MARINE POLLUTION - A PERSPECTIVE, MONITORING AND CONTROL IN INDIA

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1. INTRODUCTION

The Ocean covers approximately 70% of the earth's total surface area. In the total water content of earth, 97% is present in the Oceans. It harbours rich source of biodiversity, which population may exceeds in trillions. Oceans are the main regulatory agent of earth's climate. About 60% of the world's population live within 60 km of coastline and use the coastline for their livelihood. It was thought that human being, living only on one-third of the portion of globe, cannot pollute this vast amount of water, as the marine ecosystems are capable of serving as sink for all the pollution caused by us. However, in reality this is not true. We have come to realize that our waste, even in small quantities, have huge effects on ocean communities and species. More over, it is difficult to believe that something so massive and seemingly resilient can really be adversely affected by our activities. Environmental pollution of the coast, inshore water and deep ocean is one of the important topical issue in the context of human health and global warming. The major pollutants like oil, sewage, garbage, toxic chemicals, pesticides, heavy metal, radioactive waste, thermal pollution, and eutrophication in coastal and marine environments, their characteristics and principal impacts are discussed in detail.

1. 1. Definition of Marine Pollution

The term marine pollution was defined by United Nations working group called "Group of Experts on Scientific Aspects of Marine environmental Protection (GESAMP)". GESAMP defined it as "Pollution means introduction by man, directly or indirectly of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater and reduction of amenities".

1. 2. Why marine pollution is a concern?

We should care about the continuing environmental degradation of our oceans and costal areas because it is detrimental to human health, economic development, climate and our planet's store of biodiversity. It is interfering with the sustainability of environment and its resources.

1. 3. What is biodiversity?

The biodiversity Convention - Article 2 states that "Biological Diversity" means the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

1. 4. What is Sustainability?

Sustainability can be defined as the development that meet the need of the present, without compromising the ability of future generation to meet their own needs.

1. 5. Categories of man made effects

Man's effect on the marine environment may be divided into the following general categories.

1. Alteration of bottom substrate through degrading, changing of shoreline structures, and filling.
2. Introduction of toxic substances dangerous either to marine life or to human beings
3. Release of sewage rich in nutrients with marine microorganisms
4. Heating and release of heated water by power plants

To study the effect of a particular type of pollution or multiple type of pollution Environment Impact Assessment (EIA) are being made at needed location considering various parameters.

1. 6. Definition of Environmental Impact Assessment

EIA is the systematic, reproducible and interdisciplinary consideration of the potential effects of a proposed action and its reasonable alternatives on the physical, biological, cultural and socioeconomic attributes of a particular geographic area. Also it is a decision making process designed to help integrate economic, social and environmental concerns and of mitigating the adverse environmental impacts of activities related to projects, plans, programs or policies.

The effect of pollutant can be divided into long-term (chronic) and short-term (acute) effects. Chronic pollution involved in the introduction of a toxic substance or other anthropogenic factor, often continuously and in fairly low levels, causing degradation of the environment. Input of nutrients through sewage is a good example. In the short term inputs, it may have sharp effects, but these may dissipate with time. The oil spill in marine area is an example for the short term toxic input. Oil spill often has catastrophic effects on the marine biota when released. However, the effects may gradually reduce as the oil break down after a span of a considerable time.

In chronic studies, the organism of interest is exposed to a low concentration of the contaminant such as heavy metal, pesticides, or oil for a significant stage of its life cycle or the entire life cycle (i.e. generally weeks to years depending on the reproductive life cycle of organisms). Typical effects of endpoints include reproductive failure, growth retardation, development impairment, as well as behavioural changes. In acute studies, the organisms of interest is exposed to a low to lethal concentration of a contaminant such as heavy metal, pesticides or oil for only a small portion of its life cycle (i.e., generally less than four days). The effects of endpoints include mortality or immobility.

1. 7. Marine pollution in the coastal zone

The coastal zone is defined as "The area extending from the coastal plains to the edge of continental shores, approximately matching the region that has been alternatively flooded and exposed during the sea level fluctuation of the late quaternary period" (Lociz Science Plan, 1998).

In the earth's surface, 18% is represented by coastal zone, which provide space for 60% of the world's human population. Because, 70% of the world cities with population exceeding 1.6 million are located in this zone. Interestingly, 90% of the world fish catch is obtained from coastal zone. The coastal zone is only 8% in the hydrosphere, but responsible for 18-33% of the total primary production. The biological wealth of this zone is very high as it served as feeding, nursery and spawning grounds with rich biodiversity.

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2. SOURCES OF MARINE POLLUTION

The main sources are atmosphere, river runoff, agriculture, livestocks, urban runoff, automobiles, land clearing, sewage outfall, industrial waste etc.

2. 1. Sources of pollution in the coastal zone

In general the coastal zone receives pollutants from major ways viz., atmosphere, reverine and glacier. Also anthropogenic activities serve as the geological agents by ways of discharging the effluents through piped outfalls, direct dumping, operation of ships etc. Frequently preservatives have been intentionally used assuming that they are relatively harmless to the cultured species. These include antifoulants, of which the broad ecological effect of tributyltin (TBT) is a good example.

Pollution may arise from point source like a single sewer pipe or factory wastewater outfall, or it can arise from a variety of geographic points otherwise called as non point source. In the point source pollution the concentration of the substance or the intensity of the effect (e.g. temperature near cooling water outfalls of power plants) should decline with increasing distance from the point source. The dissipation or decline depends on the nature of substance or factor, water currents and the sedimentary environment and rate of introduction of the substance or factor. In this case management options may be developed by a regulatory agency. In contrast to this, the non-point source effects cannot be attributed to any single spot. Runoff arises due to rain is an example of a non point source. The toxic substance and other fertilizer based nutrients may spread over the coast. However, these sources are more difficult to manage, because the source is widespread over a spectrum of earth surface.

3. INDICATORS OF POLLUTION

Many organisms serve as indicators of marine pollution. For example, the ecological shift in the succession of phytoplankton communities from diatoms to dinoflagellates due to metal pollution & thermal pollution. The poor hatching of eggs and soft calcium shell of birds and mass mortalities of birds due to failure in the earlier metabolites by the interference of pesticides, large scale mass killing of birds due to casting, asphyxiation and smothering by oil pollution, reproductive failure in mammal are also some of the indicators of severe pollution.

Usually the pollutants exceeding threshold limits combined with environmental variables such as temperature, salinity, pH, dissolved oxygen, hydrogen sulphide etc., give stress to the organisms. In most cases the migratory organisms such as fishes could avoid the polluted area. Whereas the residential or sedentary organisms are exposed to the pollutants experience the stress conditions. For example the crustaceans and molluscs experience the following pollution stress conditions.

3. 1. Indicators of stress in crustaceans

1. Disoriented movements
2. Abnormal muscle opacity
3. Retardation of moulting
4. Disease in carapace & exoskeleton - white spots
5. Black gills
6. Attachment of filamentous bacteria and protozoan as epidictic biofoulents or external surfaces
7. Increased number of bacteria in haemolymph

3. 2. Indicators of stress in bivalve molluscs

1. Abnormal shell formation
2. Mantle recession
3. Lag in gametogenesis
4. Pale digestive gland
5. Regress of digestive tubules
6. Edema
7. High taurine/glycine (aminoacid) ratios in gill and mantle tissue
8. Destabilization of intercellular lysosomal memebranes, resulting in autolysis of cells.
9. Slow growth and reduced "scope for growth"

4. EFFECT OF POLLUTANTS ON MARINE ORGANISMS

Pollutants enters into to the oceans are mostly diluted, however the organisms living in the oceans tend to concentrate the pollutants into their body by various mechanisms, like adsorption, absorption, ingestion etc. The concentration of pollutant increases with higher trophic levels, i.e. from primary producers to the tertiary consumer. The threshold limit of organisms to the pollutant concentration increase with increasing trophic levels. Various mode of pollution transport in organisms includes bioconcentration, bioaccumulation and biomagnification.

4. 1. Bioconcentration

The bioconcentration is the process by which a contaminant such as oil is directly taken up (i.e., by absorption only) from water and is accumulated to levels greater than those found in the surrounding water.

4. 2. Bioaccumulation

Marine organisms can accumulate chemical species in amounts far exceeding their surrounding (sea water or sediment) concentrations. The bioaccumulation is the process by which a contaminant is taken up by organisms directly through the physical exposure pathway or through pathway or through consumption of food containing the contaminated substance. Bioaccumulation incorporates the concepts of bioconcentration and biomagnification. The term 'concentrator factor' has been used to quantify the bioaccumulation and may be defined as the concentration of the chemical species in the organisms or one of its components divided by the seawater or surrounding concentration in the environment from which the organism was living. Organisms may take up the chemical directly from seawater or from their food. Thus, depending upon the composition of the food, concentration factors can vary from one environment to another for a specific organisms with a given chemical.

