators – e.g., insects and frogs are cryptically colored (camouflaged) to avoid being detected easily by predator. Some are poisonous and thus are avoided by Prey. **Monarch Butterfly** is highly distasteful to its predators (birds) because of a special chemical present in its body.
  - **For Plants**, herbivores and predators, so plants also develop various mechanisms to protect themselves.
    - » **Thorns** (Acacia, Cactus) are the most common morphological means of defence.
    - » Many plants produce **chemicals that make herbivore sick** when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even kill it.
      - i. **E.g., Calotropis** (they grow in abandoned fields, and they produce highly poisonous cardiac glycosides and that is why you never see any cattle or goats browsing on this plant.



- ii. **A wide variety of chemical substances** that we extract from plants on a commercial scale (nicotine, caffeine, quinine, strychnine, opium, etc.) are produced by them actually as defences against grazers and browsers.

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## PARASITISM

- **Majority of the parasites harm the host.** They may reduce the survival, growth and reproduction of the host and reduce its population density. They may also render the host more vulnerable to predation by making it physically weak.
- **Ectoparasites:** Parasites feeding on the external surface of the host organisms.
  - » E.g., lice on humans, ticks on dogs.
  - » Many fish species are infested by ectoparasitic copepods.
  - » Cuscuta, a parasitic plant, has lost its chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant that it parasites.
  - » **Note:** The female mosquito is not considered a parasite, although it needs our blood for reproduction. Why?
    - Because it needs blood for reproduction not for nutrition. Human blood is required for nourishment of the offspring. A parasite depends for its entire lifespan or at least for a considerable period within a host body and completely depends on the host for nutrition and habitat.
- **Endoparasites:** Parasites that live inside the host body at different sites (liver, kidney, lungs, red blood cells, etc.)
  - » The lifecycle of endoparasites is more complex because of their extreme specialization. Their morphological and anatomical features are greatly simplified while emphasizing their reproductive potential.
- **Brood Parasitism:** Here parasitic bird lays its eggs in the nest of its host and lets the host incubate them. During the course of evolution, the eggs of the parasite bird has evolved to resemble the host's eggs in size and color to reduce the chances of the host bird detecting the foreign egg and ejecting them from the nest.
  - » Asian Koel, like many of its related cuckoo kin is a brood parasite that lays its eggs in the nests of crows and other hosts, who raise it young.

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## COMMENSALISM

- Interaction in which one species benefit, the other is neither harmed nor benefited.
- E.g.
  - » Orchid growing as an epiphyte on mango branch.
  - » Barnacles growing on the back of a whale. They don't harm whales or feed on them. They don't serve any obvious advantage to whale, but they give helpful lice a place to hang onto the whale without getting washed away in water.

- » The **cattle egret** and the grazing cattle is a classic example of commensalism. The egrets always forage close to where the cattle is grazing because the cattle, as they move, stir up and flush out insects from the vegetation that otherwise may be difficult for egrets to find.

## 4. FUNCTIONS OF AN ECOSYSTEM

**Ecosystems** perform some basic functions which are essential for supporting life on earth and maintaining ecological balance. These functions can be categorized under the following heads:

- 1) **Primary Production:** This refers to the production of food by autotrophs through the process of photosynthesis (plants, algae, bacteria etc.) and chemosynthesis (in some bacteria). Primary production provides energy and nutrients for all other organisms within the ecosystem.
- 2) **Energy Flow:** This refers to one-way transfer of energy from producers to consumers and eventually to decomposers through food chain. At each level some energy is lost as heat.
- 3) **Nutrient Cycling:** Essential nutrients, like nitrogen, phosphorus, carbon etc. are constantly recycled in the ecosystem. This continuous cycle ensures the availability of these vital elements for all organisms.
- 4) **Water Cycle/Water Regulation :** Ecosystems regulate the water cycle, which is essential for the survival of living organisms.
- 5) **Habitat Provisions:** Ecosystem provides diverse habitats for various species. Each habitat, with its particular set of features support unique set of species.
- 6) **Environmental Provisions:** Regulation of climate, air quality and water quality.
  - Absorbing Carbon, reducing global warming and mitigating effects of climate change
  - Plants also filter air pollutants and release oxygen through photosynthesis.
  - Wetlands and forests act as natural filters and help in removing sediments and pollutants from water as it flows through them. This helps in maintaining of clean water for humans and other organisms.
- 6) **Ecological Succession:** Ecological succession is the process by which natural communities replace (or succeed) one another over time.
- 7) **Soil Formation**
- 8) **Cultural and Recreational Services**

In this chapter, we will primarily focus on three important functions of ecosystem – **Energy Flow; Nutrient Cycling and Biogeochemical Cycles:**

## 1) ENERGY FLOW THROUGH AN ECOSYSTEM

Energy flow through an ecosystem refers to transfer of energy from one organism to another within a food chain or food web. The sun is the primary source of energy in most ecosystems, and it's captured by plants through photosynthesis. This energy flows through the ecosystem as one organism consume other organism for food.

### A) TROPHIC LEVEL:

- Trophic level refers to different levels of food chain where organisms obtain energy and nutrients. There are primarily four main trophic levels – Producers; Primary Consumers; Secondary Consumers; Tertiary Consumers. The energy flow through the trophic levels from producers to subsequent trophic levels is unidirectional.
- Each trophic level represents a transfer of energy and nutrients from one group of organisms to another. As organisms consume other organisms, they extract energy and nutrients from their food, and some of this energy is lost as heat. This means that there is typically less energy available at higher trophic levels, which is why food chain tend to be relatively short.
- The trophic level interaction involves three concepts viz. Food Chain, Food Web and Ecological Pyramids.

### B) FOOD CHAIN:

- Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten link is called a food chain. A food chain starts with producers and ends with top carnivores. The trophic level of an organism is the position it occupies in a food chain.
  - E.g., Grassland Ecosystem:
    - Grasses-Grasshopper-Frog-Snake-Hawk/Eagle.
  - E.g., Aquatic Ecosystem:
    - Algae -> Zooplankton (smaller animals and immature stages of large animals) -> Small fish -> large fish -> Shark

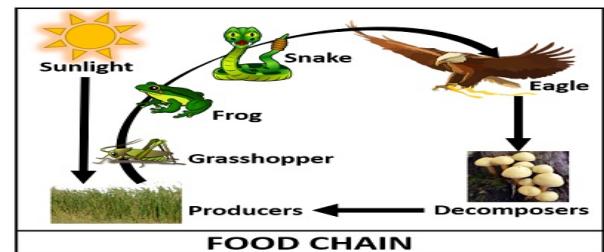
- **Diatom** (microscopic algae) -> **Crustaceans** -> **Herring** -> **Shark**
  - **Note:** Crustaceans such as copepods are typically herbivores that feed on phytoplankton, including diatoms. Herring are small fish that feed on zooplanktons, including Crustaceans.
- **E.g., Forest Ecosystem**
  - **Trees** – Caterpillar – Blue Jay (small bird) – Hawk
- **E.g., Desert Ecosystem**
  - **Cactus** -> Grasshopper -> Lizard -> Snake -> Eagle
- **E.g., Arctic Ecosystem**
  - Phytoplankton's -> Krill (crustacean)-> Arctic Cod (fish) -> Seal (mammal) -> Polar Bear (Mammal)

#### Types of Food Chains:

1. Grazing Food Chain
2. Detritus Food Chain

#### Grazing Food Chain:

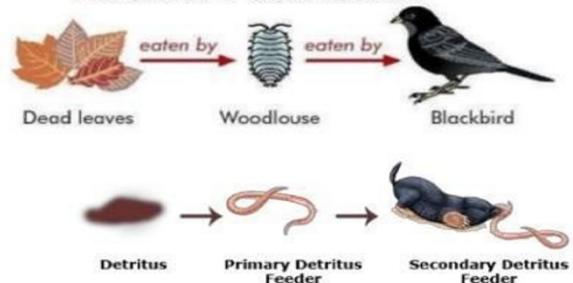
- The consumers which start the food chain, utilizing the plant or plant part as their food, constitute grazing food chain.



#### Detritus Food Chain:

- Starts from **organic matter of dead and decaying animals and plant bodies** from the grazing food chain.

#### Detritus Food Chain



E.g.: Forest Floor Detritus food chain: Leaf litter

→ Fungi → Mites → Beetles → Salamanders

E.g.: Aquatic Detritus Food chain: Dead algae and other organic matter → Bacteria → Zooplankton  
→ Small fish → Larger fish

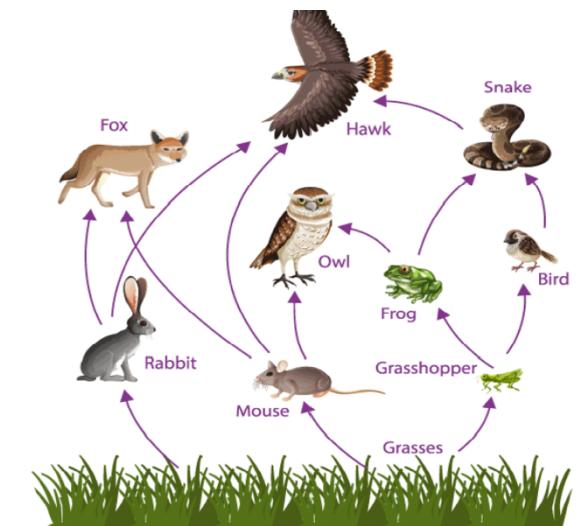
- In aquatic ecosystems, the grazing food chain is the major conduit for energy flow.
- In terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the grazing food chain.

**NOTE:**

- 1) **Detritus Food Chain is important** because it increases the soil process/fertility by the process of 'Humification'.
  - a. **Humus:** It is a dark, organic rich substance that forms as a result of decomposition of plant and animals and animal material in soil. It is a complex mixture of organic compounds, including carbon, nitrogen, phosphorus, and sulfur, as well as minerals such as calcium, magnesium and potassium. It is key to healthy soil and can help to improve soil structure, retain moisture, and provide a source of nutrients for plants. In addition, it can help restore carbon in soil.
- 2) **Catabolism:** It is a set of metabolic processes that involve the breakdown of complex molecules into simpler ones, releasing energy in the process. The term catabolism is often used in contrast to **anabolism**, which refers to the set of metabolic activities that involve the synthesis of complex molecules from simpler ones, using energy.
- 3) **Humification and mineralization** occur during decomposition in the soil. Humification leads to accumulation of a dark-colored amorphous (formless) substance called humus viz. highly resistant to microbial action and undergoes decomposition at an extremely slow rate. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralization**.

### C) FOOD WEB:

- Multiple interlinked food chains make a food web. Food web represents all the possible paths of energy flow in an ecosystem.
- If any of the intermediate food chains is removed, the succeeding links of the chain will be affected largely.
- The food web provides more than one alternative for food to most of the organisms in an ecosystem and therefore increases their chance of survival.



### D) ECOLOGICAL PYRAMIDS

The pyramidal representation of trophic levels of different organisms based on their ecological position (producer to final consumer) is called as Ecological Pyramid.

The ecological pyramids are of three categories:

1. Pyramid of Numbers
2. Pyramid of Biomass, and
3. Pyramid of Energy or Productivity

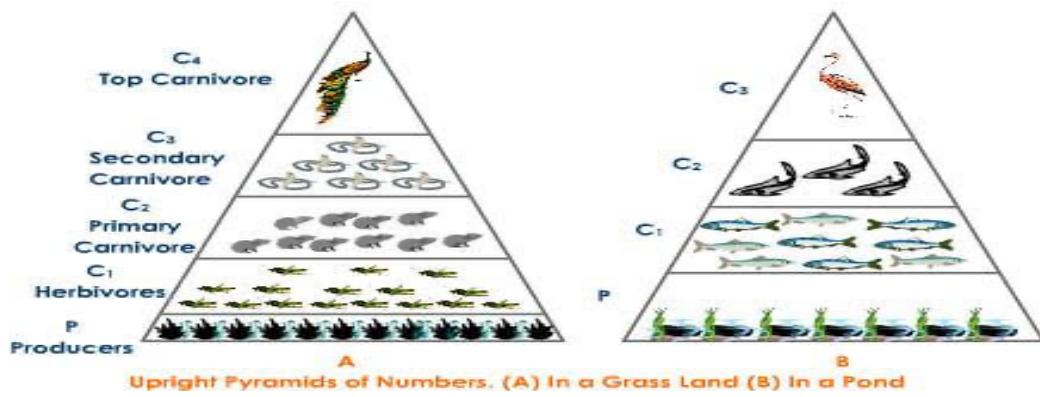
#### PYRAMID OF NUMBERS:

- It represents the total number of individuals of different species (population) at each trophic level.
- Depending upon the size, the pyramid of numbers may not always be upright, and may even be completely inverted.

##### (a) Upright:

In this pyramid, the number of individuals is decreased from lower level to higher trophic level.

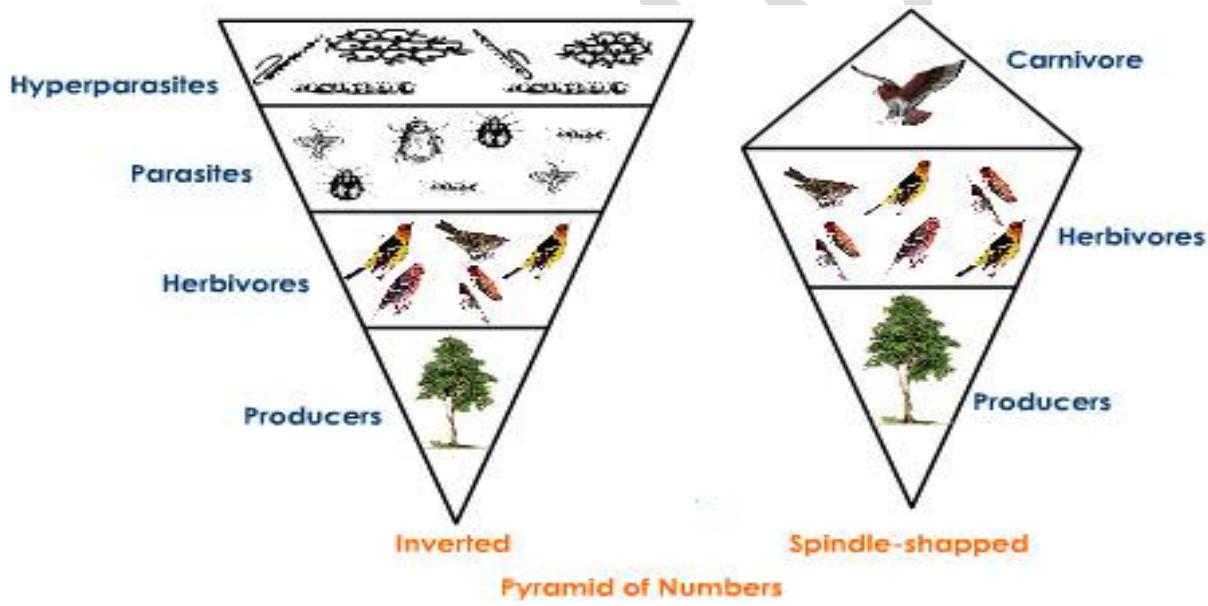
This type of pyramid can be seen in the Grassland Ecosystem and Pond Ecosystem.



### (b) Inverted:

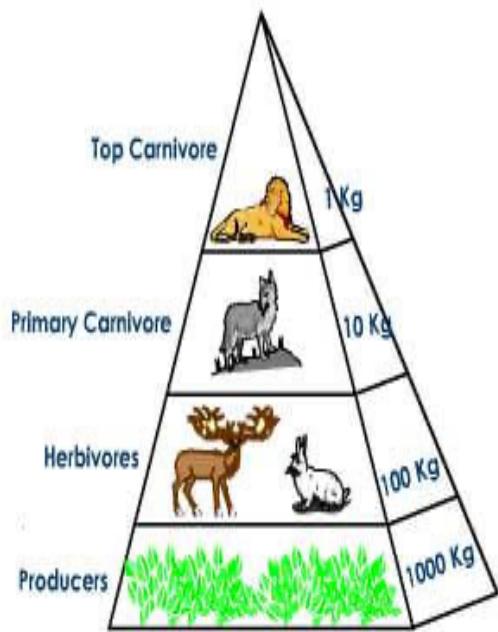
In this pyramid, the number of individuals is increased from lower level to higher trophic level. E.g., Tree Ecosystem

**NOTE: Pyramid of Number is ALWAYS Upright in Aquatic Ecosystem, but it may be Upright as well as Inverted in Terrestrial Ecosystem.**

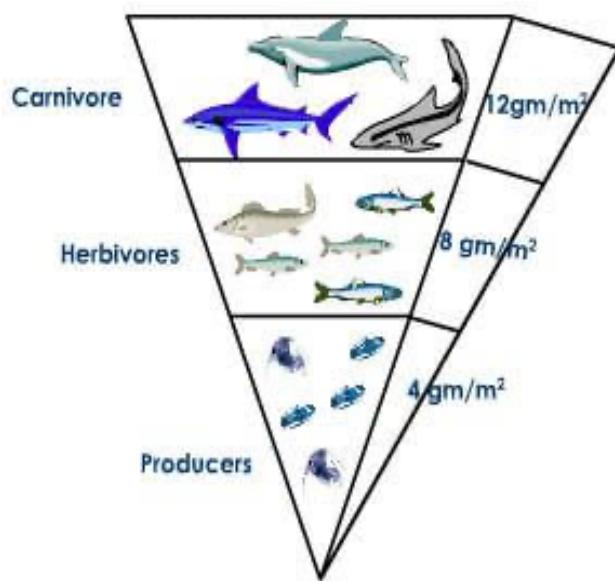


### PYRAMID OF BIOMASS:

- Biomass means the weight of an organism in a given area and volume. To calculate the biomass of pyramid, we consider the 'dry weight'.
- NOTE:** Pyramid of Biomass is ALWAYS Upright in Terrestrial Ecosystem, but in Aquatic Ecosystem, as Producers are microscopic, small phytoplankton's, they do not have much weight. Hence, pyramid of biomass is Inverted.



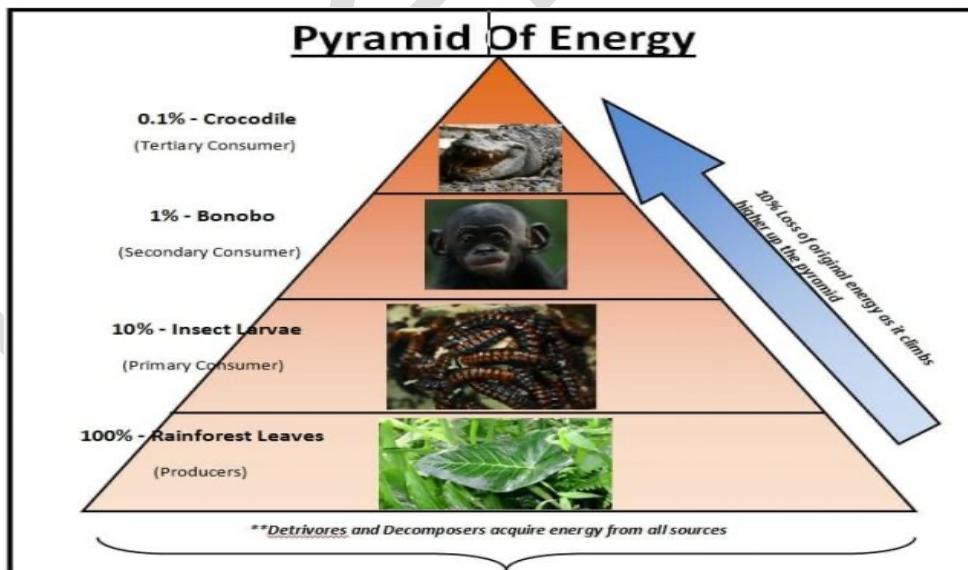
Upright Pyramid of biomass in a Terrestrial Ecosystem



Inverted Pyramid in an Aquatic Ecosystem

#### PYRAMID OF ENERGY:

- It is **most important pyramid** because it represents the amount of energy at each trophic level.
- As per Lindeman's law, **only 10 % of Energy** is transferred from lower to higher trophic level.
- At each trophic level, energy lost in respiration or in metabolism or in locomotion. **Therefore, pyramid of energy is ALWAYS uni-directional & Upright.**



**NOTE:** As ecological efficiency is LOW, therefore, organisms higher in food chains are LESSER in Number than they require more food.

As they require more food, Higher Organism in food chains, then there is GREATER chance of Biomagnification & Bioaccumulation.

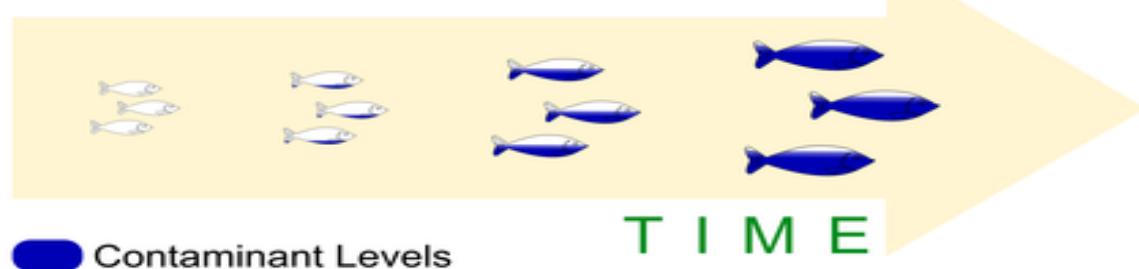
## E) POLLUTANTS AND TROPHIC LEVELS

- Pollutants, especially the non-degradable ones move through various trophic levels in an ecosystem.
- Because of the mechanisms of bioaccumulation and biomagnification even small concentrations of chemicals in the environment find their way into organisms in high enough dosages to cause problems.

### BIO-ACCUMULATION

- It refers to entry of a pollutant or toxic substance in the food chain. It actually is gradual accumulation of substances like pesticides or other chemicals, in an organism's body over time.
- It will take place when rate of absorption of pollutant is more than the rate of elimination (metabolism or excretion).
- Bioaccumulation typically occurs within individual organism, particularly those at lower trophic levels of a food chain. The concentration of pollutants in the organism may increase with repeated exposures or with prolonged exposures to contaminated environments.
- **Note:** Bioaccumulation doesn't necessarily mean higher concentration of pollutant at higher trophic levels.
- **Source of pollutant** may be food, soil, water, air etc.
- **Substances which are likely to bioaccumulate:** Long lives (doesn't easily break/destroy); Mobile; fat soluble and biologically active (thus causes damage)
- **E.g.: Mercury in Fish** (Mercury is absorbed by algae and plankton, which are then consumed by small fish. Here mercury accumulate in the tissue of the fish.)

## Bioaccumulation

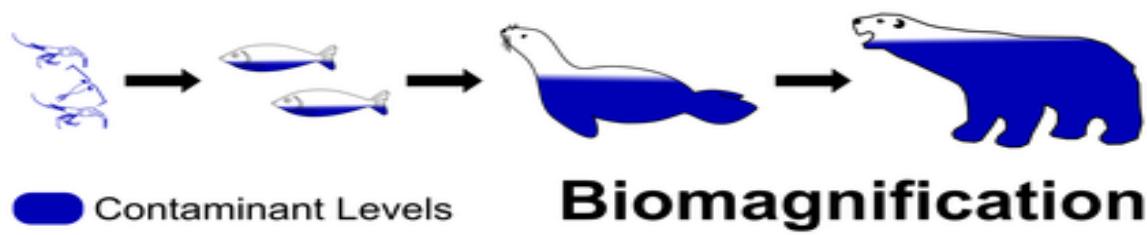


### BIO-MAGNIFICATION

**Bio-Magnification:** The tendency of pollutant to increase in concentration as it moves from lower to higher trophic level, is known as Bio-magnification. This usually occurs across the entire food chain and affects all the organisms in the food chain. The animals at the higher trophic levels are affected more.

E.g.: **DDT**: it is a pesticide which is non-biodegradable. It gets incorporated in the food chain and gets deposited in the tissues of the organisms. When DDT enters water bodies, it gets accumulated in the body of fish (bioaccumulation) and when these fish are eaten by bigger fish, the concentration of DDT increase at each successive step (biomagnification).

**Note:** Biological magnification specifically refers increasing concentration of material in each higher connecting link in the food chain. However, bioaccumulation examines the increased presence of particular substance in a single organism.



#### Causes of Bio-accumulation & Bio-magnification:

1. **Agricultural Products:** Highly toxic substances such as herbicides, pesticides, fungicides etc. and these substances can also penetrate into the soil.
2. **Organic Contaminants:** Bio-solids used in agriculture farms are treated using toxic chemicals that may contain heavy metals.
3. **Plastic Pollution:** Disposal of plastic waste near or in water bodies. It is caused by 'Ghost Nets' for fishing nets. For instance, Bisphenol A is one of the major contaminants released into the water bodies.
4. **Mining:** Zinc, Copper, Lead and other chemicals may be released into the aquatic and farm environment.
5. **Toxic Gases and Air Pollution:** Exhaust gases from vehicles, refineries industries can be dissolved by the rainwater and fall as acidic rain. These chemicals are absorbed by soil and water bodies.

#### Effects of Bio-accumulation and Bio-magnification:

- On Human Health:** Accumulation of mercury and Polycyclic Aromatic Hydrocarbons affect the tissues of marine organisms. Therefore, in recent years, the consumption of seafood has been linked to certain types of cancer, kidney failure, brain damage etc.
- On aquatic animals-** Toxic chemicals such as selenium and mercury include effects on reproductive process of fish.

#### Some Important Bio-accumulators:

- DDT:** It is pesticide and insecticide, generally used for control the malaria population (i.e., mosquito population).
  - (a) DDT has been banned under Stockholm Convention, but it is used in tropical countries like India to control the spread of growth of malaria, dengue etc.
  - (b) Effects: Headache, Noroviral disorder, thinning of egg-shells & loss of fertility which ultimately result to Cancer.
- Endosulfan:** It is an insecticide which is used in Cashew, Rubber & Plantation agriculture (tea plantation).
  - (a) It is cheap but dangerous bioaccumulate because it is associated with birth defects including cryptorchidism (absence of testis in male), neurological disorder including autism (mental retardness), cancer etc.
  - (b) Endosulphane was added to the list of POPs in the year 2011. Government of India has banned the use of endosulphane, but the matter is in sub-judice.

## 2) BIO-GEO-CHEMICAL CYCLING OR NUTRIENT CYCLING

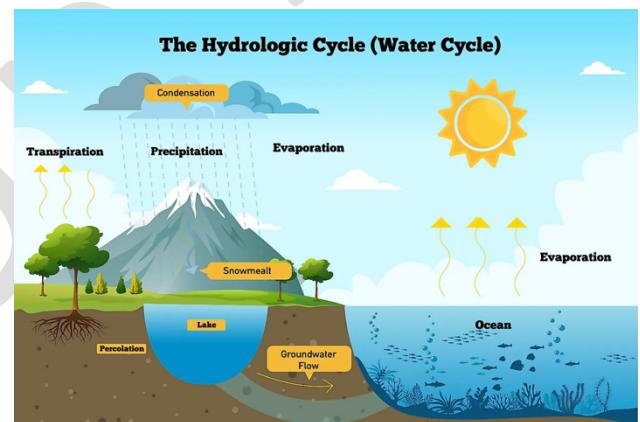
- “Nutrient Cycle” or “Biogeochemical cycle” refers to the movement or exchange of nutrients among the living and non-living constituent of an ecosystem. Nutrient Cycling is the process through which components change into different forms and then return to their original state.
- Based on the nature of reservoir, a nutrient cycle is divided into two types of cycles viz. Gaseous cycle; and Sedimentary Cycle.
  - o **Gaseous Cycle:** In Gaseous cycle, atmosphere or hydrosphere acts as the primary reservoir and elements primarily cycle through the atmosphere and living organisms, with minimal

involvement of soil or sediments. It includes, water cycle (hydrologic); carbon cycle; nitrogen cycle etc.

- **Sedimentary Cycle:** In this cycle, earth's crust act as the primary reservoir. It includes phosphorus cycle; sulphur cycle etc.
  
- **Biogeochemical Cycle (Nutrient Cycle)** can also be divided into perfect nutrient cycle and imperfect nutrient cycle.
  - **Perfect Nutrient Cycle** is one in which nutrients are replaced as fast as they are utilized. Most of the gaseous cycles are generally perfect cycles.
  - **Imperfect Nutrient Cycle** sees loss of some nutrients from cycle and the nutrients get locked into sediments and so become unavailable for immediate cycling.

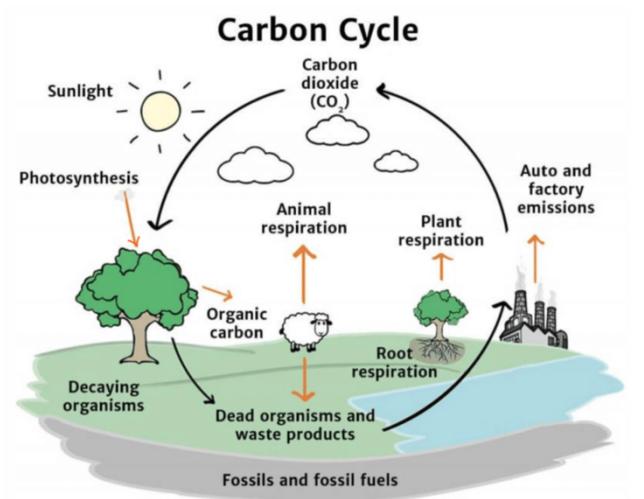
#### A) WATER CYCLE (HYDROLOGIC CYCLE)

- Water Cycle is the continuous circulation of water in the Earth-Atmosphere system which is driven by solar energy. There are various reservoirs of water on earth including ocean, atmosphere, lakes, rivers, soils, glaciers, snowfields, and groundwater. Water moves from one reservoir to another through the process of evaporation, transpiration, condensation, precipitation, percolation, ground water flow, deposition etc.



#### B) CARBON CYCLE

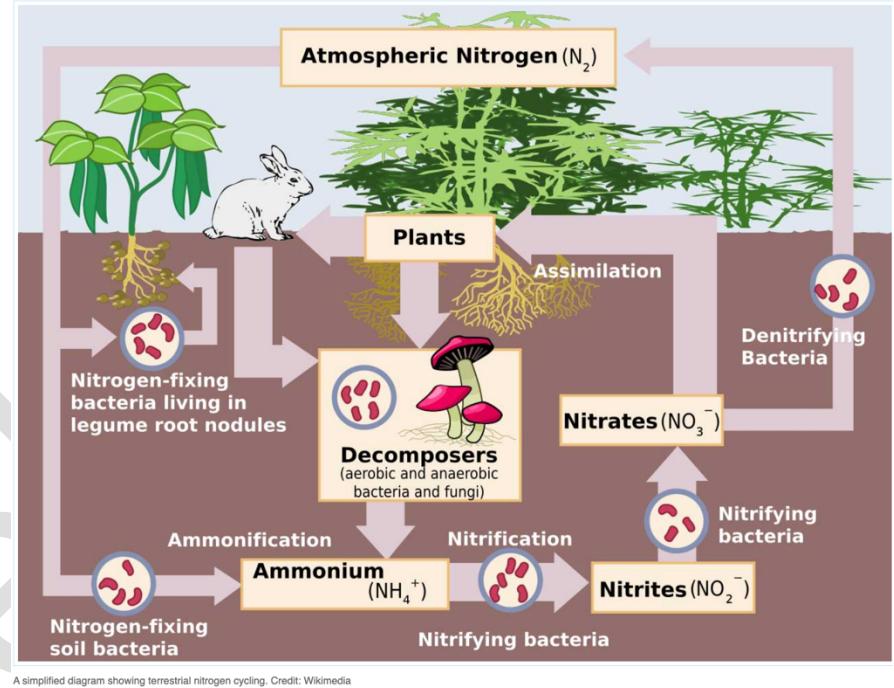
- The carbon cycle is the process that circulates the carbon between plants, animals, and microbes; minerals on earth; and the atmosphere.
- **Photosynthesis** leads to carbon from atmosphere moving to green plants and then to animals. **Respiration and decomposition** of dead organic matter leads to return of carbon back to atmosphere. This is usually a short-term cycle.
- Some carbon also enters a long-term cycle. It accumulates an undecomposed carbon in the peaty layers and as insoluble carbonates in the bottom sediments of aquatic systems. In the deep ocean, carbon can remain buried for millions of years.



years until geological movement uplifts the rocks and erosion releases carbonates and bicarbonates. Fossils also trap carbon for millions of years.

### C) NITROGEN CYCLE

- Nitrogen is the key component of the bodies of living organisms. Nitrogen atoms are found in all proteins and DNA.
- Though, Nitrogen is the most abundant element in the atmosphere (N<sub>2</sub> is 78% of atmosphere), it is still a limiting nutrient in nature and agriculture. It is because it is not available in atmosphere in usable form.
  - Note: A limiting nutrient is the nutrient that's in the shortest supply and limits growth.
- **Nitrogen Fixation:** It is the process by which bacterial and other single celled prokaryotes convert atmospheric nitrogen (N<sub>2</sub>) into biologically usable form i.e. ammonium ion (NH<sub>4</sub><sup>+</sup>).
  - Some species of nitrogen fixing bacteria are free living in soil or water (aerobic Azotobacter and anaerobic Clostridium), while others are symbiotic nitrifying bacteria (living in association with leguminous plants) and symbiotic bacteria living in non-leguminous root nodule plants (e.g. Rhizobium) as well as blue green algae (e.g. Anabaena, Spirulina).
  - Ammonium ion can directly be taken up as a source of nitrogen by some plants, or are oxidized to nitrites or nitrates by two groups of specialized bacterial:
    - Nitrosomonas bacteria promote transformation of ammonia into nitrite.
    - Nitrobacter bacteria convert nitrite into nitrate.



- Nitrates synthesized by bacteria in the soil are taken up by plants and converted into amino acids, which are the building blocks of proteins. This can further go to higher trophic levels.
- **Organic Nitrogen** will again be converted into N<sub>2</sub> gas by bacterial. Nitrogenous compounds from dead organisms or wastes are converted into ammonia-NH<sub>3</sub> – by bacteria, and the ammonia is converted into nitrite and nitrates. In the end, the nitrates are made into N<sub>2</sub> gas by denitrifying prokaryotes (e.g. Pseudomonas). This nitrogen escape into atmosphere, thus completing the cycle.

**Note:** Nitrogen fixation also happens by other mechanisms:

- 1) Industrial Process (fertilizer factories)

- 2) **Atmospheric phenomenon** (thunder and lightning): The periodic thunderstorms convert the gaseous nitrogen into the atmosphere to ammonia and nitrates which eventually reach the earth's surface through precipitation and then into the soil to be utilized by plants.

**Note1:** Water Cycle, Carbon Cycle and Nitrogen Cycle were Gaseous Cycle.

**Note2:** Phosphorus, Calcium, Magnesium and sulphur circulate using sedimentary cycle. The elements involved in sedimentary cycle generally follow a pattern of Erosion -> Sedimentation -> Mountain Building -> Volcanic Activity and biological transport through the excreta of marine birds.

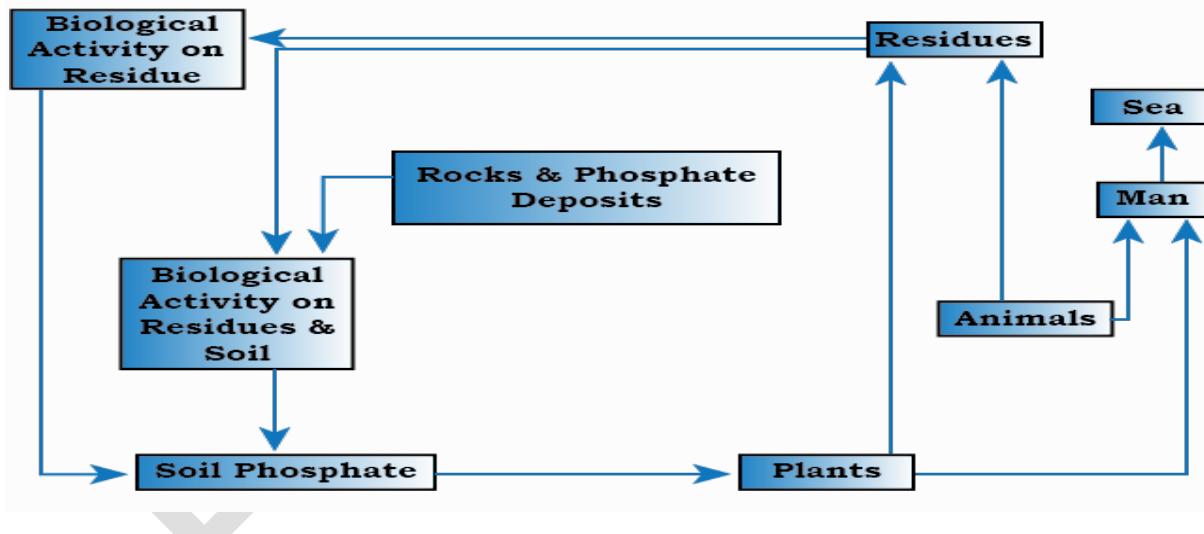
#### D) PHOSPHOROUS CYCLE

Unlike carbon and nitrogen, phosphorus occurs in large amounts as a mineral in phosphate rocks and enters the cycle from erosion and mining activities.

By the process of weathering and erosion, phosphate enter rivers and streams that transport them to ocean.

In Ocean, phosphorus will accumulate on continental shelves in the form of insoluble deposits. After millions of years, the crustal plates rise from the sea floor and expose the phosphates on land. After more time, weathering will release them from rock and the cycle's geochemical phase begins again.

