UNIT 10 MARINE POLLUTION

Structure

10.1 INTRODUCTION

The continued degradation of the human environment has become a major topic in every corner of the globe. Air, water and soil are the three main components of the environment. Seawater makes up around two-thirds of the world's surface and is essential for biological and ecological balance. People are drawn to the water for a variety of reasons, including adventure, nutrition, commerce, industry, and enjoyment. Humans have used the ocean in this fashion many times before, but it is projected that they will exploit it on a larger scale in the future. However, the greatest detrimental use of the ocean by humans has been the disposal of various sizes of waste.

Mankind is polluting the maritime environment with a rising amount and variety of waste products resulting from evolving technology, without completely knowing how these pollutants may interact with our surroundings and, as a result, harm our health. Our culture has not progressed far enough to collect tremendous amounts of material wealth or to handle and manage the enormous volumes of waste it produces. The use of seas and oceans for dumping industrial waste, human waste, and nuclear waste is based on the assumption that the sea has an infinite capacity to receive and absorb anything. We have yet to recognize, however, that we are choking our seas, killing our fish, deteriorating marine life, and causing ecological imbalances.

Ocean pollution or Marine pollution became increasingly apparent in the late 1960s. Due to the very vast volume of oceans, it was believed by most scientists that they had unlimited ability to dilute ocean pollution and thus render pollution harmless. At U. N. Conference on the Human Environment, in the year 1972, it was a major area of discussion. In the present society, plenty of disposable and single-use plastic is used on daily basis for many packaging and transportation activities, from shopping bags to shipping packaging to plastic bottles. To replace plastic with an environmental-friendly product will be a challenging task and also one has to see its economic viability.

The marine word originates from the Latin word Marinus means about the sea or the French word marin, marine, which means sea. Marine pollution results from the mixing of chemicals/trash materials from various anthropogenic activities that are washed, blown, or tossed into the ocean, causing harm to the ocean environment, particularly the health of all marine species.

Chemical pollution, radioactivity, solid waste, human-induced sedimentation, energy (i.e., heat and noise), oil spills, diseases, parasites, and invading species (biological pollution) are only a few examples of marine pollution.

Marine pollution may be sub-categorized into four most common varieties viz., plastic, light, noise and chemical pollution. Over 8 million tons of plastic are being dumped into the sea every year. Marine trash consists of mainly manufactured products. Shopping bags and drinking water bottles, as well as cigarette butts, bottle caps, food wrappers and fishing gear are mostly plastic. Plastic waste is extremely durable and takes hundreds of years to decompose. Microplastics (less than 5 mm in diameter) are consumed by small organisms, which absorb the chemicals in the plastic into their tissues. When larger animals eat smaller species that consume microplastics, dangerous chemicals become part of their tissues due to biosynthesis Man-made noise pollution poses a far bigger hazard to marine animals than it does to those who live on land or in the air. Noise pollution not only confuses animals that rely on sonar signals to forage, mate, and navigate their way across the ocean, but it also shortens their lifespan and puts entire species at risk.

Fertilizer use for agricultural purposes results in chemical spills into streams, which eventually end up in the ocean. As a result, substances like nitrogen and phosphorus accumulate in the coastal seas, promoting algal bloom growth. These blossoms are potentially hazardous to wildlife and humans, as well as a threat to the local fishing and tourism industries.

10.2 OBJECTIVES

After studying this unit, you should be able to:

- define marine pollution and its types;
- describe the sources, causes, extent and intensity of marine pollution;
- describe the mechanism and process of marine pollution and
- explain the ecological impacts of marine pollution.

10.3 DEFINITION OF MARINE POLLUTION

Humans' purposeful or without intention introduction of substances into the marine environment causes damage to living resources and poses a health risk to humans. People obstruct maritime activities like fishing, impair seawater quality, and reduce recreational opportunities. When human-made pollutants enter the water and cause harm, such as industrial, agricultural, and residential waste, excess carbon dioxide, or invading species, this is known as marine pollution (Glossary of Environment Statistics, 1997).

10.4 SOURCES AND CAUSES OF MARINE POLLUTION

Everything that is carried by rivers eventually ends up in the seas, adding to the salt content of the water. Rivers collect massive volumes of sewage, faeces, waste, agricultural runoff, industrial effluents, biocides, and heavy metals as they travel. Heterotrophic organisms' digestion of organic matter is incomplete, resulting in the buildup of acids, bases, alcohols, and different gases. Coliform bacteria, Gram-negative non-spore producing bacilli commonly seen in the colon, are the most common bacteria. *E. coli* and *Enterobacter* species are included in this group. Lactose is fermented into acid and gas by these bacteria. *Streptococcus, Proteus*, and *Pseudomonas* are among the non-coliform bacteria found.Polluting organisms multiply quickly under certain conditions and use the majority of available oxygen. Nutrients, for example, enter the water body through sewage treatment plants or urban/suburban run-off. As a result, a high nutrient concentration develops quickly, allowing algae to bloom quickly. Water becomes oxygen-depleted as a result of this. Protozoa, tiny animals, fish, and plants have very little oxygen accessible. Because of the lack of oxygen, a layer of dead organisms, dirt, and silt accumulates at the bottom, allowing anaerobic species such as *Clostridium, Desulfovibrio*, and others to thrive and create gases. H_2S, a gas, reacts with lead or iron to form a precipitate, turning the mud black and making the water deadly. As a result of depletion in oxygen, the suspended bacteria die because of their waste products.