4. 3. Biomagnification

Biomagnification is the increase in tissue concentrations of a bioaccumulated chemical substance such as oil as it passes up though the trophic levels.

4. 4. Biodegradation

Biodegradation is the process of degradation of a contaminant such as oil because of its use as a food a source for certain microorganisms. This process is limited to a great extent by temperature, nutrients and oxygen availability.

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5.TYPES OF POLLUTANTS

There are two types of pollutants. They are biodegradable and non-biodegradable pollutants. Most of the materials, which reach the sea, disintegrate either through simple chemical reactions or because of the activities of bacteria and some larger organisms. There are some substances nevertheless which are either extremely stable or else they have a very slow rate of degradation. The biodegradable pollutants are not persistent in the environment (e.g. oil, organic compound in sewage). But the non-biodegradable pollutants are persisting in environment for longer time (e.g. Heavy metals, plastics, nuclear wastes etc.). In general most of the toxic compounds are considered as Xenobiotics. The term Xenobiotics referred to "bioaccumulative chemical of concern" or "persistent organic pollutants" by the Environmental Protection Agency (EPA) USA . Some of the compounds are organochlorine compounds (Ocs), chlorodanes (CHLs), hexachlorobenzene (HCB), organophosphorus compounds (Ops), polychlorinated biphenyls (PCBs), butyltin compounds (BTs) etc. Some of the biodegradable and non-biodegradable pollutants are discussed in detail.

5.1. SEWAGE

Sewage is discharged into the oceans all over the world mostly from urban settlement. Sewage adds to the amount of small particles suspended in the water column and contributes large amounts of nutrients.

5.1.1. Characteristics

The raw sewage contains higher concentrations of organic particulate matter, home washings, detergents, small amount of oil, higher concentration of nutrients, toxic heavy metals etc. Also, the sewage contains higher concentration of bacteria and viruses, which includes harmful pathogenic forms. Sewage always has the characteristic of bad odour, which is always not preferable, irritant and harmful to human and other organisms.

5.1.2. Sources

The main sources of sewage are the coastal outfall located near the cities. Also the increasing shipping activities also add higher concentration of sewage to the harbour and shipping routes. Moreover many rivers transport sewage from the inner regions of the land.

5.1.3. Fate and effect of sewage

In open coast, the effect of sewage is difficult to detect due to higher mixing up of tidal, wave and current actions. However in semi-enclosed areas like small bays, harbours etc., the effects are devastating such as higher Biochemical Oxygen Demand. The organic load concentration is expressed by means of a quantity called Biochemical Oxygen Demand (BOD).

Biochemical Oxygen Demand is the amount of oxygen required by the microorganisms for the decomposition of the organic compounds dissolved in a given volume of sewage.

Consequently high BOD values indicate high concentrations of organic material and therefore low quantities of dissolved oxygen (DO). Near sewage outflow areas in temperate waters, the benthic invertebrate communities have degraded, Kelp beds have disappeared and diseased fish have become more prevalent. Sewage input in the coastal environment normally increases the nutrient concentration of the outfall area. In tropical waters, outflows near coral reefs have caused a bloom of algal species that grows over the coral, and eventually it leads to the death of coral and its associated forms. This some times leads to the change in the ecological succession, that is the coral reef may be replaced by an algal reef.

5.2. OIL

Oil is discharged in to the sea in various forms as crude oil and as separate fractions. Most of the oil fractions are biodegradable. Oil and its fractions are used in various ways from household needs to automobiles and industries. The spilled oil more devastation in the marine environment.

5.2.1. Characteristics of oil

Petroleum oils are very complex mixtures of large numbers of hydrocarbons, containing also small amounts of sulphur, nitrogen, oxygen and different metals combined with the hydrocarbons. Crude oil has the total mixture ranges from the lightest hydrocarbon, methane to very large and complicated molecules.

5.2.2. Sources of oil pollution in marine environment

The main ways in which oil enters in to the sea are,

- Natural release

- Tanker operations
- Oil tanker and other ship accidents
- Operation of ships other than tankers
- Offshore oil drilling and production platforms
- Ship-shore oil terminal operation
- Refinery operations
- Discharge of oil products on land and subsequent discharge by runoff

5.2.3. Statistics on source of marine oil release

. 45% is due to marine transportation

. 32% is due to routine loading, discharging and flushing of tanker ships

. 8% is due to natural seeps

. 15% by other means

5.2.4. Fate of oil in the sea

As the oil enters into sea it is exposed to processes, which modify it both physically and chemically. This process is called weathering. As the oil tends to float on the surface of sea, the prevailing wind, wave, tide and current conditions make the oil to spread to a wider spectrum of area from the point of release. The majority of crude oil forms sticky layers on the surface, which prevents free diffusion of gasses, clogs adult organisms feeding structures and decreases the sunlight available for photosynthesis. Volatile components of an oil spill eventually evaporate into the air, leaving heavier tars behind which forms into tar balls, which fall to the bottom and may be assimilated by bottom organisms or incorporated into sediments.

5.2.4.1. Weathering

The alteration of physical and chemical properties of discharged oil through a series of natural processes, which begin when the discharge occurs and continue until the oil is removed. Major processes, which contribute to weathering, include evaporation, dissolution, photooxidation and emulsification.

Dissolution

Very little fraction of miscible fraction of oil is dissolved in the seawater and other fractions are immiscible.

Evaporation

Evaporation is the single most important weathering process for the first several days of an oils discharge. Evaporation results in the loss of lighter fractions through volatization from petroleum products (e.g. benzene, naphthalene).

Emulsification

The process whereby oil is incorporated into the medium of concern, usually water in the form of small droplets. Emulsions in water can either be oil-in-water or water-in-oil, formed as a result of wave actions. There is some solution of hydrocarbons in the water and this also is more marked in the more volatile constituents. The oil-in-water leading to the wide dispersion of fine oil droplets in the sea. The water-in-oil composition leading to the formation of semisolid masses known as 'chocolate mousse'.

Tar ball formation

If silt or sediment is present, oil may be absorbed on to it and may fall with it to the seabed. This effect can be seen as tar ball formation, which is mostly observed over the seabed of oil spilled area.

5.2.4 2. Biodegradation of oil

Some of the oil constituents are naturally attached by bacteria present in the sea. The simpler compounds, the normal paraffin, which have straight chains of carbon atoms, are most easily broken down and consumed. The other higher and complex molecular weight fractions are broken down very slowly.

5.2.5.Effect on marine organisms

When there is a major oil spill the degree of effect depends on many factors such as

- Type oil
- Quantity of oil
- Phsiography of the area
- Weather conditions at the time of spill
- Biodiversity of the area
- Season of the spill
- Previous exposure of the area to oil
- Exposure to other pollutants and
- Treatment of oil spill.

As the oil is of floating type it tend to spread and eventually reach the coastline. In many coastal areas, animals and plants situated between high and low water marks were heavily coated with oil and smothered. The exposure of organism to oil adds foreign smell in its body and tissues and the process is called tainting. The shellfish can be tainted either by deposition of oil on their shell or by ingestion of naturally emulsified oil during normal feeding. The local fish population in the immediate vicinity of oil discharge can acquire a marked taint from oil components dissolved in the water.

Almost all groups of organisms like invertebrates, vertebrates like fishes, reptiles, mammals etc., are affected by oil. When the plumage of a diving birds get oiled, the water repellent properties of the feathers are destroyed, they loose the insulation provided by the feather and its flying capacity. This leads to a condition called hypothermia, subsequently the bird may die. Birds may also ingest the oil. All these cause large scale death of marine birds. It is estimated that between 150,000 and 450,000 marine birds killed by routine releases of oil from tankers

The tainting can be cleared by rearing the affected organisms in clean water for a considerable period. In shellfishes, during the process of moulting, the tainted shells are removed. Also, the bird's feathers and some animal's body can be cleaned with detergent. In this type of clean up, the chances of recovery is observed in many cases. Most forms of marine life recover within about five years, as crude oil is not as highly toxic as it is biodegradable.

5.2.6. Poly Aromatic Hydrocarbons (PAH)

The polynuclear aromatic hydrocarbons (PAH) in particular 3, 4 benzopyrene are well known carcinogens (cancer producing). These compounds are present in crude oil in small amounts. The PAH assimilated by marine organisms can be passed upwards through food chain towards man. This will lead to serious concern of human health.

5.2.7. Environmental degradation due to oil

The environmental degradation of oil includes the destruction of algal beds, spreading of oil over rocky shores, incorporation in beach sediment and subsequent loss in scenic beauty.

5.3. HEAVYMETALS

Normally the metals having the atomic weight more than twenty is considered as heavymetals. The term "heavymetals" is used to denote elements with specific weight higher than those of Iron (Fe) and mainly Lead (Pb), Mercury (Hg), Copper (Cu), Cadmium (Cd) and Chromium (Cr).