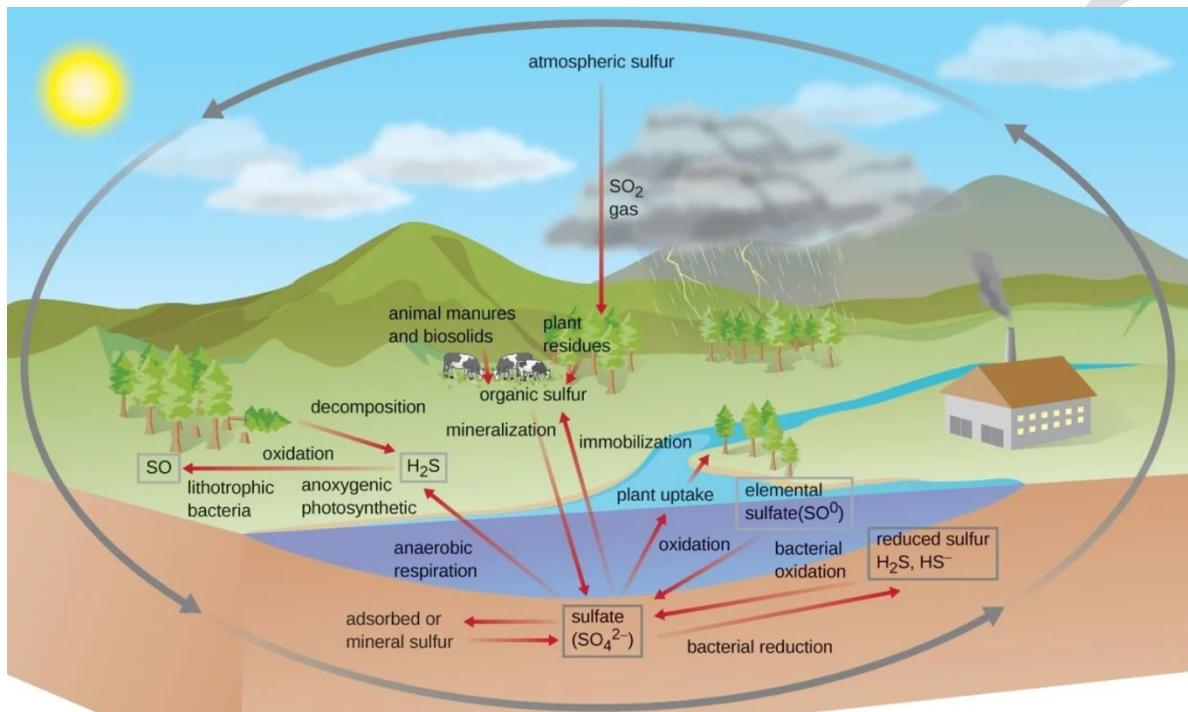
**Note:** Phosphorus is a primary nutrient that causes eutrophication in lakes causing algal blooms.



#### F) SULPHUR CYCLE:

- **Sulphur Reservoir** is in the soil and sediments where it is locked in organic (coal, oil and peat) and inorganic deposits (pyrite rock and sulphur rock) in the form of sulphates, sulphides and organic sulphur.
- **Release:** Weathering of rocks; Erosional runoff and decomposition of organic matter. It is carried to terrestrial and aquatic ecosystem in salt solutions.

- **Note:** The sulphur cycle is mostly sedimentary except two of its compounds Sulphur dioxide ( $\text{SO}_2$ ) and Hydrogen Sulphide ( $\text{H}_2\text{S}$ ) which add gaseous component to its sedimentary cycle.
- **Various ways in which Sulphur enters atmosphere:** Volcanic eruption, burning of fossil fuels, from surface of ocean and from gases released by decomposition. Atmospheric hydrogen Sulphide ( $\text{H}_2\text{S}$ ) also gets oxidized to sulphur dioxide and is carried back to earth as Acid Rain.



### 3) ECOLOGICAL SUCCESSION:

- The process by which communities of plant and animal species in an area are replaced or changed into another over a period of time is known as ecological succession. Succession is a universal process of directional change in vegetation, on an ecological time scale. The process involves a progressive series of changes with one community replacing another until a stable, mature, climax community develops.

#### (A). Stages in Ecological Succession:

- 1. Pioneer Species:** The first plant to colonize an area. Pioneer Species will occupy the bare rocks. E.g., Bacteria, Fungus, Weeds, Moss, Lichens and in Tundra region, Rhododendrons.
- 2. Climax Community:** The final stage of succession is called climax community. A climax community is stable, mature, more complex and long-lasting.
  - E.g.: Temperate Deciduous forests; Tropical Rain forests etc.

**3. Seral Community:** A seral community is temporary and transitional stage in ecological succession, leading to the development of a stable and self-sustaining climax community. During ecological succession, a seral community represents a stage where a specific set of plant and animal species are dominant, but **they are not the final or permanent community.**

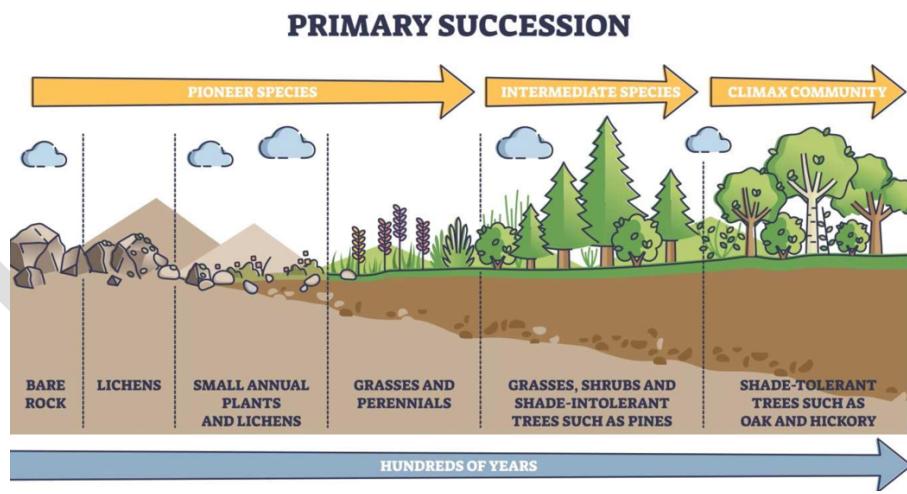
**NOTE:** Each ecological succession is characterized by **the increased productivity**, the shift of nutrients from the reservoirs, increased diversity of organisms, and a gradual increase in the complexity of food webs.

#### A) TYPES OF ECOLOGICAL SUCCESSION:

1. Primary Succession
2. Secondary Succession

#### PRIMARY SUCCESSION:

- Primary succession takes place an over where no community has existed previously. Such areas include rock outcrop, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines etc.
- In primary succession on a terrestrial site, the new site is first colonized by a few hardy pioneer species that are often microbes, lichens and mosses.



#### SECONDARY SUCCESSION:

- Secondary succession is the sequential development of biotic communities after the complete or partial destruction of the existing community.

- A mature or intermediate community may be destroyed by natural events such as floods, droughts, forest fires etc. or anthropogenic activities such as deforestation, agriculture, overgrazing etc.
- This abandoned land is first invaded by hardy species of grasses that can survive in bare, sunbaked soil.
- These grasses may be soon joined by tall grasses and herbaceous plants. These dominate the ecosystem for some years along with mice, rabbits, insects etc. Eventually some trees come up in this area, seeds of which may be brought by wind or animals.
- And over the years, a forest community develops. Thus, an abandoned land over a period becomes dominated by trees and is transformed into a forest.

#### **ECOLOGICAL SUCCESSION IN WATER/AQUATIC:**

- In primary succession in water, the pioneers are the small phytoplankton, and they are replaced with time by free-floating angiosperms, then by rooted hydrophytes (aquatic plants), grasses and the finally, trees.
- The climax again would be a forest. As the time passes, the water body is converted into land.

#### **NOTE:**

1. All the succession whether taking place in water or on land, proceeds to a similar climax community-the mesic.
2. Secondary Succession is faster process than the primary succession because the secondary succession starts on a well-developed soil already formed at the site.
3. Succession would happen faster in the area existing in the middle of the large continent. Here seeds related to various species would reach much faster, establishing and ultimately resulting in climax community.
4. In Savanna or Grasslands, Succession do not take place due to water and fire limits.
5. In Tropical Evergreen forests, original dense forest/vegetation does not re-grow once it is cleared because the soil is deficient in nutrients due to intense leaching.
6. In Tundra region, natural vegetation consists of Moss, Lichens & Rhododendrons, because in such tough conditions, only pioneer species can survive.

7. **Human beings affect 'secondary succession'** by causing 'soil erosion, global warming, loss of biodiversity, introduction of invasive alien species etc.' E.g., Due to introduction of invasive alien species such as pine, wattle, eucalyptus in Shola Forests of Western Ghats, forest fires (canopy fires occurs in Western Ghats) are increasing.
8. **Autogenic and Allogenic Succession:**
  - a. **Autogenic:** Succession brought about by living inhabitants of the community itself, the process is called autogenic succession.
  - b. **Allogenic:** Succession brought by outside forces.
9. **Autotrophic and Heterotrophic Succession:** Succession in which, initially the green plants are much greater in quantity is known as autotrophic succession; and the ones in which the heterotrophs are greater in quantity is known as heterotrophic succession.



# TARGET PRELIMS 2024

## BOOKLET-12; EB&CC-2

### AIR POLLUTION

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## 2. POLLUTION AND POLLUTANTS

- Pollution refers to introduction of harmful materials (pollutants) into environment.
- Many things which are useful to people produce pollution.
  - » **Vehicles, Electricity production, Fertilizers, Pesticides, Plastic etc.**
- **There** are various types of pollution - Air Pollution, Water Pollution, Soil/Land pollution, plastic pollution, noise pollution, light pollution etc.
- There are various ways of classifying pollutants:
  - i. **Primary vs Secondary**
    - **Primary Pollutants:** It is an air pollutant emitted directly from the source.
      - Examples of primary pollutants: (Particulates, CO, NO<sub>2</sub>, SO<sub>2</sub> etc.)
    - **Secondary Pollutant:** It is not directly emitted from the source as such, but forms when other pollutants (primary pollutants) react in the atmosphere.
      - Examples of secondary Pollutants: (Ozone, NO<sub>2</sub>, Acid Rain, Haze (Organic Aerosol))
  - ii. **Quantitative Pollutants vs Qualitative Pollutants**
    - **Quantitative Pollutant:** These substances are naturally present in environment. They become problematic only when their quantity increase.
    - **Qualitative Pollutant:** These are not naturally present in environment and are introduced in environment by human activities. E.g., Fungicide, herbicide etc.
  - iii. **Persistent Pollutant vs Non-Persistent Pollutant**
    - **Persistent Pollutants** are those pollutants which remain consistent in the environment for a long period of time without any change in its original form. (For e.g., nuclear wastes, pesticides, plastics etc.)
    - **Non-Persistent Pollutants** are the opposite of persistent pollutants and breakdown in the simple form.
  - iv. **Biodegradable vs non-Biodegradable**
    - Biodegradable pollutants are the pollutants which can be decomposed by micro-organisms.
    - **Non-biodegradable pollutants** are those which are not decomposed by microbial action (e.g., plastics, glass, DDT, salts of heavy metals etc.)
  - v. **Natural vs Anthropogenic**

## 3. AIR POLLUTION

- Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere: WHO.

- **Sources** of Air pollution:
  - Vehicular emissions, industrial fuel burning, energy production, forest fires, household combustion etc. are important sources of air pollution.
- **Pollutants** of major public health concern include PM, CO, Ozone, NO<sub>2</sub>, SO<sub>2</sub>, Smog, Hydrocarbon, CFCs etc.

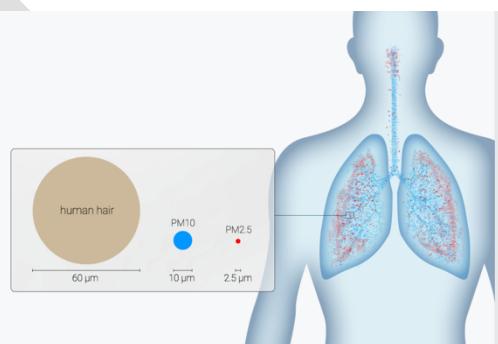
## 1) CO<sub>2</sub>

It is a greenhouse gas which results into global warming.

## 2) SUSPENDED PARTICULATE MATTER (SPM)

### A) PM2.5

- PM2.5 is defined as ambient airborne particulates (including dust, soot, dirt, smoke, and liquid droplets) that measure upto 2.5 microns in size. These particles include a range of chemical makeups and come from a range of source.
- **Main sources** include fossil fuel powered vehicles, power generation, Industries, Agriculture and biomass burning etc.
  - **Chemical reaction between gases** can also be a source of PM2.5 This include reactions between: SO<sub>2</sub>, NO<sub>2</sub>, Ammonia, Black carbon, Mineral dust, water, volatile organic carbon.
- Among criteria pollutants commonly measured in real time, fine particulate matter (PM2.5) is currently understood to be the most harmful to human health. Due to very small size, they can remain suspended in air for long periods and the microscopic size allows these particles to be absorbed deep into the bloodstream upon inhalation.
- **Exposure to PM2.5** have been linked to negative health effects like cardiovascular diseases, respiratory illness, premature mortality, low birth weight, and stroke.
- **PM2.5 can also cause negative environmental impact:** Damage to materials and buildings; Acid Deposition; increase ozone levels.



### B) PM10

- **PM10** are suspended coarse particles, either solid or liquid, with a diameter of 10 micrometers or less. For comparison, a human hair is, on average, 50 to 70 micrometers in diameter. They are also sometimes referred to as floating dust or aerosols.
- **Difference between PM2.5 and PM10**
  - **Size:** PM2.5 is very fine, and PM 10 is larger and coarser.
  - **Less Harmful:** PM10 is less likely to cross from lungs to the bloodstream. Though they can penetrate deep into lungs.
- **Various sources:**
  - Smoke, Dust, and dirt from unsealed road, construction, landfill and agriculture

- Pollen
- Mold
- Smoke
- Industrial sources
- Fossil fuel burning
- Sea Salt

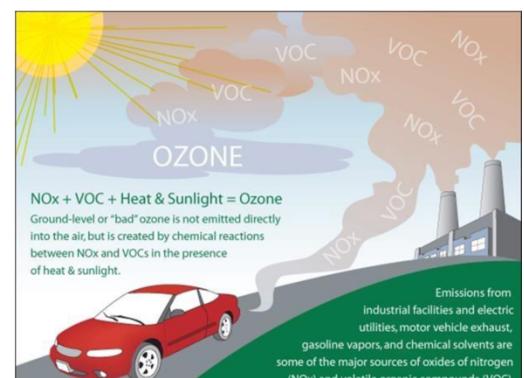
- **Health Impact:**
  - **Short term** - Difficulty breathing; coughing; eye, nose and throat irritation; Chest tightness and pain; Fatigue; General respiratory discomfort.
  - **Long term impact:** Heart failure, asthma, heart failure, cancer, adverse birth outcomes etc.
- **Environmental Impact:** Can corrode organic and inorganic material from vegetation to buildings. Painted surfaces, stone, fabrics, metal, and wood can become damaged and discolored.

### 3) CARBON MONOOXIDE

- CO is an odorless, colorless, and tasteless gas produced by the incomplete combustion of carbon in fossil fuels such as wood, propane, charcoal, oil, coal or other fuel.
- **Carbon monoxide Poisoning:** It occurs when carbon monoxide builds up in your bloodstream. When too much CO is in the air you're breathing, your body replaces the oxygen in your RBCs with carbon monoxide. This prevents oxygen from reaching your tissues and organs.
  - **Science behind this:**
    - Hemoglobin binds carbon monoxide (CO) 200 to 300 times more with oxygen, resulting in the formation of carboxyhemoglobin and preventing the binding of oxygen to hemoglobin due to competition of the same binding sites.
  - **Signs and symptoms** of CO Poisoning: Dull headache, weakness, dizziness, nausea or vomiting, shortness of breath, confusion, blurred vision, loss of consciousness etc.
  - It can particularly be dangerous for people who are sleeping or intoxicated. People may have a irreversible brain damage or even die before they realize the problem.

### 4) OZONE

- **Ozone ( $O_3$ )**
  - Ozone is a gas composed of three atoms of oxygen ( $O_3$ ).
    - » **Key Properties:** It is a bluish gas. It is also a major oxidant.
  - It occurs in both earth's upper atmosphere and at ground level.
  - Ozone can be "good" or "bad" for health and the environment depending on where it's found in atmosphere.
- **What is Ground Level Ozone Pollution?**
  - Ozone pollution is a **secondary pollution** and is not emitted by source directly. It is created by chemical reactions between oxides of Nitrogen (NOx) and Volatile Organic Compounds that are



emitted from combustion sources like vehicles, industry, power plants etc. in **the presence of sunlight and heat.**

- It is most likely to reach unhealthy levels on hot sunny days in urban environment. It may also reach high level during colder winter months because of high pollution and sunlight.
- Since it can also be transported for long distances by wind, it may also impact rural areas.

- **Unprecedented Ozone Levels have made Delhi Air More Toxic: CSE analysis (June 2022)**
- **Why increasing in Delhi**
  - High level of pollution, with high sunshine and high ambient temperatures.
- **Negative Impact of Ozone Pollution**
  - **Health Impacts** -> Breathing problems, chest pain, cough, throat irritation; Further people with certain genetic conditions, and people who have lower intake of Vitamin C and Vitamin E are at greater risk of Ozone exposure.
  - **Environmental Impact** -> impact sensitive vegetation during growing season
- **Monitoring of Ozone**
  - **NAAQS (National Ambient Air Quality Standards)** by CPCB measures Ozone
  - AQI and SAFAR measurements also has listed ozone as a pollutant which is regularly measured.
- **Increase in Ozone levels even during lockdown: CSE Study (June 2020): Class Discussion**

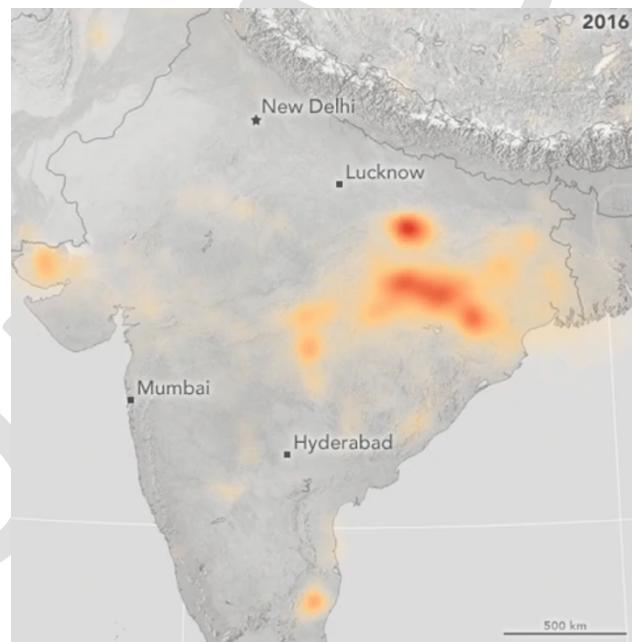
## 5) NITROGEN DIOXIDE

- **Details**
  - **Physical features:** It is a deep red-orange gas and when released into the air, it is seen as a reddish-brown haze. It has a pungent and acrid odour.
  - NO<sub>2</sub> is a major contributor in the formation of Smog and a precursor to many harmful secondary pollutants, including ozone and particulate matter. It is highly reactive with other chemicals and is strong oxidizing agent.
  - **Sources of NO<sub>2</sub>**
    - **Natural Sources:**
      - Lightning Strikes
      - Volcanoes
      - Oceans
      - Biological decay
    - **Manmade sources:**
      - **Combustion** creates oxides of nitrogen, a major portion of which is nitrogen dioxide. When vehicles emit oxides of nitrogen, 90-95% of the emissions are nitric oxide (NO). However, nitric oxide quickly oxidizes in outdoor air when reacting to oxygen, ozone, and volatile organic carbons (VOCs) to form nitrogen dioxide.
  - **It is both a primary and secondary pollutant.**
    - As primary pollutant, NO<sub>2</sub> is emitted in limited amounts through vehicles.

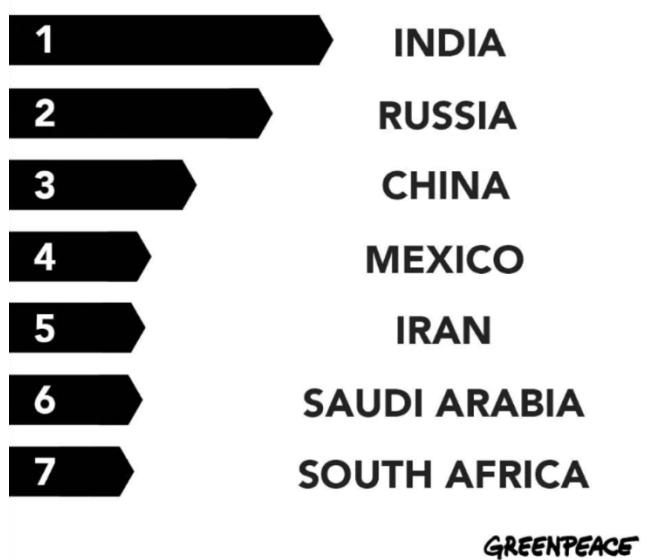
- It is also a secondary pollutant as it can be formed through oxidation. Nitrogen dioxide further oxidizes into **Nitric Acid (HNO<sub>3</sub>)**, which can enter the environment through the ground as droplets or nitrate containing particles.

## 6) SO<sub>2</sub>

- **Basics**
  - SO<sub>2</sub> is a colorless gas which has a nasty, sharp smell. It reacts with other substances to form harmful compounds, such as sulfuric acid, sulfurous acid, and sulfate particles.
- **Main Sources** - Burning of Fossil fuels and ships, locomotives using furnace oil/ heavy oil; Other small sources are - **industrial processes** like extracting metal from ore; nature sources such as volcanoes.
- **Why Sulphur dioxide pollution is problematic?**
  - **Health Issues:** Respiratory diseases; contribute to PM pollution.
  - **Environmental Issues ->**
    - **Harm trees and plants** -> Damaging foliage and decrease growth of trees and plants.
    - **ACID Rain** -> harms sensitive ecosystem
  - **Damage Cultural Heritage**
    - Deposition of sulfur particles may cause discoloration and damage of monuments, statues etc.
    - The fine particles may reduce visibility (Haze)
- **India has emerged as the largest SO<sub>2</sub> emitter in the world: NASA data.**
  - India has **highest number (more than 15%) of all anthropogenic SO<sub>2</sub> hotspots** in the world detected by the **Ozone Monitoring Instrument (OMI)** satellite. These include Singaruli, Nevyeli & Chennai, Talcher & Jharsuguda, Korba, Kutch etc.
- **Key reasons for High Sulphur pollution in India**
  - Nearly all the SO<sub>2</sub> emission in India comes from coal burning power plants which are the major source of energy for India.
  - The vast majority of power plants in India lack flue-gas desulfurization technology to reduce their air pollution.



Worst emitters of SO<sub>2</sub> pollution in the world



- **Note: Flue Gas Desulfurization (FGD)** is a set of technologies used to remove SO<sub>2</sub> from exhaust gas of fossil fuel based power plants.

## 7) BENZENE

- **Details**
  - Benzene (C<sub>6</sub>H<sub>6</sub>) is an aromatic, organic compound with a single six-member unsaturated carbon ring. It is clear, colorless, volatile, highly inflammable liquid with a characteristic order and a density of 874/m<sup>3</sup>.
  - Benzene in air mostly occurs in vapor phase, with residence times varying between 1 day to two weeks, depending on the environment, the climate and the concentration of other pollutants.
  - It is an **air pollutant** emitted from gasoline stations, motor vehicle exhausts and fuel evaporation, the burning of coal and oil, and various other sources. Urban areas generally have higher ambient air concentration of benzene than other areas.
  - **Indoor sources** of benzene pollution are material used in construction, remodeling, and decorating. Benzene is also present in particle board, furniture, plywood, fiberglass, flooring adhesives, paints, wood paneling, paint removers etc. Therefore, new buildings or recently decorated indoor environments have been associated with high concentration of benzene from materials and furnitures. Use of **fuel for space heating** like coal, wood, gas, Kerosene, LPG etc. also produce benzene.
  - **Negative Health Impacts of Benzene**
    - » Cancer, damage to immune system, neurological, reproductive or developmental issues.
  - In addition of being an air pollutant, it may also pollute water.
- **Joint Committee by NGT**
  - The joint committee consisted of officials from MoEF&CC, CPCB, SPCBs, NEERI etc. The committee was directed to assess the ambient air quality levels in the state, especially in major cities of Kerala.
  - **Key findings**
    - » Petrol refueling stations were a major source of benzene emissions, volatile organic compounds, and particulate matter 2.5 concentration.
  - **Key recommendations**
    - » Installation of vapor recovery systems at the fueling stations
    - » Retrofitting of diesel vehicles with particulate filters to improve air quality.
    - » Stringent action against industrial units that don't comply with emission norms.
    - » Retrofitting of emission control devices of generators and replacing diesel generators with gas-based ones.
    - » Promoting battery operated vehicles and banning old diesel vehicles in a phased manner, greening of open areas, and creation of green buffers along traffic corridors.

## 8) AMMONIA

- **About Ammonia**
  - Ammonia is a colorless gas with characteristics pungent odor.
  - **Natural sources** include decaying organic matter and animal waste.

- **Manmade sources** include fertilizer manufacturing, waste disposal sites, industrial processes etc.
- It doesn't last long in environment and thus doesn't bio-accumulate.

#### - Applications

- 80-90% of ammonia all over the world is used for **making fertilizer** (ammonium nitrate is an important nitrogen fertilizer)
- It is a precursor of various nitrogenous compounds. Virtually, all synthetic nitrogen compounds are derived from ammonia.
- It is also used in making household cleaners, plastics, dyes, pharmaceuticals etc.
- It is an anti-septic and is used in food preservation industry.
- Scientists are also experimenting with using ammonia as a storage of renewable energy. (Nitrogen gas and water use energy to convert into Ammonia). Later Ammonia can be used a fuel in the fuel cell.

#### - Ammonia Pollution

- Majority of airborne ammonia comes from fertilizers.
- Ammonia can also contribute to formation of PM<sub>2.5</sub> (ammonia combines with VOC, NO<sub>x</sub>, SO<sub>2</sub> etc. to form PM<sub>2.5</sub>)



#### - Health Impacts:

- At higher concentration ammonia is toxic, caustic, and hazardous. Exposures at high levels of ammonia can be irritating to a person's skin, eyes, throat, lungs, and cause coughing and burns.
- **Long term health concerns** associated with Ammonia exposure include – severe cardiovascular and respiratory effects, decreased lung function, asthma aggravation, premature death etc.

#### - Environmental Impacts -> Eutrophication, Soil Acidification; biodiversity loss -> promote species which prefer nutrient fueled growth to outcompete other species.

#### - Indo-Gangetic Plain Global Hotspot of atmospheric Ammonia: Study by IIT KGP (Dec 2020)

- The study titled “**Record high levels of atmospheric ammonia over India: Spatial and temporal analysis**” has been published in the international Elsevier journal “*Science of the Total Environment*”. In this study, the seasonal and inter-annual variability of atmospheric ammonia emitted by the agricultural sector was analyzed and the key highlights have raised certain concerns:
  - » The general trend in atmospheric ammonia over India is negative in most seasons. But, in USA, China and Europe, this trend is positive.
  - » For the period 2008-2016, the atmospheric ammonia during the month of June to Aug have grown rapidly at a rate of 0.08% annually.
  - » The Indo-Gangetic Plain is a global hotspot of atmospheric ammonia.
    - **Reason:** Intense agri activity and a lot of fertilizer use and production
  - » Atmospheric Ammonia has a positive correlation with Fertilizer use, hot weather (high temperature supports volatilization) and fires.

- » It has a negative correlation with total precipitation as wet deposits helps in the removal of ammonia.

#### - Water Pollution

- An ammonia concentration of upto 0.5 ppm (BIS) is maximum limit for drinking water. But, if the ammonia concentration is more than 1 ppm, it would negatively impact our health in long run. Similarly, ammonia concentration of more than 1 ppm in water bodies is dangerous for fish population.
- **High Ammonia Concentration in Yamuna River** is regularly disrupting water supply in Delhi.
  - For e.g., in July 2020, the ammonia concentration in Yamuna River reached 3 ppm. This led to reduction of water supply from Yamuna for Delhi, as Delhi Jal Board doesn't have technology to treat this high concentration of water.
- **Why ammonia pollution is so high?**
  - Industrial units of Sonipat and other drains joining the river along the way may be contributing to this.
- **Way Forward – Precision agriculture; Regulation of discharge; Reducing Nitrogen feed to animals; Improving water treatment technology; maintaining ecological flow of water.**

## 9) SMOG

- **Smog**
  - Smog is a kind of air pollution, originally named for the mixture of smoke and fog in the air.
    - » **Classical smog** results from the large amount of coal burning in the area and is caused by mixture of Sulphur dioxide and smoke.
    - » Today, **most of the smog** that we see is **Photochemical Smog** (or ground level Ozone). It is produced when Nitrogen oxides in presence of **sunlight** react with **Volatile Organic Compounds (VOCs)** in the atmosphere.
      - **Nitrogen oxides** come from car exhaust, coal power plants, and factory emissions.
      - **VOCs** are released from petrol, paints, and many cleaning solvents.
      - When sunlight hits these chemicals, they form airborne particles and ground-level Ozone or Smog.

#### - Harmful impacts of SMOG

- **Health Impacts:** Ground level ozone, SO<sub>2</sub>, NO<sub>2</sub>, CO are especially harmful for senior citizens, children, and people with heart and lung conditions such as bronchitis and Asthma.
  - It may inflame breathing passage, impacting the functioning of lungs thus causing breathlessness, wheezing and coughing. It can also cause irritation to eyes and nose. It also dries out the protective membrane of the nose and throat and interfere with the body's



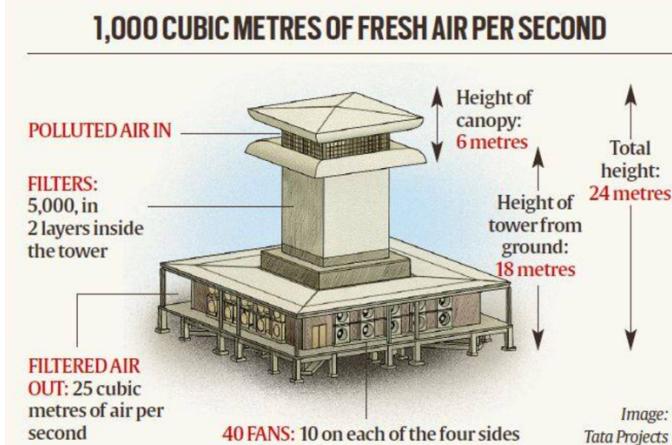
ability to fight infection, increasing susceptibility to illness.

- **By decreasing visibility**, it slows down traffic and increases the chance of accidents.
- Smog also negatively affects the **aesthetics** of the city by making sky brown and gray.

- **Supreme Court verdict:**

- **The Supreme Court** in Nov 2019 asked the CPCB and the Delhi government to come up with a road map on installing smog towers in the NCR to combat air pollution. In Jan 2020, the SC directed that the two towers should be installed by April as a pilot project.

- **Components of Delhi's first Smog tower by Government of Delhi:**



- The tower uses a '**down draft air cleaning system**' developed by University of Minnesota.
  - Polluted air is sucked in at a height of 24 meters, and filtered air is released at the bottom of the tower, at a height of about 10 meters from the ground.
  - When the fan at the bottom layer operates, the negative pressure created sucks in the air from the top. The 'macro layer' in the filter traps particles of 10 microns and larger, while the 'micro layer' filters smaller particles of around 0.3 microns.
  - This method is **different from the 'Updraft system'** - in which air is sucked in from the ground and is propelled upwards by heating and convection. Filter air is released at the top of the tower.
- **Expected Impacts**
  - Computational fluid dynamics modelling by IIT Bombay suggest that towers could have an impact on air quality of upto 1 KM.
- **Criticism**
  - Experts say that there isn't enough evidence to show that Smog towers work.

## 10) AEROSOL POLLUTION

- **What is aerosol?**

- » An aerosol is a **mixture of tiny particles suspended in a gas**, typically air. This particle can be solid, liquid, or a combination of both. These particles can range in size from a few nanometers to several tens of micrometers and can be produced naturally or by human activities.
  - » **Examples of natural aerosols** include dust, pollen, sea salt, and volcanic ash.

- » Examples of Human made aerosols include smoke, soot, exhaust fumes from vehicles, and particles generated by industrial processes like mining and manufacturing. They include PM2.5 and PM10.
- Impacts that aerosols can have:
  - » On Human Health: they may cause respiratory problems and exacerbating heart disease.
    - A study published in Science Advances showed that excess infant deaths in India were estimated to be three million - the highest among the eight regions evaluated in the study.
  - » On Environment: They can contribute to climate change by altering the balance of radiation in the atmosphere and affecting cloud formation.
- Aerosol Optical Depth (AOD):
  - » It is a measure of how much atmospheric aerosols, such as smoke, dust, and pollution, are scattering and absorbing sunlight.
    - It is typically measured using specialized instruments that detect the amount of light that is scattered or absorbed by aerosols in the atmosphere.
    - It is the quantitative estimate of the aerosol present in the atmosphere and it can be proxy measurement of PM2.5.
  - » The value of AOD range from 0 and 1. 0 indicating crystal-clear sky with maximum visibility whereas a value of 1 indicates very hazy conditions.
  - » AOD value less than 0.3 falls under green zone (safe), 0.3-0.4 is the blue zone (less vulnerable), 0.4-0.5 is orange zone (vulnerable) while over 0.5 is the red zone (highly vulnerable)
- Aerosol Pollution in West Bengal and Bihar (Nov 2022)
  - A study by Bose Institute in Kolkata as revealed that aerosol pollution in WB is anticipated to rise by 8% and continue to remain in the "highly vulnerable" red zone for aerosol pollution. This is the second highest forecasted aerosol pollution level in the country after Bihar.
  - India's regional weather patterns and topography makes the country highly vulnerable to aerosol pollution.
- Why?
  - West Bengal receives Indo-Gangetic Plain air pollution outflows and its local emissions have put WB in the highly vulnerable zone.

## 11) FLY ASH

- Introduction
  - Fly ash is a coal combustion byproduct produced in coal based thermal power plants. It refers to ash that is driven out of coal fired boilers together with the flue gases.
  - In modern coal fired power plants, fly ash is captured by electrostatic precipitators or other particle filtration equipment before the flue gas reaches the chimney.
  - The composition of fly ash varies considerably, but all fly ash includes substantial amount of Silicon di oxide (SiO<sub>2</sub>), Aluminium oxide (Al<sub>2</sub>O<sub>3</sub>) and Calcium oxide(CaO), the main mineral compounds in coal-bearing rock strata.
  - **Note:** The ash that falls to the bottom of the boiler is called bottom ash.

- **Key characteristics of fly ash**
  - **Harmful for human health:** Fly ash contains toxic constituents like lead, cadmium, chromium, arsenic which can be very dangerous for human health. They contribute heavily to particulate matters in air and cause lung problems.
  - **Bad for environment**
    - Toxic content results in both soil pollution and water pollution (toxic leaching)
  - **Affects large land area.**
    - If fly ash is not captured at the power plant itself, it spreads easily through air and affects large land area.
  - **It is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water.** Hence it can be used in construction process.
- **Reducing Fly Ash pollution**
  - Washing the coal at its place of origin is an important step which ultimately reduces the amount of ash being produced.
  - Increasing R&D, for enhancing the efficiency of power plants, would also help in reducing the ash content.
  - Capturing fly ash before it is released in air by Chimney using various types of precipitators.
- **Where can the captured fly Ash be used?**
  - Cement industry uses Fly Ash in the manufacturing of Portland Pozzolana Cement.
    - Recently, scientists at IIT-Hyderabad have found ways to turn fly ash into products like paints, textile coatings etc.
  - It can also be used fly ash bricks/blocks/ and tiles manufacturing, road embankments construction etc.
  - Fly ash may also be utilized in agriculture as soil conditioners.
  - It is also used as a substitute of soil/sand for reclamation of low lying areas.
  - In mining it can be used for backfilling of mines.
- **Steps taken to promote the use of Fly Ash?**
  - i. **Various notification for fly ash utilization** since 1999
    - The **2016 notification** calls for every agency engaged in construction activity within a radius of 300 km of coal-based thermal power plant to use ash based products for construction.
    - It also mandates the use of ash-based bricks or products in all government schemes and programs.
  - ii. **Maharashtra** is the first state to have a Fly Ash Utilization Policy. It is also looking to export fly ash to countries like Singapore and Dubai where it is in demand.
  - iii. **GST rates** on fly ash and its products have been reduced to **5%**.
  - iv. Launching of **ASHTtrack Mobile App** for better management of fly ash produced by thermal power plant in Feb 2018.
    - It will act as an interface between fly ash producers (thermal power plants) and potential ash users such as road contractors, cement plants etc and thus will help in increasing the utilization of fly ash being produced at coal based thermal power plants.
  - v. **Various awareness campaigns**

- Through workshops and other programs.
- **Draft Fly Ash Notification (2021)** - it is the proposed 5th amendment to the 1999 fly ash notification.
  - It introduces a concept of 3-5 years compliance cycle to achieve a target of 100 percent fly ash utilization by the end of cycle.
  - It also gives an extension of 10 years to power plants to progressively utilize their legacy ash.

## 12) INDOOR AIR POLLUTION

- Indoor Air Pollution or Household Pollution is the air pollution whose source lies within the household. Various recent studies have found that indoor PM2.5 level in most Indian households is much higher than the outdoor PM2.5 concentration of the respective geographic area.
 