Man-made pollution, such as discarded plastics and other household debris, as well as pesticides and industrial chemicals, eventually find their way into the sea, wreaking havoc on marine life and the environments on which they rely. Accidents involving ships and oil spills add further pollutants to the mix. According to estimates, 80 per cent of marine pollution originates on land. Land-based pollutants like agricultural run-off and fertilizers from sewage outflows are leading to ocean 'dead zones,' which have minimal or no oxygen and can no longer sustain life. There are now over 500 of these "dead zones" all around the globe. Furthermore, coastal 'megacities' have grown as a result of increased urbanization along the world's coastlines (cities with a population of 10 million or more). Thirteen of the world's twenty megacities were located along coasts in 2012. Many of these people place a strain on infrastructure, which includes poor waste and sewage management. Implementing effective waste reduction measures, recycling, and appropriate waste and sewage treatment in such locations is critical to ensure the health of our oceans' lifetime. Marine pollution is also caused by the discharge of oils and petroleum products, as well as the dumping of radioactive waste into the sea. Turbulence and ocean currents can distribute toxins in the water, or they might concentrate in the food chain. Adsorption, precipitation, and accumulation processes may cause them to settle at the bottom. Species diversity may be lost as a result of bioaccumulation in the food chain. Changes in the physical, chemical and biological characteristics of seawater are linked to marine pollution. Oceans span almost 71 per cent of the Earth's surface.

Some of the marine pollutants/ categories of marine pollutants are pathogens, sediments, solid wastes, freshwater, brine, toxic inorganics/organics, petroleum and oil, and oxygen demanding materials. These marine pollutants may come from various sources. The marine pollution may also be the natural in origin. Some of the sources of marine pollutants may be various commercial and developmental activities.

Table 10.1: Sources of oil pollution in the sea

S. No.	Sources	Percentage (%)
1.	Natural sources	10
2.	Industrial wastes etc.	62
3.	Refineries/ terminals	1
4.	Non-tanker accidents, bilge and fuel oil, dry docking	15
5.	Tanker operations	7
6.	Tanker accidents	3
7.	Offshore	2

Some of the sources of marine pollution (Table 10.1) along with their causes and effects are discussed below in detail:

1. **Oil Spills**

   There are several ways through which the oil can reach the sea:

   - Natural release such as oil seeps from the bottom of oceans and enters the marine environment. Crude oil is formed during long periods through natural processes involving organic matter from dead organisms.
   - An oil tanker and other ship accidents

   Major Oil spills

   - Gulf oil spill, Persian Gulf, January 23, 1991- During the fight between Iraq and Kuwait, a large amount of oil was allowed to flow into the sea, resulting in marine pollution and the destruction of sea life. A significant amount of oil pours into the water as a result of oil ship crashes.

- Nowruz oil field, Persian Gulf, February 1983
- Amoco Cadiz, Brittany, France, March 16, 1978- In March 1978 about 2, 30,000 tonnes of shipment through the English Channel spilled from the hold of supertanker Amoco Cadiz resulting in the spreading of an oil blanket of 120 km long and 6 km wide.
- Torrey Canyon, South England, March 18, 1967
- The Urquiola oil spill, La Coruna, Spain, May 12, 1976
- Hawaiian Patriot, North Pacific February 26, 1977
- On March 25, 2005, 110 tonnes of oil spilled in Goa port.
- Such accidental oil spills in the sea seem to continue due to an increase in commercial activities and the requirement for energy.

2. Tanker Operations

The sea transports half of the world's crude oil production, which is close to three billion tonnes per year. After unloading its oil cargo, a tanker must take on seawater as ballast for the return journey. The ballast water is stored in the cargo compartments where the oil was previously stored. These compartments are cleansed with water before a new cargo of oil is loaded, which discharges the unclean ballast along with the oil into the sea. Because of its visibility, oil contamination in the water usually gets the most attention. It is sea-based pollution that is perhaps the worst of the marine environment's pollutants. Some modern tankers feature separated ballast, which prevents the ballast water from coming into contact with the cargo. By adopting new techniques of ballast, oil spills can be reduced.

3. Dry Docking

All ships require dry-docking regularly for maintenance, repairs, and hull cleaning, among other things. Residual oil finds its way into the sea during the period when the cargo compartments need to be emptied.

4. Tanker Accidents

Every year, a considerable number of oil tanker accidents occur. This can sometimes lead to huge disasters in the marine environment.

5. Off-shore Oil Pollution

Water is present in the oil that has been taken from the seabed. Even after passing through oil separators, the discharged water includes some oil, contributing to marine contamination. Drilling mud contains 70-80 per cent oil and is injected down oil wells as they are being drilled. They're deposited on the seabed beneath the drilling platform, polluting the water significantly.

10.5 EFFECTS OF MARINE POLLUTION

Oil spills on the water surface first generate slicks that float to the surface. The oil may sink if it is absorbed by solid particles. Phytoplankton, a microscopic organism that acts as a biological blotter, absorbs floating and suspended oil. Because these species represent the foundation of the food chain, they are consumed by higher kinds of marine life, which then transmit the oil pollution onto even higher organisms.