5.3.1. Sources

Coal combustion, electric utilities, steel and iron manufacturing, fuel oils, fuel additives, and incineration of urban refuse are the major sources of oceanic and atmospheric contamination by heavy metals. Heavy metal contaminated runoff from the land, rain of pollutants from the air, and fallout from shipwrecks pollute the ocean with dangerous metals.

5.3.2. Effect on organisms

In general, the effects of heavy metals toxicity can be classified into three main categories:

- The blocking of essential functional groups of the biomolecules (e.g. proteins, enzymes)
- The displacement of a metal ion from a biomolecule
- The modification of the structure of biomolecules in space which is very important for their function

5.3.3. Some metal pollutants and their effect in human beings and marine organisms

5.3.3.1. Lead

Affects human central nervous system. A poison by ingestion and moderately irritating. A common air contaminant due to use of bad fuel in the auto industry, now being phased out through the introduction of lead-free petrol; also in air in the vicinity of industrial plants using lead where precautions are not taken. It is a carcinogen of the lungs and kidneys. Lead is flammable in the form of dust when exposed to heat or flame. From the point of view of industrial poisoning, inhalation of lead is much more important than is ingestion. Lead is a cumulative poison. Increasing amounts build up in the body and eventually a point is reached where symptoms and disability occur. Lead can cause irreversible behavioral disturbances, neurological damage and other developmental problems in young children and babies.

5.3.3.2. Cadmium

This metal is toxic to humans by inhalation and other routes. It can enter through ingestion, intraperitoneal, subcutaneous, intramuscular and intravenous routes. Has no known biochemical or nutritional function. Also cadmium is highly toxic to freshwater and marine organisms. It is bioaccumulative through the food chain. Increased exposure can increase risk of lung cancer. Cadmium was responsible for the "Itai-itai" disease in Japan .

5.3.3.3. Chromium

The metal exists in two forms, i.e. trivalent and hexavalent. Hexavalent chromium in high dosages has been implicated as the cause of digestive tract cancers, cutaneous and nasal mucous membrane ulcers and dermatitis. Certain chromate salts, i.e. calcium chromate are carcinogenic, at least when inhaled.

5.3.3.4. Zinc

The Zinc is human skin irritant and produces pulmonary system effects. The difficulty arises from oxidation of zinc fumes prior to inhalation or presence of impurities such as cadmium, antimony, arsenic and lead. Zinc however is a needed micronutrient for humans. It is needed in agriculture. It is used in galvanising industry. The real problem is of its association with heavy metals like lead.

5.3.3.5.Arsenic

Toxic by subcutaneous, intramuscular and intraperitoneal routes and reported to produce systemic, skin and gastrointestinal effects. It is also a human carcinogen and experimental teratogen.

5.3.3.6. Mercury

The silvery-white liquid metal used in common thermometers, is a potent neurotoxin, capable of causing severe brain damage in developing foetuses and mild tremors and emotional disturbances in exposed adults. Implicated in the occurrence of Minamata disease in Japan , largest source of mercury contamination is through aquatic animals in whom it accumulates and gets bio-transferred to organocompounds, e.g. methyl mercury. Mercury and lead poisoning cause brain damage and behavioral disturbances in children.

5.3.3.7. Copper

It is also dangerous to marine organisms and it has been used in marine anti-fouling paints.

5.4. PESTICIDES

Pesticides are toxins (chemical compounds) used in agricultural farm to kill the unwanted pest organisms attaching the cultivated plants. A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses. Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Under United States law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

5.4.1. Types of pesticides

There are natural and artificial pesticides. The natural pesticides are biodegradable and are mostly derived from the extracts of plants and animals. However, artificial pesticides are man made and produced extensively only after the industrial revolution. These pesticides belong to four main categories.

Table 1. TYPES OF PESTICIDES

S. No.	Type of pesticide	Example	Characteristics
1.	Organochlorine compounds	DDD- Dichloro-diphenyl-dichloroeathane	• Persistent in the environment or decompose very slowly • Half life is 9 -116 years. • Accumulate many organisms • Higher concentrations in higher organisms - mammals like dolphins, whales, porpoise etc. • Detected in antartic penguins.
2.	Organophosphate esters	Parathion	• Very toxic • Much toxic than previous
3.	Carbamates	Baygon	• Decompose rapidly through hydrolysis • Half-life period approximately one week
4.	Chlorophenyl-acids	2,4,5-T	• Hazardous compounds • Used in Vietnam War for defoliation.

Table 2. SOME COMMON KINDS OF PESTICIDES AND THEIR FUNCTION

Pesticides	Function
Algicides	Control algae in lakes, canals, swimming pools, water tanks, and other sites.
Antifouling agents	Kill or repel organisms that attach to underwater surfaces, such as boat bottoms.
Antimicrobials	Kill microorganisms (such as bacteria and viruses).
Attractants	Attract pests (for example, to lure an insect or rodent to a trap). (However, food is not considered a pesticide when used as an attractant.)
Biocides	Kill microorganisms.
Disinfectants and sanitizers	Kill or inactivate disease-producing microorganisms on inanimate objects.
Fungicides	Kill fungi (including blights, mildews, molds, and rusts).
Fumigants	Produce gas or vapor intended to destroy pests in buildings or soil.
Herbicides	Kill weeds and other plants that grow where they are not wanted.
Insecticides	Kill insects and other arthropods.
Miticides	(also called acaricides) Kill mites that feed on plants and animals.
Microbial pesticides	Microorganisms that kill, inhibit, or out compete pests, including insects or other microorganisms.
Molluscicides	Kill snails and slugs.
Nematicides	Kill nematodes (microscopic, worm-like organisms that feed on plant roots).
Ovicides	Kill eggs of insects and mites.

Pheromones	Biochemicals used to disrupt the mating behavior of insects.
Repellents	Repel pests, including insects (such as mosquitoes) and birds.
Rodenticides	Control mice and other rodents.

Table 3. THE TERM PESTICIDE ALSO INCLUDES THESE SUBSTANCES

Pesticides	Function
Defoliants	Cause leaves or other foliage to drop from a plant, usually to facilitate harvest.
Desiccants	Promote drying of living tissues, such as unwanted plant tops.
Insect growth regulators	Disrupt the molting, maturity from pupal stage to adult, or other life processes of insects.
Plant growth regulators	Substances (excluding fertilizers or other plant nutrients) that alter the expected growth, flowering, or reproduction rate of plants.

5.4.2. Sources of pesticides in Marine environment

Pesticides are the good examples of non-point source pollutants. These toxic materials used in the highland for agricultural and other purposes end up into the sea either through runoff into streams and rivers or having been transported by the wind (dust and aerial spray).

Depending on the type of the chemical, its partial and vapour pressure, evaporation, condensation and deposition occur at various places of the globe leading to their global partitioning. Because of such conditions these chemicals, which originate from lower latitudes, move to higher latitudes. Depending on various conditions, these chemicals migrate in a series of relatively short jumps termed as "grasshoffer effect". Because of this grasshopper effect, concentrations of such chemicals even in the remote parts of the world (Arctic and Antarctic) may rise even if the use of these chemicals are curtailed in source countries.

5.4.3. Effect on organisms

Existence of contamination by these chemicals in the environmental media leads to potential impact on almost all species including human. All the organisms, obtain their first dosage of these chemicals from their food and water, while the mammalian species derive these toxins from theirs mothers through milk. While the plants and lower trophic level organisms also accumulate these chemical in their bodies, the effect of these chemicals on these organisms in not openly seen. Organochlorines have been found to cause microsomal enzyme induction, accelerating body steroids such as estrogens and also to have an effect on the normal reproductive activities of many experimental animals. It is generally known that 5% eggshell thinning occurs at a concentration 5 mg/g of DDE in the bird egg. It is also found that concentrations of 20-1000 mg/g of DDE in the liver of birds are considered to pose a threat to individual bird reproduction and therefore on the population as a whole.

5.5.POLYCHLORINATED BIPHENYLS (PCBS)

PCBs are a series of technical mixtures consisting of many isomers and compounds that vary from mobile oily liquids to white crystalline solids and hard noncrystalline resins.

5.5.1. Sources of PCBs

PCB's usually come from older electrical equipment like transformers, insulations etc.

5.5.2. Effects on organisms

Toxic by ingestion, inhalation and skin contact. A suspected human carcinogen, affects skin and liver. Usual signs of systemic intoxication include nausea, vomiting, weight loss, jaundice, edema and abdominal pain. Severe liver damage may cause coma and death. PCB's (polychlorinated biphenyls) typically cause reproduction problems in most marine organisms. The reduction in sperm motility in human with increasing PCB concentration was observed indicating the possible effect of these chemicals on the reproductive capability of mammalian species.

5.6. RADIOACTIVE MATERIALS

The world's oceans have been a sink for radioactive waste from the production of nuclear weapons and electric power since 1944.

5.6.1. Sources

The sources of radioactivity may be natural and anthropogenic. Radioactive waste enters the ocean from nuclear weapon testing (this is banned by international conventions), the releasing or dumping of wastes from nuclear fuel cycle systems, nuclear accidents (Chernobyl accident in USSR in May 1985), ongoing pollution from smaller but more or less continuous leaks from nuclear power stations (Sellafield) or nuclear submarines and carriers etc.