- **Causes:**
  - Use of **the traditional biomass** (Cow dung cake, firewood, coal etc.) for cooking is the leading cause of air pollution.
  - Burning fuels such as dung, wood, coal in inefficient open hearth produce a variety of health-damaging pollutants, including particulate matter, methane, CO, polycyclic aromatic hydrocarbon and VOCs.
  - These pollutants may **further accumulate** in the indoor environment if the indoor air is not well ventilated.
  - **Tobacco** consumption
  - **Building Materials** (Deteriorating asbestos containing insulation, paints, varnishes, wood flooring, etc.)
  - Products for household cleaning and maintenance, personal care, or hobbies.
  - Broken CFLs, Tubelights etc.
  - **Increased penetration of closed ventilation** due to Air-conditioners etc. makes situation worst.
  - **Outdoor sources** such as Radon, Pesticides, outdoor air pollution.
- **Health Impacts**
  - Household air pollution is responsible for 3.2 million deaths per year in 2020.
  - Household air pollution leads to non-communicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer.
  - The most common effect of IAP is called **sick building syndrome**, in which people experience uncomfortable or acute health effects such as irritation of nose, eyes and throats, skin ailments, allergies and so on.
- **Key steps being taken by government.**
  - **RAISE initiative**.
  - **Unnat Chulha Abhiyan** – By Ministry of New and Renewable Energy for providing a clean cooking energy solution with a view to reduce consumption of fuel wood with higher efficiency and low emissions.
  - **PM Ujjwala Yojna**

## A) RADON ( $Rn^{222}$ )

- It is an odorless, invisible, radioactive gas, naturally released from rocks, soil, and water.
  - It is a noble gas and thus doesn't react chemically with other substances.
- It is formed by decay of uranium and thorium in the earth's crust.
- It can seep into buildings and accumulate to dangerous levels, especially in areas with poor ventilation.
- **Harmful Impacts:**
  - Carcinogen: It can cause lung cancer.
    - In USA, radon is the leading cause of lung cancer after smoking.
- **The risk of developing lung cancer** from radon exposure depends on the level of radon in air, the duration of exposure, and whether or not the person is smoker.
  - **Note:** For smokers the risk is higher as smoking can damage the lungs and make them more susceptible to the harmful effects of radon.
- **Detection of Radon:**
  - Since, radon is colorless, odorless gas, the only way to know if the building has higher levels of radon is to test for it.
    - The test is relatively easy and inexpensive, and it can be done by homeowners and professionals.
- **Some Steps that can be taken are:**
  - Sealing cracks in the foundation
  - Installing a ventilation system
  - Relocating to different house

## 13) PET COKE (PETROLEUM COKE) AND ASSOCIATED ISSUES

- **Introduction: What is Pet Coke**
  - » It is a type of coke derived from oil refining process. It is the final carbon-rich solid material from the bottom of the barrel after refining of heavy oils.
    - **Coking Process:** In petroleum coker units, residual oils from other distillation processes used in petroleum refining are treated at high temperature and pressure leaving petcock after driving off gases and volatiles, and separating off remaining light and heavy oils.
  - » **Properties**
    - Petcoke is 90% carbon and emits 5-10% more carbon dioxide (CO<sub>2</sub>) than coal on a per-unit-energy basis when it is burned.
      - As they have higher energy content, they emit between 30-80% more CO<sub>2</sub> than coal per unit weight.
    - It also contains higher sulfur content which makes it burning more polluting.
    - It is cheaper and burns hotter than coal.
  - » **Used less in western countries.**
    - Its higher sulfur content makes it a less attractive fuel in US and thus power hungry India becomes an easy export destination.
  - » **Impact of use of petcock in India**
    - **India is the largest user** of the Pet coke.
    - It is making a bad situation worse in India due to its higher CO<sub>2</sub> and Sulfur emissions.

- **Ban on Pet Coke Import as fuel (Aug 2018)**
  - DGFT has banned import of Pet-Coke as fuel.
  - Import is allowed for only Cement, Lime Kiln, Calcium carbide and gasification industries, when used as feedstock or in the manufacturing process of actual condition.

#### 14) FUEL OIL/ HEAVY OIL/ FURNACE OIL -> ISSUES CONCERNING THEM

- **Introduction**
  - » Fuel oil/ Heavy Oil/ Furnace Oil is the heavier fraction obtained from petroleum distillation.
  - **Note: Fractional Distillation**
    - Crude oil is separated into fractions by fractional distillation. The fractions at the top have lower boiling points than the fractions at the bottom.
    - » All the fractions are processed further in refining units.
    - » **Bunker Fuel** is the fuel used aboard vessels (heavy ships). Generally the heaviest variety of oil i.e. fuel oil is used there. It is also known as marine fuel oil.
- **Some features of heavy fuel oil:**
  - » Heavy fuel combustion products remain high in NO<sub>x</sub>, So<sub>x</sub>, Particulate matter and CO<sub>2</sub>.
  - » It has high viscosity when compared to Diesel, Kerosene and Petrol. To be used as fuel it's viscosity should be less and therefore it needs to be kept at higher temperature. It is also mixed with lighter fuel (e.g. diesel) to reduce its viscosity.
- **In case of oil spills heavy oil is more aggravating in nature because:**
  - i. Marine fuel is hazardous and very toxic to marine life.
    - The incombustible material that remains after the combustion mainly consists of the metals vanadium, silicon, aluminium, nickel, sodium, and iron that are present in the original heavy fuel oil supply
    - Marine organisms are very susceptible to these heavy metals.
  - ii. It evaporates at a slower pace when compared to other fuel (petrol, Kerosene, diesel etc) and thus remain in water for longer period impacting marine diversity more.
- Despite the above limitations the use continues because of the cheap price and large availability (as it keeps getting produced in oil refineries)

#### 15) AGRI-SUBSIDY AND AIR POLLUTION

- High MSP for Rice -> Rice grown in Haryana, Punjab etc. -> Stubble burning.

- Power subsidy -> more use of water -> paddy cultivation -> stubble burning
- Fertilizer subsidy -> Overuse -> Indo-Gangetic plains emerging as atmospheric ammonia hotspots

## 16) WHO'S AIR QUALITY GUIDELINES

- In Sep 2021, WHO revised the air quality guidelines. This was the first major update to the standards in 15 years.
- **Why was there a need of update?**
  - New studies have found that even smaller quantity of pollutants were harmful for human beings.
- Therefore, WHO has strengthened nearly all pollutant standards in comparison to the quality guidelines established in 2005 (published in 2006)
  - **Expected Impact:** If the target levels are implemented and achieved by governments, it would lead to saving of lakhs of lives.
- **The new guidelines recommend air quality levels for 6 pollutants**, where evidence has advanced the most on health effects from exposure.

**Recommended 2021 AQG levels compared to 2005 air quality guidelines**

| Pollutant                             | Averaging Time           | 2005 AQGs | 2021 AQGs |
|---------------------------------------|--------------------------|-----------|-----------|
| PM <sub>2.5</sub> , µg/m <sup>3</sup> | Annual                   | 10        | 5         |
|                                       | 24-hour <sup>a</sup>     | 25        | 15        |
| PM <sub>10</sub> , µg/m <sup>3</sup>  | Annual                   | 20        | 15        |
|                                       | 24-hour <sup>a</sup>     | 50        | 45        |
| O <sub>3</sub> , µg/m <sup>3</sup>    | Peak season <sup>b</sup> | -         | 60        |
|                                       | 8-hour <sup>a</sup>      | 100       | 100       |
| NO <sub>2</sub> , µg/m <sup>3</sup>   | Annual                   | 40        | 10        |
|                                       | 24-hour <sup>a</sup>     | -         | 25        |
| SO <sub>2</sub> , µg/m <sup>3</sup>   | 24-hour <sup>a</sup>     | 20        | 40        |
| CO, mg/m <sup>3</sup>                 | 24-hour <sup>a</sup>     | -         | 4         |

- **Expected impact of the new guidelines:**
  - » Spur greater global reactions in pollution emissions.
  - » Contribute to fight against climate.
- **Note:** These guidelines are not legally binding on any country. But, countries and legislative bodies regularly refer to WHO guidelines when setting airborne pollutant control legal policy.
- **Implications for India**
  - » As per the new WHO guidelines, almost the entire India, specially the Urban areas would now be considered polluted for entire year.

## 4. INSTITUTIONS, INITIATIVES, SCHEMES, PROGRAMS ETC.

### 1) CENTRAL POLLUTION CONTROL BOARD (CPCB)

India's Central Pollution Control Board sets national ambient air quality standards and is responsible for both testing air quality and assisting governments in planning to meet such standards.

1974

## 2) AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

Provides for the prevention, control and abatement of air pollution through boards established under this Act like Central Pollution Control Board.

1981

## 3) ENVIRONMENT POLLUTION (PREVENTION AND CONTROL) AUTHORITY (EPCA) [1998 - 2020]

- **About EPCA**
  - » EPCA was a **Supreme Court mandated body** tasked with taking various measures to tackle air pollution in National Capital Region (NCR).
  - » MoEF&CC notified this body in 1998 under the EPA, 1986.
  - » **Mandate**
    - Protect and improve the **quality of environment** and prevent and control **environmental pollution** in the **NCR**.
    - It is also mandated to implement the **Graded Response Action Plan (GRAP)** in NCR as per the pollution level.
  - » The Authority can take complaints **suo motu** or on the basis of a **filed complaint**.
- **Key contributions of EPCA** in 22 years of its existence
  - » Notification of Graded Response Action Plan
  - » Early adoption of BS-VI fuels standards
  - » Suggestions for Construction of the regional rapid transport system
- **Note:** The 22-year-old Environment Pollution (Prevention and Control) has been dissolved. (Oct 2020)

## 4) THE COMMISSION FOR AIR QUALITY MANAGEMENT IN NATIONAL CAPITAL REGION AND ADJOINING AREAS

- **Need**
  - A major reason behind high pollution levels in NCR has been the inability of CPCB, EPCA etc. to impose rules on the ground.
- The new permanent Commission envisages a multi-sectoral, participatory, multi-state dynamic body with a statutory status.
- **Details**

- The commission has been set up to monitor and check air pollution levels in the NCR and adjoining region.
    - » It **supersedes all existing bodies**. The commission shall have exclusive jurisdiction in respect of matters covered by the law.
    - » **Powers of CPCB/SPCB continue:** The CPCB and its state branches have the power to implement provisions of the Environment Protection Act for air, water and land pollution.
      - However, in case of **dispute** or clash of jurisdictions, the Commission's writ will prevail specific to matters concerning air pollution.
  - **The commission** will look at:
    - » Coordination between states
    - » Planning and execution of policy and interventions
    - » Operations of industry
    - » Inspections
    - » Research into the cause of pollution etc.
  - The powers to **levy fines - ranging up to Rs 1 crore or five years of prison** also lies with the commission.
  - The commission will be empowered to constitute special investigative groups for stricter implementation of air pollution norms on the ground.
  - **Structure**
    - » There will be at least six permanent members and it will be headed by a former or incumbent secretary to the GoI, or chief secretary to a state government.
    - » Overall, there would be **18 members** which would include five ex-officio members representing the five states; technical members from CPCB and ISRO; three representatives from NGOs with experience in combating air pollution; one representative from NITI Aayog.
  - **NGT:** Only the NGT, and not civil courts, is authorized to hear cases where the commission is involved.
  - **Area covered:** Delhi, Punjab, Rajasthan, Haryana and Uttar Pradesh
- **How is it different from EPCA?**
- **EPCA** was a Supreme Court mandated body, whereas the commission will be a **statutory body**.
  - **Area coverage:** EPCA - NCR, Commission -> NCR and adjoining areas.
    - » The pollution in Delhi is also caused by adjoining areas and therefore it has been given powers accordingly.
  - **State representation** was absent in EPCA but is present in the commission.
    - » The new 18-member commission brings together the Centre, states, and other stakeholders on one collaborative platform.
  - **Improved coordination:** the body has the mandate/powers to coordinate among states, which was absent in case of EPCA.

## 5) GRADED RESPONSE ACTION PLAN (GRAP)

- **GRAP** is the Delhi's **five-step escalating plan** to counter air pollution.
  - It was formulated in 2016 by Environmental Pollution Control Authority (EPCA) and approved by SC in the same year.
- **MoEF&CC had notified GRAP** for Delhi and NCR in 2017 and it draws its authority from this notification.
  - It institutionalized measures to be taken when air quality deteriorates.
  - The plan is **incremental in nature**. The **nature scope and rigor of measures** to be taken is linked to levels of pollution viz. Severe+ or Emergency, Severe, Very Poor, Moderate to Poor and Moderate.
  - **Note:** GRAP works only as an emergency measure and doesn't include actions by various state governments to be taken throughout the year to tackle industrial, vehicular and combustion emission.
  - Various directives of GRAP kick in based on the recommendations of a committee of experts;
- **Note:**
  - Since the formation of "the Commission for Air Quality Management in National Capital Region and Adjoining Areas", it is the designated agency for the implementation of the plan.
- **Significance**
  - GRAP has been successful in doing two things that had not been done before:
    - Creating a step-by-step for the entire Delhi-NCR region.
    - Getting on board several agencies: All pollution control boards, industrial area authorities, municipal corporations etc.
    - Fixed accountability and deadlines. For each action to be taken under a particular air quality category, executing agencies are clearly marked. In a city like Delhi which has multiplicity of authority, this has had a crucial difference.
    - EPCA along with GRAP has contributed in **three major policy decisions**:
      - Closure of thermal power plant at Badarpur, bringing BS-VI fuel to Delhi before the deadline set initially, and the ban on Pet Coke as a fuel in Delhi-NCR.
- **Limitations of GRAP**
  - **Focus on Delhi** - other states have managed to delay several measures, citing lack of resources;
- **How was GRAP implementation different in 2022:**
  - On 5th Aug 2022, the CAQM issued statutory direction, for the implementation of revised schedule of the GRAP.
  - **Key Changes in the revised action plan:**
    - a. Restriction on polluting activities will be dependent on Air Quality Index (AQI) rather than PM2.5 and PM10 concentration.
    - b. Measures could be taken up to three days in advance based on forecasts, the revised plan states.
      - **Earlier**, measures were implemented only after the PM2.5 and PM10 concentrations (micrograms per cubic meter) reached a certain threshold.
  - The **GRAP** for Delhi-NCR is divided into four stages. As per the plan, actions under stages 2-4 are invoked at least three days in advance of the AQI reaching the projected levels.

| Stage | Key steps in each stage: |
|-------|--------------------------|
|-------|--------------------------|

|   |  |
|---|--|
| <b>Stage-1: "Poor"</b><br><br>AQI: 201-300    | <p><u>Ban on construction and demolition activities at specific sites.</u></p> <p>Agencies must ensure that all solid waste is lifted from dedicated dump sites, and none is dumped on the open land.</p> <p>Heavy fines are to be imposed for <u>openly burning municipal solid waste and biomass</u>.</p> <p>Roads will be <u>mechanically cleaned</u> and water will be <u>sprinkled from time to time</u>.</p> <p>Authorities will ensure that <u>thermal power plants comply with emission norms</u> and that <u>industries use approved fuel</u>.</p> <p>The <u>ban on firecrackers</u> should be followed as per the directions of respective courts</p> <p>Social Media is to be used to <u>update people about pollution levels and control room contact details so that violations can be reported to the authorities</u>.</p> |
| <b>Stage-2: Very Poor</b><br><br>AQI: 301-400 | <p><b>Daily Mechanized sweeping</b> of roads; Water sprinkling with dust suppressants at least on alternate days;</p> <p><u>Use of Coal and firewood in eateries would be banned.</u></p> <p><u>Use of Diesel Generators</u> might be allowed only in <u>certain cases</u>. Parking fees may be raised to discourage private transport.</p> <p><u>Resident Welfare Associations</u> would be required to provide <u>electric heaters</u> to security staff during winter to prevent the burning of solid waste or biomass.</p>   |
| <b>Stage-3: Severe</b><br><br>AQI: 401-450    | <p>The frequency of cleaning roads intensifies in this stage. Water would be <u>sprinkled daily before traffic hours</u>.</p> <p>Strict ban on <u>all construction activities except ongoing work on roadways, railways, metro, hospital etc.</u> Authorities will levy <u>different rates on public transport services to encourage off-peak travels</u>.</p> <p>The <u>state government</u> will be empowered to impose restrictions on BS-III petrol and BS-IV diesel light motor vehicles (4-wheelers)</p>   |
| <b>Stage-4: Severe Plus</b><br><br>AQI > 450  | <p>Entry of <u>all trucks</u> except those carrying essential commodities, or providing essential services is to be stopped into Delhi. This will be <u>followed by a ban on plying of diesel-operated medium goods and heavy goods vehicles in Delhi</u>, except those carrying essential items.</p> <p><b>All construction and demolition</b> activities would have to be <u>stopped</u>.</p>  |

The respective government could meanwhile, take a call on allowing public, municipal and private offices to work at 50% strength.

If required, the Centre can allow work from home for central government employees.

Additional emergency measures like closing schools and other educational institutes, non-emergency commercial activities and plying of vehicles on an odd-even basis may also be enforced.

- **Revised GRAP to deal with adverse air quality scenario (Nov 2022)**

- In a move to mitigate dust arising out of C&D activities sites and intensify actions to further ameliorate the overall air quality of the NCR, the CAQM has mandated all C&D projects in NCR to deploy adequate number of anti-smog guns, in proportion of the total area of construction for the project.
    - Different number of guns have been recommended based on different size of the project. (1-> 5,000 - 10000 sqm; 2 for 10001-15,000 sqm; 3 for 15,001 - 20,000 sqm; 4 for 20,000 sqm)

- **Role of Citizens:**

- GRAP also includes a graded advisory for public:
    - **Under Stage-1**, the measures include properly tuning the engines of their vehicles, ensuring accurate air pressure in tyres, and updating PUC (pollution under control certificates). Turn off engines at red lights; don't dispose of waste or garbage in open space. Report air pollution activities through apps 311, Green Delhi, SAMEER"
    - **For Stages-2, 3 and 4**, the commission advises the public to opt for public transport, or work from home if required.
    - **Under stage-4**: the elderly and those with respiratory, cardiovascular, cerebrovascular or other chronic diseases are advised to avoid outdoor activities and stay indoors once stage-4 is implemented.

## 6) NATIONAL CLEAN AIR PROGRAM

- It is a pollution control initiative that was launched by the **Ministry of Environment** in Jan 2019 with the intention to cut the concentration of coarse particulate matter(**PM10**) and fine particles or **PM2.5** by at least **20%** (20-30%)in the **next five years** (i.e. by 2024), with **2017 as the base year** for comparison.
- It is a long term time bound national level strategy to tackle air pollution across Indian in a comprehensive manner.
- **Which are the cities covered?**
  - **132 Non-attainment Cities** identified on the basis of Ambient Air Quality Data for the period 2011-2015 and WHO report 2014/18.
- **Objectives**
  - Ensure implementation of **prevention, control and abatement** measures for air pollution
  - Improve the **monitoring network**.

- Enhance public awareness regarding air pollution and capacity building measures.
- Who all are participating?
- Apart from experts from industry and academia, various ministries like Ministry of Road Transport and Highways, Ministry of Petroleum and Natural Gas, Ministry of New and Renewable Energy, Ministry of Heavy Industries, Ministry of Housing and Urban Affairs, Ministry of Agriculture, Ministry of Health, NITI Aayog, and CBCB are participating.
- Key Steps being Taken
- i. Pollution Reduction measures
    - Plantation drives, promotion of better technology, sectoral interventions like electric vehicle promotion, promoting renewable energy, waste management etc.
    - City specific Plan - A separate emergency action plan will be created for each of the 132 cities. It will include measures for strengthening the monitoring network, reducing vehicular/industrial emissions, increasing public awareness etc.
  - ii. Enhancing R&D and Data collection
    - Studies related to air pollution and its impact will be taken on
    - Monitoring infrastructure will be expanded and will start covering rural areas as well.
    - A National Emission inventory will be established to provide proper inputs for future policy making.
  - iii. Strengthening various pollution related institutions
    - A National Apex Committee under MoEF&CC, a steering committee under Secretary (environment) and a monitoring committee (under joint secretary) will be established.
    - There will be project monitoring committees at the state-level with scientists and trained personnel.
    - In Addition sectoral working groups, National level project monitoring units, State level project monitoring units, city level review committee under Municipal Commissioner and DM level committee in the districts are to be constituted under NCAP for effective implementation and success of the program.
  - iv. Increased focus on awareness generation and people's participation.

## 7) BHARAT STAGE EMISSION STANDARDS (BS NORMS)

- Intro:
  - » Bharat stage emission standards (first introduced in 2000) have been instituted by the GoI to regulate the output of certain air pollutant (NO<sub>x</sub>, CO, HC, PM, SO<sub>x</sub>) by vehicles and other equipment using internal combustion engine. As stage goes up, the control on emissions become stricter.
  - » The standards and timeline for implementation are set up by the Central Pollution Control Board under the Ministry of Environment, Forest and Climate Change.
- Dates of Application
  - » BS-4: BS-IV norms are applicable throughout the country from 1st April 2017.
  - » BS-V: GoI has decided to skip the standards and directly move to BS-VI standards by 2020.

- » **BS-VI:** Introduced in Delhi from 1st of April 2018, it is applicable **throughout the country from April 2020** for all vehicles.

- **Differences in BS-IV and BS-VI standards**

- » The main difference between BS-IV and BS-VI norms is the **amount of Sulphur** in the fuel.
  - Reduction in Sulphur will make it possible to equip vehicles with better catalytic converters that capture pollutants.
- » Similarly, **NO<sub>x</sub> emission** from diesel is expected to come down by 70% and by 25% in petrol vehicles. Further, the **restrictions on PM** has been increased in both diesel and petrol vehicles.
- » There are also lower limit for **HC and NO<sub>x</sub>** in diesel engine.

|                              | <b>g/km</b> | <b>g/km</b> | <b>g/km</b>           | <b>g/km</b>                | <b>g/km</b>  | <b>Sulphur</b>           |
|------------------------------|-------------|-------------|-----------------------|----------------------------|--------------|--------------------------|
| <b>Petrol Emission Norms</b> | <b>CO</b>   | <b>HC</b>   | <b>NO<sub>x</sub></b> | <b>HC + NO<sub>x</sub></b> | <b>PM</b>    |                          |
| BS-III                       | 2.3         | 0.2         | 0.15                  | ---                        | --           |                          |
| BS-IV                        | 1.00        | 0.1         | 0.08                  | ---                        | --           | 50 ppm                   |
| <b>BS-VI</b>                 | <b>1.00</b> | <b>0.1</b>  | <b>0.06</b>           | <b>---</b>                 | <b>0.005</b> | <b>10 ppm (10 mg/kg)</b> |
| <b>Diesel Emission Norms</b> | <b>CO</b>   | <b>HC</b>   | <b>NO<sub>x</sub></b> | <b>HC + NO<sub>x</sub></b> | <b>PM</b>    |                          |
| BS-III                       | 0.64        | --          | 0.50                  | 0.56                       | 0.05         |                          |
| BS-IV                        | 0.50        |             | 0.25                  | 0.30                       | 0.025        | 50 ppm                   |
| BS-VI                        | 0.50        | --          | <b>0.06</b>           | <b>0.17</b>                | <b>0.005</b> | <b>10 ppm</b>            |

- **Other Key Changes being brought:**

- **Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR)** are being introduced with the roll-out of Bharat Stage VI norms, which were not a part of Bharat Stage IV.
- **Real Driving Emissions (RDE)** will be introduced in India for the first time with the implementation of Bharat Stage VI emission norms. It will measure a vehicle's emission in real-time conditions against laboratory conditions.
- **Onboard diagnostics** has been made mandatory for all vehicles.
- BS VI would require usage of **Fuel Injection Technology** for two wheelers. This will the first such norm in India. This will filter out some PMs, some NO<sub>x</sub> etc.

## 8) PETROL VS DIESEL COMPARISON

- **Conversion to CNG**

- » Converting petrol car to CNG only costs around 30,000 rupees, whereas in case of diesel car it costs around 1,50,000 rupees, as it requires fundamental changes in the engine of the car and is an expensive time-consuming process.

- **Is Diesel worse than petrol?**

- » **More SPMs:** A diesel car emits 22 times more Suspended Particulate Matters (SPM) - the tiny particles which easily penetrate your lungs, hearts and even brains.

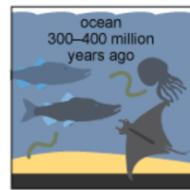
- » **More Nitrogen di oxide:** Diesel emits four times more nitrogen di oxide.
- » **Less CO<sub>2</sub> and better fuel economy:** However, a diesel car emits 15% less CO<sub>2</sub> than petrol and since it is more efficient fuel (it burns more than petrol), it also gives a higher fuel economy.

## 9) NATURAL GAS

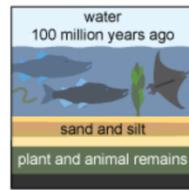
- Natural gas is a fossil fuel containing different organic compounds. It primarily consists of **methane**. Some other compounds in it includes ethane, propane etc. It is a colorless, tasteless and odorless gas.
- **How is natural gas formed?**
  - It is a fossil fuel which is formed due to extreme pressure and heat for millions of years on remains of plants and animals buried under the surface of the earth.

### Petroleum and natural gas formation

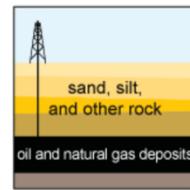
Tiny marine plants and animals died and were buried on the ocean floor. Over time, the marine plants and animals were covered by layers of silt and sand.



Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned the remains into oil and natural gas.



Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and natural gas deposits.



- **Advantages of Natural Gas**
  - **Environmentally more clean than other fossil fuels:** It releases very less byproducts into the atmosphere as pollutants.
  - **Economical** - it is cheaper than other fossil fuels.
  - **Safer to use:** Unlike LPG cylinders which has the risk of leakage and accident, natural gas is lighter than air. In case of leakage, it dissipates quickly into air avoiding fire.
  - **Abundance**
  - **Easy to deliver - Piped transportation** make it easy to transport.
- **Limitations**
  - **Non-Renewable Fossil Fuel** - Emits CO<sub>2</sub> - Global Warming, Climate change.
  - **Easily inflammable**
- **Natural Gas comes in four basic forms:**
  - **Liquified Natural Gas** (liquified at -160 degree celsius). This facilitate transportation in large volumes in cryogenic tankers across seas/ land.
  - **Regasified LNG (RLNG)**: LNG re-gasified at import terminals before transporting it to consumers through pipelines.
  - **Compressed Natural Gas (CNG)**: Compressed to a pressure of 200-250 kg/ cm<sup>3</sup> - used for fuel transportation.
  - **Piped Natural Gas**: Natural gas distributed through a pipeline network that has safety valves to maintain the pressure, assure safe, uninterrupted supply to the domestic sector for cooking and heating/ cooling applications.

## 5. RECENT AIR POLLUTION ISSUES

### 1) DELHI'S AIR POLLUTION PROBLEM

#### - Introduction

- » Delhi's air quality dips drastically every year with the arrival of harvest season during October-November. Though, government generally blames the stubble burning in the neighboring states as the key cause, but the air pollution in Delhi is a complex phenomenon that is dependent on a variety of factors.

#### - Key Factors include:

##### i. Input Pollutants

- Dust is the biggest cause of pollution during winters. Dry cold weather leads to dust being easily available in the entire region.
- Vehicular Pollution is the second biggest cause of pollution in winters.
  - According to a study by IIT Kanpur, around 20% of PM2.5 in winters comes from vehicular pollution.
- Stubble burning
  - At the time of Rabi harvesting around 25% of PM content in Delhi is due to stubble burning.
- Industries, thermal power plants, burning of waste during winters
- Diwali Pollution

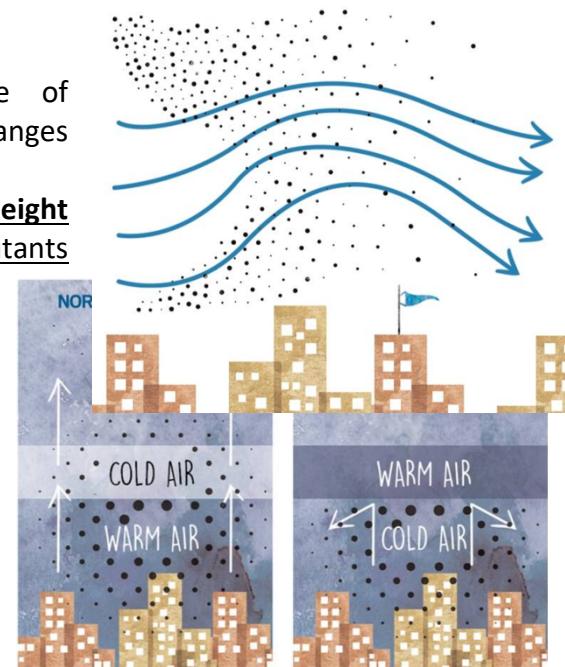
##### ii. Meteorological Factors

- **Wind Direction:** With the departure of Monsoon, the wind direction in Delhi changes from easterlies to westerlies.
- **Dip In Temperature brings the inversion height to lower levels.** The concentration of pollutants in the air increases when this happens.
  - Note: Inversion Height is the layer beyond which pollutants cannot disperse into the upper layer of the atmosphere.

- iii. **Low Wind speed in winters:** High wind speeds are effective in dispersing pollutants, but with arrival of winters, the average wind speed decreases.

##### iii. Other factors

- When compared to other metropolitan (i.e. Kolkata, Mumbai and Chennai) - Delhi is surrounded by high density region on all the sides. The other three cities are located near the coast, thus leaving the breathing space for the cities.



- **Steps taken in Delhi in the past to fight Air Pollution:**
  - In 1996, the Supreme Court took a note of the extremely poor air quality of Delhi and ordered the closure and relocation of over 1,300 highly polluting industries from Delhi's residential areas beyond the NCR in a phased manner. Multiple brick kilns were also directed to be relocated outside the city limit.
  - In 1998, the Supreme Court ordered the MoEF&CC to establish an authority for Delhi, which led to the creation of **Environment Pollution Control Authority (EPCA)** in 1998.
  - Supreme Court subsequently ordered conversion of the whole fleet of DTC buses, taxis and autos to CNG.
  - During this time centre also took several steps:
    - It revamped its Air Quality Monitoring Program and established a network of monitoring stations, under the National Air Quality Program.
    - In 2009, National Ambient Air Quality Standards were revised to include the 12 categories of pollutants including PM 2.5 - a noxious pollutant which can penetrate deep into the lungs and even enter the blood stream.
- **Steps taken in recent years to deal with pollution in Delhi**
  - **The Commission for Air Quality Management in National Capital Region and Adjoining Areas**
    - Formed in Oct 2020 through an ordinance to strengthen the air pollution control system in NCR and adjoining region
    - Replaces the EPCA
  - **Ban on Coal and other unapproved fuels from 1st Jan 2023**
  - Introduction of **BS-VI norms for Vehicles**
  - **Graded Response Action Plan (GRAP)**
  - **Push for Electric Vehicles - Delhi's Electric Vehicle Policy, 2019** subsidizes buying of electric vehicle and encourage people to move to electrical
  - **Various steps for controlling stubble burning**
  - **Prohibition on polluting crackers and promotion of green crackers**
  - **Odd-Even rule for vehicles** as emergency measures
  - **Construction of Eastern and Western Peripheral Expressways**
    - To provided fast alternative routes to vehicles not destined for Delhi.

## 2) BAN ON COAL AND OTHER UNAPPROVED FUEL IN DELHI (JAN 2023)

- CAQM has imposed a ban on coal and other unapproved fuels from 1st of Jan 2023. Industries using them would be closed and heavy fines would be imposed on them.
  - **Exceptions:**
    - Use of low sulphur coal in thermal power plants in Delhi NCR is allowed. It can be used wherever the primary purpose is power generation.
    - Firewood and biomass briquettes can be used for religious purposes and cremation.
    - Wood or bamboo charcoal can be used for tandoors and grills of hotels, restaurants, banquet halls (with emission control systems), and open eateries and Dhaba.
    - Use of wood charcoal for cloth ironing is allowed.
- The ban was notified by CAQM in June 2022

### 3) STUBBLE BURNING – CLASS DISCUSSION

#### A) PUSA DECOMPOSER

- a technology developed by IARI to manage paddy stubble in fields. It can rapidly degrade paddy straws in the field and convert them into compost, which then doesn't pose any issues for sowing of wheat crops, as per IARI scientists.
  - » It contains seven strains of fungi, which is to be mixed with water, 150 gms of jaggery and 50 gms of besan, to prepare a 25-litre solution that can be sprayed on 1 hectare of field.
  - » **Results:** Farmers of north Delhi found in 2020 that PUSA decomposer took about 20-22 days for stubble to decompose. This has helped in increasing soil fertility (less fertilizer use) and reduced the need of extensive ploughing to mix stubble with soil.

### 4) FIRE CRACKERS

- **Introduction**
  - » Firecrackers are among the most poisonous air pollutants. The **chemical footprint left by them have a devastating impact on human health and especially affects children**.
  - » CPCB in a study in Delhi in 2016 found that the levels of Aluminium, Barium, Potassium, Sulphur, Iron and Strontium rose sharply in Diwali night, from low to extremely high.
- **Science behind Firecrackers**
  - » Firecrackers use fuel and oxidizers to produce a combustion reaction, and the resulting explosion spreads the material in a superheated form. The metal salts in the explosive mix get 'excited' and emit light. Metals in the mix, which have varying arrangement of electrons in shells outside their nucleus, produce different wavelength of light in this reaction, generating spectacular colors.
    - For e.g. **Barium compounds** produce green light, Strontium and lithium salts produce red colors.
- **But firecrackers are big health hazards.**
  - » Chemicals such as barium nitrate and cadmium compounds cause respiratory irritation and gastrointestinal problems.
  - » Aluminium sulphide is known to cause Alzheimer's.
  - » Lithium and copper compounds cause hormonal imbalance and so on.
- In order to tackle the air and noise pollution during the festival season, the Supreme Court in a judgment (**Arjun Gopal & others Vs Union of India & others**), in Oct 2018 have mandated a series of steps to reduce the pollution from firecrackers. The key highlights of the Supreme Court Judgment includes:
  - i. **Improving the quality of crackers to reduce Air pollution**
    - a. Use of reduced emission firecrackers (**improved crackers**) only.
      - Avoiding use of ash as filler material -> Reduce particulate matter by 15-20%.
      - Use of charcoal meeting the PESO specifications.
    - b. Use of Reduced emission firecrackers (**green crackers**)
      - To reduce emission of PM, NO<sub>x</sub>, and SO<sub>2</sub> due to in-situ water generation as dust suppressant.

- c. **Firecrackers only with permitted chemicals** to be allowed -> PESO shall test and check for the presence of banned chemicals like lithium/arsenic/antimony/lead & mercury.
  - d. **Banning of Barium salts in Firecrackers**
    - Barium emits poisonous gas causing respiratory problems and may have health complications due to long-term exposure.
    - **Why Barium so common in firecrackers:** emits green light, low cost, readily available.
  - e. **Enough facilities should be created to ensure use of quality raw material** in gun/flash powder as per the Petroleum and Explosives Safety Organization (PESO) specifications. This will address the issue of high content of unburnt/partially combusted material.
  - f. **PESO to ensure firecrackers satisfy decibel levels**
- ii. **Time Limit**
    - a. Firecrackers are only allowed from **8-10 pm** in Diwali and **11.55 pm - 12.30 pm** in Christmas and New year.
  - iii. **Blanket ban on online sale**
  - iv. **Ban on series cracker ('laris').**
  - v. **Stations house officer** will be held liable for contempt of court in case of violation of any judgment.

## 5) NGT BANS FIRE CRAKERS (NOV 2020)

- In Nov 2020, NGT has prohibited the sale and use of firecrackers during Deepavali in the NCR and in urban centres that recorded poor or worse air quality in Nov 2019.
- Sale of green crackers are allowed in cities and towns where air quality is moderate or below. But bursting of firecrackers are restricted to two hours during Diwali, Chatth, Christmas, and New Year.
- **Significance:**
  - A response to deteriorating air quality in various parts of the country. Primacy to precautionary principle in sustainable development over employment and revenue losses.
- **In July 2021, the SC upheld the NGT judgement.**

## 6) PETROLEUM AND EXPLOSIVE SAFETY ORGANIZATION (PESO)

- PESO is an statutory authority entrusted with the responsibility under the Explosives Act, 1884; Petroleum Act, 1934; Inflammable Substances Act, 1952, Environment (Protection Act), 1986 and rules made under those acts.
- It is a subordinate office under Department of Industrial Policy & Promotion.
- It is the nodal organization to look after the safety requirements in manufacture, storage, transport and use of explosives and petroleum.
- The organization is headed by Chief Controller of Explosives with its headquarter at Nagpur (MHA).
- **Other Recent Developments**
  - » In May 2018, Union Cabinet approved formation of Group 'A' service of the technical cadre of PESO in the name of Indian Petroleum & Explosives Safety Services (IPESS).
  - » The measure will enhance the capacity and efficiency of the organization and it will also enhance the career progression of its Group 'A' Officer.

- **Barium Nitrate** is used to produce green light and can produce more colors in combination with other chemicals.
  - » It is used in all light emitting fireworks.
  - » **Health Hazards:** Barium salts, as per the SC, can lead to health complications.
  - » **A replacement** of the salt is yet to be explored

## 7) GREEN CRACKERS

- **What are Green Crackers?**
  - » **Green Crackers** are firecrackers produced using less harmful raw materials and additives to reduce emissions.
    - CSIR-NEERI has defined Green crackers as those which will reduce emission by 30% and can limit sound to 125 decibels (at a distance of 5 meters).
    - Since the Supreme Court had banned barium nitrate, the green chemicals contain Potassium nitrate and zeolite in green crackers instead.
    - They newly developed crackers also include Safe Water Releaser, Safe Minimal Aluminum Cracker and Safe Thermite Crackers.
      - The additives in Safe Water Releaser give out water, air and dust suppressants.
      - The Safe Minimal Aluminium minimizes the use of aluminium, potassium nitrate and sulfur.
      - The Safe Thermite Cracker is based on a combination of metals, including aluminium, and metal oxides like iron oxides to produce heat.
  - » The **packaging** of these crackers contains a **QR code** and a **green logo** that states that they have been certified by CSIR and NEERI.
- **Supreme Court** in Nov 2019 has said that it wants every consignment of the material used in manufacturing green fire crackers to be tested for quality control.
  - » Quality control mechanism should be set up in each manufacturing unit of green fire crackers within 15 days and such units be monitored by officials from the Petroleum and Explosive Safety Organization (PESO).
- **Are Green Crackers completely Green?**
  - » **No**
  - » They produce 30% less PM2.5 and 50% less SO<sub>2</sub> emissions. But they still produce PM2.5 and SO<sub>2</sub>.