As a result, predator concentrations among marine mammals, birds, and humans grow, altering the food chain, and water birds frequently float to shore to die with oil-soaked feathers. To summarize, oil has the potential to affect both marine life and recreational options along the coast. Marine pollution from oil spills has the following effects on the sea: Modifying physical and chemical properties; Crude oil forming sticky layers-prevents free diffusion of gases and decreasing the photosynthesis, Series of chemical and physical changes that cause spilled oil to break down and become heavier than water, and Winds, waves, and currents may result in natural dispersion, breaking a slick into droplets.

Oxidation occurs when the lighter substances within the oil mixture become vapours which leaves heavier components of the oil and may sink to the ocean floor. Heavier oils leave a thicker, more viscous residue, which may have serious physical and chemical impacts on the environment. Biodegradation occurs when microorganisms feed on oil and to sustain biodegradation, nitrogen and phosphorus are added to encourage the microorganisms to grow and reproduce. Emulsions consist of a mixture of small droplets of oil and water and are formed by wave action, and greatly hamper weathering and cleanup processes. Two types of emulsions exist, water-in-oil and oil-in-water. Oil and water emulsions cause oil to sink. Waves and turbulence at the sea surface cause dispersion of all or part of a slick to break up into fragments and droplets of varying sizes. The oil that remains suspended in the water has a greater surface area than before dispersion occurred which encourages other natural processes like dissolution, biodegradation and sedimentation to occur.

CHECK YOUR PROGRESS 1

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the unit.

1. Define marine pollution.

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2. Discuss how oil spills affect the sea.

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10.6 EXTENT OF MARINE POLLUTION

In today's globe, marine pollution is becoming more of an issue. Chemicals and rubbish are the two main types of contamination in our oceans. Chemical or nutrient contamination is a source of concern for health, the environment, and the economy. When chemicals infiltrate waterways and eventually run into the sea as a result of human activity, particularly the use of fertilizers on farms, this form of pollution happens. The growth of blue-green algae is aided by increasing the concentration of substances such as nitrogen and phosphorus in coastal waters.

All produced objects that end up in the water, particularly plastics, are considered marine garbage. Various plastic products, such as shopping bags and beverage bottles, and fishing tackle, are common types of marine garbage. Due to its tremendous durability, plastic trash is particularly hazardous as a contaminant. Decomposition of plastic items might take hundreds of years. Humans and animals are at risk from this waste. Microplastics are minute particles of degraded plastic that are eaten by small organisms and absorb chemicals from the plastic into their tissues. Microplastics, which have a diameter of fewer than 5 millimetres, are detected in a variety of marine species, including plankton and whales. Toxic substances become part of the tissue when giant animals devour microscopic organisms that absorb microplastics. This is how microplastic contamination works its way up the food chain until it reaches the food we eat.

Disposable and single-use plastic is widely employed in today's culture. Changing society's attitude toward plastic use will be a long and costly process. Cleaning up some items may be impossible because many types of trash do not float but end up in the water. In ocean gyres, plastics that do float tend to gather in enormous "patches." These spots are more like specks of microplastic pepper whirling throughout an ocean soup, according to the National Oceanic and Atmospheric Administration. Even some promising techniques for mitigating marine pollution are insufficient. Biodegradable plastics often only degrade at temperatures much higher than those found in the ocean. Many countries have implemented legislation that prohibits the use of disposable plastic products. Pollutants are dumped in the ocean and fish and other sea creatures are affected by this trash daily.

Eighty per cent of non-biological marine pollution is due to terrestrial activity. The most obvious entry is through a pipe that flows directly into seawater (sewage, industrial, chemical, food waste). Rivers flow into the sea and carry pollutants from the entire catchment area. Plastic debris kills 100,000 marine mammals and 2 million sea birds die annually. In coastal waters, the type, composition and density of floating debris vary greatly among locations. The spatial distribution is influenced by anthropogenic activities, hydrographic and geomorphologic factors, prevailing winds, and entry points (Barnes *et al.,* 2009; Derraik, 2002). Generally, the distribution and composition of marine debris floating at sea depend largely on near-shore circulation patterns (Aliani *et al*., 2003; Lattin *et al.*, 2004; Ribic *et al.*, 2010; Thiel *et al*., 2003). Prevailing winds also affect the pattern of debris abundance. Greater quantities of plastics were observed at downwind sites (Browne *et al*., 2010; Collignon *et al.*, 2012). Collignon *et al.* (2014) observed that the density of floating debris was five times higher before a strong wind event than afterwards. This was explained by the wind stress increasing the mixing and vertical redistribution of the plastic particles in the upper layers of the water column. However, most land-based litter is carried by water currents through rivers and stormwater (Ryan *et al.*, 2009). The density of the debris in southern California, United States coast water, after the storm was seven times higher than before the storm (Moore *et al*., 2002). The weight of plastic increased by more than 200 times after a storm in Santa Monica Bay, California, United States (Lattin *et al.*, 2004). Higher densities of debris in coastal waters are also associated with human population density (Lebreton *et al.*, 2012; Thiel *et al.*, 2003).