5.6.2. Fate of radioactivity in the marine environment

Dumping of high-level radioactive waste is no longer permitted in the ocean, but dumping of low-level wastes is still permitted. Low-level waste contains less radioactivity per gram than high-level waste. High-level wastes usually have longer half-lives. For example, one common high-level waste that is produced by spent nuclear fuel has a half-life of 24,100 years. It has been suggested that contained nuclear waste should be disposed in the deep sea.

5.6.3. Half life

The time required for half the atoms in a given quantity of a radioactive element to disintegrate.

5.6.4. Effect on organisms

So little is known about the deep sea environment or the consequences of containment leakage and failure, that the effects could be devastating. The bioaccumulation process is not associated with the radioactivity properties of a molecule but with its chemical properties. If, however, a bioacumulated molecule happens to be radioactive, its effects on the organism are much more severe.

Radioactive materials bring about two principal sorts of consequences at the organism level:

- Direct toxicity caused by the ionization atoms and molecules of living materials (and especially water) resulting in the production of strong oxidizing agents, which are harmful to living tissues.
- The mutagen activity: here radiation is a factor, which causes errors during the DNA transcription leading to genome alteration. These errors, called mutations, are in most cases lethal or else lead to teratogenesis when they occur during reproduction. They can also result in cancer when they take place during the division of somatic cells.

5.7. NUTRIENTS

The nutrients are mainly of nitrogen, phosphorus and silicates. Nutrients are used by plants and animals in a complicated cycle, returned to the environment and then re-used. They are essential for the growth of marine primary producers like phytoplankton, seaweed and seagrass. Studies have shown that too much nutrient in the sea and abnormal algal blooms can upset the balance of plants and animals living near the seabed.

5.7.1. Sources

Agriculture in the land, aquaculture practices in the coastal areas and release of sewage as outfall are some the major sources. Fertilizers used on land are washed into the ocean via rivers and streams. Also the aquaculture farms located near the coastal zone also release the wastewater in to the streams and estuaries or directly to the marine environment. Apart from this the sewage released into the coastal areas also contains higher concentration of nutrients.

5.7.2. Fate of nutrients in the sea

The higher nutrient concentrations are always utilized by phytoplankton. The release of excess nutrients into coastal waters leads to the condition called Eutrophication. Eutrophication leads to higher production of phytoplankton called bloom. The death and decay of phytoplankton lead to higher oxygen consumption, which is detrimental to the organisms.

5.7.3. Effects of nutrients

High nutrient concentrations cause phytoplankton blooms such as, red tides, various yellow and green foams, slimes, and slicks. Although algal blooms are natural, a higher frequency of their occurrence in the past twenty years indicates an unhealthy ecosystem. The toxicity of recent blooms is increasing, which can have a direct effect on the organisms that feed on them. Also, phytoplankton naturally contains DMS (dimethyl sulfoxide), which is released from dead phytoplankton into the atmosphere and can be changed to sulfuric acid, which eventually contribute to acid rain.

5.8. THERMAL POLLUTION

In this type, the normal temperature of marine source water column is increased to 7-8?C from the ambient temperature.

5.8.1. Source

Mostly the power generating plants along the ocean coastlines use the marine waters for cooling purposes, which leads to heated water expelled into the marine environment.

5.8.2. Fate of increased temperature in the marine environment

The excess temperature usually gets reduced by various ways. As the water has higher specific heat, it takes prolonged time for cooling unless there is an external mechanism to accelerate this. The dilution by surrounding water, evaporation and precipitation may accelerate cooling within a reasonable time.

5.8.3. Effects

Thermal pollution seems to only effects the communities immediately adjacent to the discharge. In continuous discharge the exposure time is also continuous, which generally result in community shift that is more heat tolerant species may replace the normal biota. The longtime exposure to the heat conditions may be detrimental to the normal biota. Many studies have been done on the effects of thermal pollution on the marine environment. Thermal discharge is most noted in the tropical areas, where organisms are near their thermal maximum. For example, mangrove trees in a thermal heated bay no longer reproduce and no new seedlings can be found in the lagoon.

5.9. SOLID WASTES

Plastic is produced in large amount and has danger of solid waste into the marine environment. Plastic is not biodegradable and therefore effecting the oceans for long periods of time. When compared to other types of pollutants the biological consequences are low.

5.9.1. Source of Solid wastes

Solid wastes are dumped into the sea mainly by the anthropogenic activities.

5.9.2. Type of solid wastes

Mostly of non biodegradable plastics made materials such as used bottles, cups, plastic bags, plastic fishing nets, metal pieces, abandoned wreckage ships, etc. are dumped into the sea. This is also called Ocean dumping.

5.9.3. Statistics on plastic

- Six-pack holders will not decompose for 400 years
- Each square mile of ocean surface off the North East coast of the U.S. has more than 46,000 pieces of plastic floating
- 100,000 marine mammals and 2 million sea birds die every year after ingesting or being caught in plastic debris
- Adding ingredients to plastics that would hasten decomposition would add 5-7% to costs, but this price increase is unacceptable to industries.

5.9.4. Usefulness of solid waste

The solid waste on the other hand acts as a substratum for many fouling marine organisms. The initial biofilm formation on a new substratum and subsequent macro fouling is useful in some ways. If the solid waste is not releasing any toxic substances then it can be used build artificial reefs and has been considered as a very good way to increase the environmental heterogeneity (biodiversity) in areas which function as nursery or feeding grounds for important fishing stocks.

5.9.5.Effect on organisms

There have been cases that fish having been trapped inside plastic bags other plastic objects and dying of suffocation. Also in some cases have been reported of fish getting entangled in plastic fishing nets which have been torn off from fishing boats and drift in the water column, causing a phenomenon known as "ghost fishing". Sea turtles mistake plastic bags for jellyfish eat and die from internal blockages. Seals and sea lions starve after being muzzled by six-pack rings or entangled by nets. Birds have become entangled in discarded fishing line and drowned, while lost drift nets are particularly dangerous to marine forms.

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7. ENVIRONMENT RELATED LEGISLATION IN INDIA (SOME SELECTIVE LIST)

The government of India has enacted several legal provisions, laws, and policies for management of environmental resources in the country. The legal provisions facilitate pollution enforcement through appropriate actions against the defaulter polluting industries and other polluting sources. Only a few are given below.

Table 15. CENTRAL ENACTMENT

Type of pollution	Act
Water pollution	The River Boards act, 1956 The Merchant Shipping (Amendment) act, 1970
Radiation	The atomic Energy act, 1962 The Radiation Protection Rules, 1971
Pesticides	The Poison Act, 1919 The Factories Act, 1948 The Insecticides Act, 1968
Other	The Indian Fisheries Act, 1987 The Indian Forest Act, 1927 The Forest Conservation Act, 1980 The Wild Life (Protection) Act, 1972 The Wild Life (Protection) Amendment Act, 1991

Table 16. ENVIRONMENTAL POLLUTION MANAGEMENT LEGISLATION

Type of pollution	Act
Water pollution	The Water (Prevention Control of Pollution) Act, 1974 The Water (Prevention and Control of Pollution) Rules, 1975 The Water (Prevention and Control of Pollution) Second Amendment Rules, 1976. The Water (Prevention and Control of Pollution) Cess Act, 1977 as amended by Amendment Act, 1991.
Air Pollution	The Air (Prevention and Control of Pollution) Act 1981 as amended by Amendment Act, 1987. Air (Prevention and Control of Pollution) Rules, 1982 Air (Prevention and Control of Pollution) Amendment Rules, 1988
Environment	The Environment (Protection) Act, 1986 The Environment (Protection) Rules, 1986 The Environment (Protection) Amendment Rules, 1987 The Environment (Protection) Third Amendment Rules, 1987 The Environment (Protection) Amendment Rules, 1997 The National Environment Tribunal Rules, 1995 Notification on Emission Standards and Guidelines for Location of Industries, mining operations etc. for various areas.
Notifications for Standards/ Guideline etc.	Hazardous Waster (Management and Handling) Rules, 1989 Temperature limit for Discharge of Condenser Cooling from Thermal Power Plant

8. SEA LEVEL RISE THROUGH GLOBAL WARMING

The gaseous pollutants (green house gases like corbon-di-oxide, dimethyl sulphoxide, chlorofluorocarbon-CFC etc.) released into the air, have direct implication on the atmosphere. These gaseous pollutants found to increase the temperature of atmosphere through depletion of ozone layer, which in turn increase the sea surface temperature well as meting of ice in the polar regions. Through computer models, scientists are working to understand how increases in carbon dioxide and other "greenhouse" gases in the atmosphere might change the earth's climate. But so far, complex interactions between oceans, atmosphere, land, and the sun have made precise climatic predictions impossible. Oceans are crucial in shaping climate because they store and move heat around the planet, and they're a major source and storehouse for gases (such as carbon dioxide) that affect climate.

dioxide) that affect climate

Effects of Climate change

The climate change may lead to various impacts such as

- melting of polar ice caps
- accelerated erosion of beaches and coastal shore areas through raging storms
- salt water contamination of coastal aquifiers
- salt water intrusion in to a great distance landward into estuaries and bays
- destruction of coastal terrestrial vegetation and replacement of salt tolerant species
- increased frequency of flooding and subsequent submergence of costal areas
- Organisms such as coral may bleach and submerge

If the sea level increased in few centimeter, then the existence of many coastal cities and islands will be under sever threat due to flooding and subsequent reduction in living habitat. In most islands, the area is small and the elevation from mean sea level is also in few meters. These islands are under severe threat of submergence. Thus concerted efforts must be taken to save the earth from global warming.