## 8) SMELTING INDUSTRY AND POLLUTION

- Smelting is a metallurgical process that involves heating raw ore or metal in order to extract or refine a desired metal.
  - » The process involves use of high temperatures and chemicals to break down the ore, allowing the desired metal to be separated from the other materials in the ore or metal.
  - » Generally, the raw material is usually heated to a high temperature in a furnace, along with a reducing agent such as coke or charcoal, which helps to reduce the metal oxide in the ore or metal to a pure metal.

- Smelting is used in the extraction of metals like iron, copper, lead and zinc as well as in the production of alloys such as steel.
- **Smelting is also a major source of Pollution:**
  - » It releases large amounts of pollutants such as sulfur dioxide and heavy metals into the air, water, and soil. The industry also causes noise pollution.

## 9) ODOUR POLLUTION

- **Introduction**
  - World Health Organization recognizes Odour (unpleasant smell) as a pollution and says it affects the quality of life and social well-being of individuals. The unpleasantness is created by presence of compounds such as Ammonia, Hydrogen Sulphide, butyric acid, ethyl and methyl mercaptan and dimethyl sulphide.
  - **Impact**
    - Effect of odour varies from person to person but at sufficiently high concentrations, odour compounds may have direct effect on human health.
    - It may lead to vomiting, headaches, nausea, stress, anxiety, frustration, restriction in outdoor activities, children unable to sleep and discomfort for elderly and others.
- **Main Sources of Odour Pollution**
  - MSW dumpyards, oil refineries, fish markets, slaughter houses, distilleries, pharmaceuticals, biomedical and hazardous waste disposal sites and pesticide plants.
- **Steps Taken**
  - i. **Central Pollution Control Board (CPCB) issues detailed guidelines for proper Monitoring and Management of Odour at Urban Municipal Solid Waste Landfills (Sep 2017)**
    - The guidelines were based on the 'scientific pilot study' of East Delhi's Ghazipur landfill site.
    - **Buffer zones: Green Belt around land fill** sites and suggested selection of appropriate plant species for vegetation cover to assist in reducing odour.
    - **Trapping LFG gases:** MSW landfill sites should be designed to tap landfill gases (LFG) efficiently to mitigate fugitive odorous emissions.
    - **Legislative norms on baseline data:** The guidelines also suggested for initiating legislative norms for creating baseline data on odour.
    - Need for **gradual shift for installation of Continuous Odour Measurement Systems** (Sensor based) similar to Continuous Air Quality Monitoring Stations (CAAQMS).
      - This is needed as manual measurement is time consuming
    - **Various Considerations before choosing landfill sites**
      - Present population and projected growth for the next 20 years
      - Whether the selected site is free from the impact of other odorous sources and the topography of the site (slope, proximity to water sources like river and natural springs)
      - Selection should be integrated with the urban development plan of the city so that even expansions of the city in next two or three decades are not encompassing the selected MSW site

## 6. VARIOUS AIR QUALITY MEASURING INITIATIVES IN INDIA

### 1) NATIONAL AIR QUALITY MONITORING PROGRAMMES (NAMP)

- CPCB is executing a nation-wide program of ambient air quality monitoring known as National Air Quality Monitoring Program (NAMP).
- Objective of NAMP is:
  - i. To Determine status and trends of ambient air quality
  - ii. To Ascertain whether the prescribed air quality standards are violated
  - iii. To obtain the knowledge and understanding necessary for developing preventive and corrective measures
  - iv. To understand the natural cleansing process undergoing in the environment through pollution, dilution, dispersion, wind-based movement, dry deposition, etc.
- Pollutants covered:
  - i. Under NAMP, four air pollutants viz., Sulphur dioxide (SO<sub>2</sub>), Oxides of Nitrogen (NO<sub>2</sub>), Respirable Suspended Particulate Matter (RSPM/ PM10), and Fine Particulate Matter (PM 2.5) have been identified for regular monitoring at all the locations.
  - ii. The monitoring of meteorological parameters such as wind and wind direction, relative humidity (RH) and temperature were also integrated with the monitoring of air quality.

### 2) NAAQS (NATIONAL AMBIENT AIR QUALITY STANDARDS) BY CPCB

- Ambient Air Quality refers to the condition or quality of air surrounding us in the outdoors.
- NAAQS are the standards for ambient air quality set up by CPCB and are applicable nationwide.
  - The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.
- The current standards were set up in 2009 and were an improvement over previous standard. It covers **12 pollutants**:
  - CO, SO<sub>2</sub>, NO<sub>x</sub>, PM10, PM2.5, Ozone, NH<sub>3</sub>, lead, Arsenic, Benzene, Benzopyrene, Nickel.

### 3) AIR QUALITY INDEX (AQI)

- Air Quality Index is a number used by government agencies to communicate to the public how polluted the air quality is or how polluted it is forecasted to become.
- In India, National Air Quality Index, was launched in Sep 2014 as part of Swachh Bharat Abhiyan by MoEF&CC.
- The CPCB, the nodal agency for air pollution data in India, has developed a color coded air-quality index to mark hazardous levels for the public benefit.
- There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and severe.
- It considers 8 pollutants (PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, SO<sub>2</sub>, CO, O<sub>3</sub>, NH<sub>3</sub>, and Pb.)
- Initially it was launched in 10 cities and today it covers 24 cities in 10 states.

| Color    | AQI                 | Remark   |
|----------|---------------------|--|
| Green    | Good 0-50           | Minimal Impact   |
| Yellow   | Satisfactory 51-100 | May cause minor breathing discomfort in sensitive people.  |
| Orange   | Moderate 101-200    | May make breathing difficult for people with lung diseases and cause discomfort in children, older adults and heart patients.  |
| Red      | Poor 201-300        | May make breathing difficult after prolonged exposure, and cause discomfort to people with heart diseases.   |
| Dark Red | Very Poor 301-400   | May cause respiratory illnesses in people on prolonged exposure. Effect may be more pronounced in those with lung and heart diseases.  |
| Black    | Severe 400          | May cause respiratory problems even in healthy people, and seriously impact those with lung/heart diseases. Even increased breathing during light physical activity can impact health. |

- **Need of AQI**

- Traditionally air pollution data has been reported in very voluminous way. It was important that information of air quality is put up in public domain in simple linguistic term that is easily understood by common person.



# TARGET PRELIMS 2024

## BOOKLET-13; EB&CC-3

### WATER – RIVER, GROUND WATER AND OCEANS

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## 2. INTERNATIONAL EFFORTS – CONVENTIONS, REPORTS, MEETS ETC.

### 1) WATER CONVENTION

- Negotiated under: United Nation Economic Commission for Europe.
- Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) was adopted in Helsinki in 1992 and entered into force in 1996.
  - » It is a legally binding instrument and aims to protect and ensure the quantity, quality and sustainable use of transboundary water resources by facilitating cooperation.
  - » It provides inter-governmental platform for day-to-day development and advancement of transboundary cooperation.
  - » It was initially negotiated as a regional (Pan-European) instrument. Later, it turned into a universally available legal framework for transboundary water cooperation, following the entry into force of amendments in Feb 2013, opening it to all UN Member States.
- It has emerged as a powerful tool to achieve the objective of SDG 6 (clean water and sanitation)
- **Is India a member?**
  - » No
- **Report:** "The Water Convention: 30 Years of Impact and Achievements on the Ground"

### 2) WORLD WATER DAY: 22<sup>ND</sup> MARCH

- **About World Water Day**
  - » WWD is an annual UN Observance Day which highlights the importance of fresh water. The day is used to promote awareness related to water conservation and advocate sustainable management of the freshwater resources.
  - » **UN-Water** is the convener for World Water Day and selects the theme for each year in consultation with UN organizations that share an interest in that year's focus.
  - » The day was first formally proposed in the 1992 UN Conference on Environment and Development in Rio de Janeiro. UNGA adopted the resolution regarding this in Dec 1992.
  - » The **first WWD** was observed on 22nd March 1993.
- **World Water Day, 2023**
  - » The theme for the year 2023 is "Accelerating Change."
    - It focuses on accelerating change to solve water and sanitation issues.

### 3) THE UN WORLD WATER DEVELOPMENT REPORT, 2023

- **Who Publishes the report.**
  - The UN World Water Development Report (WWDR) is an **UN-Water's flagship report** on water and sanitation issues, focusing on a different theme each year.
  - The report is published by UNESCO, on behalf of UN-Water and its production is coordinated by the UNESCO World Water Assessment Program.

- **Key Highlights of the 2023 Report:**
  - It assesses the role of partnerships and cooperation among the stakeholders in water resources management and development and their role in accelerating progress towards water goals and targets.

### 3. INITIATIVES IN INDIA

#### 1) REPORT: COMPOSITE WATER MANAGEMENT INDEX (CWMI)

- **Introduction**
  - The CWMI is a first of its kind, comprehensive scorecard for identifying, targeting and solving problems in water sector across the country. It was first published in 2018.
  - **It is expected to:**
    - » Promote data-based decision making and thus scientific management of water.
    - » Encourage competitive and cooperative federalism.
    - » Establish a clear baseline and benchmark for state-level performance on key water indicators.
    - » Uncover and explain how states have progressed on water issues over time, including identifying high-performers and under-performers, thereby inculcating a culture of constructive competition among states.
    - » Identify areas of deeper engagement and investment on the part of the states.
    - » Eventually, the NITI Aayog plans to develop the index into a composite national-level data management platform for all water resources in India.
- **The indicators in the Water Index have been grouped into nine major broad themes.**
  - i. Source Augmentation and Restoration of water bodies
  - ii. Source Augmentation (ground water)
  - iii. Major and medium irrigation (supply side management)
  - iv. Watershed development - supply side management
  - v. Participatory Irrigation Practices - Demand side management
  - vi. Sustainable on-farm water use practices - Demand side management
  - vii. Rural Drinking water
  - viii. Urban water supply and sanitation
  - ix. Policy and Governance
- **Note:** CWMI 3.0 is worked in progress; CWMI 2.0 was published in Aug 2019
- **Note:** NITI Aayog now plans to combine CWMI 3.0, 4.0, 5.0 and 6.0 to cover the years 2021-22, and 2022-23. It is also contemplating data coverage to district level.

#### 2) GOVERNMENT INITIATIVES

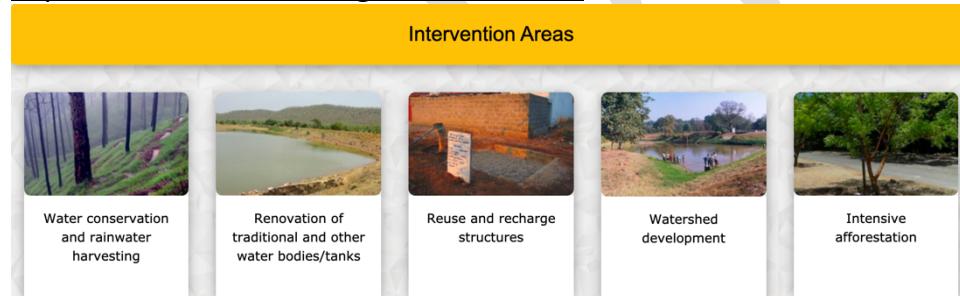
##### A) MINISTRY OF JAL SHAKTI

- A Unified Ministry of Jal Shakti was launched in May 2019 as an immediate response to the escalating water crisis in the country.

- The ministry was formed by **merging of two ministries**: Ministry of Water Resources, River Development & Ganga Rejuvenation and Ministry of Drinking Water and Sanitation.
- **Functions** of the new ministry ranges from providing clean drinking water, international and inter-state water disputes, cleaning Ganga river, its tributaries and sub tributaries.
- **Why?**
  - All water related initiatives are complementary to each other and therefore it's better to have one ministry for better coordination and integrated data management system.

## B) JAL SHAKTI ABHIYAN

- **What is Jal Shakti Abhiyan?**
  - » It is Jal Shakti Ministry's flagship **water-conservation campaign**.
- **Need of the program:**
  - » In 1951, per-capita water availability in India: 5,000 cu m per year
  - » In 2011 -> 1,545 cu m per year
- **Jal Shakti Abhiyan-1**
  - » **Campaign was first launched in 2019** which was focused on water-stressed districts and blocks (256 districts and 1592 blocks). It was run through citizen participation during Monsoon season. (July - Sep and Oct - Nov (for states receiving north-east retreating Monsoon))
  - Under this, Gol worked with state and district officials in this water stressed districts to promote water conservation and water resource management by focusing on accelerated implementation of five target interventions:



- **Special Intervention Areas**

| Special Intervention Areas  |  |  |  |   |
|---|--|--|--|---|
|   |  |  |  |   |
| <b>Block and District Water Conservation Plan</b><br>Development of Block and District Water Conservation Plans (To be integrated with the District Irrigation Plans) | <b>Krishi Vigyan Kendra Mela</b><br>Krishi Vigyan Kendra Melas to promote efficient water use for irrigation (Per Drop More Crop), and better choice of crops for water conservation | <b>Urban Waste Water Reuse</b><br>In urban areas, plans/approvals with timebound targets to be developed for waste water reuse for industrial and agriculture purposes. Municipalities to pass by-laws for the separation of grey water and blackwater | <b>Scientists and IITs</b><br>Scientists and IITs to be mobilised at the national level to support the teams | <b>3D Village Contour Mapping</b><br>3D Village Contour Maps may be created and made accessible for efficient planning of interventions |

- It was aimed at **making water conservation a Jan Andolan** through asset creation and extensive communication.
- **No separate funds** were allocated for JSA-1 and funds from convergence of different central and state government schemes were utilized.
- **Jal Shakti Abhiyan 2.0** couldn't be undertaken due to **COVID-19 restrictions**.
- However, Ministry of Jal Shakti has taken up the "***Jal Shakti Abhiyan: Catch the Rain***" (**JSA: CTR**) with the theme "Catch the rain, where it falls when it falls" covering both rural as well as urban areas of **all districts in the country**, during the pre-monsoon and monsoon period - i.e., upto 30th Nov 2021.
- "Jal Shakti Abhiyan: Catch the Rain" (JSA: CTR) -2022, **the third in the series of JSAs**, has been launched on 29.3.2022.
  - » It covers all blocks of all districts (rural as well as urban areas) across the country during 29th March 2022 to 30th Nov 2022 - the pre-monsoon period.
  - » The targeted interventions of the campaign in the current year are (1) water conservation and rainwater harvesting (2) enumerating, geo-tagging & making inventory of all water bodies; preparation of scientific plans for water conservation based on it (3) Setting up of Jal Shakti Kendras in all districts (4) intensive afforestation and (5) awareness generation.
  - » In this campaign, additional activities/ sub-interventions have been incorporated under the intervention 'water conservation & rainwater harvesting' which include spring shed management, protection of water catchment areas and creation/ renovation of 'amrit sarovars'

#### C) JAL JEEVAN MISSION (JJM) (WATER FOR LIFE) (HAR GHAR NAL SE JAL)

- JJM was launched in 2019 to provide **functional household tap connection (FHTC)** to every household by the end of 2024
- **Need:**
  - » Water inequality is a major concern in India. 81% of households in India were without tap connection (14.6 cr /17.87 cr)
  - » Safe drinking water together with a comprehensive sanitation program is important for reducing the disease burden of the poor.
- **Details**
  - » JJM restructures and subsumes the National Rural Drinking Water Program (running since 2009). The scheme is also known as **Har Ghar Nal Se Jal (HGNSJ)**.
- **The Broader Objectives of JJM are:**
  - » To provide Functional Household Tap Connections (FHTC) to every rural household by 2024 with a service level of 55 litres per capita per day (lpcd).
  - » To prioritize provision of FHTCs in quality affected areas, desert areas, drought prone areas and Sansad Adarsh Gram Yojna villages.
  - » To provide functional tap connection to Schools, Anganwadi centres, GP buildings, Health centres, wellness centres and community buildings



- » To monitor functionality of tap connections.
  - » To promote and ensure voluntary ownership among local community by way of contribution in cash, kind and/ or labour and voluntary labour (shramdaan)
  - » To assist in ensuring sustainability of water supply system, i.e. water source, water supply infrastructure, and funds for regular O&M
  - » To empower and develop human resource in the sector such that the demands of construction, plumbing, electrical, water quality management, water treatment, catchment protection, O&M, etc. are taken care of in short and long term.
  - » To bring awareness on various aspects and significance of safe drinking water and involvement of stakeholders in manner that make water everyone's business.
  - » A dedicated fund called '*Rashtriya Jal Jeevan Kosh*' has been set up by Ministry of Jal Shakti to mobilise and accept contributions received from other sources such as Corporate Social Responsibility to fund JJM.
- **Cost:** The total project is estimated to cost Rs 3.60 lakh crore.
  - » **Center: State:** 50: 50 (90:10 for NE and Himalayan States and 100% for UTs)
- **Implementations**
  - » JJM is implemented by the Department of Drinking Water and Sanitation (DDWS) under the recently formed MJS.
- **Steps which are planned:**
  - » augment local water sources.
  - » recharge existing sources and.
  - » promote water harvesting and de-salination wherever required.
  - » Reuse grey water or discharged water.

#### D) MISSION AMRIT SAROVAR

- **Ministry:** Ministry of Rural Development (MoRD)
  - Mission Amrit Sarovar was launched on National Panchayati Raj Day on 24 April 2022 with the objective to conserve water for the future.
  - The Mission is aimed at developing and rejuvenating 75 water bodies in each district of the country during this Amrit Varsh, 75th Years of Independence.
- **The impact of this initiative has been.**
  - » About 32 crore cubic meters of water holding capacity has been enhanced.
  - » Water Users' groups have been associated with each Amrit Sarovar inter-alia improving the livelihoods base of the local community.
  - » Participation of freedom fighters, Martyr's families, Padma Awardees, and other eldest citizens of the local areas helped in community participation at a large scale, promoting social harmony and patriotism, and making this mission a mass movement.
  - » People's participation has been seen in this mission in a form of "Shram -Daan".
  - » This will result in the creation of a total carbon sequestration potential of 1,04,818 tonnes of carbon per year.

### 3) JALDOOT APP

- **Ministry: MoRD**
- MoRD has developed 'JALDOOT App' which will be used across the country to capture water levels of selected well.
  - » It will enable Gram Rojgar Sahayak (GRS) to measure the water level of selected wells twice a year (pre-Monsoon post-Monsoon).
  - » In every village adequate number of measurement locations (2-3) have to be taken

#### A) NATIONAL WATER AWARDS

- **Why in news?**
  - 5th National Water Awards Launched on Rashtriya Puraskar Portal ([www.awards.gov.in](http://www.awards.gov.in)) (Oct 2023)
    - Application for awards could be filed here. Last date for submitting applications is 15th Dec 2023.
- **Department and Ministry:** The Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD, & GR), Ministry of Jal Shakti .
- **Details**
  - NWA were instituted to recognize and encourage exemplary work and efforts made by states, districts, individuals, organizations, Panchayats, ULB, School, Industry, Society, Water User Association, Individual etc. across the country in attaining the government's vision of a 'Jal Samridh Bharat'.
  - It also strives to create awareness among the people about the importance of water and motivate them to adopt the best water usage practices.
  - SO far, it has provided a good opportunity to start-ups as well as leading organizations to engage and deliberate with senior policymakers on how to adopt the best water resources management practices in India.
  - The first National Water Award was launched by the Jal Shakti Ministry in 2018.

## 4. WATER POLLUTION RELATED ISSUES

### 1) RIVER POLLUTION

- **Why in news?**
  - » The number of polluted stretches in India's rivers has fallen from 351 in 2018 to 311 in 2022, though the number of most polluted stretches is practically unchanged: Report by CPCB (made public in Dec 2022)
- **Current River Pollution Situation in India** (Dec 2022)
  - » CPCB in association with pollution control boards/committees in different states/Uts monitors water quality of rivers and water bodies across the country through a network of monitoring

stations under the **National Water Quality Monitoring Program**. Total 4,484 locations in 28 states and 7 UTs including rivers, lakes, creeks, drains and canals are observed.

» **Standards of measurement by CPCB:**

- CPCB measures pollution level on the basis of **Biological Oxygen Demand**. If BOD is less than 3mg/L, it means the river stretch is fit for 'outdoor bathing'. If BOD of a point is > **3.0 mg/L**, it is identified as polluted locations.
  - Two or more polluted locations on a river in a continuous stretch are considered as a "polluted river stretch".
- **Polluted stretches** are classified between **Priority1** (BOD of 20-30 mg/L) to **Priority-5** (BOD of 3-6 mg/L).
- The success of river cleaning program is measured on the basis of how the river stretches are moving from Priority-1 to Priority 5 and if the priority-5 stretches are getting reduced.

» **Situation in 2018 report:** Number of stretches under various priorities:

- P1 (45); P2 (16); P3 (43); P4 (72); P5 (175);

» **Situation in 2022 report**

- P1 (46); P2(16); P3 (39); P4 (65); P5 (145);

» **Thus, there are no changes or slight changes in Priority 1 and 2.** This indicates that number of worst polluted regions remain the same.

- **Gujarat and Uttar Pradesh** have the maximum number (6) of Priority 1 river stretches.
- **Maharashtra** has the maximum number of polluted river stretches.

- **Factors:**

- **Discharge of untreated or partially treated sewage and Industrial effluents** from cities/towns in their respective catchments is the main cause of river pollution in states.
- **Illegal dumping of solid waste** on the banks of the rivers
- **Shortage of STP/ETP Capacity**
  - As per CPCB report (March 2021), the sewage generation in urban areas is at **72,368 million liters**/ day whereas total operational treatment capacity was only 26,869 MLD.
- **Poor operations and maintenance of Sewage and Effluent Treatment plants**
- **Non-points sources of pollution**
- **Rapid Industrialization and Urbanization** is further compounding the issue.
- **Min-Ecological flow** is not being ensured in many rivers.

- **Key steps being taken.**

- » It is the responsibility of states/UTs/local bodies to ensure treatment of sewage and industrial effluents before it being discharged into water bodies.
- » **MoEF&CC** is contributing in conservation of rivers by **providing financial and technical assistance** for abatement of pollution in identified stretches of rivers in the country through the Central Sector Scheme of Namami Gange for rivers in Ganga Basin and the Centrally Sponsored Scheme of National River Conservation Plan (NRCP) for other rivers.
- » Further, under MGNREGA, rejuvenation of small rivers is being prioritized.

- » In Addition, sewerage infrastructure is created under the AMRUT and Smart Cities Mission of MoHUA.
- » **Law and Regulations:**
  - As per the Environmental (Protection) Act, 1986 and the Water (Prevention and Control of Pollution), Act 1974, the industrial units are required to install effluent treatment plants (ETPs) and treat their effluents to comply with stipulated environmental standards before discharging into river and water bodies.
  - CPCBs, SPCBs and Pollution Control Committees (PCCs) monitor the industries with respect to treatment of effluent discharge standards and act for non-compliance under the provision of various acts.

## 2) NAMAMI GANGE

- **Introduction**
  - There have been several initiatives to clean Ganga so far. **National Ganga Action Plan 1** was started in 1986, **NGA-2** in 1993 and later extended to other states. Till 2014, more than 4,000 crores had been spent. But the river had remained dirty.
  - So, when government launched the Namami Gange in mid-May 2015, there was a new hope.
- **Namami Gange Program** was launched from June 2014 to 31<sup>st</sup> March 2021 to rejuvenate River Ganga and its tributaries with a budget of Rs 20,000 crores.
  - A total of Rs 14,084 crores has been released by GoI to NMCG, from FY15 to 31<sup>st</sup> Jan 2023, out of which Rs, 13,607 crores have been released by NMCG to state governments, state mission for clean ganga, and other agencies for the implementation of projects related to Ganga Rejuvenation.
  - In 2023, Government approved **Namami Gange Mission-II** with a budgetary outlay of Rs 22,500 crores till 2026. It includes projects of existing liabilities (Rs 11,225 crores) and new projects/interventions (Rs 11,275 crores)
  - **Eight Mains Pillars of Namami Gange Scheme**
    - Sewage Treatment Infrastructure
    - River Surface Cleaning
    - Industrial Effluent Monitoring
    - Ganga Gram
    - Afforestation
    - River Front Development
    - Biodiversity Protection
    - Public Awareness
- **Improved Governance Structure under Namami Gange:**
  - **Implementation** by NMCG and its state counterparts - State Program Management Groups (SPMGs).
  - **National Ganga Council** (replaced NGRBA) which is headed by PM and has chief ministers of five ganga basin states - UK, UP, Bihar, Jharkhand and West Bengal.

- It has the overall responsibility for the superintendence of pollution prevention and rejuvenation of River Ganga Basin, including Ganga and its tributaries.
  - **For Monitoring**
    - High level task force chaired by Cabinet secretary and assisted by NMCG.
    - State level committee chaired by Chief Secretary and assisted by SPMG.
    - District level committee chaired by the District Magistrate.
  - An **empowered task force**, headed by Union Water Resource Minister, was created and it has on board the chief secretaries of the five Ganga basin states. It is supposed to meet every three months.
  - **State Ganga Committee** have been formed. These committees would be the **nodal agency to implement the Program in states**. Further, they would also conduct safety audits of the river and river remedial measures.
  - **Synergy between different ministries** - Ministry of Jal Shakti have signed MoUs with 10 other ministries to synergize the activities under Namami Ganga.
  - **Focus on involvement of more stakeholders** including states, ULBs and PRIs, People and private sector (through PPP projects)
  - **4 Battalion of Ganga Eco-Task force** has also been envisaged to spread awareness and for protecting the river.
- **Mains Focus** on Namami Gange is on **pollution abatement interventions** which include
- Interception, diversion and treatment of waste water through bio-remediation, in-situ treatment, innovation technologies, STPs, Effluent Treatment Plants etc.
  - **Rehabilitation** of existing STPs
  - Immediate short-term measures for arresting pollution at exit points on river front to prevent inflow of sewage etc.
- **Other Steps under the Namami Gange Program**
- i. Hariyali is a plantation project along the stretch of Ganga in all five states through which it flows.
  - ii. **Ganga Gram Yojana**
    - To develop STP, toilets etc. in all villages along the river ganga. Based on Sichewal model (a Punjab village) which is based on cooperation of villagers for water management and waste disposal.
    - Government will spend Rs 1 crore per village in this plan.
  - iii. **Smart Ganga Cities**
    - Program for infra development along cities on Ganga river.
  - iv. **Promotion of organic farming** in villages along the Ganga.

## A) NATIONAL GANGA COUNCIL (NGC)

### - About National Ganga Council

- » National Ganga Council (NGC) chaired by the Prime Minister is an authority created in Oct 2016 under the River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016, dissolving the National Ganga River Basin Authority.
- » It has been given the overall responsibility for the superintendence of pollution prevention and rejuvenation of River Ganga Basin, including Ganga and its tributaries.

### - Composition

- » PM is the ex-officio chairperson.
- » Union Minister of Jal Shakti is the ex-officio Vice Chairperson.
- » The other ex-officio members of the council are from various ministries and CMs of the corresponding states among other stakeholders.

### - Jurisdiction

- » The Jurisdiction of NCG extends to states through which Ganga, its tributaries and sub-tributaries flow - Himachal, Uttarakhand, Uttar Pradesh, Haryana, NCR of Delhi, Rajasthan, Madhya Pradesh, Bihar, Chhattisgarh, Jharkhand, West Bengal etc.

## 3) ECOLOGICAL FLOW OF RIVERS

### - What is ecological flow (e-flow) of a river?

- Ecological flow (or environmental flow) is the acceptable flow regimes that are required to maintain a river in the desired state. It is the quantity and timing of water essential for the river to fulfil its ecological, social and economic functions.

### - In Oct 2018, the central government **notified the minimum e-flow for River Ganga** with an aim to maintain the natural pattern of the river flow (*Aviral Dhara*)

- NMCG has laid down these norms. It's applicable to the upper Ganga River Basin - starting from the Originating Glacier to **Haridwar** - and the main stem of Ganga upto Unnao district in Uttar Pradesh.
  - The e-flow notification specifies that the upper stretches of the Ganga — from its **origins in the glaciers and until Haridwar** — would have to maintain:
    - **20% of the monthly average flow of the preceding 10-days between November and March**, which is the dry season.
    - **25% of the average during the 'lean season' of October, April and May; and**
    - **30% of monthly average** during the monsoon months of June-September.

## 4) GROUND WATER ISSUES

### Introduction: Global Situation

- As per World Water Development Report, 2022, Ground water accounts for 99% of the liquid freshwater on earth. It has continued to serve humankind for many millennia and currently around 50% of water used in domestic purpose and 25% of water used for irrigation globally comes from groundwater.

### India's Situation:

**Annual extractable** groundwater availability in India (2017) is **393 BCM**.

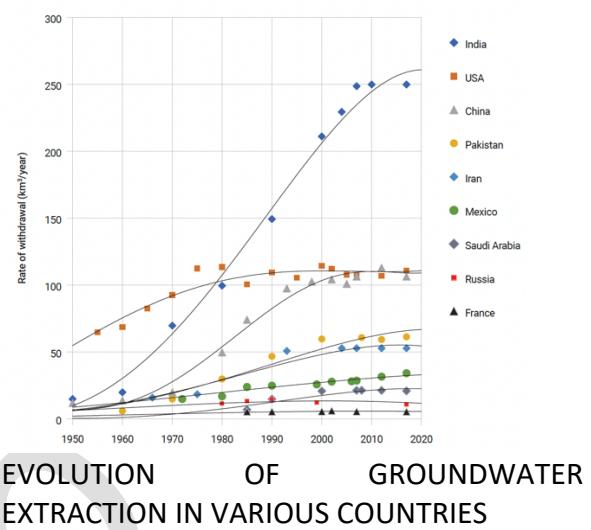
- India is the largest user of ground water in the world, extracting **253 BCM** per year, which is 25% of the global ground water extraction. It extracts more groundwater than USA and China combined together.

Most of the ground water extracted in India is for **Irrigation** (228 billion Cubic Meter (BCM)) which accounts for 90% of the total extraction.

- In India, 60% of irrigation requirement is fulfilled by groundwater.

The remaining **10%** (225 BCM) is for drinking, domestic as well as industrial uses.

- **Industrial use** accounts for only 5% of the total extraction



EVOLUTION OF GROUNDWATER EXTRACTION IN VARIOUS COUNTRIES

- **Satellite Gravimetry** has provided convincing evidence in support of the alarming rates of groundwater depletion.
- The data is supported by local level water table measurements in wells, where in 61% decline has been seen by CGWB.
- As per the 2022 assessment by the CGWB, 14% of assessments units in the country (1006/7089) have been categorized as 'Over-exploited' where the annual groundwater extraction is more than annual available Ground Water Resource. 4 States/Uts viz. Haryana, Punjab, Rajasthan, Dadra & Nagar Haveli and Daman & Diu have stage of Ground Water Extraction greater than 100%.
- **Key Challenges:**
  - **Depletion due to Over-extraction:**
    - » Over the years, groundwater has become the dominant source of irrigation as well as for domestic purpose. This is primarily due to unavailability of surface irrigation in regions such as Rajasthan.
    - » Installation of tube-wells have increased in north-western plains. Since the 1980s, 77% of the total addition to irrigation has come from tubewells. This has allowed farmers in the region to grow water intensive crops like Wheat and Rice. It has also allowed increase in cropping intensity by allowing for sowing of crops during dry winters.
    - » **Electricity Subsidy for agriculture and increased rural electrification** has also been a factor behind over-exploitation of ground water.

- » Expansion of solar powered irrigation systems which have led to very affordable cost of ground water extraction.
- » Weak law and regulations to prevent or limit diffuse groundwater pollution.
- » Industry that withdraws groundwater include manufacturing, mining, oil, and gas, power generation, engineering, and construction.
  - Bottled water industry is emerging as a major extractor.
- Destruction of wetlands, aquifers etc. which used to act as water sinks and contributed to ground water recharge.
- Pollution: (Both from Agriculture and Industry)
- Irreversibility: Once polluted, the aquifers tend to remain with polluted water.
- Climate Change: CC impacts groundwater through impacting precipitation, leakage from surface water, sea water intrusion into coastal aquifers

- Key Efforts for Groundwater:

- Recent Schemes:
  - » Jal Shakti Abhiyan: First launched in the year 2019, it focuses primarily upon effectively harvesting the monsoon rainfall through creation of artificial recharge structures, watershed management, intensive afforestation, awareness generation etc. JSA for the year 2023 was launched on 4th March 2023 with the theme "Source Sustainability for Drinking Water".
  - » Amrit Sarovar Mission - launched in April 2022 - focuses on developing and rejuvenating 75 water bodies in each district of the country as part of celebration of Azadi ka Amrit Mahotsava.
  - » Atal Bhujal Yojana is being implemented by central government in collaboration with states. It has an outlay of Rs 6,000 crores and is being implemented in certain water stressed areas of Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. The Primary aim of the scheme is demand side management through scientific means based on water budgeting of the area involving local communities at village levels leading to sustainable groundwater management in targeted areas.
- Institutions:
  - » Central Ground Water Authority (CGWA) has been constituted under Section 3(3) of the "Environment (Protection) Act, 1986" for the purpose of regulating and control of ground water by industries, mining projects, infrastructure, projects etc. in the country.
    - The latest guidelines in this regard with Pan- India applicability was notified by Ministry in 2020. CGWA and State issues No Objection Certificate (NOC) for extraction of groundwater to various industries/project proponents as per their jurisdiction and as per the extant guidelines.
  - » CGWA is also implementing National Aquifer Mapping Program (NAQUIM) in the country. These reports along with management plans are shared with States/Uts for suitable intervention.

- MoHUA has formulated Model Building by Laws (MBBL), 2016 for the states/ Uts, wherein adequate focus has been given on requirement of rainwater harvesting and water conservation measures. 35 states/Uts have adopted the features of the Model Bye Laws.
- Major and Medium projects under Accelerated Irrigation Benefit Program are also reducing dependency on ground water extraction.

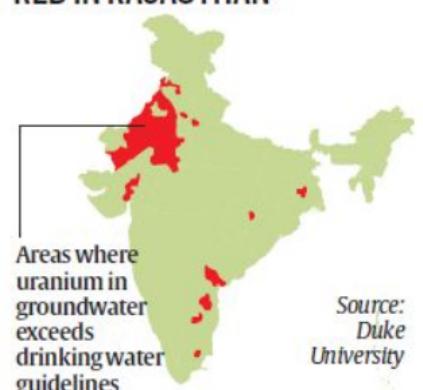
#### A) INSTITUTIONS FOR GROUND WATER

- Central Ground Water Authority, Ministry of Jal Shakti has the mandate of regulating ground water development and management in the country.
  - It has been doing it through measures such as issue of advisories, public notice, grant on NOC for ground water withdrawal etc.
  - It has been constituted under section 3(3) of the Environment (Protection) Act, 1986 to regulate and control development and management of ground water resources in the country.
- Central Ground Water Board (under ministry of Jalshakti) monitors water levels and quality through a network of 23,916 "National Hydrograph Monitoring Stations" - 6,503 dug wells and 16,693 piezometers.
  - Note: **Piezometer** is a device placed in a bare hole to monitor the pressure of groundwater.

#### 5) URANIUM CONTAMINATION OF GROUND WATER

- How much of Uranium in Water is acceptable?
  - » WHO has set a provisional safe drinking water standard of 30 micrograms of Uranium per liter for India. This standard is also consistent with the US Environment Protection Agency Standards.
  - » In India, the Indian Standard IS 10500: 2012 for Drinking Water specification has specified the maximum acceptable limits for radioactive residues as alpha and beta emitters, values in excess of which render the water not suitable.
    - But Individual radioactive elements have not been specifically identified.
    - As per Information provided by Bureau of Indian Standards (BIS), they are **working to incorporate** maximum permissible limit of Uranium as 30 micrograms/liter.
- Situation in India:
  - » According to a study published in *Environmental Science and Technology* - there is **high Uranium Contamination in Ground Water of 16 Indian States**.
  - » A report by Duke University, USA in association with Central Ground Water Board and State Ground Water Departments states that Andhra Pradesh, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, MHA, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, UP, WB and J&K have localized occurrence of Uranium concentration.

#### RED IN RAJASTHAN



- » WHO has also said that there is prevalence of concentration above 30 mg/l of Uranium in some localized pockets of few states/UTs in the country.
- » Why the contamination?
  - Ground Water Depletion and Nitrate Pollution may be aggravating the already present natural uranium contamination to dangerous levels.
  - Process:
    - Many of India's aquifers are composed of clay, silt and gravel carried down from Himalayan weathering by streams or uranium-rich granitic rocks. When over-pumping of these aquifers' groundwater occurs and their water levels decline, it induces oxidation conditions that, in turn, enhance uranium enrichment in the shallow groundwater that remains.
    - Though the primary source is geogenic, anthropogenic factors such as ground water table decline and nitrate pollution may further enhance uranium mobilization.
- » Impact
  - Uranium contamination of drinking water may be responsible for chronic kidney diseases. Radioactivity is not an issue here, but the toxicity is.