In the open ocean, spatial patterns of debris are influenced by the interaction of large-scale atmospheric and oceanic circulation patterns, leading to particularly high accumulations of floating debris in the subtropical gyres (Howell *et al.*, 2012; Goldstein *et al.*, 2013; Martinez *et al.*, 2009). Substantial accumulations of debris are now in oceanic gyres far from land (Law *et al*., 2010). The models developed by Martinez *et al*. (2009) suggest that marine debris deposited in coastal zones tends to accumulate in the central oceanic gyres within two years after deposition. The persistent floating debris will accumulate in mid-ocean sub-tropical gyres, forming so-called garbage patches (Kaiser, 2010; Lebreton *et al*., 2012).

Although the type of litter found in the world's oceans is highly diverse, plastics are by far the most abundant material recorded. Plastic debris was first reported in the oceans in the early 1970s (Carpenter and Smith, 1972; Colton and Knapp., 1974). Plastics are estimated to represent between 60 per cent and 80 per cent of the total marine debris (Derraik, 2002; Gregory and Ryan, 1997). Almost all aspects of daily life involve plastics, and consequently, the production of plastics has increased substantially in the last 60 years and this trend continues. The fragmentation of plastics generates microplastics. For example, in sampling the South Pacific subtropical gyre, 1.0-4.7mm particles accounted for 55 per cent of the total count and 72 per cent of the total weight (Eriksen *et al.,* 2013). Research on the amount, distribution, composition and potential impact of microparticles has received increasing attention.

Plastic debris continues to accumulate in the marine environment. Goldstein *et al*. (2013) show that the density of microplastics within the North Pacific Central Gyre has increased by two orders of magnitude in the past four decades. In contrast, there is no significant trend in the density of surface water plastics in the North Atlantic from 1986 to 2008, despite increases in plastic production during this time (Law *et al.*, 2010). Some form of loss must be taking place to offset the presumed increase in the input of plastics to the ocean. Possible sinks for floating plastic debris include fragmentation, sedimentation, shore deposition, and ingestion by marine organisms (Law *et al*., 2011).

Beach Debris

Millions of volunteers in more than 150 countries are involved in beach-cleanup activities on International Coastal Cleanup Day every year (Ocean Conservancy, 2011). The volunteers' participation contributes to extensive sampling and helps to obtain more information from a wider range of sites (Rees and Pond, 1995). For most beaches, the major debris is plastic. The spatial distribution of plastic debris is affected by multiple factors, including land, uses, human population, fishing activity, and oceanic current systems (Ribic *et al*., 2010).

Beach debris density may be linked to the number of tourists and the cleaning frequency (Bravo *et al*., 2009; Kuo and Huang, 2014). For example, beach debris densities in central Chile were lower than in northern and southern Chile, which could be due to different attitudes of beach users or intensive beach cleaning in central regions (Bravo *et al*., 2009). Santos *et al.* (2005) found that the quantity of litter depends on beach visitor density. Ocean current patterns, sand types, wave action, and wind exposure have further effects on litter abundance. For example, in Monterey Bay, California, the United States, the seasonal variability in debris abundance may be a function of oceanic winds, as well as the possibility that seasonal current patterns may drive debris deposition (Rosevelt *et al.*, 2013).

Although marine debris density is usually associated with population density, a few studies contradict this. Ribic *et al.* (2010) shows no trends over several decades in beach-debris densities along the Eastern Atlantic seaboard of the United States, although large percentage increases in coastal population occurred in the south-east Atlantic region and a smaller percentage increase in coastal population occurred in the north-east region.

Benthic Marine Debris

The occurrence of litter on the seafloor has been far less investigated than in surface waters or on beaches, principally because of the high cost and the technical difficulties involved in sampling the seafloor. Nevertheless, a few investigations of benthic debris have been recorded, including on the continental shelves, on raised seabed features, such as seamounts, ridges and banks, in canyons and polar regions. The surveying methods for the density and composition of benthic marine debris include bottom trawling, coring, scuba diving, the use of submersibles, snorkelling, manta tows and sonar (Spengler and Costa, 2008) and more recently, towed camera systems and Remotely Operated Vehicles (ROVs).

Abundances of benthic debris range from dozens to more than hundreds of thousands of items per square kilometre. As more areas of Europe's seafloor are being explored, benthic litter is progressively being revealed to be more widespread than previously assumed. Pham *et al.* (2014) reported data on litter distribution and density collected during 588 videos and trawl surveys across 32 sites in European waters (35-4500 m depth). Debris was found to be present in the deepest areas and at locations as remote from land as the Charlie-Gibbs Fracture Zone across the Mid-Atlantic Ridge. The highest litter density occurred in submarine canyons, and the lowest density was found on continental shelves and ocean ridges. As for most other marine environments studied, plastic was the most prevalent litter item found on the seafloor. Woodall *et al* (2015) showed that the litter was ubiquitous on deep-sea raised benthic features, such as seamounts, banks and ridges, A total of 56 items were found in the Atlantic Ocean over a survey area of 11.6 ha, and 31 items in the Indian Ocean over 5.6 ha, with a significant difference in the type of litter between areas sampled in the Indian Ocean (where the dominant litter type was fishing gear) and sites in the Atlantic Ocean (which had mixed refuse).