Global warming is becoming potential threat to fisheries and biodiversity. The extinction of species has increased from 30,000 in 1970s to 50,000 in 1980s and at this rate 10-20% of the earth's 10 million species of plant and animals would have disappeared forever. Coastal zones, which provide habitat for 80% of the 13,200 species of marine fish in the world oceans are being affected at alarming rate. Extensive bleaching of corals is spreading fast and there is destruction of valuable fish habitats especially breeding and spawning grounds.

9. Conclusion

Our earth, the Mother Nature took 4600 million years to create us, the human being. We are being we, because everything including life forms changed in relation to time gradually and only the fittest adopted towards the change in environment otherwise survived. The gradual change is suddenly intervened by human cultural development and industrialization activities without giving enough time for the evolution takes its own time. The improvements in technological breakthrough with the resulting industrialization and urbanization lead to various forms of environmental degradations, which are being realized by this civilization on earth. This ultimately leads to pollution in all forms, which resulted in the uncertain predictions of global warming. Thus, if there should be a civilized future generation, stop degrading the environment. Slow down the process of sudden change in climate and environment and find new technologies to combat the pollution. Or else let the nature takes its own time. Save the earth for our future generation. Do something even if it is very small.

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6.STATUS OF MARINE POLLUTION MONITORING AND CONTROL IN INDIA

6.1. Types of Indian Coastal environment

The Ministry of Environment and Forests under the Environment (Protection) Act, 1986 has declared the coastal stretches as Coastal Regulation Zone (CRZ) for regulating the activities in the CRZ. It declares coastal stretches of seas, bays, estuaries, creeks, rivers and backwater, which are influenced by tidal action (in the landward side) up to 500 meters from the High Tide Line (HTL) and land between Low Tide Line (LTL) and HTL as Coastal Regulating Zone and imposes restrictions on the setting up and expansion of industries operations and processes.

Table 4. CATEGORIES OF COASTAL REGULATION ZONE IN INDIA

S. No.	Description	Category
1.	Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals| coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of out standing natural beauty| historical| heritage areas, areas rich in genetic diversity; areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the Central Government or the concerned authorities at the State | Union Territory level from time to time Area between the Low Tide Line and the High Tide Line.	**CRZ-I**
2.	The areas that have already been developed up to or close to the shoreline. For this purpose "developed area" is referred to as that area within the municipal limits or in other legally designated urban areas, which is already substantially build up and which has been provided with drainage and approach roads and other infrastructure facilities, such as water supply and sewerage mains.	**CRZ-II**
3.	Areas that are relatively undisturbed and those, which do not belong to either Category-I or II. These will include coastal Zone in the rural areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas, which are not substantially building up.	**CRZ-III**
4.	Coastal stretches in the Andaman & Nicobar, Lakshadweep and small island except those designated as CRZ-I, CRZ-II or CRZ-III.	**CRZ-IV**

6.2. Types of Indian marine environment based on uses

In the coastal zone marine water is subjected to several types of uses. In 1974 the water act (Prevention and control of pollution) was created to keep the coastal water clean and free from pollution, the water bodies area classified according the use. The pollution Control boards at Centre and littoral States have adopted 5 km in to the sea from the highest high tide, as the extent, over which their authority to control waste discharges will extend for the purpose of the water (Prevention and Control of Pollution) Act, 1974.

Coastal waters of India have been used for various activities like fishing, shipping hourbour activities, industrial-cooling purposes etc. Depending of the types of uses and activities, water quality criteria have been specified to determine its suitability for a particular purpose. Among the various types of uses there is one use that demands highest level of water quality/purity and that is termed as "designated best use" in that stretch of the coastal segment. Through a survey conducted during 1980-86, all the activities in the Indian coastal areas were identified and based on the "designated best use' concept (i.e., exact or near quality requirement for different uses) the following classifications of seawater has been made. Based on this, primary water quality criteria have been specified for the following five designated best uses:

Table 5. CLASSIFICATIONS OF SEAWATER USES IN INDIA

S. No.	Designated Best Use	Class
1.	Salt pans, Shell fishing, Mariculture and Ecologically Sensitive Zone	SW-I
2.	Bathing, Contact Water Sports and Commercial fishing	SW-II
3.	Industrial Cooling, Recreation (non-contact) and Aesthetics	SW-III

4.	Harbour	SW-IV
5.	Navigation and Controlled Waste Disposal	SW-V

6.3. What is Water Quality?

The operational definition is "The water quality is that a body of water should be able to support its designated uses, which could include shellfishing, swimming, other body contact, recreational boating, or fishing".

Any physical, chemical, or biological condition that prevents the designated use(s) of a body of water represents poor water quality. The EPA and the State of North Carolina have defined limits for many water quality parameters that are considered to prevent designated uses. Some of the important water quality parameters and regulatory limits for them are:

6.3.1. Dissolved oxygen

Dissolved oxygen (DO) is critical for aquatic life and also controls chemical processes. DO is important to aquatic organisms for several reasons: most of them (like fish) need it to breathe and many of the microbes need it to perform their decomposition function ("aerobic" decomposers). DO enter the water from the air and from aquatic plant photosynthesis. Oxygen is consumed by respiration (Biological Oxygen Demand) and some chemical reactions. North Carolina considers values less than a daily mean of 5.0 mg/liter (ppm) or instantaneous value of 4.0 mg/l to be low and less than 2.0 mg/l to be dangerous to aquatic life.

6.3.2. Turbidity

Turbidity is caused by suspended material that blocks light. High levels of turbidity can slow the growth of aquatic plants and reduce visibility for aquatic animals that need to see their prey. Turbidity is a measure of how much light is scattered by materials suspended in the water. Scattered light is much less available for aquatic plants, so high levels of turbidity can limit the growth of aquatic plants as well as restrict the visibility of prey and enemies to aquatic animals. Consequently, there are standards for turbidity in fresh (50 NTU) and salt (25 NTU) waters. An NTU is a Nephelometric Turbidity Unit. North Carolina has standards of 25 and 50 NTU for tidal and freshwaters, respectively.

6.3.3. Fecal coliform bacteria

Fecal Coliform Bacteria are indicators of recent contamination by fecal matter from warm blooded creatures, including humans, other mammals and birds. The mFC membrane filtration technique, which is a standard EPA and NC approved method, to enumerate fecal coliforms in water samples. Most of the bacteria detected by this method are E. coli, the most abundant bacterium in the guts of humans. While E. coli itself is usually not a pathogen, its presence is an indicator of the possible presence of real pathogens that can cause disease. Water borne disease is not a trivial problem; the threat of disease transmission is the reason that shellfish beds are frequently closed and posted. We have also found the human pathogen, Klebsiella pneumoniae, in water samples quite frequently.

Coliform bacteria themselves are not necessarily pathogenic, but they indicate the likelihood that more dangerous organisms, such as the organisms that cause salmonellosis, cholera or hepatitis, are present. Although contamination of waters by human wastes is especially serious, animal wastes can also transmit disease. Consequently, high levels of fecal coliform bacteria, regardless of the source, imply a high risk of disease transmission. Two additional warnings apply: a) some pathogens live longer in surface waters than fecal coliform bacteria, and b) many bacteria are alive in the water but cannot be cultured and detected by the standard techniques. Owing to the risk of disease transmission by contact with waters contaminated by fecal wastes, standards for this water quality parameter are quite stringent, but enforcement of those standards is somewhat complicated, requiring repetitive testing for a defined period. As guidelines, waters designated for shellfishing should not have average fecal coliform levels above 14 colony forming units (CFU) per 100 ml. Waters designated for most other uses, e.g., swimming, should not average above 200 CFU/100 ml.

6.3.4. Total Nitrogen and Phosphorus

Total Nitrogen is a measure of the quantity of the important plant nutrient, nitrogen, present in the water in dissolved and particulate forms. It is one measure of the degree of nitrogen loading to surface waters. We use a persulfate digestion method to assay for total nitrogen, whereas many labs use the more vigorous Kjeldahl digestion. We prefer the persulfate method as it gives a more realistic estimate of the biologically available nitrogen in a sample and includes nitrate-nitrite nitrogen as well. Total Phosphorus is a measure of the important plant nutrient, phosphorus, which not only stimulates aquatic weed growth, but also blooms of nitrogen-fixing blue-green algae (cyanobacteria) and bacteria.