## 6) DETERGENT AND WATER POLLUTION

- Water pollution caused by detergents is emerging as a big concern all over the world.
- How much of detergent is consumed in different countries?
 

| Country                  | Per capita detergent consumption per year |
|--------------------------|---|
| India                    | 2.7 kg                                    |
| Phillipines and Malaysia | 3.7 kg                                    |
| USA                      | 10 kg                                     |
- Pollution due to detergents
  - Nonylphenol, a hazardous chemical present in detergents, is known to enter water bodies and food chain. It also bio-accumulates and can cause severe environmental and health risks.
    - » It has been detected from human breast milk, urine and blood.
    - » The Bureau of Indian Standards (BIS) has set the standard of phenolic compounds in drinking water at 0.5 mg/L and surface water at 5.0 mg/L.
  - The detergents are also suspected to contain carcinogenic compounds.
  - Many laundry detergents contain 35 - 75% of phosphate salt. This can cause many water pollution problems.
    - » It can inhibit biodegradation of organic substances.
    - » Eutrophication can also be caused by phosphate salts.
      - This may choke water bodies with algae and other plants. It can also deprive water of available oxygen, causing the death of other organisms.
      - » In Belgium, phosphate has been restricted since 2003 in detergents.
  - Detergents can also harm biodiversity

- » They are capable of destroying the external mucus layers that protect the fish from bacteria and parasites, causing severe damage to the gills.
  - Fish can die at detergent concentration near 15 ppm. Even at a concentration of 5 ppm, fish eggs would be killed.
- Detergents may also cause the water to grow murky. This blocks out light and disrupts the growth of plant. Turbidity also clogs the respiratory system of some fish species.
- **Way forward**
  - Finding **sustainable substitutes for harmful components** (for e.g. for Nonylphenol)
  - Efficient Use - Reduce
  - **Nanotech** - to develop newer varieties of fiber -> don't need harmful chemical detergent to wash.
  - **Improved Regulation** for chemical sector -> identify harmful chemicals; phase out these chemicals.

## 7) FRESH WATER SALINATION SYNDROME (FSS)

- **Introduction**
  - » Approx. 70% of the earth is covered by water; only 2.5% of that is fresh water.
- **How is FSS caused?**
  - » Road salts
  - » Human accelerated weathering of infrastructure, rocks and soils
  - » Sea-level rise and saltwater intrusion
  - » Evaporative concentration of salt ions from hydrologic modifications and climate
  - » Disturbance in vegetation and local groundwater hydrology.
- **Impacts**
  - » Increased water toxicity
  - » Reduction in freshwater resources
  - » FSS also increases chances of heavy metal pollution of water.
    - For e.g. saltwater can mobilize elevated levels of arsenic in water.
  - » Salination may degrade fertile land and make agriculture unviable.

## 8) HEAVY METAL POLLUTION

- **Heavy Metals and their Health Impacts**
  - » Heavy Metals are metals with relatively high densities, atomic weights, and atomic numbers.
    - Some heavy metals are either essential nutrients (Iron, Cobalt, Zinc etc.) or relatively harmless (such as ruthenium, silver, indium etc.), but can be toxic in large amounts.
    - Other heavy metals like (**Lead, Cadmium, Mercury, Chromium, Arsenic etc.**) are highly poisonous.
      - **Lead** was the most common cause of heavy metal poisoning. But with phasing out of leaded petrol all across the world, this would go down.

- Lead poisoning may lead to damage to brain, nervous system, Kidney etc. It may also interfere with the development of RBCs
  - **Mercury** - covered separately in details.
  - **Cadmium** - Industrial waste, batteries etc. are the most important source of cadmium poisoning. It negatively hampers the heart condition. It may also cause cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular etc.
  
- » Long term exposure to heavy metals may result in slowly progressing physical, muscular, and neurological degenerative process.
  
- » Once dispersed in the biosphere, these metals **cannot be recovered or degraded**. Hence, environmental effects of metal pollution tend to be permanent.
  
- **Sources of Heavy Metal Poisoning:**
  - **Mining**
    - For e.g. mining releases chromium, cadmium, lead and mercury - all toxic heavy metals.
    - Raniganj in West Bengal, Jharia in Bihar and Singrauli in Madhya Pradesh are considered some of the "hot spots" of metal pollution.
  - **Tailings**
  - **Industrial Waste**
  - **Agricultural runoffs**
  - **Occupational exposures**
  - **Paints**
  - **Treated Timber**

#### **A) LEAD POISONING**

- **Lead:**
  - » It is a naturally occurring toxic metal found in the Earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world.
  
  - » There is no safe level of lead in the body.
    - Mental impairment can occur due to the presence of five micrograms of lead per deciliter (mcg/dL) of blood. Levels in excess of 100 mcg/dL can be fatal.
  
  - » **Where is lead used?**
    - More than 3/4th of the global lead consumption happens in manufacture of lead acid batteries for motor vehicles.
    - It is also used in products like pigments, paints, solder, stained glass, lead crystal glassware, ammunition, ceramic glazes, jewellery, toys and some cosmetics and traditional medicines.
  
  - » **Important sources of environmental contamination:**
    - **Mining**
    - **Smelting**

- Manufacturing
  - Recycling activities
  - Use of leaded paint and leaded aviation fuel
  - Drinking water - delivered through lead pipes or pipes joined with lead solder may contain lead.
- » Much of the global use of lead is now obtained through recycling.
- Health Issues:
    - » Young children are particularly vulnerable to the toxic effects of lead. It also causes long-term harm in adult, including increased risk of high blood pressure and kidney damage.
    - » Pregnant women, if exposed to high level of lead, may suffer from miscarriage, stillbirth, premature birth or low birth weight.
  - Sources and routes of exposure:
    - » Inhalation of lead particles generated by burning materials containing lead for e.g. during smelting, recycling, stripping etc.
    - » Ingestion of lead contaminated dust, water (from leaded pipes) and food (from lead-glazed or lead soldered containers).
    - » Some traditional medicines (in India, Mexico and Vietnam), also had presence of lead.
  - World Freed from toxic leaded Petrol: UNEP (Aug 2021)
    - » Details
      - A global campaign led by the UNEP and its Partnership for Clean Fuels and Vehicles (PCFV) have successfully led to freeing world from the toxic leaded petrol.
    - » India and leaded Petrol
      - India was among the early countries to take steps against lead. The process of phase down started in 1994 and got completed in 2000.

## B) MERCURY POLLUTION

- Introduction
  - » Mercury occurs naturally in the earth's crust, but human activities, such as mining and fossil fuel combustion, have led to widespread global mercury pollution.
  - » Mercury emitted into the air eventually settles into water or onto land where it can be washed into water. Once deposited, certain microorganisms can change it into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish.
- Prescribed standards by Indian government and WHO
  - » Drinking water: 0.001 mg/l
  - » Industrial waste: 0.01 mg/l
- Sources of Mercury Pollution
  - » An element in the earth's crust.
  - » Other Natural sources include volcanic eruptions and emissions from the ocean.
  - » Anthropogenic Sources include:
    - Coal burning power plants are the largest human caused source of mercury.
    - Use of Mercury to separate gold from ore bearing rock (another major source of mercury pollution)

- Other sources of mercury pollution includes.
    - Burning hazardous waste
    - Producing chlorine
    - Breaking mercury products and spilling mercury
    - Improper treatment and disposal of or wastes containing mercury (Kodaikanal Mercury Poisoning by Hindustan lever)
- **Exposure**
  - Most human exposure to mercury is from eating fish and shellfish contaminated with methylmercury
  - **Breathing mercury vapor:** When products that contain elemental mercury break and release mercury to the air, particularly in warm poorly ventilated indoor spaces.
- **Harmful effects:** Mercury is **poisonous in all forms** - inorganic, organic or elemental. It is a neurotoxin; it is particularly harmful in the early stages of development, it can impair motor skills and can adversely affect immune system
- **Airborne Mercury**
  - » Until recently species that do not eat fish were thought to be safe from the harmful effects of Mercury. However recently researchers have documented mercury in Bicknell's thrushes, terrestrial birds that inhabit mountain top in northeast Illinois, where habitat lie downwind of the coal burning epicenter of the Ohio.
- **Mercury Pollution in India**
  - Mercury contamination in India is reaching alarming levels largely due to the discharge of mercury-bearing industrial effluents ranging from 0.058 to 0.268 mg/liter.
  - **Centre for Science and Environment** have compiled data from various sources to identify critically polluted mercury regions in India:
    - High level of mercury in fish stocks have been found, mainly in coastal areas.
      - Mumbai, Kolkata, Karwar and North Koel (in Bihar) are some of the severely affected areas.
      - Koel river showed mercury concentration almost 600-700 times above the limits.
    - Mercury in ground water and Surface water was detected throughout the country
    - Further, near **industrial units** such as chlor-alkali, cement, chemical units and thermal powerplants, levels higher than the permissible limits were found.
- **Minamata Convention on Mercury**
  - It is an international treaty designed to protect human health and the environment from anthropogenic emissions and release of mercury and mercury compounds.
    - Convention was ratified by delegates from 140 countries in January 2013.
  - **Why is global response needed?**

- **Mercury pollution is global problem** that requires global action because it moves with air and water, transcends political boundaries, and can be transported thousands of miles in the atmosphere.
- **Major Highlights**
  - Bans new mercury mines; phase out existing mines.
  - Control measures on air emissions from power plants.
  - Regulate informal sectors like small scale gold mining.
  - Phase out or reduce mercury use in products like batteries switches etc.;
  - Addresses supply and trade, safer storage and disposal and strategies to address contaminated sites.
  - Technical assistance, information exchange, public awareness and research and monitoring
  - Parties to report on measures taken to implement certain provisions.
- **India ratified** the convention in 2018.
  - This allows India to get technological and financial assistance in the fight against mercury pollution.
  - The convention has given five year time to India to control and reduce emissions from new power plants and 10 years' time for already existing power plants.
- **Minamata COP-5 (Nov 2023)**
  - Held in Geneva
  - Parties decided new dates to phase out mercury-added products including cosmetics,
  - Strengthened ties with indigenous people.
  - Advanced the first effectiveness evaluation of the convention.
  - Reached an agreement on a threshold for mercury waste.

## C) ARSENIC POLLUTION

- **Introduction**
  - » **Arsenic** is an odorless and tasteless metalloid which is widely distributed in the earth's crust.
  - |                       |   |
|-----------------------|---|
| <b>Periodic Table</b> | Elemental arsenic is a member of Group VA of the periodic table, with nitrogen, phosphorus, antimony and bismuth. It has an atomic number of 33 and an atomic mass of 74.91 |
|-----------------------|---|
  - » **Arsenic contamination of the ground water is one of the most serious drinking water issue** being faced in India.
  - » **BIS** stimulates a permissible limit of 0.01 mg/L of arsenic in water. But, as per the latest CGWB study, **21 states** across the country have pockets of arsenic levels higher than this limit.
- **Key Areas impacted by Arsenic Pollution in India**
  - » The states in **Ganga-Brahmaputra-Meghna** river basin are the most affected. They include - UP, Bihar, Jharkhand, WB, and Assam.
  - » Other arsenic affected areas include Punjab, Haryana, Manipur, Chhattisgarh and Karnataka.
- **Sources of Arsenic Pollution**

- » Arsenic is introduced in soil and groundwater through weathering of rocks and minerals followed by subsequent leaching and runoff.
- » **Anthropogenic sources** - coal fired power plants, burning vegetation, and Volcanism.
- » **Ground water contaminated with Arsenic** is also entering food chain.
  - The chemical has found its way into rice, wheat and potato. A unique observation was that in several samples, arsenic content in food items was higher than that in drinking water.



#### - Impact

- Long-term intake of arsenic polluted water leads to **arsenic poisoning** or arsenicosis, with **cancer of skin, bladder, kidney or lung or diseases of skin, blood vessels of legs and feet**.
- **Key Recent steps:**
  - Under Jal Jivan Mission (Har Ghar Nal se Jal), since, planning, implementation, and commissioning of piped water supply scheme based on a safe water source may take time, purely as an interim measure, state and Uts have been advised to install community water purification plants (CWPP) especially in Arsenic and Fluoride affected habitations to provide potable water to every household at the rate of **8-10 litres per capita per day** to meet their drinking and cooking requirements.

## D) RADIOACTIVE POLLUTION IN WATER

#### - Details

- » Radioactive pollution of water is a newly emerging, but grave concern of water pollution and human health.
- » Radioactive elements are naturally found in earth's crust. Percolation of naturally occurring radioactive materials (NORM) from the soil sediments to the aquifer causes groundwater contamination.
- » **Anthropogenic sources include:**
  - Nuclear weapon investigation.
  - nuclear calamities.
  - nuclear powerhouse;
  - dumping of radioactive waste are the major sources.
  - Use of radioisotopes in industries and scientific laboratories are the minor sources.
- » This pollution is more prevalent in groundwater as compared to surface water since it is much exposed to radioactive elements found in rocks. Sometimes magma also releases radioactive gases in environment.

- » A number of radionuclides are found in surface and sub-surface waters, among which 3H, 14C, 40K, 210Pb, 210Po, 222Rn, 226Ra, 228Ra, 232Th, and 234,235, 238 U are common.
  - **Uranium, thorium, and actinium** are three NORM series that contaminate water resources.
  - **Radium**, a descendent of NORM series, is one of the decidedly radiotoxic elements found in aquatic systems and can be penetrated into groundwater via (i) aquifer rock dissolution (ii) decaying of 238U and 232Th, or (iii) desorption process
- **How is radioactivity measured?**
  - » It is measured in **Becquerel** (SI unit) or in curies.
    - Energy absorbed per unit mass is measured by Gray, while the unit Sievert measures the quantity of radiation absorbed by human tissues.
- **A small amount** of radiation is found in all types of water, but the extended amount of radiation is harmful to human health.
- **Harmful Impacts of nuclear radiation:**
  - » Immediate: recoverable consequences distressing skin, lungs, genitals, and causing of hair fall.
  - » Long standing: permanent outcomes such as various infections like radiation damage, bone marrow fatality, cataract initiation, cancer stimulation, cholera, etc.
  - » Genetic effects: ionizing radiation induces mutations in germ cells
- **WHO guidelines:**
  - » Guidelines for drinking water quality and a permissible limit of reference dose level of 0.1 microsieverts per year.

#### **E) THERMAL POLLUTION: WATER POLLUTION FROM THERMAL POWER PLANTS**

- **Thermal Pollution** is the degradation of water quality by any process that changes ambient water temperature.
- **Heat** is considered a **water pollutant** if it is caused by human activities.
- **Major causes of thermal pollution include:**
  - **Coolant from thermal power plants**
  - **Industry effluents**
  - **Alteration of vegetation cover** - increases the heating of water.
- **Negative impact of Thermal Pollution**
  - **Oxygen** deficiency (reduced solubility and high metabolism)
  - **Temperature** sensitive aquatic organisms die.
  - **Decrease in decomposition of organic matter** (oxygen deficiency leads to aerobic decomposers not functioning effectively)
  - **Primary productivity and diversity** of aquatic plant species decline
- **Note:** Even unnatural lowering of temperature of a water body is harmful.
  - Aquatic biodiversity is very sensitive to temperature change.

## 9) MARINE POLLUTION

### A) LISBON DECLARATION

- Why in news?
  - All 198 members of the UN have unanimously adopted the Lisbon Declaration on Ocean Conservation in July 2022 on the last day of the UN Ocean Conference 2022.
- Details
  - Participants agreed to work on preventing, reducing and controlling marine pollution. It includes:
    - Nutrient Pollution
    - Untreated Wastewater
    - Solid Waste Discharges
    - Hazardous Substances
    - Emissions from the marine sector, including shipping, shipwrecks
    - Anthropogenic underwater noise
  - The nations committed to follow science based and innovative action on an urgent basis.
  - They also agreed that developing countries (particularly small island developing states) and LDCs need assistance with capacity building.
  - Developing and promoting innovative financing solutions to help create sustainable ocean-based economies as well as expanding nature-based solutions to help conserve and preserve coastal communities.
  - Member nations also committed to empowering women and girls, recognizing their participation is crucial to building a sustainable ocean-based economy and achieving the UN-mandated SDG14.
- The conference has set the stage for the fifth session of the intergovernmental conference on an international legally binding instrument for the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction.

### B) HIGH SEAS TREATY

- Why in news?
  - Negotiators from almost every country in the world finalized a new global treaty meant for conservation of sustainable use of biological resources in the high seas (March 2023)
- Background:
  - The High seas are open ocean areas that are outside the jurisdiction of any country. It consists of around 64% of the ocean surface and around 43% of earth. These are home to millions of marine species and trillions of micro-organisms.
  - Existing Legal Framework for High Seas:
    - UNCLOS
    - Antarctic Treaty System
  - Limitations:

- UNCLOS is not primarily focused on sustainability and environment protection. Though, it asks countries to protect the ocean ecology and conserve its resources, it doesn't provide the specific mechanisms or processes to do so.
- Technical Name of the Treaty: the 'Agreement under the UNCLOS on Conservation and Sustainable use of marine biodiversity in areas beyond national jurisdiction (BBNJ)'
- Key Highlights of the Treaty:
  - The nations of the world have agreed to a Framework for the Conservation and Sustainable Use of Resources in the open oceans.
  - The **High Seas Treaty** will work as an implementation agreement under UNCLOS, much like Paris Agreement under UNCLOS.
  - Key Provisions:
    - The treaty has **Four Main Objectives**:
      - Demarcation of **Marine Protected Areas** (MPAs), rather like there are protected forest and wildlife areas.
        - Under this, a state or group of states can submit a proposal for MPA along with relevant information. It also provides guidelines for implementation, monitoring, and review of MPAs established.
        - **Note:** As of now, only 1.44% of high seas are protected according to IUCN.
      - Sustainable use of marine genetic resources and equitable sharing of benefits arising from them.
      - Initiation of the process of Environmental Impact Assessments for all major activities in the oceans
        - The agreement includes an obligation to conduct EIAs for activities with potential impacts on the high seas that will apply to new activities such as geo-engineering.
        - It also includes a new impact threshold to trigger a screening process, which means more activities will now be subject to at least some assessment.
      - **Capacity building and Technology transfer.**

|                                 |   |
|---------------------------------|---|
| <b>Marine Protected Areas</b>   | MPAs are where ocean systems, including biodiversity, are under stress, either due to human activities or climate change. These can be called the national parks or wildlife reserves of the oceans. Activities in these areas will be highly regulated, and conservation efforts similar to what happens in forest or wildlife zones, will be undertaken |
| <b>Marine Genetic Resources</b> | Oceans host very diverse life forms, many of which can be useful for human beings in areas like drug development. Genetic information from these organisms is already being extracted, and their benefits are being investigated. The treaty seeks to ensure that any benefits arising out of such efforts, including                                     |

|  |   |
|--|---|
|  | monetary gains, are free from strong intellectual property rights controls, and are equitably shared amongst all. The knowledge generated from such expeditions are also supposed to remain openly accessible to all  |
| <b>Environmental Impact Assessment</b>           | The high seas are international waters that are open for use by all countries. Under the provisions of the new treaty, commercial or other activities that can have significant impact on the marine ecosystem, or can cause large-scale pollution in the oceans, would require an environmental impact assessment to be done, and the results of this exercise have to be shared with the international community  |
| <b>Capacity Building and Technology Transfer</b> | The treaty lays a lot of emphasis on this, mainly because a large number of countries, especially small island states and landlocked nations, do not have the resources or the expertise to meaningfully participate in the conservation efforts, or to take benefits from the useful exploitation of marine resources. At the same time, the obligations put on them by the Treaty, to carry out environmental impact assessments for example, can be an additional burden |

- **COP**, which acts as the decision making body of the treaty, will take the work forward and will also act as a platform to work with existing authorities that regulate fishing, shipping and mining.
- **Difficult road ahead:**
  - The treaty is a result of 20 years of protracted negotiation. The details of all the major contentious provisions, including EIA, sharing of benefits from genetic resources, and mobilization of funds for conservation activities, are still to be worked upon. Many issues remain unaddressed, including mechanisms for policing the protected areas, the fate of the projects that are addressed to be heavily polluting, and resolution of disputes.
  - Process of ratification is also not going to be easy. (UNCLOS took 12 years to become international law and Kyoto Protocol took 8 years - because necessary number of ratifications were not achieved)
    - Treaty must be ratified by a minimum 60 countries for it to come into force

### C) MARINE LITTER / MARINE PLASTIC POLLUTION

- **Introduction:**

- » **What is marine litter?**

- It's any man-made, long standing solid material that humans have incorrectly disposed of and that has ended up on the beach, in estuaries, rivers, seas and ocean.
- **Plastic** is the most common type of litter found at sea. Around 8 million tonnes of plastics end up in the world's ocean every year. It is estimated that more than 1 lakh of turtles and marine mammals die every year due to these plastic marine litter. It is estimated that around 18,000 plastic pieces are floating on every square kms of the world's ocean.

- » **Reasons for Increasing Marine Litter:**

- Very slow rate of degradation of litter items, mainly plastic
- Continuously growing quantity of the litter and debris disposed in oceans due to increased population, industrialization, single use plastics etc.
- **Harmful impacts**
  - Affects public health (plastics have now been found in human blood).
  - Threatens marine ecosystem
    - Animals get trapped in this litter. They also sometimes confuse marine litter with food.
    - Ghost Fishing: Nets, Fish Aggregation Devices (FAD) and other gears continue to fish for decades after getting discarded.
  - Impacts fishery and tourism sector

- **Key steps taken by India:**

- **Marine Plastics Survey Program of NCCR (National Centre for Coastal Research)**
  - This program studied the distribution of microplastics in coastal locations in the Bay of Bengal and Arabian Sea in particular along the International Shipping Routes.
  - It found that 50% composition of marine litter was by single use plastics from 2018 - 2021 at various beaches of India.
- **2021 Amendment to Plastic Waste Management Rules, 2016**
  - Ban on several single use plastic from July 2022;
  - Increase in thickness of plastic bags.
- **EPR guidelines related to Plastic packaging materials.**
- **Swatch Sagar Surakshit Sagar:**
  - Commemorating the 75th year of India's independence, a coastal cleanup drive was carried out at 75 beaches across the country across 75 days over 7500 km long coastline. This unique first ever national campaign culminated on "International Coastal Clean-Up Day" on 17th Sep 2022.
  - This drive was aimed at removing 1,500 tonnes of garbage from the sea coast which will be a huge relief to marine life and the people staying in coastal regions.
- At UN Ocean Conference in Lisbon, India has assured the world community that under PM Modi, it is committed to protecting at least 30% of our lands, waters and oceans, and thus adhere to its commitment of 30X30 by 2030 in a mission mode.
  - **Note:** India is part of the High Ambition Coalition for Nature and People, which was initiated at the "One Planet Summit" in Paris in January 2021, to promote an international agreement to protect at least 30 per cent of the world's land and ocean by 2030
- **International Cooperation:** Under the Commonwealth Litter Program (CLIP), the UK's Centre for Environmental Fisheries and Aquaculture Sciences (CEFAS) and India's National Centre for Coastal Research (NCCR) launched a pilot project to understand deteriorating sea water quality due to marine litter.

- **Key International Initiatives:**

- **London Dumping Regime** (of International Maritime Organization): it regulates deliberate dumping of plastic waste at sea from vessels and platforms.
- **International Convention for the Prevention of Pollution from Ships (MARPOL)**: It regulates both deliberate and accidental discharge of plastics from vessels.
- But, the **problem with both these rules is lack of enforcement**. It is hard to monitor and enforce the prohibition on plastic pollution from vessels on the high seas. Flag states often lack incentives to do so.

## D) OCEAN DEOXYGENATION

- **Ocean Deoxygenation**
  - » It is the phenomenon of oxygen loss in ocean caused by excessive growth of algae due to nutrient pollution. The nutrient pollution may be caused by fertilizers, sewage, animal or aquaculture waste.
- **The IUCN Report 'Ocean deoxygenation: Everyone's problem'** is the largest peer reviewed study to date of the causes, impacts, and potential solutions to ocean deoxygenation.
- **Key Findings**
  - » **Ocean regions with low oxygen concentration** have expanded to all depths of the Ocean
  - » The **volume of area depleted with oxygen**, known as "**anoxic waters / dead zones**" have **quadrupled**.
  - » **What if the present situation continues?**
    - Under a business-as-usual scenario, the ocean is predicted to lose 3-4% of its global oxygen by 2100.
      - **Local changes** will be more severe.
    - Further, **most of the oxygen loss** will take place in the upper 1,000 meters, which is the richest part of the Ocean for biodiversity.
- **Reasons for Ocean Deoxygenation**
  - » **Climate Change and Nutrient Pollution** are the main drivers of the ocean oxygen loss.
  - » Ocean oxygen loss is also closely related to Ocean Warming and Acidification caused by anthropogenic carbon dioxide emissions and biogeochemical consequences related to anthropogenic fertilization of the ocean.
- **Adverse impact of low oxygen levels**
  - » **Balance of Marine Life**: The IUCN report has started impacting the balance of marine life, favoring species tolerant of low-oxygen conditions, like jellyfish, some squid and microbes, at the expense of species sensitive to low-oxygen, including most fish and many marine species.
  - » Negatively hamper **cycles of nitrogen and phosphorus**

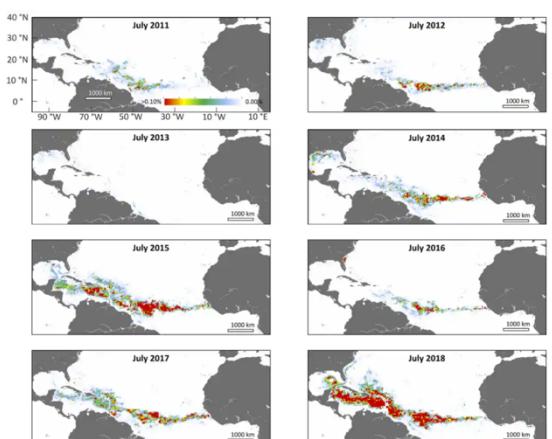
## E) SARGASSO SEA WEED

- **About Sargasso Seaweed**
  - » **Between 2000-2010** there was little sea weed in the central Atlantic: most was found in the Gulf of Mexico and Saragossa Sea.

- » **Explosion** in Sargassum seaweed first materialized in 2011. It developed in subsequent years into a vast band - in 2018 this stretched for 5,500 miles.
  - The bloom peaks in the middle of the year and develop larger from small populations of the seaweed in the central Atlantic, with some contributions from west Africa.
  - A number of natural and man-made factors align together to make this happen.
- » **Problems caused by this explosion.**
  - Thick mats can block sunlight
  - Sometimes, when they die and sink, they may be deadly for fish and Corals.
  - They are also proving disastrous for humans. Increasingly huge quantities are washing up in tourist destination, creating stinking masses that threaten the tourism industry and pose a threat to health.
- » **Reasons:**
  - Alignment of circumstances like conducive sea-surface temperature and salinity combining with an increase in nutrients - in part from the upward movement of cool, nutrient rich water in the eastern Atlantic and an increase in discharge from the Amazon in the preceding years.

#### - About Sargasso Sea

- » Located entirely within the Atlantic Ocean, it is **the only sea without a land boundary**. While all **other seas in the world are defined at least in part by land boundaries**, the Sargasso Sea is **defined only by ocean currents**. It lies within the Northern Atlantic Subtropical Gyre. The Gulf Stream establishes the Sargasso Sea's western boundary, while the Sea is further defined to the north by the North Atlantic Current, to the east by the Canary Current, and to the south by the North Atlantic Equatorial Current. Since this area is defined by boundary currents, **its borders are dynamic**, correlating roughly with the Azores High Pressure Center for any particular season.
- » It has been named after genus of a free floating seaweed called Sargassum.
  - While there are many different types of algae found floating in the ocean all around world, the Sargasso Sea is unique in that it harbors species of sargassum that are 'holopelagic' - this means that the algae not only freely floats around the ocean, but it reproduces vegetatively on the high seas. Other seaweeds reproduce and begin life on the floor of the ocean.
  - Sargassum provides a home to an amazing variety of marine species.
    - Turtles use sargassum mats as nurseries where hatchlings have food and shelter. It also provides essential habitat for shrimp, crab, fish and other marine species.



## F) DEAD ZONES

### - Introduction

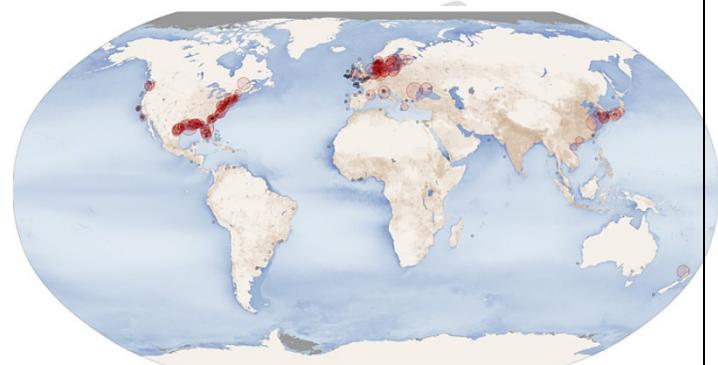
- » Excess nutrient pollution in oceans/lakes create a situation of **hypoxia** i.e. reduction in availability of oxygen in the water. This situation is often referred as **Dead zone** as most marine life either dies, or if they are mobile, leave the area. Because of creation of dead zones, habitats which are normally teeming with life become essentially **biological deserts**.

### - Can Dead zone occur naturally?

- » Yes, dead zones may occur naturally. But, environmentalists are concerned about those which are created or enhanced by human activities.

### - Key factors responsible for creation of dead zones?

- » There are many physical, chemical and biological factors that combine together to create dead zones, but **nutrient pollution is the primary cause** of those zones created by human activities.
- » **Nutrients -> Algae -> Decomposition -> Oxygen Depletion.**
- » **Climate Change -> Rising temperatures ->** reduce the dissolved oxygen, increase metabolism rate and oxygen demand.



## G) THE GREAT PACIFIC GARBAGE PATCH (GPGP)

- The Great Pacific Garbage patch is located about halfway between Hawaii and California. It is the largest accumulation zone of ocean plastic on earth.
- It consists of higher concentration of waste item, but much of the debris is actually small pieces of floating plastic that are not immediately evident to naked eyes.
- While great pacific patch is a term regularly used in the media, it doesn't paint the correct picture of the marine pollution problem in the North Pacific Ocean. Marine debris concentrates in various regions of the North-Pacific, not just in one area. The exact size, content, and location of the "garbage patches" are difficult to accurately predict.



### • Why is it difficult to clean up the patches?

- i. Very large and shifting area
- ii. Uneven distribution of debris

- iii. Small pieces of plastic forms the largest chunk
- iv. Marine life doesn't allow simple skimming of these debris

## 10) PROTECTION OF COASTAL REGION

- **Introduction**
  - » Coastal zones are places of enormous ecological, cultural, social and economic significance. They contain unique and sensitive ecosystem of great natural and economic value and is home to numerous endangered species. The region also serves as home to 50% of the world's population and generated 40% of the global economic activities.
- **Key Problems Faced by Coastal Regions:** Recent decades have seen drastic increase in population, rapid industrialization, increased pollution and climate change. All these factors have negatively hampered the coastal region.
  - Along much of the earth's coast **a warming climate and sea level rise** are already negatively affecting natural ecosystems and human communities
  - **Coastal Erosion** has started hampering a number of coastal regions. E.g. Vishakhapatnam
  - **Rapid Industrialization and Deforestation**
  - **Pollution** due to mining, municipal waste disposal and industrial waste disposal are also leading to environmental problems in coastal regions.
  - **Invasive Species** -> Biodiversity loss
- **Efforts by India to Protect Coastal Regions**

### A) COASTAL REGULATION ZONE

- » CRZ notification is issued under the **Environmental Protection Act, 1986** for regulation of activities in the coastal area by the MoEF&CC. The first CRZ was issued, in 1991 which was replaced by the 2003 and then by 2011 notification.
- » It classifies the coastal land upto 500 m from the HTL and a stage of 100 m along the banks of creeks, estuaries, backwater and river subject to tidal fluctuations as the **Coastal Regulation Zone (CRZ)**. The **CRZ** are further classified in **four categories**:

  - **CRZ-1** are ecologically sensitive areas.
    - **CRZ 1-A** constitute the ecologically sensitive area and the geomorphological features which play a role in maintaining the integrity of the coast viz: Mangroves, corals, sand dunes, salt marshes, national parks, WLS, Reserved forests, nesting grounds for turtles, birds etc.
    - **CRZ 1-B** consist of inter-tidal zones (between HTL and LTL)
  - **CRZ-2** are areas that have been developed upto or close to the shoreline. Unauthorized structures are not allowed in this zone.
  - **CRZ-3** are areas that are relatively undisturbed (both urban and rural)
  - **CRZ-4** are areas covered between Low Tide Line and 12 nautical miles seaward

- » **CRZ Notification, 2018: Easing of Norms for CRZ** approved by Cabinet (Dec 2018)
  - The comprehensive review was necessitated because of **demands of various stakeholders** to review the CRZ notification, 2011 as it was hindering developmental activities.
  - **Aimed at streamlining of CRZ clearances** and promoting economic growth while keeping in mind conservation principles of coastal regions.
  - The notification is based on the recommendations of the **Shailesh Nayak** (former secretary, Ministry of Earth Science) headed committee.
- » **Key Changes**
  - **Delegation of Project Clearance Power to State Governments.**
    - **Only Projects in CRZ-1 and CRZ-IV will require permission from Union Ministry.** The Powers to clear projects in CRZ-2 and CRZ-3 have been **delegated to State Governments**
  - **Defreezing of Floor Area Ratio (FAR)** in construction norms
    - Earlier, for CRZ-2, it was frozen to 1991 Development Control Regulation (DCR) levels, Now, it will be based on laws which are in vogue.
  - **Relaxation of No Development Zone (NDZ) criteria**
    - Densely populated (density > 2,161 per sq km) rural areas (under CRZ-III) referred as CRZ-III-A, now have a NDZ of 50 m from the High Tide Line (HTL) as against earlier 200 meters.
    - Further, for island close to the mainland coast and for all backwater islands the new NDZ is 20 m.
  - To **fight pollution**, treatment facilities have been made permissible activity in CRZ-I B area, subject to necessary safeguards.
  - **Steps to Facilitate Tourism:**
    - Permission of temporary tourism facilities such as shacks, toilet blocks, change rooms, drinking water facilities etc, in beaches even in the NDZ of the CRZ-III.

## 11) BLUE FLAG BEACHES

- **Why in news?**
  - » Two more Indian Beaches enter the coveted list of Blue Beaches (Oct 2022)
- The iconic blue flag is one of the world's most recognized voluntary eco-labels awarded to beaches, marinas, and sustainable boating tourism operators.
  - » The Blue flag program was started in France in 1985 and in areas out of Europe in 2001.
  - » The certification is provided by the **Foundation for Environmental Education (FEE)**.
  - » To get blue flag certification **33 stringent criteria** under **four major heads** should be met and maintained.
    - Environment Education and Information
    - Bathing Water Quality
    - Environment Management and Conservation
    - Safety and Services
- **Spain** with 620+ blue flag beaches have highest number of blue flag beaches in the world.

- **Blue Flag Beaches in India**
  - » As of Jan 2024, **12 Indian beaches** have blue flag certifications.
  - » **Two Beaches - Minicoy Thundi Beach and Kadmat Beach** - both in Lakshadweep were awarded the certification in Oct 2022.
    - The Thundi Beach is one of the most pristine and picturesque beaches in Lakshadweep archipelago where white sand is lined with turquoise blue water of the lagoon. It is a paradise for swimmers and tourists alike
    - The Kadmat beach is specially popular with cruise tourists.
    - Both these beaches comply with all 33 criteria mandated by the Foundation for Environment and Education.
  - » **Two beaches** - the Eden Beach in Puducherry and Kovalam Beach in Tamil Nadu were awarded Blue Flag certification in Sep 2021.
  - » **Eight Beaches** under blue flag certification earlier were: Kappad (Kerala), Shivrajpur (Gujarat), Ghoghla (Diu), Kasakod and Padubidri (Karnataka), Rushikonda (Andhra Pradesh), Golden (Odisha) and Radhanagar (Andaman and Nicobar Islands)

## 12) COASTAL EROSION

- **Introduction:**
  - Coastal erosion refers to wearing away of land and the removal of beach and dune sediments by wave action, tidal currents, drainage or high winds.
  - **Wave action** is the main cause of coastal erosion. Wave energy is a result of three factors: the speed of the wind blowing over the surface of the sea; the length of fetch; and the length of time the wind has been blowing.
- **Causes of Coastal Erosion** can be divided into two broad categories: **Natural or Manmade**:
  1. **Natural Causes:**
    - i. These include waves, winds, tides, near shore currents, sea level rise etc.
    - ii. Another major natural factor is phenomenon of subsidence. It is a regional phenomenon that lowers the surface area in a specific region.
    - iii. Catastrophic events like severe storms, tidal surges, and cyclones can cause severe erosion.
  2. **Manmade Factors:**
    - i. **Infrastructure creation in coastal regions:** For e.g., building houses via land reclamation or within sand dune areas.
    - ii. **Sand removal above replenishable quantities** from the coast upsets the longshore sand transport budget and can result in erosion.
    - iii. **Coral Mining and other means of damaging protective corals** may cause beach degradation.
    - iv. **Structures like seawalls, breakwaters** also have a side effect as it increases erosion of adjacent areas.
    - v. **Deforestation:** Damaging of mangroves and other coastal vegetation is a major factor.
    - vi. **Climate Change** which is mostly human induced is leading to sea level rise which is eroding more and more coastal regions.

## vii. Unscientific Coastal Management

### - Factors that influence Erosion Rates

» The ability of waves to cause erosion of the cliff face depends on many factors.

#### • Primary Factors

- **Erodibility of sea facing rock** is controlled by rock strength and the presence of fissures, fractures, and beds of non-cohesive materials such as silt and fine sand.
- Power of the waves
- Beaches ( they dissipate wave energy on the foreshore and provide a measure of protection to adjoining land)
- The Adjacent bathymetry, or configuration of the sea floor, controls the way energy arriving at the coast, and can have an important influence on the rate of cliff erosion.

#### • Secondary Factors

- Weathering and transport slope processes.
- Slope Hydrology
- Vegetation
- Human Activity
- Resistance of cliff foot sediment to attrition and transport.

### - Impact of Coastal Erosion

- Floods including worsening impact of high tide flooding.
  - Saltwater penetration into rivers, coastal agriculture plains

### - Coastal Erosion Control Strategies: There are three coastal erosion control methods.

#### - Soft Erosion Controls/ Non-Structural Methods

- These methods are **temporary options of slowing the effects of erosion**.
  - **Artificial nourishment** of beaches
  - **Coastal Vegetation** such as mangrove and palm plantation
  - **Dune Reconstruction/rehabilitation**
  - Other options are **beach scraping** and **beach bulldozing** which allows for the creation of artificial dunes in front of building or as means of preserving building foundation.