Litter from fishing activities (derelict fishing lines and nets) was particularly common on seamounts, banks, mounds and ocean ridges. A significant source of benthic debris is lost and discarded fishing gear, which is of particular concern due to ghost fishing effects that can kill both commercial and non-commercial species. Laist (1996) reports annual gear loss rates of about one per cent for gillnet fisheries and between 5 and 30 per cent for trap fisheries in United States fisheries. Whereas trap loss rates in the American lobster fishery are relatively low (5-10 per cent) because the fishery involves more than 3 million deployed traps, the lobster fishery alone may account for the loss of more than 150,000 traps per year.

Hydrography, geomorphology, and anthropogenic activities all affect the abundance, type, and location of debris reaching the seafloor (Barnes *et al*., 2009; Galgani *et al*., 2000; Schlining *et al*., 2013). Because they facilitate the transport and deposition of debris, submarine canyons act as conduits for debris, transporting it from the coast to the deep sea (Ramirez-Llodra *et al*., 2013; Schlining *et al*., 2013). Ramirez-Llodra *et al*. (2013) suggests that debris in a canyon mainly originates from coastal areas, and that plastic debris can be transported easily by canyon-enhanced currents, whereas heavy debris is usually discarded from ships. Wei *et al*. (2012) indicate that the debris density was higher in the eastern than that in the western Gulf of Mexico, primarily because of shipping lanes, offshore oil- and gas installation platforms, as well as fishing activities. The litter density and diversity were independent of the depth of water and distance from land. Galgani *et al.* (2000) report that only small amounts of debris were collected on the continental shelf, mostly in canyons descending from the continental slope. Ramirez-Llodra *et al.* (2013) report accumulation of litter with increasing depth, but the mean weight at different depths, or between the open slope and canyons, showed no significant variation. Schlining *et al.* (2013) found debris clustered just below the edge of canyon walls or on the outside of canyon meanders. Wei *et al*. (2012) indicated that the total density of anthropogenic waste was significantly different between parallel depth transects. Woodall *et al* (2015) concluded that the pattern of accumulation and composition of the litter was determined by a complex range of factors both environmental and anthropogenic.

Debris continuously accumulates on the deep seabed; some research shows a significant increasing trend. Watters *et al.* (2010) reported a significant increase in the amount of litter at some shelf locations in California, United States, between 1993 and 2007. The debris density has continued increasing and has doubled during the last decade in the Arctic deep-sea (Bergmann and Klages, 2012). The density of microplastics in sediments has been increasing along the Belgian coast (Claessens *et al*., 2011). However, some studies did not observe significant temporal increases, for example, in litter abundance between 1989 and 2010 in Monterey Canyon, central California, United States (Schlining *et al*., 2013).

10.7 INTENSITY OF MARINE POLLUTION

The sea absorbs a variety of chemicals that flow into it, but the sea itself remains relatively unchanged. However, with the expansion of the world's industries in recent decades, marine pollution has become increasingly serious, and the marine environment in the region has altered dramatically. As a result, oceans, as a vital part of human development, are now confronting various adverse issues. The marine ecology is then gradually impacted by pollution from land, ships, and maritime accidents. In the face of escalating marine pollution, we can no longer remain silent. The preservation of the marine environment should be considered one of humanity's most critical issues today. To protect the maritime ecosystem, everyone must take action. The bay near the mainland is where the majority of marine pollution occurs. Temperature, pH, salt, transparency and species are all influenced by the ecological balance of the ocean, which is threatened by the concentration of population and industry, large amounts of sewage and solid waste discharged into seawater. Oil pollution, toxic build-up, plastic pollution, and nuclear contamination are all examples of marine pollution. Worldwide, the most polluted areas are the Mediterranean Sea, New York Bay Baltic Sea, Tokyo Bay and the Gulf of Mexico. Coastal pollution is found serious in Japan, the United States, the East and the South China Sea.

As a result of human production and lifestyle, the majority of the massive volumes of pollutants formed in the water enter the ocean through a variety of routes. Damage to marine biological resources, maritime development, and the quality of the marine environment endangers humanity. As a result, protecting the ecosystem in the sea is crucial.

The UNESCO Intergovernmental Ocean Commission on the Status of the Global Large-Scale Marine Ecosystem Research Report, released on July 14, 2016, indicated that over 50% of fishing resources are overfished, and seawater warming affects 64 key marine ecosystems. Furthermore, more than half of the world's coral reefs are threatened, with the number rising to 90% by 2030. There are currently 66 main marine ecosystems on the planet, each covering over 200,000 square kilometres. In the ocean, these zones are often incredibly productive, but they are also extremely sensitive to human activity. The report points out that between 1957 and 2012, the temperature of 64 major marine ecosystems rose. And three of them are the East China Sea, the Scotia Sea, and the waters of the northeastern continental shelf of the United States, where the seawater temperature rises fastest; the maximum temperature rise is 1.6 °. In addition to seawater temperature, this publication also looked at productivity, fisheries, pollution and environmental protection, marine health and socio-economic development, and integrated management of large-scale marine ecosystems. The world's largest marine ecosystems, on the whole, get low marks. In the case of plastic pollution, the East and Southeast Asian waterways, the Mediterranean Sea, and the Black Sea are all in higher danger. According to the estimate, the ocean contains between 5 and 50 trillion tonnes of plastic trash. The actual figure is unknown, but it is undoubtedly large and does not include plastic debris that has accumulated on the ocean floor or beaches. Some garbage decomposes in six months, while others might last hundreds of years in the sea. In maritime habitats, plastic garbage decomposes more slowly than on land, which can have significant consequences. These plastic containers emit harmful compounds and do not contribute to the natural nutrition cycle in the ocean. By 2050, eutrophication of saltwater will have put 21 per cent of the world's major marine ecosystems at risk, primarily in Southeast Asia and Africa. Huge marine ecosystems, particularly large bodies of water near developing countries, are often next to densely populated areas and are thus most affected by human activities. The most important issues harming marine ecosystems include ocean acidification, rising seawater temperature and commercial transportation.