These plant nutrients occur at variable but typically low levels in natural waters. Elevated levels of nitrogen and/or phosphorus can stimulate excessive plant growth ("eutrophication"), which can be very harmful to aquatic ecosystems. There are no general standards for nitrogen or phosphorus, but there are discharge standards for all NPDES permit holders ("point source" dischargers). Non-point sources of nitrogen and phosphorus are not currently regulated. Some countries banned high-phosphate detergents, in order to control algae blooms in rivers receiving sewage effluents.

6.3.5. Total suspended solids

Sediment loading to surface waters raises turbidity and suspended solids levels and causes siltation, other pollutant loadings, and problems for aquatic life. Sedimentation is a serious problem in areas downstream of improperly managed land-disturbing activity. Suspended solids cause siltation, clog the gills of aquatic animals, and carry toxic chemicals and nutrients with them when they enter the water. High levels of suspended solids are considered to be one of the most widespread water quality problems, and are frequently caused by human activities.

6.3.6.Chlorophyll a

Chlorophyll a is a measure of phytoplankton biomass. All plants have the photosynthetic pigment chlorophyll a, so its concentration in the water is a measure of plant abundance. This technique is very sensitive, so it is a good measure for phytoplankton, which is otherwise hard to quantify. North Carolina has a standard for chlorophyll a of 40 micrograms per liter (µg/l), a level above which water quality is considered to be impaired by excess phytoplankton. However, chlorophyll a measures only the biomass of small phytoplankton. Larger aquatic plants that grow on surfaces or the big aquatic weeds that fill many ponds are not measured by this technique. Furthermore, there appears to be no accepted standard method for the measurement of these larger plants, so measures of chlorophyll a in a body of water may grossly underestimate the actual amount of plant growth there. High levels of plant growth indicate excessive nutrient loading and can cause problems with low dissolved oxygen at night.

Because shallow waters usually have enough light for plants to grow, unusually high levels of chlorophyll a usually indicate excessive nutrient loading. Chlorophyll a levels above 40 µg/liter are considered excessive by North Carolina.

6.4. How can water quality data be used?

Using these data following decisions can be made

6.4.1. Characterize baseline water quality conditions

Example: Dissolved oxygen values are controlled partly by temperature, because the solubility of oxygen declines as the water warms up. Dissolved oxygen values are therefore usually lower in the summer than in the winter. Consequently, comparisons of dissolved oxygen values among monitoring locations or times must take into account this temperature covariance.

6.4.2. Compare average water quality conditions among sites

Example: Fecal coliform counts are typically very low (geometric mean is less than 12 CFU/100 ml). The most likely differences between stations could cause significant difference in fecal coliform levels are the presence of some septic tanks and of a septage disposal area immediately upstream of drainage entering the sampling location. This means that we can identify possible causes of water problems, target more specific investigations to pinpoint sources, determine which areas need the most work to improve water quality, and evaluate progress as problems are remediated.

6.4.2. Compare average water quality conditions among sites

Example: Fecal Coliform counts at have averaged less than 10 CFU/100 ml. Statistical tests can confirm that two data points are "outliers" that are not attributable to normal variation for particular site. This means that the data can be used to define unusual events, natural or human-caused, that impact water quality.

6.4.4. Compare our data to other data sets

These kinds of comparisons give us confidence that our results compare well to those of others.

6.4.5. Test the effectiveness of storm water management models and measures

Example: The Storm Water Quality Management Plan Implementation Report uses a model devised by EPA to predict the concentrations of pollutants in a modeled watershed based on information about current land use practices and soil types. Water quality data now in hand can be compared to predicted water quality conditions to identify areas where current pollutant loadings are higher than predicted by the model, thus indicating places where assumptions about land use impacts and protective measures, such as buffers, do not hold, and where prompt action should be considered. Example: The Storm Water Quality Management Plan Implementation Report also predicts pollutant loadings under various scenarios, including the Action Scenario, in which SBWSA's wastewater and storm water management systems are fully implemented. Water quality data can be used to evaluate the actual performance of various storm water management practices as they are brought on line, identify areas where additional measures are needed, and identify areas where existing conditions support acceptable water quality within the overall management framework.

6.4.6.Bring in the authorities to investigate problems

We can ask the authorities to investigate the water quality and take appropriate control measures.

6.5. Water quality standards in India

6.5.1. Standard prescribed for Indian coastal waters marine outfalls

The standard along with rationale/remarks for various parameters, for different designated best uses, are given in the following Tables.

Table 6.PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-I WATERS
(For salt pans, Shell fishing, Mariculture and Ecologically Sensitive Zone)

S. No.	Parameter	Standard	Rationale/Remarks
1.	pH range	6.5 - 8.5	General broad range, conductive for propagation of aquatic lives, is given. Value largely dependant upon

			soil water interaction
2.	Dissolved Oxygen	5.0 mg/ml or 60 percent saturation value, whichever is higher.	Not less than 3.5 mg/l at any time of the year for protection of aquatic lives.
3.	Colour and Odour	No noticeable colour or offensive odour.	Specially caused by chemical compounds like cresols, phenols, naphtha, pyridine, benzene, toluene etc. causing visible colouration of salt crystal and tainting of fish flesh.
4.	Floating Matter	Nothing obnoxious or detrimental for use purpose.	Surfactants should not exceed an upper limit of 1.0 mg/l and the concentration not to cause any visible foam.
5.	Suspended solids	None from sewage or industrial waste origin	Settleable inner matter not in such concentration that would impair any usage specially assigned to this class.
6.	Oil and Grease (including Petroleum Products)	0.1 mg/l	Concentration should not exceed 0.1 mg/l as because it has effect on fish eggs and larvae
7.	Heavy Metals: Mercury (as Hg) Lead as (Pb) Cadmium as (Cd)	 0.01 mg/l 0.01 mg/l 0.01 mg/l	Values depend on: (i) Concentration in salt, fish and shell fish. (ii) Average per capita consumption per day. (iii) Minimum ingestion rate that induces symptoms of resulting diseases.

Note: SW-I is desirable to be safe and relatively free from hazardous chemical like pesticides, heavymetals and radionuclide concentrations. In areas where fisheries, salt pans as the governing considerations, and presence of such chemicals apprehended/reported, bioassay test should be performed following appropriate methods for the purpose of setting case-specific limits.

Table 7. PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-II WATERS
(For Bathing, Contact Water Sports and Commercial Fishing)

S. No.	Parameter	Standard	Rationale/Remarks
1.	pH range	6.5 - 8.5	Range does not cause skin or eye irritation and is also conducive for propagation of aquatic lives.
2.	Dissolved Oxygen	4.0 mg/l or 50% saturation value whichever is higher.	Not less than 3.5 mg/l at any time of protection of aquatic lives.
3.	Colour and Odour	No noticeable colour or offensive odour.	Specially caused by chemical compounds like cresols, phenols, naphtha, benzene, pyridine, toluene etc. causing visible colouration of water and tainting of odour in flesh.
4.	Floating Matters	Nothing obnoxious or detrimental for us purpose.	None in concentration that would impair usage specially assigned to this class.
5.	Turbidity	30 NTU (Nephelo Turbidity Unit)	Measured at 0.9 m depth.
6.	Feacal Coliform	100/100 ml (MPN)	The average value not exceeding 200/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
7.	Biochemical Oxygen Demand (BOD) (3 days at 27°C)	3 mg/l	Restricted for bathing (aesthetic quality of water). Also prescribed by IS:2296-1974).

Table 8. PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-III WATERS
(For industrial Cooling, Recreation (non-contact) and Aesthetics)

S. No.	Parameter	Standard	Rationale/Remarks
1.	PH range	6.5 - 8.5	The range is conducive for propagation of aquatic species and restoring natural system
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value whichever is higher	To protect aquatic lives
3.	Colour and Odour	No noticeable colour or offensive odour	None in such concentration that would impair usages specifically assigned to this class
4.	[illegible]	[illegible]	[illegible]

4.	Floating Matters	No visible/Obnoxious floating debris, oil slick, scum	As in (3) above
5.	Feacal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months
6.	Turbidity	30 NTU	Reasonably clear water for Recreation, Aesthetic appreciation and Industrial cooling purposes
7.	Dissolved Iron*	0.5 mg/l or less	It is desirable to have the collective concentration of dissolved Fe and Mn less or equal to 0.5 mg/l to avoid scaling effect
8.	Dissolved Manganese (as Mn) *	0.5 mg/l or less	-

* Standards included exclusively for Industrial Cooling purpose: Other parameters same.