#### - Most common method is the **Beach nourishment** projects.

- It involves placing **additional sand on a beach** to serve as a buffer against erosion or to enhance the recreational value of the beach.

- Because nourishment doesn't stop erosion, it has to be repeated to maintain the beach.

#### ▫ **Advantages**

- Restores and widens recreational beach
- Beach nourishment doesn't leave hazards on the beach or on the surf zone.

#### ▫ **Disadvantages**

- Erodes faster than natural sand so continuous refurbishing required.

- Number of Storms affecting the beach makes the life time of the nourishment vary.
  - Expensive, and must be repeated periodically.
  - Process of nourishment may damage, destroy or otherwise hurt marines and beach life by burying it, squishing it under bulldozers, changing the shape of the beach, or making the water near the beach too muddy.
  - Difference in "grain size" of the added sand affect the way waves interact with beach. This will affect surf conditions and bars on the submerged part of the beach.
- **Hard Erosion Controls/ Structural Measures**
  - More permanent solution than soft erosion methods.
  - **Seawalls and groynes (or groin)/breakwaters** serve as permanent infrastructure; Tetrapod-based seawall are also included in the category.
  - **Limitations**
    - » Not immune from normal wear and tear and will need **refurbishment or rebuilt**.
    - » Further, as the understanding of natural shoreline function improves, there is a growing acceptance that structural solution can cause more problems than they solve. It interferes with natural water currents, and prevent sand from shifting along coastline.
    - » They also cause erosion to adjacent beaches and dunes and lead to unintended diversion of stormwater and waves onto other properties.
- **Combination of the Structural and Non-Structural Methods** (i.e. combination of hard erosion control and soft erosion control)
  - This hybrid method reduces limitations of both the methods and provides better efficacy and efficiency.
  - Some of the common approaches of combination are:
    - a. **Combining Beach nourishment with artificial headlands/groynes**.
    - b. **Revegetation with temporary offshore breakwaters/ Artificial reefs** is commonly used.
  - Using a combination of beach nourishment and groynes/artificial headlands promotes the trapping of the downdrift movement of the sediments, thus reducing downdrift erosion. This also reduces the frequency of re-nourishment.
- **Relocation**
- **Situation of Coastal Erosion in India:** Ministry of Earth Sciences has informed the Lok Sabha that about 34% of coastal region in India is under varying degree of erosion.
  - Of the rest, 40% is stable and 26% is accreting in nature.

### 13) BIOLUMINESCENCE

- **Why in news?**

- Vishakhapatnam Beaches are glowing due to a phenomenon called **bioluminescence** (April 2023)
- **Details**
  - Bioluminescence, the glow of the waves, is caused by tiny marine organisms called **Phytoplankton**, which emit light on the ocean surface at night.
  - It is best experienced during a moonless night.
- **Bioluminescent** is widespread among deep sea animals in general. Many marine creatures like sponges, jellyfish, worms, species of fish, arthropods, echinoderms, and unicellular algae exhibit bioluminescence to either evade predators, attract prey or during mating.
- **Why did it happen in Vishakhapatnam?**
  - In Vishakhapatnam this phenomenon is most likely the result of algal bloom (Significant accumulation) of the **dinoflagellate species of noctiluca and ceratium**. These emit light when disturbed by breaking waters. This occurs when the luciferase enzyme reacts with luciferin compound in the presence of oxygen to produce a cold light.



- Some other beaches in India where this phenomenon is visible are - Havelock Island in the Andamans, Thiruvanmiyur beach in Chennai, Mattu beach in Karnataka and Bangaram Island in Lakshadweep.



# TARGET PRELIMS 2024

## BOOKLET-14; ENVIRONMENT-4

### ENVIRONMENTAL POLLUTION-3

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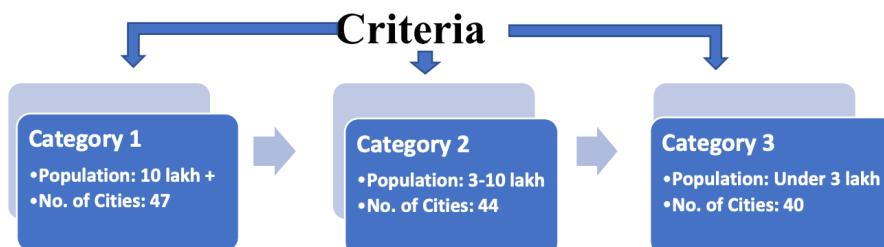
## 2. AIR RELATED CURRENT UPDATES

### 1) WORLD AIR QUALITY REPORT, 2023

- Published by a Swiss Air Purifier Company **IQAIR**.
- **Key Highlights** (March 2023)
  - » Delhi ranked 4th out of 50 of the world's most polluted cities in terms of PM 2.5 in 2022.
  - » India ranked 8th with a population weighted average of PM2.5 level of 53.3 micrograms/m<sup>3</sup> in 2022.
  - » Chad, Iraq, Pakistan, Bahrain and Bangladesh are the most polluted countries in 2022.
- **Situation after Diwali 2023**
  - » The Day after Diwali (13th Nov 2023), Delhi was the most polluted city in the world with an AQI of 287.
- **Live Situation:** <https://www.iqair.com/in-en/world-air-quality-ranking>

### 2) SWATCH VAYU SURVEKSHAN, 2023

- "Swatch Vayu Survekshan" is an initiative by MoEF&CC to rank cities on the basis of implementation of activities approved under city action plan and air quality in 131 NCAP cities.
- **Objectives:**
  - Create Awareness; Inform citizens about the health impacts related due to exposure; comparing air quality conditions at different locations/cities; to achieve the goal of NCAP "Clean Air for All".



- All 131 cities covered under NCAP are assessed based on ranking framework submitted by cities/ULBs on PRANA portal (Dashboard to capture progress of NCAP program).
- **Air Quality** is improving on the basis of PM10 data.

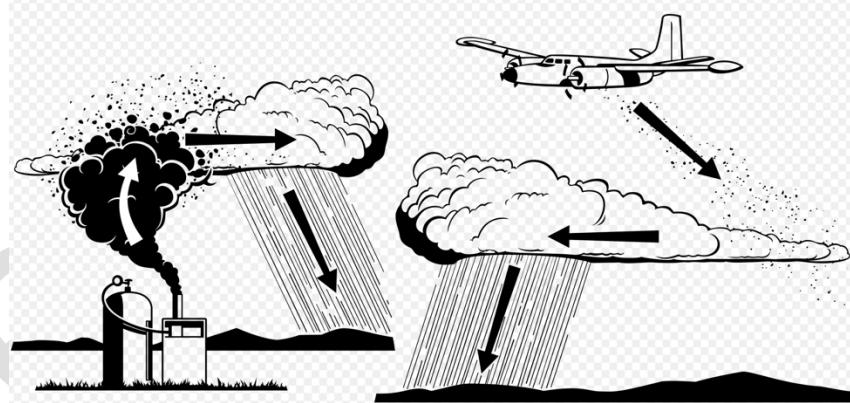
| AIR QUALITY  | 2019-20                  | 2020-21                   | 2021-22                  | 2022-23                  | 2023-24   |
|--|--------------------------|---------------------------|--------------------------|--------------------------|---|
| ▫ Reduction in annual PM10 levels vis a vis base year 2017 | Improvement in 85 cities | Improvement in 102 cities | Improvement in 95 cities | Improvement in 90 cities | Calculated on Financial Year basis so the data is awaited |

### 3) CLOUD SEEDING

- **Understanding Cloud Seeding:**
  - » How clouds are formed naturally?

- Clouds are made up of tiny water droplets or ice crystals that form when water vapor in the atmosphere cools and condenses around a tiny particle of dust or salt floating in the atmosphere. Without these tiny particles raindrops or snow flakes can't form and precipitation will not occur.
- » **What is cloud seeding?**
  - It is a weather modification technique aimed at enhancing precipitation from clouds. The idea of cloud seeding was first conceived during WW-II and has since then become a much practiced activity in different dry regions of the world.
- » **How does it work?**
  - In cloud seeding, clouds are injected with salts like silver iodide, potassium iodide, or sodium chloride which act as seed. These salts provide additional nuclei around which more cloud droplets would form.
- » There are two principal cloud seeding techniques:
  - Hygroscopic Cloud Seeding:** It aims at speeding up droplet coalescence in liquid clouds, leading to production of large droplets that start to precipitate. Here seeding material is generally large salt particles.
  - Glaciogenic Cloud Seeding:** In this method the idea is to trigger ice production in supercooled clouds, leading to precipitation. It is usually done by dispersing efficient ice nuclei, such as silver iodide particles or dry ice (solid carbon dioxide) into the cloud, causing heterogeneous ice nucleation.

- » **How is cloud seeding done?**
  - It is done using ground based generators or aircraft.



- » **What are the conditions required for cloud seeding to be done?**
  - Moisture laden clouds:** Cloud seeding can only happen if there is sufficient cloud and sufficient depth of cloud.
  - Wind speed below a certain level**
  - Temperature** - cloud should be cold enough to contain supercooled liquid water

#### - Application/advantages

- » **Fighting water scarcity:** Rainfall in drought prone areas.
- » **Increasing winter snowfall** - which can supplement the natural water supply for communities in the surrounding area.

- » It can also be done to prevent hailstorm, dissipate fog etc.
  - » **Increasing hydro power generation** (for e.g. in Tasmania, Australia)
  - » **Fighting air pollution and Water pollution**
    - Rainfall can wash off pollution from air
    - More rainfall can also ensure ecological flow in rivers leading to reduced scope of pollution.
  - » **Controlling forest fires**
  - » **Atmospheric studies** - Studying cloud seeding can help scientists understand how normal cloud formation would occur.
- **Could cloud seeding be used to fight air pollution in Delhi?**
- » In India, cloud seeding hasn't been tried for fighting pollution.
    - **China** has tried this option.
  - » In winters, cloud from over Delhi due to Western Disturbances and thus some experts suggested cloud seeding for rainfall to occur.
- **Has Cloud seeding been done before in India, and has it been successful?**
- » It has been attempted in Monsoon, in places such as Karnataka, Maharashtra, and Tamil Nadu.
  - » A recent experiment, the fourth phase of the **Cloud Aerosol Interaction and Precipitation Enhancement Experiment (CAIPEEX-IV)** that took place in monsoon seasons of 2018 and 2019. It was conducted in drought-prone Solapur in Maharashtra. It pointed to relative enhancement of 18% in rainfall.
    - The approx. cost of producing water through this method was 18 paisa per litre, the cost will drop by more than 50% if we use indigenous seeding aircraft.

#### 4) COAL FIRED POWER PLANTS

- **Why in news?**
- » Only 5% of India's coal-based thermal power capacity meets SO<sub>2</sub> emission norms: CSE report (June 2023)
- **Introduction:**
- » Coal is the most important and abundant fossil fuel in India. It accounts for 55% of India's energy needs. Infact, India's industrial heritage was built upon Indigenous coal.
- **Environmental Impacts of Coal Based Thermal Power Plants:**
- » **Air Pollution:** Burning of coal produces air pollutants like NO<sub>2</sub>, SO<sub>2</sub>, CO, PM, Mercury etc. which are primary air pollutants in the world.
  - » **Acid Rain:** Pollutants like NO<sub>2</sub>, SO<sub>2</sub> etc. are primary contributor of Acid rain. It can harm forests, aquatic ecosystems, and buildings and it can also lead to soil and water acidification.
  - » **Climate Change due to global warming**
  - » **Excessive water Extraction:** Coal based thermal power plants require huge quantities of water which is often drawn from nearly rivers, lakes, or groundwater sources.
  - » **Water Pollution:** Leakage of heavy metals and acids from the exposed coal seams may cause water pollution. They can leach into the groundwater and nearby waterbodies, posing risks to

drinking water source and health of aquatic ecosystem. In addition, the release of warm water from the thermal power plant also causes thermal pollution.

» **Other issues created by mining of coals**

- **Emission Norms:**

- » The MoEF&CC had notified the emission norms for coal-based power plants in Dec 2015.
- » In 2021, **MoEF&CC divided the power plants on the basis of distance from polluted cities** to enforce deadlines and extended the **deadlines**.
  - i. **Category A** - coal based power plants within 10 kms radius of NCR and of cities with million+ population. (deadline changed from 31st Dec 2022 to 31st Dec 2024)
  - ii. **Category B** - power plants within 10 kms radius of critically polluted areas or non-attainment cities. (deadline changed from 31st Dec 2023 to 31st Dec 2025)
  - iii. **Category C** - remaining plants throughout the country. (deadline changed from 31st Dec 2024 to 31st Dec 2026)
    - This has the longest deadline and most of the country's coal based power plants fall in this category.
- » Even after multiple extension, only 5% of the coal fired power plants have installed FGD (Flue Gas Desulfurization) systems, which are air pollution control devices for SO2 emissions (June 2023 : CSE Analysis)
- » Similarly, another analysis by the Centre for Research on Energy and Clean Air (CREA) has found less than 8% of India's coal based power plants have installed the SO2 emission reduction technology recommended by MoEF&CC (Dec 2023)

- **Problems caused by Coal Based power plants**

- » **Older technology** -> Larger emissions of CO, NOx, SOx, Ozone etc.
- » **Lesser Fly ash Utilization** due to weak fly ash guidelines and poor implementations.
- » **Difficulty** in achieving the **Paris Agreement Targets**.

- **Why moving away from coal based power plants may be difficult?**

- » Very large dependency -> 75% of India's annual power output.
- » **Phasing in renewable energy sources and phasing out conventional sources rapidly** may lead to instability in the electricity grid which may potentially cause blackout.
- » **Political Economy Risk:** Aggressive early retirement of coal based capacity, without detailed analyses, could result in real or perceived electricity shortage in some states.

## A) FLUE GAS DESULFURIZATION (FGD)

- FGD is a set of technologies that remove SO2 from exhaust flu gases of fossil fuel power plants, and from the emissions of other sulfur dioxide emitting processes such as waste incineration, petroleum refineries, cement and lime kilns.
- FGD systems use a scrubbing solution to absorb SO2.
  - » The most common type of FGD is wet scrubber which uses a limestone slurry or seawater to absorb SO2.
    - The SO2 reacts with the scrubbing solution to form sulfate particles which can then be removed.
    - The removal efficiency is upto 99%.

- » **Drug scrubbers** can also be used. It uses sorbent such as sodium bicarbonate or calcium oxide to absorb SO<sub>2</sub>,
- » **Regenerative scrubbers**, use a chemical solvent to absorb SO<sub>2</sub> and then regenerate the solvent for reuse.

## B) CIRCULATING FLUIDIZED BED COMBUSTION (CFBC)

- CFBC is a type of combustion technology used in thermal power plants to increase the efficiency of combustion and reduce emissions.
- It works by suspending a bed of inert particles (like sand or limestone) in a stream of air, creating a fluid like state. Fuel is injected in the bed and burned, with the heat transferred to the particles and then to a heat exchanger to produce steam or hot water.

## C) CENTRE FOR RESEARCH ON ENERGY AND CLEAN AIR

- It is an independent organization focused on revealing trends, causes, and health impacts as well as the solutions to air pollution.
- It uses scientific data, research and evidence to support the efforts of government, companies and campaigning organizations worldwide in their efforts to move towards clean energy.
- It is registered in Finland with staff across Asia and Europe.
- It is funded by philanthropic grants and revenue from commissioned research

## 3. NITROGEN POLLUTION

- **Introduction**
  - » While nitrogen is the dominant gas in the atmosphere, it is inert and doesn't react. However, when it is released as part of compounds from agriculture, sewage and biological waste, nitrogen is considered 'reactive' and may be polluting and causing greenhouse effect.
  - » The release of these reactive nitrogen compounds in the atmosphere have increased over the years because of increased use of **fertilizers for agriculture** and increased **industrial pollution**. NO<sub>x</sub> emissions grew at 52% from 1991 to 2001 and 69% from 2001-2011.
  - » In fact, a study in 2017 showed that we have **breached the planetary boundary of N (Nitrogen)**. This planetary boundary is set at 44 Tg (Tera-grams) per year globally. But currently we use 150 Tg N per year, primarily through fertilizer usage.

### » Key Forms of Nitrogen

- N<sub>2</sub> - Un-reactive di-nitrogen; forms 78% of the air we breathe  
N<sub>2</sub>O - Reactive nitrogen; fixed in soil by microbes; reacts to form different compounds with various impacts  
NH<sub>3</sub> - Ammonia; used for making fertilisers; can escape into the air as a pollutant  
NH<sub>4</sub>NO<sub>3</sub> - Ammonium nitrate, acts as fertiliser; when synthesised in

the atmosphere, contributes to particulate matter, water pollution and results in eutrophication

N<sub>2</sub>O - Nitrous oxide, a greenhouse gas; depletes ozone layer

NO<sub>x</sub> - Mixture of NO and NO<sub>2</sub>; a major air pollutant

NO<sub>3</sub> - Nitrate; the form in which nitrogen gets fixed in soil; can pollute water sources; forms ozone, which adds to particulate matter load

- » **More Details about N<sub>2</sub>O:** It is a greenhouse gas 300 times more potent than CO<sub>2</sub>. It has the third highest concentration - after CO<sub>2</sub> and methane - in our atmosphere among greenhouse gases. It can live in our atmosphere for upto 125 years.

- **2020 Study about N<sub>2</sub>O published in Nature:**
  - » Human emission of N<sub>2</sub>O increased 30% in 36 years.
  - » 43% of the total emissions came from human sources.
  - » The increase means that climate burden from non-carbon sources is also increasing.
  - » Dichotomy between Climate Crisis and Food Security - Major proportion of the N<sub>2</sub>O emissions in the last four decades came from the agricultural sector, mainly because of the use of nitrogen-based fertilizers.
  - » Most of the emission have come from developing countries like China, India and Brazil.
- **Key causes of Nitrogen Pollution**
  - » Emission from chemical fertilizer –
    - About 50% of the nitrogen used in global agri sector is released in environment (atmosphere, water bodies etc.).
    - Most important source.
    - Difficult to control (non-point source, food security concerns etc.)
  - » Sewage and organic solid wastes (second largest source):
  - » Burning of fossil fuels: Vehicular pollution, mostly from road transport is another major NOx producer.
  - » Industries
- **Key threats due to nitrogen pollution**
  - Air Pollution: Emissions of Ammonia, nitrogen oxide and nitrous oxide contribute to particulate matter and acid rain. These cause respiratory problems and cancers for people and damage to forests and buildings.
  - Water Pollution - Eutrophication
  - Negatively hampers soil health -> brings down the yield of agri-land.
  - Climate Change: Nitrous Oxide (N<sub>2</sub>O) -> GWP: 300 times of CO<sub>2</sub>; Also contributes to Ozone depletion.
  - Negative impact on Health, economy and livelihood
    - Deteriorating soil quality impacts Agri output and livelihood. Further, particulate matter and acid rains have adverse impact on health.

#### A) UNEP'S COLOMBO DECLARATION ON SUSTAINABLE NITROGEN MANAGEMENT (OCT 2019)

- Sri Lanka, with support from the UNEP, convened an event at which member states came together to adopt what is called the "Colombo Declaration".
- **Key Highlights**
  - Halve nitrogen waste by 2030.
  - The member countries also endorsed UN's plan for a sustainable nitrogen management called "Nitrogen for Life", which stems from the Sustainable Nitrogen Management Resolution which was adopted during the fourth session of the UN environment Assembly held from 11-15th March 2019, at the UNEP headquarter in Nairobi.
- **Analysis**

- This is the first-time governments have agreed to work together on a major quantitative global goal for improved nitrogen management.

## 4. SOLID WASTE

- **Introduction**
  - » Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas.
- Solid waste may be **categorized in three ways:**
  - » **Origin** (domestic, industrial, commercial, construction or institutional)
  - » **Contents** (organic material, glass, metal, plastic, paper, hazardous chemical)
  - » **Hazard Potential** (toxic, non-toxin, flammable, radioactive, infectious)
- As per **Indiawaterportal.org** the total MSW generated in urban India has been estimated at **68.8 million tons per year (TPY)**.
  - » This is expected to go to 165 million tonnes by 2030.
- But the Solid waste collection efficiency in India is around 70% at present, while it is 100% in many developed countries.
- Therefore, around 30% of MSW is not collected and thus lies littered around in Indian cities. Even the waste which is collected is not treated and thus is highly hazardous.
- **Problems of unscientific MSW disposal** -> Untreated, unprocessed and indiscriminately dumped waste causes air, water and soil pollution which have adverse impact on health situation. Further, this type of dumping goes against the **4Rs principle of environment Protection.**
- **Factors for increasing Solid Waste in India**
  - **Population, Urbanization, Increasing Per-Capita Income**
  - Increased Consumerism, Use and throw culture.
  - **Plastic waste** -> non availability of good alternative
  - **Technology change** -> Increasing electronic waste.
  - **COVID-19** also led to shooting up of domestic hazardous waste.
- **Proper Solid waste management**
  - SWM reduces or eliminates the adverse impact on the environment & human health. It includes a number of processes including segregation, collection and treatment and disposal in an environmentally sound manner.
  - The local authorities are responsible for the development of infrastructure for collection, storage, segregation, transportation, processing and disposal of MSW

## 5) TREATMENT AND DISPOSAL OF SOLID WASTE

### A) OPEN DUMPING, LANDFILLS AND SANITARY LANDFILLS

- **Advantage:** Waste limited to well defined area; Reduces contact between waste and environment.
- **Disadvantages** - Open dumps get exposed to natural elements, stray animals and birds and may cause air pollution, water pollution and soil pollution.

## B) THERMAL TREATMENT

- **Incineration plants (Waste to Energy Method)**
  - Incineration is combustion of waste in the presence of oxygen. Waste gets converted in CO<sub>2</sub>, Water Vapor and Ash along with heat.
  - **Advantages** - reduction in volume; kills many diseases causing germs.
  - **Limitations** - Air pollution -> Health issues; Climate Change
- **Pyrolysis**
  - Here material is exposed to very high temperatures in an inert (oxygen less) environment. The material decomposes due to the limited thermal stability of chemical bonds of material, which disintegrates.
  - Pyrolysis is thus a thermo-chemical treatment, which can be applied to any organic (carbon-based) product. It produces volatile products and leaves a solid residue enriched in carbon, char.
- **Plasma Arc Gasification (PAG) process**
  - It is a waste treatment technology that uses a combination of electricity and high temperature to turn municipal waste (garbage or trash) into usable by-products without combustion.
    - » It shouldn't be confused with incineration. This technology doesn't combust the waste as happens in incinerators. It converts the organic waste into gas that contains all its chemical and heat energy and converts the inorganic waste into an inert vitrified glass called slag.
    - » This process reduces the volume of waste reaching the landfills and also generate electricity.

## C) BIOLOGICAL TREATMENT METHODS - USE OF MICROORGANISMS

- **Bio-Gasification**
  - » It is a waste-to-Energy technique where biological decomposition of organic matter of biological origin under un-aerobic condition is done to produce methane and other secondary gases.
- **Composting**
  - » In this process, the organic waste is converted into compost through decomposition. Compost is rich in nutrients and can be used as soil conditioner, a fertilizer, addition of vital humus and humic acids and as a natural pesticide in soil.
  - » It can also be used for erosion control, land and sea reclamation, wetland construction, and as landfill cover.

- **Vermiculture/Vermicomposting:** It is the process of making compost through decomposition process. But here, decomposition is done by using various species of worms, usually red wiggler, white worms, and other earthworms.
- **Bioremediation**
  - » It involves use of bio-culture or microorganisms to degrade organic waste and contaminants that pose environmental and human risks. Here the environment is altered to stimulate the growth of micro-organisms and degrade pollutants. The organic waste is eventually converted into soil.
  - » **Various approaches** - Biostimulation; Bioaugmentation; a combination of both etc.

## D) BIOMINING

- Biomining involves use of separator machines or large sieves to separate waste material of different sizes, thereby obtaining soil, plastic, wood and metal components in isolation for appropriate processing.

## 6) LANDFILLS IN DELHI AND KEY CONCERNS

- **Why in news?**
  - » Our target is to clear all three landfill sites in Delhi by December 2024: CM Kejriwal (March 2023)
- Chronic negligence of sustainable and scientific treatment has resulted in an ever-growing mass of municipal solid waste (MSW) making its way into dumpsites in India.
- There are **three main landfills** in Delhi - **Bhalswa** in north, **Gazipur** in east and **Okhla** in south with **total estimated waste of 20 million tonnes (as of Oct 2022)**
  - » Note: In 2019, the total legacy waste at these three sites totaled to **28 million tonnes**.
- **Present Situation of Landfills:**
  - » **Bhalswa** (36 acres): **8 million tonnes**.
  - » **Gazipur** (70 acres): **14 million tonnes**
  - » **Okhla** (46 acres): Currently the site contains around **4 million tonnes** of legacy waste. In last few years, around **2.5 lakh tonnes** have been removed from it. (at its peak it contained around 6.5 million tonnes of waste)
- **Harmful Impacts of landfills:**
  - » **Ground Water and River Water Pollution:** Leachate from these landfills are not only contaminating ground water but are also reaching Yamuna River.
  - » **Other concerns due to landfills** -> Air Pollution (methane); Odour Pollution; Wastage of Resources; breeding ground for diseases.
  - » **Prolonged exposure** to compounds such as **dioxins** which are carcinogenic.

**Dioxin:**

Dioxins are a group of chemically-related compounds that are persistent environmental pollutants. They are found throughout the world in environment and they accumulate in the food chain, mainly in the fatty tissue of animals.

More than 90% of human exposure is through food, mainly meat and dairy products, fish, and shellfish. Many national authorities have programs in place to monitor the food supply.

They are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer.

Due to omnipresence of dioxins, all people have background exposure, which is not expected to affect human health. However, due to the highly toxic potential, efforts need to be undertaken to reduce current background exposure.

Prevention or reduction of human exposure is best done via source-directed measures, i.e., strict control of industrial processes to reduce the formation of dioxins.

- **Ecological Loss:** A study conducted by experts from the NEERI, CPCB and IIT Delhi assessed that ecological damage due to these three landfill sites is 450 crore rupees per annum.

## 7) LANDFILL FIRE – CAUSES

Methane Gas; Sabotage; collection of scrap metals; difficult to extinguish.

## 8) SOLID WASTE MANAGEMENT RULES, 2016

- In 2016, The Environment ministry had revised the solid waste management rules after 16 years.
- **Salient Features**
  - » **Extended Beyond Municipal Areas** - Covers urban agglomerations, census towns, notified townships, areas under control of railways, airports, airbases, port and harbour, SEZ etc.
  - » **Source Segregation** of waste has been mandated to channelize the waste to wealth by recovery, reuse, and recycle.
    - Waste generators have to segregate the waste in **three streams** - Wet (biodegradable; Dry (plastic, paper, glass, metal etc.) and Domestic Hazard wastes (diapers, napkins, empty containers etc.)
      - They should handover the waste to authorized rag pickers or waste collector or local bodies.
      - **Street vendors** to keep separate containers for separate wastes.
      - **Sanitary napkins and diapers** manufacturers or brand owners explore the possibility of using recyclable material in the product and shall provide a pouch or wrapper for disposal of each napkin or diapers along with packet of their sanitary products.
      - Educate masses in wrapping and disposal of their products.

- » The rules emphasized on integration of waste pickers/ rag pickers and waste dealers in the formal system by state governments, SHGs or any other group to be formed.
- » **Ban on open throwing burning or burying; Provisions for User Fee** for waste collectors and 'Spot Fine' for Littering and non-segregation.
- » **Provisions for Bulk and institutional generators** -> directly responsible for segregation and sorting the waste and manage in partnership with local bodies.
- » **The developers of SEZs, Industrial estate, industrial parks etc.** to earmark 5% of the total area of the plot or minimum 5 plots/sheds for recovery and recycling facility.
- » All manufacturers of disposable products such as tin, glass, plastics packaging etc. or brand owners who introduce such products in the market should provide necessary financial assistance to local authorities for the establishment of waste management system.
- » **The Biodegradable waste** -> processed through composting, bio-methanation etc.
- » **Promoting Waste to Energy**
  - Industrial units within 100 km of Solid waste RDF plants should get at least 5% of their fuel from them.
  - Non-recyclable waste with high calorific value (1500 K/cal/kg or more) should not be disposed of and should only be utilized for refuse-derived fuel or by giving away the feedstock for preparing refused derived fuel.
  - **High calorific wastes** shall be used for co-processing in cement or thermal power plants.

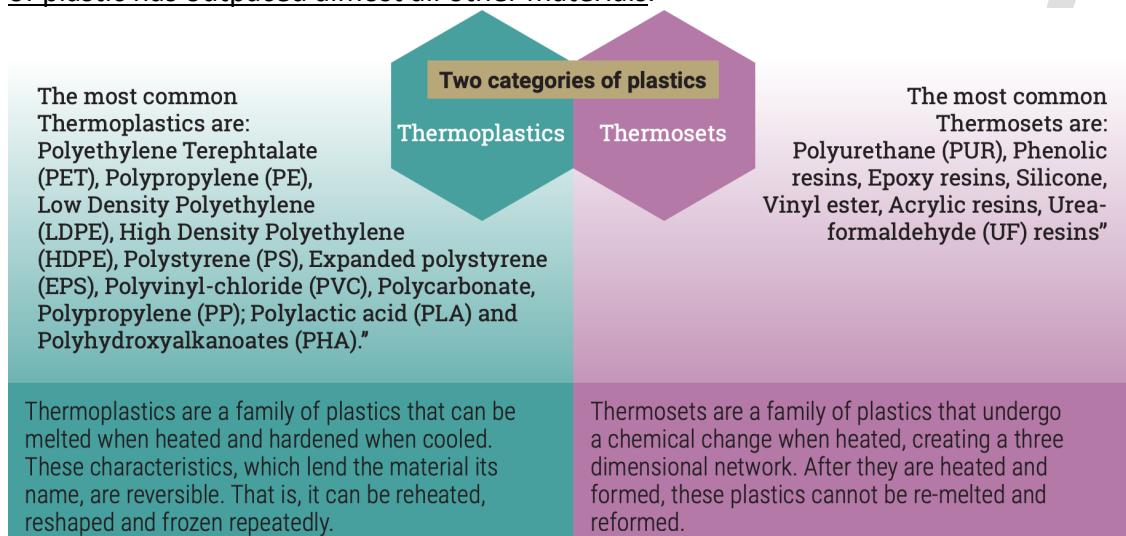
## 5. DOMESTIC HAZARDOUS WASTE

- **Details**
  - **A lot of harmful chemicals are used for domestic purposes**
    - » Chemicals to sanitize houses.
    - » Power bulbs, CFLs, Tube lights
    - » Medicines, ointments etc.
  - Caution is not applied while they are thrown in garbage.
  - **Current Concerns:**
    - » India hasn't estimated how much domestic hazardous waste do we generate.
    - » Traces of toxic waste can be found in most landfills.
    - » Absence of robust framework and infrastructure
    - » Segregation of domestic hazardous waste remains a distant dream for most cities.
- **Indore Municipal Corporation has shown the way:**
  - It has introduced a 3-way source segregation in 2018-19: **Wet, Dry and Domestic Hazardous**. Later, it has asked its residents to follow a five-way source segregation (wet, dry, hazardous, e-waste, and sanitary) to improve the purity levels of waste that can be recycled.
  - In Jan 2021, they added plastic waste as the sixth category.
  - The municipal corporation has taken an authorization of sending 1,000 tonnes of domestic hazardous waste to a treatment facility every year.

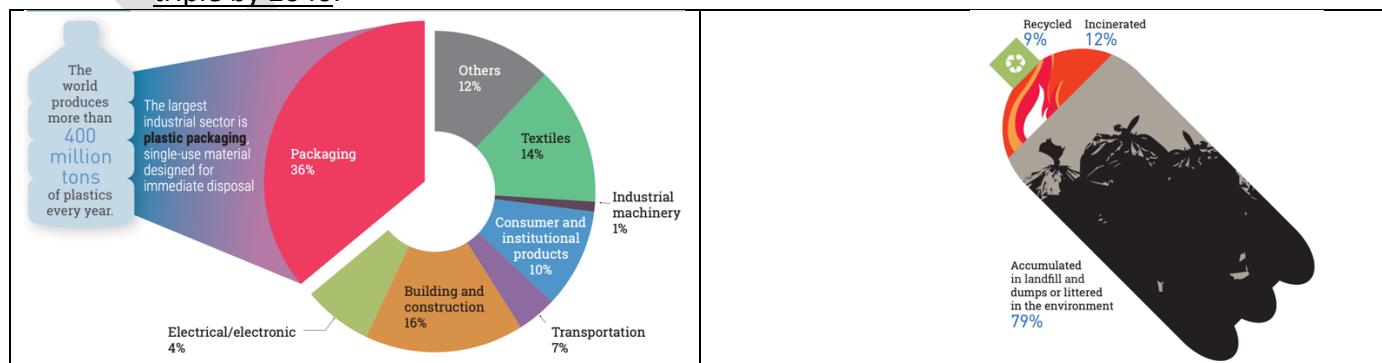
- **Bhopal has brought similar initiatives** and is making citizens segregate wastes into 4 categories (wet, dry, hazardous and sanitary)

## 6. PLASTIC POLLUTION

- Plastic is a lightweight, hygienic and resistant material which can be molded in wide range of applications and is cheaply manufactured. Because of these reasons, since the 1950s, the production of plastic has outpaced almost all other materials.



- **Negative Impact on Humans:** A study published by **World Wildlife Foundation** in 2019 estimates that **an average human may be ingesting as much as 5 gram of plastic every week**. This is because almost 1/3rd of the plastic waste that is getting generated ends up in nature, especially water, which is the largest source of plastic ingestion.
- **Extent of Plastic Pollution:**
  - » Globally, plastic production stands at about 400 million tonnes, and could double by 2040.
  - » **Global Plastic Production by Industrial Sector, 2015**
- **How is plastic disposed off?**
  - According to the UNEP, as of 2015, of the 9 billion tonnes of Plastic that the world has ever produced, only 9% has been recycled and 12% has been incinerated, the balance 79% has accumulated in landfills or in the natural environment. About 11 million tonnes of plastic is dumped into the ocean each year, and this figure is projected to double by 2030 and nearly triple by 2040.



- » India produces around **10 million tonnes of plastic** per year of which around 5 million tonnes is rendered waste every year. Therefore, it's crucial that this waste is properly managed.

## A) GLOBAL PLASTIC OUTLOOK: POLICY SCENARIO TO 2060

- Recently released by OECD
- It is 2<sup>nd</sup> of the two reports, and provides a set of coherent projections on plastics to 2060, including plastic use and waste as well as the environmental impacts.
- **Key Projections:**
  - Tripling of the use of plastic and plastic waste by 2060
  - Largest increase will come from emerging economies in Africa and Asia
  - This is expected to double GHG emission, ozone depletion, acidification and human toxicity.

### 1) MICROPLASTICS

- Plastic never truly biodegrade, but simply breaks up into smaller and smaller pieces. These tiny fragments are called micro (1 micro meter - 5 micro meter) and nano (less than 1 micro meter) plastics.
- The world sea floor is littered with an estimated 14 million tonnes of microplastics. They contribute to about 80% of the ocean debris. As per the UNEP, in the last four decades, the concentration of microplastics is supposed to have increased drastically in the sea surface water.
- **Microplastics** are divided into **two categories**:
  - i. **Primary Microplastics:** They enter the environment directly as tiny particles. They may be tiny particles designed for industrial use or microfibers shed from clothing and other textiles like fishing nets. Example of microplastics include micro beads found in personal care products, plastic pellets used in industrial manufacturing, and plastic fibers used in synthetic textiles.
  - ii. **Secondary Microplastics** form from the breakdown of larger plastics such as water bottles. This happens when larger plastics undergo weathering through exposure to sea waves, UV rays of sun, wind abrasion etc.
- **Impact of Microplastics**
  - **Introduction in food chain**
  - They can also alter the functioning of important habitats, impact hatching, growth rates and food consumption of multiple different animals and cause mass death in coral species.
  - A study in March 2022, found micro-plastics in nearly 80% of the individual blood samples.
  - In June 2022, for the first time microplastics have been found in freshly fallen snow in Antarctica. Samples from 19 sites showed that all of them contained micro-plastics.
  - **Nano plastics** can cross over cellular membranes into the brain, where it can cause Behavioural and neurological problems.

### 2) SINGLE USE PLASTICS

- **What is Single use plastic?**

- » Single use plastics (SUP) are disposable plastics intended to be used only once before they are thrown away or recycled.
  - They include grocery bags, food packaging, bottles, straws, containers, cups and cutlery.
  - These are the waste products of a throwaway culture that treats plastic as disposable material rather than a valuable resource to be harnessed.
- Plastic Waste Management Amendment Rules 2021 defined SUP as "a plastic commodity intended to be used once for the same purpose before being disposed of or recycled".  
  - » The rules also provides for phasing out of single use plastics.
- **Ban on several forms of Single Use Plastics from July 1, 2022:**
  - » As per the Plastic Waste Management Rules, 2016, there is a complete ban on sachets using plastic material used for storing, packing, or selling Gutkha, tobacco and Pan Masala.
  - » As per the PWM (Amended) Rules, 2021:
    - Carry bags made up of virgin or recycled materials and of less than 75 microns is banned wef 30th Sep 2021.
    - Import, stocking, manufacture, distribution, sale and use of the following identified SUP items, which have low utility and high littering potential is banned from 1st July 2022.
      - ear buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice- cream sticks, polystyrene [Thermocol] for decoration.
      - plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packing films around sweet boxes, invitation cards, and cigarette packets, plastic or PVC banners less than 100 microns, stirrers.
  - » **Why ban these items?**
    - "difficulty of collection and therefore recycling".