Seawater turbidity, which is generated by marine pollution, has a significant impact on the photosynthesis of marine plants like phytoplankton, lowering ocean production and putting fish at risk. Heavy metals, hazardous natural chemicals, and other poisonous contaminants build on the bottom, poisoning marine animals and other species. Oil is being dumped into the ocean, causing a large amount of dissolved oxygen to be absorbed by the oil; the oil film concealing the water has caused a split between seawater and air, which may be the cause of ocean hypoxia. Hypoxia in seawater can lead to the demise of marine life. Algal plankton can proliferate in seawater quickly due to nitrogen and phosphorus pollution.

Most of the world's coastal areas are reportedly degraded by pollution, which has a significant impact on commercial coastal and marine fisheries. Therefore, the management of water pollution is recognized as an urgent need for the sustainable management and conservation of existing fisheries and water resources. Unfortunately, as Williams (1996) explains, pollution problems are characterized by interconnections, complex interactions, uncertainties, conflicts, and limitations that make problem management difficult. Furthermore, one of the key problems in implementing efficient management methods to address marine pollution has been recognized as the information gap, which is related to poor scientific knowledge of marine pollution.

10.8 MECHANISM AND PROCESS OF MARINE POLLUTION

Disposal into waterways is a very ancient practice of dealing with waste and the open waterways have been used by people for dumping all kinds of waste produced. Consequently, most of the aquatic environments are now polluted to some extent; situations are even critical near intensive human settlements. Pollution of water bodies from a large variety of sources and their various impacts has been reported from different ecosystems for a long. Progressive increases in nutrient concentration and altered nutrient ratio have been reported from the Baltic Sea, Wadden Sea, North Sea, Black Sea, Adriatic Sea, Dutch Sea, Japan Sea, the Gulf of Thailand, the Indian Ocean and the bays and coasts of many countries (HELCOM, 1996; Sheppard, 2000a, Sheppard, 2000b). As a result of human intervention and mobilization of nutrients, surface waters and groundwaters throughout the developed world now have elevated concentrations of N and P compared to concentrations in the middle of the 20th century (Cloern, 2001). For example, concentrations of nitrate have increased five times and phosphate 20 times in the Black Sea from the 1960s to the 1980s (Gomoiu, 1992). Cloern (2001) reported a decadal-scale of increasing N and P in the Northwest Black Sea, central Baltic Sea, Archipelago Sea and the Irish Sea and three rivers in North America and Europe including the Mississippi River; increasing phytoplankton productivity in the Adriatic Sea, Belt Sea and the Wadden Sea decreasing dissolved oxygen concentrations and Secchi depths in different coastal seas from the 1960s to 1990. Likewise, levels of N and P in the Dutch Seas have increased four and two times respectively from 1930 to 1980 (GESAMP, 1990). Three to five times increases in N and P export have been reported in Queensland, Australia, in the last 65 years (Moss *et al.*, 1992). Progressive increases in primary productivity and decreases in dissolved oxygen due to eutrophication have been reported in the Baltic Sea from 1958 to 1989 (HELCOM, 1996). A decrease in bottom oxygen was found in the northern Adriatic Sea during the period 1911 to 1984 (Justic *et al.,* 1995). The long-term increase in nutrients in the Baltic has caused an increase in phytoplankton biomass, a decrease in water transparency, proliferation of filamentous algae, and also large-scale changes in species diversity of benthic and fish communities (Bonsdorff *et al.,* 1997). Globally, increases in frequency and severity of hypoxia are evident, especially in coastal and estuarine areas; many ecosystems are now near the verge of hypoxia-induced catastrophe (Diaz and Rosenberg, 1995).

In the last two decades, there has been an increased frequency and scale of toxic algal blooms including red tides in coastal waters of Brunei, Malaysia, South Africa, Hong Kong, Japan and Thailand and an increase in PSP frequency has been found in both temperate and tropical regions (Viviani, 1992). Long-term monitoring programs show a general decrease in environmental levels of DDT and PCB in many coastal waters. For example, the annual geometric means of DDT, PCBs and PAHs in mussels at 154 sites in coastal waters of the USA showed a general decrease from 1986 to 1993 (Beliaeff *et al.,* 1997). Likewise, Blomkvist *et al.* (1992) showed a significant decrease in RDDT and PCB in the blubber of 109 specimens of ringed seals (*Phoca hispida botica*), grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) in Swedish waters since the early 1970s. Analysis of sediment core samples in Clyde estuary, UK showed a significant decrease in PAH deposition over time (Hursthouse *et al.*, 1994). The decreased concentration of xenobiotics in the marine environment reflects the general reduction in the use and discharge of these compounds in the northern hemisphere. Unfortunately, very few long-term studies have been carried out in tropical and subtropical coastal waters. The decreasing trend observed in temperate regions may not apply to tropical and sub-tropical waters, since a reduction in use and disposal of toxic organic chemicals in the latter regions may not be the same.