Table 9. PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-IV WATERS
(For Horbour Waters)

S. No.	Parameter	Standard	Rationale/Remarks
1.	pH range	6.5 - 9.0	To minimize corrosive and scaling effect
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value whichever is higher	Considering bio-degradation of oil and inhibition to oxygen production though photosynthesis
3.	Colour and Odour	No visible colour or offensive odour.	None from reactive chemical which may corrode paints/metallic surface
4.	Floating materials, Oil, grease and scum (including, Petroleum products)	10 mg/l	Floating matter should be free from excessive living organisms which may clog or cat operative parts of marine vessels/equipment
5.	Feacal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months
6.	Biochemical Oxygen Demand (3 days at 27°C)	5 mg/l	To maintain water relatively free from pollution caused by sewage and other decomposable wastes

Table 10. PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-V WATERS
(For Navigation and Controlled Water Disposal)

S. No.	Parameter	Standard	Rationale/Remarks
1.	pH range	6.0 - 9.0	As specified by New England Interstate Water Pollution Control Commission.
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value whichever is higher	To protect aquatic lives
3.	Colour and Odour	None is such concentrations that would impair any usage specifically assigned to this class	As in (1) above
4.	Sludge deposits, Solid refuse floating solids, oil and grease & scum	None except for such small amount that may result from discharge of appropriately treated sewage and/or industrial waste effluents	
5.	Feacal Coliform	500/100 ml (MPN)	Non exceeding 1000/100 ml in 20 percent or samples in the year and in 3 consecutive samples in monsoon months

6.5.2. Water quality criteria for inland waters and others

The flowing tables illustrate the primary water quality criteria for designated best use classes of inland water sources. Similarly Central Pollution Control Board has also set the standards for the marine and coastal waters based on the best use class.

Table 11. PRIMARY WATER QUALITY CRITERIA FOR DESIGNATED-BEST-USE-CLASSES

Designated-Best-Use	Class of water	Criteria
Drinking water source without conventional treatment but after disinfections	A	• Total coliform organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6 mg/l or more • Biochemical Oxygen Demand 5 days 20°C 2 mg/l or less
Outdoor bathing (Organised)	B	• Total coliforms organism MPN/100ml shall be 500 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 5 mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3 mg/l or less
Drinking water source after conventional treatment and disinfection	C	• Total coliforms organism MPN/100ml shall be 5000 or less • pH between 6 and 9 • Dissolved Oxygen 4 mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3 mg/l or less
Propagation of wild life and fisheries	D	• pH between 6.5 to 8.5 • Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
Irrigation, industrial cooling, controlled waste disposal	E	• pH between 6.0 and 8.5. • Electrical Conductivity at 25°C micro mhos/cm Max. 2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2mg/l

6.5.3. Effluent standards prescribed for all the industries in India

Table 12. EFFLUENT STANDARDS FOR ALL INDUSTRIES

Parameter	Units	Standards			
		Inland surface water	Public sewers	Land for Irrigation	Marine Coastal Areas
Colour and Odour Suspended Solids	mg/l, max	See note 1.	-	See note 1	See note 1
Suspended solids	mg/l, max	100	100	200	a) For Process Waste water-100 b) For cooling water effluent, 10 percent above total suspended matter or influent cooling water.
Particle Size of Suspended Solids		Shall pass 850 micron sieve	-	0	a) Floatable solid, max 3 mm b) Settable solids max 850 microns
Dissolved Solids (Inorganic)	mg/l, max	2100	2100	2100	-
pH value	SU	5.5 to 9	5.5 to 9	5.5 to 9	5.5 to 9
Temperature	° C, max	Shall not exceed 40 in any section of the stream within 15 meters downstream from the outfall	45 at the point of discharge	-	45 at the point of discharge
Oil and Grease	mg/l, max	10	20	10	20
Total Residual Chlorine	mg/l, max	1	-	-	1
Ammoniacal Nitrogen (as N)	mg/l, max	50	50	-	50
Total Kjeldahl Nitrogen (as N)	mg/l, max	100	-	-	100
Free Ammonia (as NH 4)	mg/l, max	5	-	-	5
Biochemical Oxygen Demand (5	mg/l, max	30	350	100	100

days at 20°C)					
Chemical Oxygen Demand	mg/l, max	250	-	-	250
Arsenic (as As)	mg/l, max	0.2	0.2	0.2	0.2
Mercury (as Hg)	mg/l, max	0.01	0.01	-	0.01
Lead (as Pb)	mg/l, max	0.1	1	-	1
Cadmium (as Cd)	mg/l, max	2.0	1	-	2
Hexavalent Chromium (as Cr +6)	mg/l, max	0.1	2	-	1
Total Chromium (as Cr)	mg/l, max	2	2	-	2
Copper (as Cu)	mg/l, max	3	3	-	3
Zinc (as Zn)	mg/l, max	5	15	-	15
Selenium (as Se)	mg/l, max	0.05	0.05	-	0.05
Nickel (as Ni)	mg/l, max	3	3	-	5
Boran (as B)	mg/l, max	2	2	2	-
Percent Sodium	% max	-	60	60	-
Residual Sodium Carbonate	mg/l, max	-	-	5	-
Cyanide (as CN)	mg/l, max	0.2	2	0.2	0.2
Chloride (as Cl)	mg/l, max	1000	1000	600	-
Fluoride (as F)	mg/l, max	2	15	-	15
Dissolved Phosphates (as P)	mg/l, max	5	-	-	-
Sulphate (as SO 4)	mg/l, max	1000	1000	1000	-
Sulphate (as S)	mg/l, max	2	-	-	5
Pesticides	mg/l, max	Absent	Absent	Absent	Absent
Phenolic Compounds (as C 6 H 5 OH)	mg/l, max	1	5	-	5
Radioactive Materials:					
a) Alpha Emitters	uCi/ml, max	10^{-7}	10^{-7}	10^{-8}	10^{-7}
b) Beta Emitters	uCi/ml, max	10^{-6}	10^{-6}	10^{-7}	10^{-7}

Note 1. All efforts should be made to remove colour and unpleasant odour as far as practicable.

Note 2. The standard mentioned in this table shall apply to all the effluents discharged, such as mining and mineral processing activities, municipal sewage etc.

Conversion factor : 1 Bq = 2.7 x 10^{-11} Ci

Source : Environmental Protection Rules of Environmental Protection Act, 1986.

6.5.4. Effluent standards prescribed for thermal power plants in India

Table 13. EFFLUENT STANDARDS FOR THERMAL POWER PLANTS

Source	Parameter	Units	Standards
Condenser Cooling Water (Once Through Cooling System)	pH	SU	6.5 to 8.5
Temperature	° C	Not more than 5 ° C higher than the intake water temperature	
Free available chlorine (as Cl)	mg/l, max	0.5	
Boiler Blowdowns	Suspended Solids	mg/l, max	100
Oil & Grease	mg/l, max	20	
Copper, total (as Cu),	mg/l, max	1	
Iron, total (as Fe)	mg/l, max	1	
Cooling Tower Blowdown	Free available chlorine (as Cl)	mg/l, max	

Zinc (as Zn)	mg/l, max		
Chromium, total (as Cr)	mg/l, max		
Phosphate (as P)	mg/l, max		
Other Corrosion inhibiting material		Limit to be established on case by case basis by Central Board in case of Union territories and State Boards in case of States.	
Ash Pond Effluent	pH	SU	6.5 - 8.5
	Suspended solids	mg/l, max	100
	Oil & grease	mg/l, max	20

6.5.6.Aquaculture activities related pollution in India

Aquaculture has come under increasing scrutiny and criticism as the world tries to supply food for a population exceeding six billion. Aquaculture, the farming of aquatic organisms such as fish, molluscs, crustaceans and plants, is the fastest growing food production sector in the world, but its sustainability is not assured. Pollution, destruction of sensitive coastal habitats, threats to aquatic biodiversity and significant socio-economic costs must be balanced against the substantial benefits. Aquaculture has great potential for food production and the alleviation of poverty for people living in coastal areas, many of who are among the poorest in the world. A balance between food security and the environmental costs of production must be attained. To sustain the aquaculture production of fish and shellfish in India , aquaculture waste treatment is need of the hour. To evolve a strategy for an ecofriendly aquaculture system, reducing waste from the aqua farm is one of the most important criteria.

The coastline of India has about 1.2 million hectare of brackish water area, which has the potential to use as aquaculture farms for the culture of different species of finfishes and shellfishes, seaweeds etc. However, currently about 0.14 million hectares of area has been used for the purpose of shrimp farming. In this utilized area, about two thirds of the area is used under improved traditional and extensive culture method. About one third is still under the traditional methods of culture. In this many of the 90% of shrimp farm owners are having only 2 hectares of area with the individual pond water are of 0.5 hectares.