### 3) HARMFUL IMPACT OF PLASTIC POLLUTION

- **Physical Pollution:** Pieces of plastics, the polymers themselves, interact with bodies and ecosystems.
- **Chemical Pollution:** Added chemicals escape plastics and interact with bodies and ecosystems;
  - A number of chemicals used in the plastic are toxic and problematic. These chemicals, in lab settings, have been shown to be associated with infertility, recurrent miscarriages, feminization of male foetuses, early onset of puberty, cancer etc.
- **Environmental Impacts:** Plastics take upto thousands of year to decompose and thus contaminate soil and water.
- **Plastisphere:** Sometimes called the 'Plastisphere', bacteria, viruses and other life colonize the surface of plastic waste, creating distinct communities and population structure.
  - They may also contribute in growth of invasive species. For e.g., more than 80% of invasive species in the Mediterranean may have arrived on floating plastic waste.
- **Health and Social Impact:** Health losses, welfare losses -> unusable parks, Sewage Blocking -> Malaria, Dengue etc.
- **Economic Impact**
  - Visual pollution negatively impacts the tourism sector.
  - Further, future cost of removing these plastics from nature is higher than the cost of preventing the littering today.
- **Exacerbate disasters like floods** - an important cause of urban floods.

- Even the biodegradable plastics have many unintended consequences.
- Exacerbates Climate Change: Plastics are 80% carbon and more than 99% of plastics use crude oil, fossil gas or coal as feedstock. Manufacturing also involves burning of large quantities of fossil fuels to provide high energy demands of the industrial processes.
  - By 2015, the total estimated lifecycle emissions from plastics were **1.78 billion tonnes** of CO<sub>2</sub> equivalent (GtCO<sub>2</sub>e). For context, if the whole plastics lifecycle were a country, it would be fifth largest emitter of greenhouse gases in the world.

#### 4) PLASTIC WASTE MANAGEMENT RULES 2016 (AND 2021 AMENDMENTS)

- Key Provisions of the 2016 Rules
  - Min thickness of plastic carry bags has been increased to 75 microns by 30th Sep 2021 and **120 microns by 31st Dec 2022** (after the 2021 amendment to the rules)
  - Expand the coverage to rural areas. The earlier regulations only covered urban municipal areas.
  - Phasing out of non-reusable Multi-layered Plastic.
  - Introduces Extended Producer Responsibility for producers and generators of Plastic Waste
    - Note: India first introduced EPR to manage electronic-waste in 2012.
      - EPR was extended to Plastic manufacturers after the notification PWMR, 2016.
  - Shopkeepers and Vendors can only use plastic carry bags which have been properly labelled and marked for use or else there will be imposition of fines.
  - ULB and Panchayats have been provided with the responsibility of establishing and operating waste management systems.
  - The Land Department (or any department with business allocation of land allotment with state governments) should allocate land for establishing waste management facilities.
  - Gainful usage of Plastic waste has also been promoted in road construction, waste to oil conversion etc

#### 5) PLASTIC WASTE MANAGEMENT RULES, 2021 AND OTHER CHANGES

- Key provisions of 2021 amendment rules:
  - The min thickness of plastic carry bags has been increased from 50 microns **to 75 microns from 30th Sep 2021** and **to 120 microns with effect from the 31st Dec 2022**.
    - Note: Advantage of increased thickness - Higher cost -> more reuse; less mobile -> less pollution; less chances of being consumed by stray animals.
  - The manufacture, import stocking, distribution, sale and use of following single-use plastic, including polystyrene and expanded polystyrene, commodities shall be prohibited with effect from 1st July 2022.
    1. Ear buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice-cream sticks, polystyrene [Thermocol] for decoration;
    2. Plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packing films around sweet boxes, invitation cards, and cigarette packets, plastic or PVC banners less than 100 micron, stirrers.

**Note:** It doesn't cover compostable plastic.

**Note:** The CPCB and the SPCBs have issued notification asking manufacturers, suppliers and consumers of single use plastic items to scrap and phase them out and switch to greener and sustainable alternatives.

- **Plastic Packaging Waste**, which is not covered under the phase out of identified single use plastic items, shall be collected and managed in an environmentally sustainable way through the EPR of producer, importer and Brand Owner (PIBO), as per the Plastic Waste Management Rules, 2016.
  - For effective implementation of EPR, the Guidelines for EPR being brought out have been given legal force through the Plastic Waste Management Rules, 2021.

**A) THE MOEF&CC HAS NOTIFIED THE GUIDELINES ON EPR FOR PLASTIC PACKAGING UNDER PLASTIC WASTE MANAGEMENT RULES, 2016, IN THE GAZETTE OF INDIA ON 16TH FEB 2022.**

- **Key Highlights of the guidelines:**
  - It promotes development of new alternatives to plastics and provide further next steps for moving towards sustainable plastic packaging by businesses.
- **Obligated entities that fall under the category of EPR (Producer of Plastic Packaging; Importer of all imported packaging, Brand Owners including online platforms, Plastic Waste Processors) have to get registered in the centralized portal developed by CPCB.**
- **The amendment categorizes SUPs in 4 categories:**
  - i. **Category 1:** Rigid plastic packaging.
  - ii. **Category 2:** Flexible plastic packaging with single layer or multilayer (more than 1 layer of plastic), plastic sheets, covers made of plastic sheets, carry bags, plastic sachets, or pouches.
  - iii. **Category 3:** Multi-layered plastic packaging where at least one layer is non-plastic, such as tetra pack cartons etc.
  - iv. **Category 4:** Plastic Sheet or like used for packaging as well as carry bags made of Compostable Plastics
- The targets for minimum level of recycling (excluding end of life disposal) as per Guidelines, are given below:

| Plastic Packaging Category | 2024-25 | 2025-26 | 2026-27 | 2027-28 onwards |
|----------------------------|---------|---------|---------|-----------------|
| Category I                 | 50      | 60      | 70      | 80              |
| Category II                | 30      | 40      | 50      | 60              |
| Category III               | 30      | 40      | 50      | 60              |
| Category IV                | 50      | 60      | 70      | 80              |

- **Environmental Compensation** shall be levied based upon polluter pay principle, with respect to non-fulfilment of EPR targets by Producers, Importers & Brand Owners, for the purpose of protecting and improving the quality of the environment and preventing, controlling, and abating environmental pollution.
- **Implementation of EPR** will be done through a Customized Online Platform which would act as the Digital backbone of the system.
  - It will allow tracking and monitoring of EPR obligations and will reduce the compliance burden for companies through online registration and filing of annual returns.

- Producers, Importers and brand-owners shall have to provide the details of recycling certificates only from registered recyclers along with detailed quantity sent for end-of-life disposal, by June 30, 2022 of next financial year while filing annual return on online portal.
- Sale and Purchase of surplus EPR certificates are allowed** -> this has thus set up market mechanisms for plastic waste management.
- Levy of environmental compensation** based upon polluter pay principle, with respect to non-fulfilment of EPR targets by the producers, importers & brand owners. The funds collected shall be utilized for collection, recycling, and end of life disposal of uncollected plastic waste in an environmentally sound manner.
  - CPCB shall charge compensation on default producers, importers & brand-owners that operate in more than two states.
  - SPCB shall levy compensation on the default producers operating within their jurisdiction.
- Producers, importers, & brand owners, may operate schemes such as deposit refund system or buy back or any other model.
- CPCB shall constitute a committee under chairpersonship of Chairman, CPCB that shall be responsible for recommending measures to MoEF&CC for the effective implementation of EPR that shall include amendments to the EPR guidelines.

## 6) OTHER STEPS BEING TAKEN

- Strengthening of waste management infrastructure through the **Swatch Bharat Mission**.
- **Promotion of Alternatives:**
  - CPCB has already issued one-time certificate to around 200 manufacturers of compostable plastics.
  - India Plastic Challenge - Hackathon 2021 is launched to develop innovative alternatives to SUP.
    - It calls upon start ups/ entrepreneurs and students of HEIs to develop innovative solutions to mitigate plastic pollution and develop alternative to single use plastic.
- **Strengthening of Institutional Framework at State/National level** to better implement 2016 rules:
  - States/Uts have been asked to develop a comprehensive action plan for elimination of SUP.
  - States have been requested to form a Special Task Force for elimination of SUP and effective implementation of 2016 rules.
  - A National Level Task force has been constituted by the ministry to take coordinated efforts to ban SUP and to implement 2016 rules.
- **Awareness Generation:**
  - Mascot 'Prakriti' has been launched to spread mass awareness about how adoption of small changes in our lifestyle can play a big role in environmental sustainability. It also teaches about various efforts and initiatives that the MoEF&CC and CPCB have taken in order to ensure effective Plastic Waste Management in the country (2022)
- **Promoting Alternative uses of plastic waste:**
  - For e.g. in 2021, MoRT&H issued guidelines for use of plastic waste in road construction.
    - Indian oil is also using technology to convert plastic waste into bitumen.

- **Promoting Reduce, Reuse and Recycling:**
  - World-Wide Fund for Nature - India (WWF India) and the Confederation of Indian Industry (CII) have **joined hands to develop a platform to promote a circular system for plastics**. The new platform is called, the '**India Plastic Pact**'

## A) INTERNATIONAL EFFORTS

- a. **Steps towards Plastic Pollution Treaty:** In 2022, the UN member states agreed to start negotiating new global treaty to end plastic pollution. Now it is crucial that the treaty that is finalized is ambitious and effective enough to truly address the plastic crisis.
  - As of July 2023, 2 negotiation meetings, for the new treaty has taken place.
- b. **Awareness and Education:**
  - The theme of **World Environment Day, 2018** was "**Beat Plastic Pollution**" and it focused on increasing awareness related to plastic pollution across the world.
- c. **EU Parliament bans 10 single use Plastics** with effect from 3rd July 2021

## B) GLOBAL PLASTIC TREATY NEGOTIATIONS:

- **Why in news?**
  - 2nd Session of Intergovernmental negotiation Committee (INC) on plastic pollution was held in Paris in June 2023.
- **Background:** In 2022, the UN member states agreed to start negotiating new global treaty to end plastic pollution. Now it is crucial that the treaty that is finalized is ambitious and effective enough to truly address the plastic crisis.
  - The Intergovernmental Negotiation Committee (INC) on Plastic Pollution is in the process of developing "an international legally binding instrument on plastic pollution, including in the marine environment"
  - As of July 2023, 2 negotiation meetings, for the new treaty has taken place.
- **Why is a global Treaty on Plastic Pollution required?**
  - i. **Plastic Pollution is a global problem** which requires global solution. Most of the plastic is being dumped into oceans. This is eventually converting into micro-plastics, entering food chain and affecting everyone.
  - ii. Plastic pollution is harmful to wildlife and biodiversity which is impacting everyone.
  - iii. **Increased International Cooperation** will be feasible through a global treaty.
  - iv. The treaty may set global target for reduction
  - v. A global treaty may make the fight against plastic pollution more fair -> by giving higher responsibility to developed economies and giving more time to under developed countries.

## 7) PROMOTING ALTERNATE USE OF PLASTICS

## A) USE OF PLASTIC WASTE IN STEEL MANUFACTURING (DEC 2022: SOURCE: PIB)

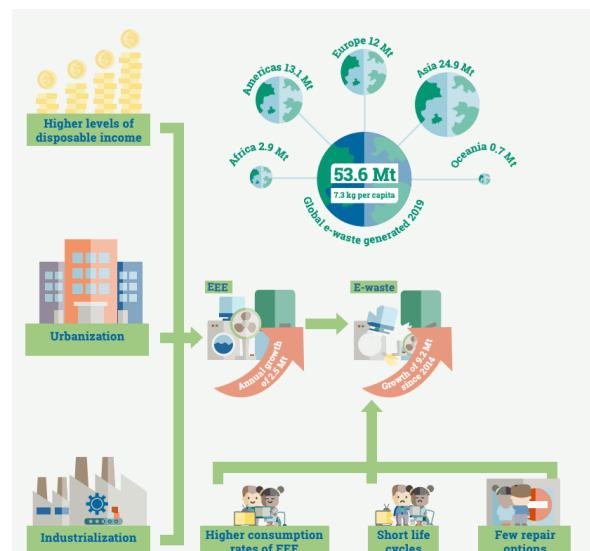
- Waste Plastic can be used as replacement of coking coal (by upto 1%) in coke making.
- Waste plastic can also be added in marginal quantities in Electric Arc Furnace (EAF) as replacement of pet coke.
- As per Plastic Waste Management Rules (PWM-2016) and subsequent amendment vide gazette notification G.S.R. 522(E) dated 06th July 2022, issued by the MOEF&CC, **only "End-of-Life Disposal" plastic is allowed for co-processing in the steel industry** and other waste plastic which can be recycled has been mandated for recycling only.
  - Presently, availability of "End-of-Life Disposal" waste plastic is a major constraint.
- Under the aforesaid Plastic Waste Management Rules, the municipalities/ local bodies are responsible for the creation and establishment of the plastic waste segregation, collection, storage, transportation, processing, and disposal system either on their own or by engaging agencies or manufacturers.

## B) ROADS MADE UP OF PLASTIC WASTE

- **Why in news?**
  - MoRT&H has issued guidelines for use of plastic waste in Road construction (July 2021)
- **Details**
  - Mandatory use of waste plastic in periodic renewal coat of pavement on National Highways and also in wearing course of service road within 50 km periphery of urban areas having population of 5 lakhs or more.
  - Indian Roads Congress (IRC) has formulated guidelines for the use of waste plastic in hot bituminous mixes for wearing courses.

## 7. E-WASTE

- E-waste is a popular name for electrical and electronic equipment (EEE) discarded after their end of life'. Discarded laptops, desktops, cellphones, and their batteries, air conditioners and television sets, cables, and wires, tube-lights and CFLs which contain mercury, are some examples of e-waste.
- It is one of the fastest growing waste stream in the world.
- **Annual waste Output**
  - Global E-waste monitor (published by UN University ) estimates that **53.6 million tonnes (7.3 kg per capita)** of e-waste was generated world over in 2019.
    - This is an increase of 21% in just five years.
    - This is expected to go to **74.7 Mt** by 2030.
  - **E-waste generation in India is expected to grow rapidly in the coming future** (income, urbanization, changing technology, import (legal or illegal), poor quality equipment, power surge issues etc. )
  - **India is already the third largest e-waste generator.**



- **Harmful effects of e-waste:**
  - Hazardous and toxic heavy metals - mercury, cadmium etc;
  - Ozone Depleting Substances;
  - High Global Warming Potential gases;
  - Unscientific extraction - Air Pollution, Water Pollution and Soil Pollution;
  - Severe negative health impacts - hampers central and peripheral nervous system, brain development, kidney, reproductive system etc.

## 1) E-WASTE MANAGEMENT RULES, 2022 NOTIFIED BY MOEF&CC IN NOV 2022

- It will replace E-Waste (Management) Rules, 2016 and will be effective from 1st April 2023. These rules will have new EPR regime for e-waste recycling.
- **Key Features:**
  - Applicable to every manufacturer, producer, refurbisher, dismantler and recycler.
  - All the manufacturer, producer, refurbisher and recycler are required to register on portal developed by CPCB.
    - No entity shall carry out any business without registration and also not deal with any unregistered entity.
    - Authorization has now been replaced by Registration through online portal and only manufacturer, producer, refurbisher and recycler require Registration.
  - Schedule I expanded and now 106 EEE (Electrical and Electronic Equipment) has been include under EPR regime.
  - Producers of notified EEE, have been given annual E-Waste Recycling targets based on the generation from the previously sold EEE or based on sales of EEE as the case may be.
    - Target may be made stable for 2 years and starting from 60% for the year 2023-2024 and 2024-25; 70% for the year 2025-26 and 2026-27 and 80% for the year 2027-28 and 2028-29 and onwards.
  - Management of solar PV modules /panels/ cells added in new rules.
  - The quantity recycled will be computed on the basis of end products, so as to avoid any false claim.
  - Provision for generation and transaction of EPR Certificate has been introduced.
  - Provisions for environment compensation and verification & audit has been introduced.
  - Provision for constitution of Steering Committee to oversee the overall implementation of these rules.
  - Provision for reduction of hazardous substances in manufacturing of Electrical and Electronic Equipment (EEE) has been provided.
    - It mandates that every producer of EEE and their components shall ensure that their products do not contain lead, mercury and other hazardous substances beyond the maximum prescribed concentration.
  - The E-Waste (Management) Rules also provide for .

## A) MANAGEMENT OF SOLAR PV MODULES/CELLS HAS BEEN ADDED IN CHAPTER V OF THE SAID RULES.

- As per these rules, every manufacturer and producer of solar photo-voltaic modules or panels or cells shall:
  - i. Ensure registration on the portal;
  - ii. store solar photo-voltaic modules or panels or cells waste generated up to the year 2034-2035 as per the guidelines laid down by the Central Pollution Control Board in this regard.
  - iii. file annual returns in the laid down form on the portal on or before the end of the year to which the return relates up to year 2034-2035.
  - iv. ensure that the processing of the waste other than solar photo-voltaic modules or panels or cells shall be done as per the applicable rules or guidelines for the time being in force;
  - v. ensure that the inventory of solar photo-voltaic modules or panels or cells shall be put in place distinctly on portal; and
  - vi. comply with standard operating procedure and guidelines laid down by the Central Pollution Control Board in this regard.

## 8. BATTERY WASTE MANAGEMENT RULES, 2022

- MoEF&CC, Government of India published the Battery Waste Management Rules, 2022 on 24th August, 2022 to ensure environmentally sound management of waste batteries.
- New rules will replace Batteries (Management and Handling) Rules, 2001.
- The rules cover all types of batteries, viz. Electric Vehicle batteries, portable batteries, automotive batteries and industrial batteries.
- The rules function based on the concept of Extended Producer Responsibility (EPR) where the producers (including importers) of batteries are responsible for collection and recycling/refurbishment of waste batteries and use of recovered materials from wastes into new batteries
  - EPR mandates that all waste batteries to be collected and sent for recycling/refurbishment, and its prohibits disposal in landfills and incineration. To meet the EPR obligations, producers may engage themselves or authorize any other entity for collection, recycling or refurbishment of waste batteries
  - The rules will enable setting up a mechanism and centralized online portal for exchange of EPR certificates between producers and recyclers/refurbishers to fulfil the obligations of producers.
- The rules promote setting up of new industries and entrepreneurship in collection and recycling/refurbishment of waste batteries.
- Mandating the minimum percentage of recovery of materials from waste batteries under the rules will bring new technologies and investment in recycling and refurbishment industry and create new business opportunities.
- Prescribing the use of certain amount of recycled materials in making of new batteries will reduce the dependency on new raw materials and save natural resources.

## 9. RADIOACTIVE WASTE IN SCRAP

- **Radioactive materials or contaminated devices are entering into the booming scrap recycling chain,** posing a grave health hazard, according to the annual data on illicit trafficking of nuclear and other radioactive material released by IAEA
- **Details**
  - » The latest data has been extracted from the IAEA Incident and Trafficking Database (ITDB), where some 143 member states and international agencies report incidents of illicit trafficking of nuclear and other radioactive material under or out of regulatory control. This is part of IAEA's nuclear security plan.

## 10. CONSTRUCTION AND DEMOLITION WASTE

- In **2016**, government for the first time came up with **Construction and Demolition Waste Management Rules**, 2016. These rules are aimed at promoting recovering, recycling and reuse of the waste generated through C&D.
  - **Mandatory segregation** of C&D waste into four types - concrete, soil, steel and wood, plastics, bricks and mortars.
  - Deposit it at **collection centers** or hand it over to **processing facilities**.
  - It makes all stakeholders responsible for waste disposal (be it small scale generators, the municipal body or the government)
  - It makes debris recycling mandatory
  - **Illegalizes the dumping** of waste outside designated areas.
  - **Waste processing authorities** -> should have authorization from SPCB and should be located far away from habitation.
  - For **effective monitoring** of the rules, specific roles have been allocated to **CPCB**, the **Bureau of Indian Standards (BIS)**, the **Indian Road Congress (IRC)** and Central Ministries.
  - **Land Department** - Provide land for storage processing and recycling of C&D waste

## 11. BIOMEDICAL WASTE MANAGEMENT RULES, 2016

- The rules are applicable for wastes from vaccination camps, blood donation camps, surgical camps or other healthcare activity.
- **Main Provisions**
  - **Pretreatment** of laboratory waste, microbiological waste, blood samples and blood bags through disinfection or sterilization on site should be carried out as prescribed by WHO or NACO (National Aids Control Organization).
  - **Waste classification in four categories instead of 10** to improve the segregation of waste sources.
    - The BMW have to be collected by the health care facilities in colored bags - yellow, red, blue/white and black according to the category of biomedical waste.

| Red Bin | Yellow Bin | Blue Bin | Black Bin |
|---------|------------|----------|-----------|
|---------|------------|----------|-----------|

|  |   |  |   |
|--|---|--|---|
| Plastic Waste such as syringes bottles etc | Infectious waste - Bandages, Cotton, Placenta etc | Glass bottles, discarded medicines etc | Needles without syringes, metal articles etc. |
|--|---|--|---|

- **Phased discontinuation of chlorinated plastic bags**, gloves and blood bags
- **Bar-code system to classify disposal of bags of containers having BMW**
  - It can be used to track and identify bags better.
- **More Stringent standards** have been prescribed for incinerators to reduce the pollution to environment.
- **States to provide land** for setting up common biomedical waste treatment and disposal facility.
- **2018 Amendment** to the rules provided for:
  - **Extension of dates to** phase out chlorinated bags to March 27, 2019.
  - **Establishing of barcode system** by both generators and operators by March 27, 2019
  - **Institute GPS in vehicles of CBMWTF**

## 1) SEQUENTIAL PRODUCTION OF BIO-DIESEL, BIO-ETHANOL, BIO-HYDROGN, AND METHANE FROM LEATHER SOLID WASTES, AND EFFLUENT TREATMENT SLUDGES

- MoEF&CC had approved the lab-cum-demonstration project titled *Sequential production of Bio-Diesel, Bio-Ethanol, Bio-Hydrogen and Methane from leather solid wastes and effluent treatment sludges* in 2015.
  - The project was approved for Central Leather Research Institute, Chennai with the total project outlay of Rs 77.11 lakh.
- The Project envisaged delivery of environmental benefits like:
  - a. Effective solid waste management techniques for tanneries
  - b. Better pollution abatement techniques
  - c. Avoidance of groundwater contamination
  - d. Efficient greenhouse emission control techniques
- **CAG Report** for financial year 2020-21 (released in Dec 2022)
  - » Only one unit of a biodiesel recovery had been established in March 2018 against the expected physical output of four distinct fuel recovery units.
    - The unit produced 80 litres of bio-diesel and none of the other three units achieved fruition by May 2022.
  - » The deliverables of 10 international publications in high-impact factored journals and three PhD degrees had also not been achieved.
  - » Key deficiencies observed by CAG Report:
    - Inaction in processing the request of Central Leather Research Institute, Chennai (CLRI) to revise the number of project fellowships. Due to this, CLRI was unable to retain the project fellows who were engaged in the project.
    - Failure to obtain formal commitment from the industry partners, which resulted in limited participation by the industry partner;
    - A lack of regular monitoring of the progress of the project, which affected the timely implementation of the project.

## 12. SOME OTHER TECHNOLOGIES

### 1) HYDROTHERMAL CARBONIZATION

- The Hydrothermal Carbonization (HTC) is a (pre)treatment of lignocellulosic biomass in hot (180 degree - 280 degree) water at saturated pressure of 2-10 MPa and residence time varying from minutes to hours. It is carried out mainly to produce solid product similar to coal. The energy density is much higher for this solid product. They can be either combusted to produce energy or disposed for soil nourishment as fertilizer (also sequestration of carbon)

## 13. NOISE POLLUTION

- **Intro**
  - » Noise pollution refers the presence of such levels of noise or sound in the environment that are disturbing, irritating and annoying to living beings. It causes discomfort and harm to living being's mental and physical health. It is one of the major causes of deafness and other health hazards. Even animals suffer from excessive environmental noise.
- **Causes of Noise Pollution** - Vehicles, factories, industries, construction sites, fire crackers, loud speakers, domestic appliances; TV/Radio etc.
- **Effects of Noise Pollution**
  - Loud and prolonged noise can cause physiological and psychological damage.
    - a. **Loss of hearing and deafness** : Noise above the tolerable threshold is the leading cause for loss of hearing and deafness.
    - b. **Cardiac Disturbance** : Noise increase the risk of cardiac disturbance including coronary artery disease or ischemic heart disease
    - c. **Sleeplessness** : Noise may make people restless. It may keep people away from sound sleep
    - d. **Headache** : Human mind can tolerate sound only to a limited extent. Excess noise cause headache.
    - e. **Stress, tension and aggressiveness**
    - f. **Mental Imbalance and nervous debility**
    - g. **Psychological imbalance**
    - h. **Difficulty in talking**
    - i. **Diabetes and Hypertension:**
      - Two 15 year long studies for long-term resident of Toronto, Canada found that exposure to road traffic noise elevated risks of acute myocardial infarction and congestive heart failure, and increased incident of Type 2 diabetes by 8% and hypertension by 2%.
    - j. **Affects biodiversity:** For instance a recent study published in the Conservation Biology journal noted that chicks of the birds which were exposed to noise were smaller than the ones in quiet nests.

- **How sound is measured?**
  - » The faintest sound that our ears can detect is known as the Threshold of Hearing (TOH). The most intense sound that our ears can detect without suffering any physical damage is one billion times more intense than TOH. This large hearing range makes a linear scale of sound measurement inappropriate.
  - » Hence, we use **logarithmic scale** to measure the sound. The unit is a decibel (dB) and TOH is assigned zero dB.
    - So 10 dB means a sound that is 10 times more intense than TOH. 20 dB refers to an intensity of sound that is 100 times more than a TOH sound, 30 dB means an intensity that is 1000 times more than TOH, and so on.
    - $10 \cdot \log_{10} (P_1/P_0)$
  - » **What is dbA?**
    - Frequency and pitch of the noise also determines whether it is harmful or not. A modified scale called decibel-A (dbA) takes pitch into account.
    - A-weighted decibels, abbreviated dBA, or dba or dB(a), are an expression of the relative loudness of sounds in air as perceived by the human ear. In the A-weighted system, the decibel values of sounds at low frequencies are reduced, compared with the unweighted decibels, in which no correction is made for audio frequency.
- **What is the safe limit for noise?**
  - » The latest 2018 WHO guidelines established a health-protective recommendation for road traffic noise levels of 53 dB.
  - » Hearing loss begins if a person is exposed more than 8 hours a day to a noise level of 80-90 dbA.
  - » A level of 140 dbA is painful and 180 dbA could even kill a person.
    - Examples of noise levels
- **What is being done to curb the noise pollution?**
  - » The **CPCB** is mandated to track noise levels, set standards as well as ensure, via their State Units, that sources of excessive noise are controlled.
  - » In 1980s and 1990s there were several court judgements in India restricting the generation of noise by industries, fire crackers, electric horns etc.
  - » Finally in 2000, Indian government notified the **Noise Regulation Rules**, which were amended in 2010.
    - Noise Regulation Rules were notified under the Environment (Protection) Act of 1986.

- Two types of noise level standards are Prescribed
    - Ambient noise level standards
    - Noise levels for designated types of machinery, appliances, and fire crackers.
  - **Ambient Noise Levels have been defined as follows:**

| Category of Area/Zone | Limits in dB(A) (Day) (6 am - 10 PM) | Limits in dB(A) (Night) |
|-----------------------|--------------------------------------|-------------------------|
| Industrial Area       | 75 dbA                               | 70 dbA                  |
| Commercial Area       | 65 dbA                               | 55 dbA                  |
| Residential Area      | 55 dbA                               | 45 dbA                  |
| Silence zone          | 50 dbA                               | 40 dbA                  |
  - **Silence zone** - zones of silence (100 meters) near schools, courts, hospitals etc.
  - The rules specify that no permission could be granted by any authority for use of public address (PA) system in the open after 10.00 pm and before 6 am. Even after permission has been procured, the sound level must fall within the limits prescribed in the Noise rules.
- **National Ambient Noise Monitoring Network (NANMN)** was launched in 2011
- Central government set up a National Ambient Noise Monitoring Network (NANMN) through **CPCB** and **the state pollution control boards (SPCBs)** to monitor noise on a 24X7 basis in **India's seven largest city.**
  - Under NANMN, during Phase 1 and Phase 2, **70 monitoring stations** have been set up in seven cities - each in Delhi, Bengaluru, Kolkata, Chennai, Hyderabad, Lucknow, and Mumbai. - which are operated by SPCBs.
  - Phase 3 plan was to launch 90 stations in 80 other cities.

- **2015 Supreme Court Judgements:** In 2015, the Supreme Court, acting on a petition filed by four infants (all aged between six months and 14 months) seeking curbs on air and sound pollution, banned the bursting of sound-emitting crackers between 10 pm and 6 am during Diwali.
- **In June 2020**, the CPCB has proposed a new set of fines between Rs 1,000 to Rs 1,00,000 for those who violate norms restricting noise pollution under the **Noise Pollution (Regulation and Control) Rules, 2000.**

- This was submitted in a report filed with National Green Tribunal in response to a set of ongoing cases over noise pollution.
- **Under the new norms:**

|  |   |
|--|---|
| ▪ <b>Violations related to norms over:</b> |   |
| Use of loudspeakers/PA systems etc.        | Confiscation of system and a fine of upto Rs 10,000         |
| Diesel generator sets                      | Sealing of the sets and a fine between Rs 10,000 to 1 lakh. |
| Sound Emitting Construction Equipment      | Seizures, sealings and a fine of Rs 50,000                  |

## 14. LIGHT POLLUTION

- Why in news?

- » International Dark Sky Week is an annual event hosted by International Dark Sky Association (IDA).
  - Astronomers and Sky enthusiasts marked the 2022 International Dark Sky Week from April 22-30. Hundreds of events were conducted across the globe where participants came together to learn astrophotography, take night walks, and observe the night sky without light pollution and learn how it negatively impacts our ecosystem.
- **Introduction**
  - » Light pollution, also known as photo-pollution or luminous pollution, is the **excessive, misdirected or invasive use of artificial outdoor lighting**.
  - » **Harmful Impact**
    - **Disturbs circadian rhythm** (the 24 hour cycle of many organisms) including humans and induces sleep disorder, and other health risks like obesity, depression, and diabetes.
    - **Unhealthy:**
      - Light pollution may cause damage to the retina in the eyes.
      - Some lights such as blue LED lights may be harmful for health.
    - **Impacts biodiversity:** It affects insects as they are drawn towards these lights. This affects their food chain and reduces pollinating activities. Other animals such as turtle are also affected as they get attracted towards these lights and thus are snapped by predators.
    - **Wastage of light** is also a reason for overuse of fuel and thus a factor behind climate change.
    - **Impacts astronomy:** Mismanaged lighting alters the color and contrast of the nighttime sky and eclipses natural starlight. It hinders study of the universe as proper study becomes difficult from areas where these artificial lights hinder celestial light. It makes stargazing difficult.



The city of Las Vegas dumps an enormous amount of light into its environment, turning the night sky above into a seemingly blank canvas.

- **Light Pollution and Satellites**
  - » A new study published in Monthly Notices of the Royal Astronomical Society: Letters shows that satellites that orbit the Earth can increase the overall brightness of the night sky by 10% above natural levels.
    - This additional light pollution has an impact over a larger part of the globe than ground-based sources

## 15. ENVIRONMENTAL IMPACT ASSESSMENT – EIA RULES AMENDED

- **Environmental Impact Assessment**
  - EIA can be defined as the study to predict the environmental, socio-economic, cultural and human-health impacts of proposed project/activity. The global environmental law for the EIA

is the "**precautionary principle**". Environmental harm is often irreparable so there should be a focus on prevention.

- It is a **decision making tool** which **compares various alternatives** for a project and chooses the one which ensures best combination of economic and environmental costs and benefits.
- **Advantages of EIA:** By considering the environmental effects of the project and their mitigation early in the project planning cycle, environmental assessment has many benefits:
  - Promotes environmentally safe and sustainable development.
  - Optimum utilization of resources
  - Saving of time and cost of the project
  - Properly conducted EIA also **lessens conflict** by promoting community participation, informing decision makers, and helping lay the base for environmentally sound project.
- **History of EIA in India**
  - » The Indian experience of EIA started in 1976-77 when the Planning Commission asked the Department of Science and Technology to examine the river valley project from an environmental angle.
  - » Till 1994, EIA was an administrative decision and lacked statutory backing.
  - » In 1994, the Ministry of Environment and Forest, under the EPA, 1986, promulgated an **EIA notification making environmental clearance mandatory** for expansion or modernization of any activity or for setting up new projects listed in Schedule 1 of the notification.
- **EIA Notification, 2006**
  - » Notified by MoEF&CC under the Environmental (Protection) Act, 1986.
  - » It makes it **mandatory for various projects** such as mining, thermal power plants, river valley, infrastructure (road, highway, ports, harbors and airports) and industries including very small electroplating or foundry units to get environmental clearance. This clearance is given only after the environmental requirements are fulfilled.
  - Unlike, the 1994 notification, it has put the **responsibility of clearing certain projects on the state government**:
    - **Category A** (National Level Appraisal): This category project mandatory require clearance and thus they don't undergo the screening process.
    - **Category B** (State level Appraisal) undergo screening process.
      - **Category B1** (mandatorily requires EIA)
      - **Category B2** (Don't require EIA)
- **Process of EIA**
  - » After 2006, EIA in India involves **four steps**:
    - Screening
    - Scoping
    - Public Hearing
    - Appraisal
  - » However, EIA process is cyclical with considerable interaction between various steps.

- The assessment is carried out by an Expert Appraisal Committee (EAC), which consists of scientists and project management experts.
  - The EAC frames the scope of EIA study and a preliminary report is prepared.
  - The report is published and a public consultation process takes place, where objections can be heard including from project-affected people.
  - The EAC then makes a final appraisal of the project and forward it to MoEF&CC. The Ministry is ordinarily obliged to accept the decision of the EAC.
- **Amendment to EIA Rules notified (July 2022)**
  - » It has exempted highway projects of strategic and defence importance, which are 100 km from the LoC, among other locations, from an environmental clearance before construction.
  - » Thermal power plants upto 15 MW based on biomass or non-hazardous municipal waste using auxiliary fuel such as coal, lignite or petroleum products up to 15% have also been exempted - as long as the fuel mix is eco-friendly.
  - » Increasing the threshold of ports which exclusively deal in fish handling and caters to small fisherman, which are exempted from environment clearance.
    - This is taking into account issues of livelihood security of fishermen involved at fish handling ports and harbors, and less pollution potential of these ports and harbors.
  - » **Toll plazas that need more width for installation of toll collection booths to cater to a large number of vehicles, and expansion activities in existing airport related to terminal building expansion without increase in airports existing area, rather than expansion of runways, etc., are two other exempted projects.**



# TARGET PRELIMS 2024

## BOOKLET-15; ENVIRONMENT-5

### CA UPDATES ON POLLUTION

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## 2. AIR UPDATES

### 1) DUST SUPPRESSANTS AND AIR POLLUTION MITIGATION

- **What are Dust Suppressants?**
  - » These are salts of calcium or magnesium that can absorb moisture.
  - » **Delhi government used** Dust suppressants on roads to control pollution. Environment Minister Gopal Rai had said “the Dust Suppressant powder would be mixed with water and sprayed on roads to keep the dust down for longer.”
- In 2019, the CPCB told the NCR states that they may consider using dust suppressants on excavated earth surfaces, piles of construction and demolition waste, and access roads in construction areas.
  - » **One of the CPCB study** had found that dust suppressants along with water is relatively more effective in control of pollution than conventional methods of dust control i.e. water spraying.
- In 2019, the Delhi Pollution Control Committee had also issued directions that all construction agencies will use dust suppressants to control dust emissions and road-owning agencies with use it in dusty patches.

## 3. WATER UPDATES

### 1) ‘WATER TRADING MECHANISM TO PROMOTE THE REUSE OF TREATED WATER’: NITI AAYOG REPORT

- **What is water trading?**
  - » This is a water market mechanism that considers water as a commodity that can be traded among users according to their needs. Under this, water rights are allocated to each sector, and they use it according to their needs – Buy when they need more water and sell when they need less.
  - » In many countries water trading has promoted water use efficiency.
- **NITI Aayog Report:**
  - » Though it may not be advisable to introduce a full-fledged water trading in India for various socio-economic reasons, trading of treated wastewater among industrial users could be tried.
- **Advantages of trading:**
  - » Increased treatment (currently only 40% of India's wastewater is treated).

### 2) GROUNDWATER EXTRACTION HAS SHIFTED THE EARTH'S AXIS: A NEW STUDY (JUNE 2023: IE)

- **Background: Earth's Axis Keep Shifting:**
  - » Earth spins around an imaginary axis which passes through the north pole, its centre of mass and the south pole – just like a top spin around its spindle.
  - » The poles and axis keep shifting naturally as the mass distribution in and on the planet changes. The phenomenon is known as “Polar Motion”.
  - » For e.g., rocks slowly circulating inside Earth's mantle causes the Planet's mass to shift, leading to a change in the position of the rotational axis.

- The study – “**Drift of Earth’s Pole Confirms Groundwater Depletion as a Significant contributor to Global Sea Level Rise 1993-2010**”, was published in the journal **Geophysical Research Letters**.
- The study noted that humans pumped out around 2150 gigatons of ground water between 1993 and 2010. This has led to planet’s axis drifting at a rate of 4.36 cm per year towards the east. Although the shift isn’t significant enough to have real-life consequences, but the study shows shift in planet’s axis and rise in global sea level.

### 3) NIT WARANGAL FACULTY MEMBERS DEVELOP INNOVATIVE WASTEWATER TREATMENT SYSTEM FOR TEXTILE INDUSTRY EFFLUENTS

- **Textile Effluents:**
- A team of faculty members at **NIT-Warangal** has developed an environment friendly hybrid wastewater treatment system for textile industry effluents.
  - » **Traditional methods** use a lot of chemicals.
  - » However, in the new method, in order to reduce pollution levels to permissible limits of discharge, the team put forward a combination of coagulation, hydrodynamic cavitation (HC) – based oxidation system and ceramic membrane (CM) – based filtration process.
  - » In the coagulation process – turbidity of the effluents is removed.
  - » HC, a process involving generation and collapse of microbubbles in a liquid, is employed afterwards to initiate the breakdown/mineralization of complex organic compounds.
  - » In place of Polymeric membrane, the novel methodology uses ceramic membranes. After two years, polymeric membranes need to be discarded. It becomes a solid waste.
    - The surface modified ceramic membrane further improves filtration efficiency, ensuring the removal of even finer particles and impurities.
  - » This integrated method achieved an 80% reduction in organic pollutants.