At present, some 65% of existing large cities (with more than 2.5 million people) are located along the coast. The world population has exceeded 6 billion, of whom 60% (3.6 billion) is living within 100 km of the coast (UNEP, 1991). A substantial proportion of wastewater generated from this population will likely be directly discharged into the coastal marine environment with little or no treatment, thereby adding to the already high nutrient input. Various studies have attempted to estimate the anthropogenic input of nutrients into the marine environment (Cornell *et al.*, 1995; Sheppard, 2000a, Sheppard, 2000b, Sheppard, 2000c). The present anthropogenic emissions and deposition of nitrogen to the North Atlantic Ocean are about five times greater than in pre-industrial time (Prospero et al., 1996). At present, atmospheric deposition of N contributes some 10–50% of the total anthropogenic N input (2-10 × 10^4 µmol N m^{-2} $year^{-1}$), and a further increase is expected in the coming years (Paerl, 1993).

There is a worldwide increase in irrigation in arid areas, large scale clearing of land vegetation, and deforestation, which contribute enormously to terrestrial runoff. Intensive farming results in overgrazing, ammonia emission, and farm waste disposal problems. Nutrient export from crop and pasture lands is typically an order of magnitude greater than those from the pristine forest (Gabric and Bell, 1993). Mariculture activities have increased dramatically in many coastal areas in the last decade, and such a trend will continue (FAO, 1992). This will further augment the nutrient input into coastal environments since some 80% of N input into a mariculture system will be lost in the marine environment (Wu, 1995). The volume of wastewater generated by human populations is typically large, and the removal of nutrients from such huge amounts of wastewater is expensive. The cost of secondary treatment (which only removes some 30-40% of N and P) for example, is some 3-4 times more expensive than that of primary treatment. Due to the high construction and recurrent costs, it is unlikely that the building of sewage treatment facilities can match population growth and GNP in developing countries.

PCBs are frequently found in fish liver, seal blubber, bird eggs and human fat in the North Sea. Octachlorostyrenes (OCSs) were found in benthic organisms from the international North Sea (Dethlefsen *et al*., 1996). Concentrations of HCHs, PCBs, and triazines have been determined in the German Bight within the water column and rainwater, and HCHs and PCBs in sediment samples (Huhnerfuss *et al.,* 1997). Concentrations of insecticides and PCBs in sediment from the Thames estuary have been associated with sewage sludge dumping. Disposal of dredged material into the North Sea amounted to approximately 70 million tons per year in the 1990s. Litter and garbage disposal from ships overboard and tourism is estimated at 600,000 m^3 per year. Organic inputs will likely continue, especially in those waters deemed to have sufficient carrying capacity to degrade, disperse and assimilate the materials (Elliott *et al.,* 1998). Shipping in the North Sea is the most intense in the world and the area is a major navigation route for some of the world's most developed and highly populated economies. The effects of TBT, the active constituent of antifouling paints, on marine fauna have been extensively demonstrated with work done in this region and adjacent coasts.

Globally, sewage remains the largest source of contamination, by volume, of the marine and coastal environment (GESAMP, 2001), and coastal sewage discharges have increased dramatically in the past three decades. In addition, because of the high demand for water in urban neighbourhoods, water supply tends to outstrip the provision of sewerage, increasing the volume of wastewater. Public health problems from the contamination of coastal waters with sewage-borne pathogens are well known, and in many developed countries improved sewage treatment and reduction of the disposal of industrial and some domestic contaminants into municipal systems have significantly improved water quality. In the developing world, however, the provision of basic sanitation, as well as urban sewer systems and sewage treatment, cannot keep pace. High capital costs, explosive pace of urbanization and in many cases, limited technical, administrative and financial capacities for urban planning and management and ongoing operation of sewage treatment systems are barriers to efficient sewage treatment (GESAMP, 2001). Recent evidence suggests that bathing in waters well within current microbiological standards still poses a significant risk of gastrointestinal disease, and that sewage contamination of marine waters is a health problem of global proportions.

Human activities now account for more than half of global nitrogen fixation (Vitousek *et al.,* 1997), and the supply of fixed nitrogen to the oceans has greatly increased. Sewage discharges are often the dominant local source near urban areas but global inputs are dominated by agricultural run-off and atmospheric deposition. The highest rates of riverine transport of dissolved inorganic nitrogen to estuaries from all sources occur in Europe and South and East Asia (Seitzinger and Kroeze, 1998). Nitrogen levels are exacerbated by the widespread loss of natural interceptors such as coastal wetlands, coral reefs and mangrove forests. Fertilizer use has stabilized in developed countries but is increasing in developing ones (Socolow, 1999), a trend expected to continue because of the enhancement of fertilizer use through widespread subsidies, which reflect the high political priority of increasing food production and reducing food costs.