In aquaculture farms, the potential pollutants are only the increased nutrients such as nitrogen and phosphorus along with total suspended particulate matter released through effluent as wastewater. Apart from this the release of microbial pathogens (bacteria, virus, fungi and protozoan) are considered to be an important pollutant to the environment. Unlike the agriculturally derived pollutant like pesticides, most of the pollutants released through aquaculture practices are recyclable or utilizable, biodegradable or renewable and controllable. In agriculture practices the chemical are used to kill the unwanted animals, without killing the crop plants. However, in the aquaculture farms only ecofriendly chemicals are used to grow the organisms. In most cases, toxic substances are not used and if at all used, it is also of very little quantity. The use of pesticides and other chemical may results in the gradual accumulation in the culture species itself, which will eventually kill the culture species and will lead to heavy financial loss to the farmers.

In some places like Kandeleru creek in Andhra Pradesh (India), the overcrowding of aquafarms on the banks resulted in imbalance in the carrying capacity of the creek, which ultimately resulted in conflict situation between farms and farming itself. Also, the untreated effluent release pose a potential threat to the ecology of creek and estuaries its organism dependent on it. Most of the aqua farms situated on the creeks and estuaries released the untreated effluent water back to the source. This leads to the gradual degradation of the water quality of the source water itself. Hence, it is needed that the coastal waters and its associated areas should be clean and should have desirable water quality parameters for the suitable utilization of coastal zone. Thus, the effluent water should be treated before released back to the environments. The treated water should contain permissible limit of pollutants such as nutrients, suspended matter, heavymetals and pathogens. The treated water should be re-utilizable. This will certainly result in lowering of production cost and environmental friendly solution. For this suitable effluent treatment system (ETS) has to be developed for each aquafarm or collection of aquafarms.

By knowing the above problems and prospect of aquaculture, the Ministry of Agriculture in its Guidelines for sustainable development and management of brackish water aquaculture has prescribed standards for the wastewater discharged from the shrimp farms. The recommended water quality parameters are as follows

Table 14. QUALITY CRITERIA AQUACULTURE WASTEWATERS

Sl. No.	**Water Quality Parameters**	**INDIA Final effluent water**		**THAILAND**
		Coastal Marine waters	**Creeks/ Estuaries - when the same inland water curses are used as water source and disposal point**	
1.	pH	6.0 - 8.5	6.0 - 8.5	7.0 - 8.7
2.	Suspended solids mg/l	100	100	100
3.	Dissolved Oxygen mg/l	> 3.0	> 3.0	> 4.0

4.	Free Ammonia (as NH_3-N) mg/l	1.0	0.5	1.8 - 2.9
5.	Biological Oxygen Demand (BOD) (5 days at 20 ° C) mg/l	50	20	10
6.	Chemical Oxygen Demand (COD) mg/l	100	75	-
7.	Dissolved Phosphate (as P) mg/l	0.4	0.2	0.4
8.	Total Nitrogen (as N) mg/l	2.0	2.0	4.0

6.6.Marine Pollution monitoring in India

In India various government, nongovernmental and autonomous institutions and universities are involved in marine pollution monitoring and control studies. Some of them are Ministry of Environment and Forests, Department of Science and Technology, Department of Ocean Development, National Institute of Ocean Technology, National Institute of Oceanography, Integrated Coastal and Marine Area Management Project Directorate, etc. Some of them are discussed below.

6.6.1. Role of Central Pollution Control Board (CPCB) and state pollution control boards in pollution monitoring in India

The CPCB is conducting many surveys along the coastal and marine environment around the Exclusive Economic Zone (EEZ) of India . Some of them are follows:

6.6.1.1. Pollution potential from fishing harbour

India 's coastline is dotted with 6 major and 27 minor fishing harbours and 2271 fish landing centres. The harbour related activities have an impact to a certain extent on the quality of coastal waters and its environment. The Central Pollution Control Board has undertaken a study on the pollution related problems in the Veraval fishing harbour area. The preliminary survey indicates that this harbour was originally designed for 800 fishing vessels to operate. However, without further expansion, more than 3000 fishing vessels of different kinds are operating here at present. The domestic wastewater generated from Veraval town and effluents from fish processing units of nearby GIDC also finds its way into the harbour area. The industries Association of Veraval has recently undertaken the work of the construction of a CETP with designed treatment capacity of 5.0 MLD.

6.6.1.2. Oil pollution and the marine environment

Indian coastal waters are located at a vulnerable position to oil pollution, since 45% of the world's oil transport originates from Middle East countries and passes through India 's Exclusive Economic Zone (EEZ). On an average, 40 super tankers pass through Indian coastal waters daily. In addition, Indian Ports and Harbours handle about 3810 tankers carrying about 84 million tonnes of petroleum/oil/lubricants every year. It is necessary to assess coastal areas with respect to oil pollution and our capability to combat the oil pollution. To evaluate the situation, relevant data/information have been collected from different government agencies by Central Pollution Control Board and compiled as a Report on Oil Pollution and the Marine Environment.

Apart from this, the state boards are conducting surveys along the coastline and presenting their reports to the local government and central government and related agencies.

6.6.2. Role of Department of Ocean Development (DOD), Govt. of India, in marine pollution monitoring

In order to fulfill the objectives in the ocean policy, the DOD has been promoting and implementing the following major research and development programme. More information is available in the web site of DOD, India .

6.6.2.1. Coastal Ocean Monitoring and Prediction Systems (COMAPS) Programme

Coastal Ocean Monitoring and Prediction System (COMAPS) programme is being implemented from 1991 onwards. The main objective of this COMAPS programme is to assess the health of Indian coastal waters on a long term basis and to facilitate the pollution control authorities to plan a strategy required for management of pollution related issues like prescription of appropriate disposal standards, as per the assimilation capacity of the receiving water bodies, water quality criteria, etc. In the light of the above, the programme was continued with physical oceanographic, microbial and pesticide pollution studies along the coastal areas of our country. During 2000-01, the programme was restructured and modified, comprising the following components:

- Pollution monitoring
- Liaison, regulation and legislation
- Consultancy services

Having identified the level of pollution in a general way in different coastal areas for the past 10 years the next level of activities identified are to:

- Carry out studies on spatial and temporal variation of pollutants in areas of immediate concern and selected areas of potential concern, identify source of pollutants and on this basis, suggest steps for control/abatement of pollutants
- Initiate modelling studies in one or two areas simultaneously
- Incorporate Impact Assessment Studies on Living Resources
- Create public awareness on these issues.

6.6.3. Integrated Coastal and Marine Area Management (ICMAM)

The ICMAM programme implemented from 1998-99 onwards has 2 major components namely, 1) Capacity Building and 2)

Development of Infrastructure for R&D and training.

The Capacity Building component funded by the International Development Association containing the activities of Development of GIS based information system for critical habitats, Determination of Waste Assimilation Capacity in selected estuaries and coastal waters. Development of guidelines to conduct EIA for coast related activities and Development of Model ICMAM Plan for selected areas.

Under the infrastructure component, which is funded by the DOD, provision of facilities for imparting training to coastal states on ICMAM related activities and R&D activities on zonation of coastal waters using the methods of use classification etc., are being undertaken. The progress made during the year under each activity is given below:

- Development of GIS based Information System for Critical Habitats
- Determination of Waste Assimilation Capacity
- Development of Guidelines for Environmental Impact Assessment
- Development of Model ICMAM Plan for Chennai, Goa and Gulf of Kachchh

6.6.4. Role of National Institute of Ocean Technology (NIOT) in marine pollution monitoring

The National Institute is involved in many ocean related activities which includes, pollution monitoring in the coastal areas (COMAPS), studies on waste assimilation capacity and waste load allocations, environmental impact assessment (EIA) surveys in various coastal and marine areas including, Gulf of Mannar, Andaman & Nicobar Islands, Gulf of Kutchchh etc.

Waste Assimilation Capacity and Waste Load Allocation at Ennore (Chennai) is being undertaken by Mission III of NIOT. The major tasks involved under this activity are as follows:

- Review of available data on sources of pollution in the project area and status of marine pollution.
- Establishment of desirable water use and water quality criteria.
- Collection of primary data relating to water quality, hydrodynamics, topography, discharge and obstruction characteristics after establishing water quality control/assurance procedures.
- Selection of a suitable model for hydrodynamics and water quality, model calibration and validation using the primary data.
- Development of an ecological model to study the impact of water quality changes with bio-diversity.
- Simulation of the models for different alternatives and discharges considering techno-economic feasibility of treatment, recycle/reuse and discharge options for both point and non-point sources.
- Delineation of cost effective waste load allocation option in consultation with the user.

A work plan containing the details of work to be done, schedules, etc., for determination of waste assimilation capacity for Tapi estuary has been prepared. Out of the 2 field exercises required for collection of data for modeling, one has been completed. Regarding the Ennore coastal waters and creek, NIOT has completed all the field exercises. NIOT have chosen the type of models required for modelling using MIKE 21 software. The modelling exercises have been initiated for both the areas.

Apart from these major programmes, NIOT is carrying out the COMAPS programme for Andaman & Nicobar Islands through Andaman Nicobar Centre for Ocean Science and Technology (ANCOST), which is the field unit of Ocean Science and Technology for Islands (OSTI), of NIOT.