### 4) COASTAL AQUACULTURE AUTHORITY

- Why in news?
  - » Coastal Aquaculture Authority (Amendment) Act, 2023 passed by both houses of the Parliament.
- **Background:**
  - » The Coastal Aquaculture Authority Act 2005 was enacted with an aim to protect coastal environment, while promoting orderly growth of coastal aquaculture farming in coastal areas.
  - » The act has established Coastal Aquaculture Authority which regulates activities connected with coastal aquaculture in the coastal areas.
  - » The act has also defined coastal aquaculture to include culturing under controlled conditions in ponds, pens, enclosures or otherwise, in coastal areas of shrimp, prawns, fish or any other aquatic life in saline or brackish water, but doesn't include freshwater aquaculture.
  - » The act also ensures continued operation of coastal aquaculture within **CRZ area** subject to restrictions imposed by the Authority.
  - » It also penalizes unregistered farms in prohibited areas.
- **Impact:**

- » **Facilitated millions of jobs, self employment opportunities, businesss and environment protection.**
  - » **Increased production of fishery sector.**
- **Need of Amendment:**
- » Some ambiguities related to the provisions of CRZ notifications - like that of "**No Development Zone**" has been misinterpreted to be applicable in the hatcheries as well. Hence, aquaculture farmers and stakeholders have been requesting to remove the ambiguities and amend some of the provision of the act to make this legislation progressive and decrease the regulatory burden.
- **2023 Amendment:**
- » **Broadens the definition** of Coastal aquaculture to include things like cage culture, sea-weed culture, bivalve culture, marine ornamental fish culture etc.
  - » **Registration given** under the Coastal Aquaculture Authority Act will be considered a valid permission under CRZ notification. This will enable lakhs of small marginal aquaculture farmers to avoid the possible need for obtaining CRZ clearances from multiple agencies.
  - » **Some Aquaculture activities** like hatcheries, nucleus breeding centres, and broodstock multiplication centres can be established in NDZ [200 m from HTL] of seas and buffer zones of creeks/rivers/backwaters.
  - » **Decriminalization** of cases of illegal coastal aquaculture and fixed penalties.
    - The original act provided for imprisonment for a period of 3 years for carrying out coastal aquaculture without registration. This was a very harsh punishment for an offence of purely civil nature.
  - » **Increase in role of the Authority:**
    - Fix standards of input and discharge of effluents from aquaculture units.
    - Prohibition of certain harmful inputs
    - Monitor and regulate various aquaculture units, inputs and outputs.
  - » The act also **prohibits the use of insecticides** and other pharmacologically active substances that can harm human health in coastal aquaculture.

## 4. PLASTIC UPDATES

### 1) PLASTIC OVERSHOOT DAY: BY EARTH ACTION (EA) (JULY 2023)

- On July 28, 2023, the Earth saw its first Plastic Overshoot Day: The point at which the amount of plastics exceed the global waste management capacity - As per Swiss based research consultancy Earth Action (EA).
  - » Nearly 68 million tonnes of additional plastic waste will end up in nature in 2023.
  - » India is among the 12 countries of the world including China, Brazil, Indonesia, Thailand, Russia, Mexico, USA, Saudi Arabia, the DRC, Iran and Kazakhstan, which are responsible for 52% of the world's mismanaged plastics.
  - » Under current scenario, despite pledges and increased waste management capacity, increased production of plastics will lead to global plastic pollution tripling by 2040.
- Plastic Overshoot Day is determined on the basis of country's Mismanaged Waste Index (MWI).

- » The imbalance between the volumes of plastic that are produced and used, as well as the world's ability to manage those volumes when they become waste, is the root cause of plastic pollution. The gap in waste management capacity and plastic consumption is called MWI.
- » India ranks fourth (after Mozambique, Nigeria, and Kenya) in terms of highest mismanaged waste with 98.55% of generated waste being mismanaged.

## 2) US STUDY FINDS HUNDREDS OF THOUSANDS OF NANOPLASTIC PARTICLES IN BOTTLED DRINKING WATER (JAN 2024)

### - About the Study:

- » The research was published in journal - *Proceedings of the National Academy of Sciences*.
- » The study analysed micro and nanoplastics in three popular brands and daily consumed bottles of water using a technique called stimulated Raman scattering microscopy. The technique passes two lasers through the sample. It is particularly suitable for the identification of microplastics due to its ability to distinguish different types of plastics based on their molecular fingerprints.
  - The team looked for seven common types of plastics: Polyamide, polypropylene, polyethylene, polymethyl methacrylate, polyvinyl chloride, polystyrene, and polyethylene terephthalate.

### - Key Findings:

- » Each litre of bottled water contains 110,000 to 370,000 plastic particles — and about 90 per cent of them are nanosized (less than 1 micrometer in size), a new study has found.
- » These nanoplastics are even smaller than microplastics and pose a greater risk to human health. Unlike microplastics, nanoplastics can move from the intestine and lungs directly into bloodstream before reaching the heart and brain.

## 3) PET46: NEWLY DISCOVERED DEEP-SEA ENZYME BREAKS DOWN PET PLASTIC (SEP 2023)

- A new study involving scientists from Professor Ruth Schmitz-Streit's research group at Kiel University has shown for the first time, using microorganisms from the deep sea, that polymers such as PET are continuously degraded by an enzyme called PET46.
  - » The results fundamentally expand the knowledge of PET degrading enzymes, the underlying mechanisms and the evolutionary understanding of the diversity of putative PET-degrading enzymes throughout the global ocean.



# TARGET PRELIMS 2024

## BOOKLET-16; EB&CC-6

### CLIMATE CHANGE, OZONE LAYER, DESERTIFICATION

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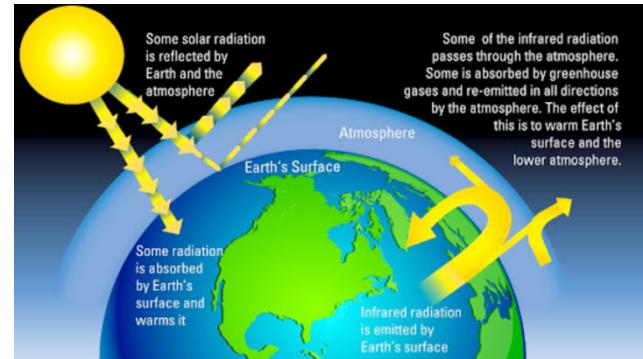
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## 2. CLIMATE CHANGE AND GREEN HOUSE GASES

- **Climate:** Long term pattern of weather in a particular area.

- **Climate Change:**

- The increasing temperature of earth due to greenhouse effect is known as climate change. It is leading to extreme weather events, melting of Polar ice, rising of sea levels etc.



- **Green House Effect:** Class discussion

- **Greenhouse Gases:** Gases in the earth's atmosphere that trap heat are known as Greenhouse gases. They let sunlight pass through the atmosphere, but they prevent the heat that the sunlight brings from leaving the atmosphere. Greenhouse gases are crucial for survival of life on earth. In the absence of Greenhouse gases, the average temperature on earth would have been -18 degree Celsius instead of the present 15 degree Celsius.

### 1) WATER VAPOR:

It is the most important Greenhouse gas and plays an important role in controlling earth's temperature.

- Water Vapors account for about 60% of the warming effect. The amount water in atmosphere rises with rising temperature and decreases with the fall in temperature. So, in a way it can be said that water vapors in atmosphere is controlled by the temperature.
- But it is the non-condensable gases (mainly CO<sub>2</sub> which is bringing the increase in the temperature after the first industrial revolution) which are really responsible for recent rise in global warming.

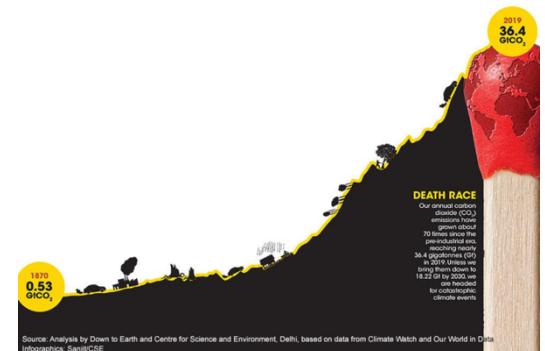
### 2) CARBON DIOXIDE (CO<sub>2</sub>)

- It is produced by **burning of carbon containing substances**, mostly fuels (Coal, natural gas, oil), Solid waste, trees, other biological materials etc.

- CO<sub>2</sub> is removed from atmosphere when it is absorbed (sequestered) by plants during photosynthesis.

- **Concentration of CO<sub>2</sub> in atmosphere:**

- For the first time in history, the atmospheric CO<sub>2</sub> level reached 419 parts per million (PPM), as measured by the United States' National Oceanic and Atmospheric Administration's Mauna Loa Atmospheric Baseline Observatory in Hawaii.
  - » This is nearly 45% above the pre-industrial baseline of 278 PPM in 1750 accepted by IPCC.
- Our annual CO<sub>2</sub> emission have grown about 70 times since the pre-industrial era reaching nearly **36.4 Gt** in 2019.



### 3) METHANE

- As per UNEP, **Methane** is a GHG which is responsible for 30% of the warming since pre-industrial times. Its contribution is 2nd only to carbondioxide.
  - » Although the warming effect of methane is 30 times greater than CO<sub>2</sub>, it is a shorter lived and lasts in the atmosphere for about 12 years. (CO<sub>2</sub> lingers for centuries)
- **Why special focus on methane is needed in our fight against climate change?**
  - » IPCC had said that the methane mitigation has the greatest potential to slow warming over the next 20 years.
    - A 0.3% reduction per year in methane is equivalent to net-zero for CO<sub>2</sub> - there would be no additional warming if this level of reduction is achieved.
- **Methane Emission: Biggest Source:**
  - **Natural Sources:** Wetlands, termites etc.
    - **Wetlands** are the largest source of methane.
  - **Agriculture** - Rice cultivation, animal husbandry etc. generate substantial amount of methane.
  - **Energy Production** (fossil fuel) - Among anthropogenic factors, after Agriculture, it is this sector which contributes to the highest methane production. It is released during the extraction, processing, and transport of fossil fuels, including coal, oil, and natural gas.
  - **Leakage:** For e.g. the ruptures in the underwater Nord stream in Sep 2022 caused the single largest such release of the greenhouse gas.
  - **Landfills** in recent times are also becoming a big source of methane emissions.
  - **Thawing of permafrost** in polar region is also releasing methane. In future, it may become a big source of methane emissions.
- **Current Emission levels:**
  - As per US NOAA, the atmospheric level of methane has jumped to 17 parts per billion in 2021, beating the previous record set in 2020.

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## A) INTERNATIONAL EFFORTS TO FIGHT METHANE POLLUTION

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### IMPROVING DETECTION:

- UNEP has launched International Methane Emissions observatory - the Methane Alert and Response System (MARS) at COP27. It is focused on scaling up global efforts to detect and act on major emissions sources in a transparent manner and accelerate implementation of the global methane pledge.

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### GLOBAL METHANE PLEDGE ANNOUNCED AT COP26

- By COP27, 150 countries have joined the initiative lead by USA and EU. They have promised to cut their methane emission by at least 30% from 2020 levels by 2030.
- **Significance:**
  - » Global warming would be reduced by at least 0.2 degree Celsius by 2050, if countries deliver according to the pledge.

- » **Health benefits:** Oxidation of methane is responsible for formation of ground-level ozone (smog), which is a harmful air pollutant.
- **Why has India not joined the pledge?**
  - » India's methane emissions are 'survival emissions' and not 'luxury' emissions.
    - The two prominent source of methane in India are enteric fermentation and 'paddy cultivation' and any restriction on them would harm small and marginal farmers.
  - » Other than harming farmers, it may also reduce agri production. Currently, India is one of the largest producers and exporters of rice.
  - » India also argues that 6th IPCC report has highlighted that CO2 is the major global warming gas and this pledge is shifting focus to methane which has a lifetime of only 12 years, whereas CO2 can survive for more than 100 years.
- **India has not joined the global methane pledge**, but it doesn't mean the India is not worried about methane emissions. There are several fronts on which India is working.
  - » **National Innovation in Climate Resilient Agriculture (NICRA)** project of ICAR has developed several technologies with the potential to mitigate methane emissions.
    - For instance, the 'System of Rice Intensification' has the potential to enhance rice yield from 36-49% with 22-35% less water than conventional transplanted rice. It also uses less seed, fertilizers, and pesticides.
      - » Key steps involve:
        1. Planting young seedlings (less than 15 days old) with only one or two leaves
        2. Planting them singly, spaced widely apart
        3. Maintaining soil moisture at a level that promotes aerobic soil conditions
        4. Controlling weeds by mechanical means, such as hand weeding or using a rotary hoe
        5. Using organic matter to improve soil fertility.
        6. Applying small amounts of fertilizer at specific stages of plant growth
      - Another technology, 'Direct Seeded Rice' reduces methane emissions as it does not involve raising nurseries, puddling, and transplanting. Unlike transplanted paddy cultivation, standing water is not maintained in this system.
      - **Harit Dhara:** It is an anti-methanogenic feed supplement developed by ICAR. It can cut down cattle methane emissions by 17-20% and can also result in higher milk production.
      - Under Crop Diversification Program, methane emission is being avoided due to diversion of paddy to alternate crops like pulses, oilseeds, maize, cotton, and agro-forestry.

## B) REPORT: METHANE GLOBAL TRACKER REPORT BY IEA (FEB 2023)

- **Summary:**
  - » **Emissions from Energy Sector:** The energy sector accounts for around 40% of the total average methane emissions from human activity, as oil and natural gas companies are known to release methane into the atmosphere when natural gas is flared or vented. The greenhouse gas is also released through leaks from valves and other equipment during drilling, extraction and transportation process.
- **How can methane emission be reduced:** Although, it's impossible to completely eliminate all the emissions, **75% of the methane emissions from the energy sector** can be reduced with the help of cheap and readily available technology. However, **fossil fuel companies have failed to take any substantial action regarding the issue.**
- The effort will cost less than 3% of the net income received by the oil and gas industry in 2022.
- **Details:**
  - » Fossil fuel companies emitted 120 million metric tonnes of methane into the atmosphere in 2022, only slightly below the record high seen in 2019.
  - » The cheap and readily available technology can reduce 75% of the methane emissions from the energy sector.

### C) BURP CONTROL: HOW CAN METHANE RELEASED IN LIVESTOCK BELCHED BE REDUCED? (DEC 2022: SOURCE - DTE)

- **Feed Supplements** - which can reduce a potent greenhouse gas belched out by stock animals like cattle, goat and sheep. A food supplement is considered ideal if it can **lower methane emissions by at least 20%**.
- In 2021, **EU approved a food supplement, Bovaer**, developed by Dutch bioscience company Royal DSM, saying it consistently reduces methane emissions from dairy cows by 30-80%.
  - **Bovaer**, is a fine granular powder containing **3-nitrooxypropanol**, which inhibits an essential enzyme responsible for the methane production.

### D) TERMITES EMIT METHANE: BUT THE EXTENT OF THEIR RISK TO GLOBAL WARMING IS UNCERTAIN (SOURCE: DTE)

- As per the Global Carbon Project, in 2008-17, the world emitted 576 Tg of methane per year, of which termites contributed 9 Tg.
- **However**, scientists say that the real emissions may be greater or lesser than this. To establish certainty, there is a need to understand the relationship between termite colonies and methane.
- **How is methane produced by Termites?**
  - In natural ecosystems, they feed on and recycle the nutrients present in dead and decaying plant and animal matter.
  - It is this cellulose-rich diet that causes their emissions.
  - **Methanogenic microorganisms** that live in the gut of termites break down the cellulose entering the body and release methane.

### 4) NITROUS OXIDE (N<sub>2</sub>O)

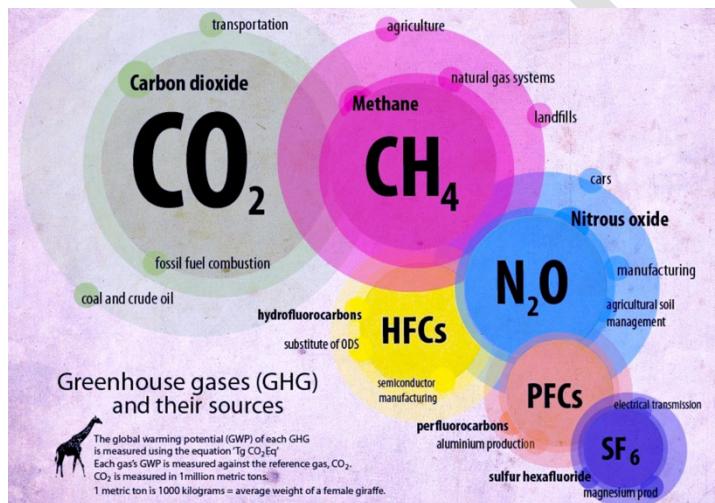
- It is the third most important GHG. It is long lived (average > 100 years), and also has ozone depleting properties.

- It is a natural part of the nitrogen cycle. Bacteria in soil and the ocean make it. It is also produced during agricultural and industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater.
- **Reports: Global Nitrous Oxide Budget**
  - N<sub>2</sub>O is accumulating in the atmosphere at an increasing rate, with **global emissions of 17 Tg N in 2016, 10% greater than in the 1980s**. **Net emission** (thus net addition) is **4.3 Tg**.
  - **Main Anthropogenic factors** is the agriculture.
    - Other factors include - fossil fuels, industry, waste and wastewater, and biomass burning.

## 5) OZONE (O<sub>3</sub>) -> ALREADY COVERED WITH AIR POLLUTION

## 6) FLUORINATED GASES (HFCS, PFCS, SF<sub>6</sub>, NITROGEN TRIFLUORIDE (NF3) ETC.)

- Not naturally found in atmosphere and are manmade.
- Fluorinated gases are used as substitute for ozone depleting substances like CFCs, HCFCs, and Halons.
- Though they are released in small quantities, but their global warming potential is very high.



## 7) BLACK CARBON

- **What is black carbon?**
  - » It is the sooty black material emitted from gas and diesel engines, coal-fired power plants, and other sources that burn fossil fuel. It comprises a significant portion of particulate matter or PM, which is an air pollutant. It consists of pure carbon in several linked forms.

- **Environment Pollutant** - It is a **short-lived** pollutant which is the key component of PM<sub>2.5</sub>. It has negative implications for our health and may cause respiratory and cardio-vascular diseases, cancer, birth defects and premature mortality.
- **Climate Change:** It is also responsible for **climate change**.
  - » BC deposits can **accelerate the pace of glacier and snow melt** in the Himalayan region.
    - How?
  - » It is also responsible for affecting the cloud formation and thus affects rainfall.
  - » A recent study has shown that it may also be depleting ozone layer.
- **Main Sources: Incomplete burning of fuel** (i.e., inefficient burning environment) produces black carbon.
  - » **Solid Fuel burning** [coal, biomass etc.]
    - Industry (primary brick kilns) and residential burning of solid fuel together account for about 45-66% of anthropogenic BC deposition in Himalayan region.
  - » **Diesel exhausts** etc. contributes to 7-18% of BC deposits in the Himalayan region.
  - » Since, India has a large population depending on **bio-mass and solid fuel**, it contributes to around 25% of the world's Black Carbon emission.
    - According to a study published in the journal *Atmospheric Research* in April 2019, India is the 2nd largest contributor to Black carbon in the world.
- **Steps taken by Government to reduce black carbon:**
  - Enhancing **fuel efficiency standard of Vehicles**, phasing out diesel vehicles and promoting electric vehicles
  - Promotion of the use of **LPG** for cooking (**PM Ujjawala Yojana**)
  - Clean Cookstoves program
  - Upgrading brick kiln technologies
  - **Real time monitoring of black carbon aerosols in the Glaciated valley of northwestern Indian Himalayas.**
- However, with all existing measures, water from glacier melt is still projected to increase in absolute volume by 2040, with impact on downstream activities and communities.

## 8) BROWN CARBON

- **Brown carbon** is emitted mainly by **biomass combustion**. It is a **light absorbing** part of the **organic aerosol** (note: soot is also light absorbing in nature). In recent years it has come under a lot of research.
  - It absorbs strongly in the ultraviolet wavelength (high frequency) and less significantly into the visible (low frequency).
- **Sources of Brown Carbon**
  - » **Tar Material** from smoldering fires or coal combustion.
  - » **Breakdown products** from biomass burning, stubble burning.
  - » **A mixture of organic compounds** emitted from soil, and volatile organic compounds given off by vegetation.

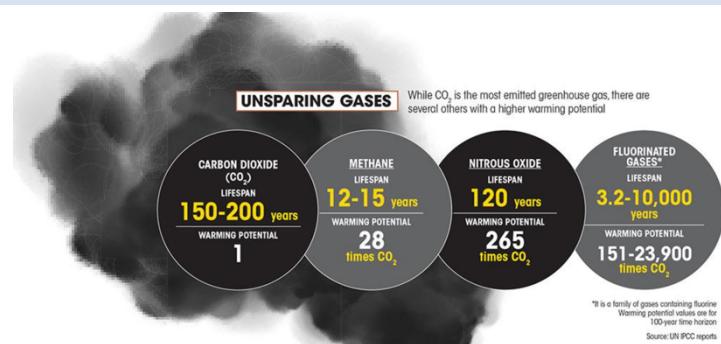
- **TAJ: The Pollutants causing discoloration identified**
  - » **Particulate carbon and fine dust particles** that are deposited on the marble are responsible for its browning.
  - » **Brown Carbon:** The group of carbon which absorbs light in the blue region of spectrum, and this is called brown carbon. Discoloration is because of what is happening to reflectance, reflectance in turn is influenced by these particles.
  - » **Presence of hematite in the dust** that is responsible for the **brown hue**. If hematite is not present in the dust then the dust would be only scattering in nature. Hematite is the ingredient that absorbs the blue wavelength of the spectrum.
- **Note: Brown Carbon vs Black Carbon**
  - » Black carbon is primarily produced by high temperature combustion and brown carbon is emitted mainly by biomass combustion.
  - » Of the total atmospheric absorption by aerosol, brown carbon contributes about 19%, while 72% is contributed by Black carbon. The remaining 9% is due to the coating effect of sulfate and organic aerosols on black carbon.
  - » Both of these are two most important light absorbing substances in the atmosphere.
- **Tarballs and its implications**
  - » Tarballs are formed from brown carbon. They are small light absorbing, carbonaceous particles formed due to burning of fossil fuels that deposit on snow and ice.
  - » Recent research has shown that tarballs from long-range transport can be an important factor in the climatic effect of glacier melting in Himalayas.
    - Nearly, 28% of particles collected from the air samples from a research station in Himalayan-Tibetan Plateau were tarballs.

#### Extra for Pre

**Blue Carbon:** It is the carbon that is stored and sequestered in the coastal ecosystem such as Mangroves, seagrass meadows and intertidal saltmarshes.

### 9) EFFECT OF A GAS ON CLIMATE CHANGE DEPENDS ON THREE MAIN FACTORS:

1. **Quantity** i.e., how much of the gas is present in the atmosphere.
  2. **Life** i.e., for what duration can the gas survive in atmosphere
  3. **Strength** i.e., how strongly they trap the heat
- For each gas a **Global Warming Potential (GWP)** is calculated by considering its duration of existence (i.e., life) and strength of its impact.



### 10) SDG AND CLIMATE CHANGE

- **Goal 13: Climate Action**
- **Targets**
  - Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
  - Integrate climate change measures into national policies, strategies and planning.
  - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
  - Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
  - Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

### 3. IPCC AND ASSESSMENT REPORT 6 (AR-6)

- **Recent News:**
  - Scotsman **James Skea** elected new IPCC chair in Nairobi. He is a professor of sustainable development at Imperial College London and will lead IPCC through its seventh assessment report (July 2023: Source: DTE)
    - » The election was held at 59th session of IPCC which was held at UNEP headquarter in Nairobi, Kenya.
- The Intergovernmental Panel on Climate Change (IPCC) is the UN body for assessing the science related to climate change. Its job is **to assess already published scientific literature** to update our knowledge of climate change science.
  - IPCC's Assessment Reports (ARs), which are produced every few years, are the most comprehensive and widely accepted scientific evaluations of the state of Earth's climate.
  - They form the basis for government policies against climate change and provide scientific foundation for the global Climate Change negotiations.
  - So far, **Six Assessment Reports** have been produced.
- **IPCC was set up in 1988** by World Meteorological organization (WMO) and United Nations Environment Program (UNEP) to provide policy makers with regular assessment of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigations.
- Currently it has 195 members and relies on thousands of scientists who volunteer their time to support its work.
  - **India** is a member of IPCC

## A) WHAT HAVE PREVIOUS REPORTS (AR-1 TO AR-5) SAID?

- The first **Assessment Report** (1990) noted that anthropogenic emissions are increasing atmospheric GHGs. In the business-as-usual scenario, temperature was likely to increase by 2 degree C compared to pre-industrial levels by 2025, and 4 degree C by 2100.
  - » The report formed the basis for the negotiation of the UNFCCC in 1992, known as the Rio Earth Summit.
- The **Second Assessment Report** (1995) revised the projected rise in global temperature to 3 degree C above pre-industrial level by 2100. It was the scientific underpinning for the Kyoto Protocol of 1997.
- The **third Assessment Report** (2001) projected the rise in global temperature to 1.4 to 5.8 degree C by 2100 compared to 1990.
- The **fourth Assessment Report** (2007) said that the GHG emissions increased by 40% between 1970 and 2004 and the atmospheric CO2 was the most in 650,000 years. In the worst-case scenario, the global temperature could rise by 4.5 degrees.
  - » The report won the 2007 Nobel Peace Prize for IPCC. It was also the scientific input for the 2009 Copenhagen Climate meeting.
- The **fifth Assessment Report** (2014) said that more than 50% of the temperature rise since 1950 is due to human activities. The rise in global temperature by 2100 could be as high as 4.8 degree C from pre-industrial times, and more frequent longer heatwaves were "virtually certain". It formed the scientific basis of the Paris Agreement in 2015.

### 1) IPCC SYNTHESIS REPORT

- **Why in news?**
  - » The IPCC has released its Synthesis report for the sixth assessment Cycle on 20th March in Interlaken, Switzerland
    - The report was signed by country representatives - an unusual step taken to ensure governments accept its findings (March 2023)
- **What is the report?**
  - » It is a compilation of the main findings of the IPCC's sixth assessment report, based on the results from three Working Groups (WGs).
    - **WG I evaluated the physical science basis of the climate change.**
    - **WG II evaluated the impacts, adaptation, and vulnerability,**
    - **WG III evaluated the mitigation.**
    - The synthesis report also drew from Special Report based on Global Warming of 1.5 degree C (Oct 2018), Climate Change and Land (August 2019), and the Ocean and Cryosphere in a Changing Climate (Sep 2019)
  - » The report was finally approved by nations after major economies like China, Brazil, Saudi Arabia, the US, and EU raised concerns about the working of the text.
  - » **Key Highlights:**

- The report highlights the urgency of drastically reducing the emission of greenhouse gases and so limit rising global temperature by 1.5 degree C from pre-industrial levels, set by the Paris Agreement.

## 2) AR-6

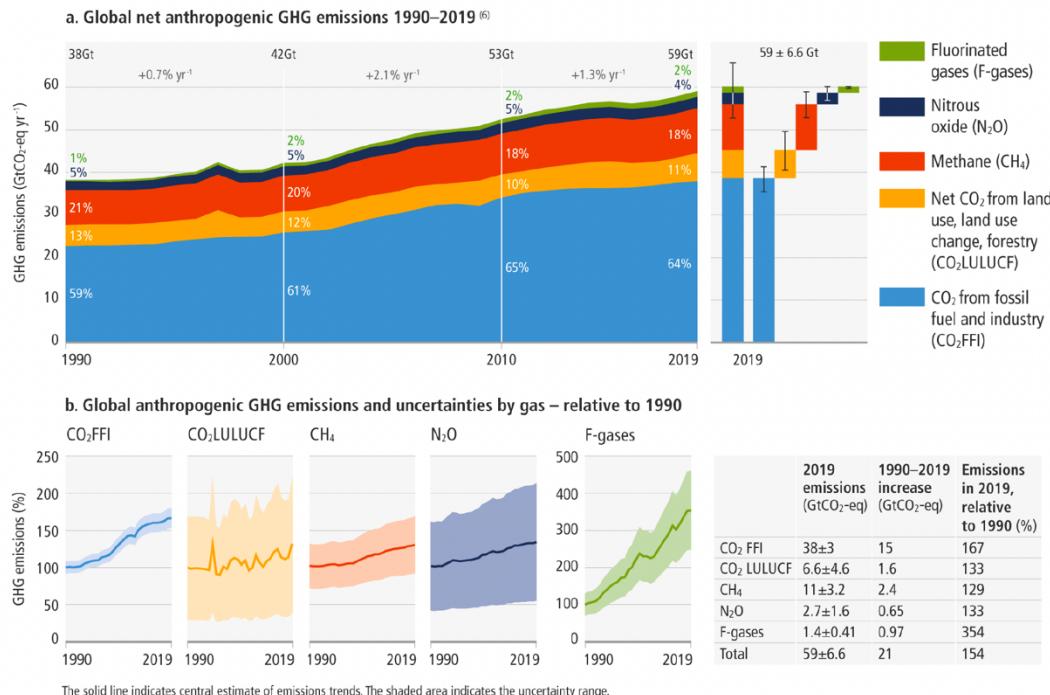
- The sixth report was published in **three parts**: - the first in Aug 2021, the second in Feb 2022, and the third in April 2022. These three parts were by **three working groups of scientists**:
  - **Working Group-1:** Deals with **scientific basis of climate change**
  - **Working Group-2:** Looks at **likely impacts, vulnerabilities, and adaptation issues**.
  - **Working Group-3:** Deals with **action that can be taken to combat climate change**.
- The first report "**Climate Change 2021: The Physical Science Basis**" highlighted the following:
  1. Climate was changing more rapidly than originally anticipated by climate scientists.
  2. Rise in **global temperature was direct result of human activities** and there is 'unequivocal evidence' about it.
  3. Temperature has already rise by 1.1 degrees from the pre-industrial 19th century.
  4. **Greenhouse gas Emissions:**
    - Emissions of Carbon dioxide, methane and nitrous oxide breached records in 2020.
    - CO<sub>2</sub> Concentration in the atmosphere - at around 416 parts per million - are the highest they have been in 2 million years.
  5. **Impact:**
    - A more intense and frequent heatwaves; increased incident of extreme rainfall; a dangerous rise in sea-levels; prolonged droughts; Melting of glaciers.
- The second report: **Climate Change 2022: Impacts, Adaptation and Vulnerability**
  - The report recognizes the interdependence of climate, ecosystem, and biodiversity, and human societies and integrates knowledge more strongly across the natural, ecological, social and economic sciences than earlier IPCC reports.

## A) THE THIRD REPORT: CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE

- The report lays out actions that the world can take to stop global temperatures rising beyond certain levels by the end of the century.
- If countries stick to current NDC commitments, it will lead to breach of 1.5 degree C temperature rise.
  - Even the 2-degree Celsius target, in that case, would rely on "rapid acceleration" of climate actions after 2030.
  - **What should be the reduction to prevent temperature rise beyond 1.5 degree C?**
    - Global GHG emissions to peak before 2025 at the latest and be reduced by 43% by 2030; at the same time methane also needs to be reduced by 43% by 2030. Global use of coal, oil and gas in 2050 must decline by about 95%, 60% and 45% respectively, relative to 2019.
    - Even if all this happens, it is almost inevitable that this ceiling would be temporarily breached but, with appropriate action, it could again dip by the end of century.

- Global warming would stabilize if emissions reach net zero.
  - For 1.5 degree C target, this meant achieving net zero emissions globally in the early 2050s; for 2 degree C, it is in early 2070s.
  - Even limiting warming to 2 degree C would require greenhouse gas emissions to peak before 2025 at the latest and be reduced by a quarter by 2030.

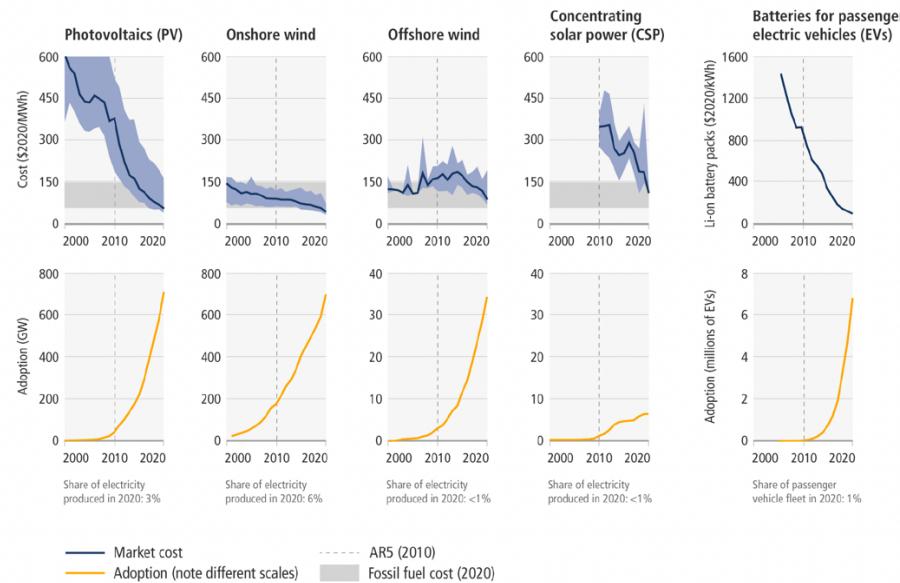
Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.



- Carbon Inequality remains pervasive as ever with LDCs emitting only 3.3% of global emissions in 2019.
  - Their average per capita emissions in the period 1990-2019 were only 1.7 tonnes CO2e, compared to global average of 6.9 tCO2e.
- The Least Developed Countries (LDCs) emitted only 3.3% of global emissions in 2019.
- Abundant and Affordable Solutions exist across sectors including energy, buildings, and transport, as well as individual Behavioural changes.
  - The report has detailed 60 different options and pathways that can lead to 40-70% reduction in global emissions.
  - It states with high confidence that "several mitigation options, notably solar energy, wind energy, electrification of urban systems, urban green infrastructure, energy efficiency, **demand side management**, improved forests - and crop/grassland management and reduced food wastage and loss, are technically viable, are becoming increasingly cost effective and are generally supported by the public".

- The per-unit costs of several low emissions technologies have fallen continuously since 2010, however innovation has lagged in developing countries due to weak enabling conditions.
  - On a unit costs basis, solar energy has dropped 85%, wind by 55%, and lithium-ion by 85%.
    - Their deployment and usage has increased multifold since 2010 - 10 times for solar and 100 times for electric vehicles.
  - Factors:** Higher public spending in R&D; Funding for demonstration and pilot projects; and demand pull instruments such as deployment subsidies to attain scale.

The unit costs of some forms of renewable energy and of batteries for passenger EVs have fallen, and their use continues to rise.



- The report covers **demand side mitigation** and states that it can help reduce emissions by 40-70% by 2050.
  - Demand Side Mitigation can be achieved through changes in socio-cultural factors, infrastructure design and use, and end-use technology adoption by 2050.

| Food | Industry | Land transport |
|------|----------|----------------|
|------|----------|----------------|

|  |   |  |
|--|---|--|
| <p>■ Socio-cultural factors</p> <p>Dietary shift (shifting to balanced, sustainable healthy diets), avoidance of food waste and over-consumption</p> <p>■ Infrastructure use</p> <p>Choice architecture<sup>1</sup> and information to guide dietary choices; financial incentives; waste management; recycling infrastructure</p> <p>■ End-use technology adoption</p> <p>Currently estimates are not available (for lab-based meat and similar options – no quantitative literature available, overall potential considered in socio-cultural factors)</p> | <p>Manufactured products</p> <p>■ Socio-cultural factors</p> <p>Shift in demand towards sustainable consumption, such as intensive use of longer-lived repairable products</p> <p>■ Infrastructure use</p> <p>Networks established for recycling, repurposing, remanufacturing and reuse of metals, plastics and glass; labelling low emissions materials and products</p> <p>■ End-use technology adoption</p> <p>Green procurement to access material-efficient products and services; access to energy-efficient and CO<sub>2</sub> neutral materials</p>  | <p>Mobility</p> <p>Teleworking or telecommuting; active mobility through walking and cycling</p> <p>Public transport; shared mobility; compact cities; spatial planning</p> <p>Electric vehicles; shift to more efficient vehicles</p> |
| <p><b>Building</b></p> <p><b>Shelter</b></p> <p>Social practices resulting in energy saving; lifestyle and behavioural changes</p> <p>Compact cities; rationalisation of living floor space; architectural design; urban planning (e.g., green roof, cool roof, urban green spaces etc.)</p> <p>Energy efficient building envelopes and appliances; shift to renewables</p>  | <p><b>Electricity</b></p> <p>■ Additional electrification (+60%)</p> <p>Additional emissions from increased electricity generation to enable the end-use sectors' substitution of electricity for fossil fuels, e.g. via heat pumps and electric cars {Table SM5.3; 6.6}</p> <p>■ Industry</p> <p>■ Land transport</p> <p>■ Buildings</p> <p>■ Load management<sup>2</sup></p> <p>Demand-side measures -73%</p> <p>Reduced emissions through demand-side mitigation options (in end-use sectors: buildings, industry and land transport) which has potential to reduce electricity demand<sup>3</sup></p> |  |

- **Individuals can also contribute in other ways:**
  - Putting political pressure on leaders.