Another important feature of marine pollution is the existence of increased pollution levels in the enclosed seas and coastal waters as compared with the open ocean. Contamination levels also increase during the transition from the southern parts of all oceans to the north, where the main industrial centres and main pollution sources are concentrated. The presence of excessive quantities of pollutants in high bio-productivity zones is particularly concerning from an ecological standpoint. These zones include the water layer up to 100 metres below the ocean surface, natural environment boundaries i.e., water-atmosphere and water-bottom sediment, enclosed seas, estuaries, and shelf waters. The most intense activities of bio-production, including the self-reproduction of the sea's main living resources, take place in shelf and coastal zones, which account for only 10% of the World Ocean's surface. Progress in protecting the marine and coastal environment over the past 30 years has generally been confined to relatively few, mostly developed countries, and relatively few environmental issues. Overall, coastal and marine environmental degradation not only continues but has intensified. There have, however, been significant changes in perspective, and new concerns have emerged. Marine and coastal degradation is caused by increasing pressure on both terrestrial and marine natural resources, and on the use of the oceans to deposit wastes. Population growth and increasing urbanization, industrialization and tourism in coastal areas are the root causes of this increased pressure.

10.9 ECOLOGICAL IMPACTS OF MARINE POLLUTION

Marine ecosystems around the world provide a wealth of ecosystem services (the benefits people obtain from nature), including food provision for billions of people, carbon storage, waste detoxification, and cultural benefits including recreational opportunities and spiritual enhancement (Worm *et al.*, 2006; Liquete *et al.*, 2013). Any threat to the continued supply of these ecosystem services has the potential to significantly impact the well-being of humans across the globe, owing to the loss of food security, livelihoods, income and good health (Naeem *et al.,* 2016).

There are substantial and increasing quantities of plastic pollution in the marine environment, (Geyer *et al.,* 2017). An estimated 4.8-12.7 million metric tons of plastic entered the world's oceans from land-based sources in 2010 alone, and the flux of plastics to the oceans is predicted to increase by an order of magnitude within the next decade (Jambeck *et al.*, 2015). While, over time, this plastic may fragment into small pieces, referred to as 'microplastics' (0.1 µm-5 mm), the vast majority is expected to persist in the environment in some form over geological timescales (Andrady, 2015). Though removing some marine plastic is possible, it is time-intensive, expensive, and inefficient.

It is now well evidenced that this plastic negatively impacts marine life (Galloway *et al.*, 2017). While research on plastic pollution has been growing exponentially over the past decade, there is a poor understanding of the holistic effects of marine plastic and the resultant impact on ecosystem services, and in turn, its bearing on human wellbeing, society and the economy. What is known tends to be based on a small scale, local research that cannot be readily transferred or scaled up (Ten Brink *et al*., 2016). The impact of marine plastic is however a global issue, and a synthesis of the currently available but disparate information is required, ideally detailing global ecological impacts, but also translating them into societal and economic terms.

A solid understanding of the ecological, social and economic impact of marine plastic is necessary to inform a global transition in the way we make, use and reuse plastic, in such a way as to eliminate negative impacts, with implications for public behaviour, legislation and governance, industry and commerce (Pahl *et al*., 2017). This knowledge is critical in laying the groundwork for effective and efficient worldwide negotiations on the long-term use, management, and disposal of plastic, a material with numerous advantages and extensive applications.

Globally, seafood is the principal source of animal protein and makes up more than 20% of food intake (by weight) for 1.4 billion people (19% of the global population) (Golden *et al.,* 2016). Marine plastic has the potential to reduce the efficiency and productivity of commercial fisheries and aquaculture through physical entanglement and damage (Mouat *et al.,* 2010), but also by posing a direct risk to fish stocks. Plastic is frequently ingested by a wide range of marine species, including those directly vital to food provision such as shellfish and fish (Rochman *et al*., 2015) at all stages of their lifecycle (Steer *et al.*, 2017; Lusher *et al.*, 2012). This plastic can be ingested directly from the environment, or indirectly consumed via plastic contaminated prey (Setala *et al*., 2014). Polymers are typically rich in additives (e.g. plasticizers, biocides, flame retardants), and once in the marine environment can readily concentrate microbial pathogens (Kirstein *et al*., 2016) and toxic persistent organic pollutants (POPS), e.g. dichlorodiphenyltrichloroethane (DDT), and polycyclic aromatic hydrocarbons (PAHs) (Rios et al., 2007); POPs can accumulate in the tissues of marine animals and biomagnify in higher predators including humans (Teuten *et al*., 2009). The contamination of the food chain with plastic and associated contaminants puts fish and shellfish stocks, and their prey, at risk of lethal and sub-lethal harm (i.e. diminished reproductive success and growth), with capacity for population-level impacts (Galloway *et al*., 2017; Sussarellu *et al*., 2016).

The consumption of marine plastic by humans will occur when the entirety of a contaminated organism, including the gut, is eaten (e.g. mussels, oysters, sprats, anchovies). Marine plastic may also exacerbate the concentrations of POPs in the flesh of shellfish and fish, posing additional risk to consumers (Rochman *et al*., 2015; Rios *et al*., 2007). While further controlled studies are required to better understand the risk to humans, the existing literature concludes the health risks of marine plastic are minimal (Galloway, 2015; Lusher *et al*., 2017). Nevertheless, the 'perceived risk' of the contamination of seafood with microplastic may be detrimental to fisheries.

Overall, evidence suggests that the productivity, viability, profitability and safety of the fishing and aquaculture industry are highly vulnerable to the impact of marine plastic, particularly when coupled with broader factors including climate change and over-fishing. The high dependency on seafood for nutrition leaves the well-being of a significant proportion of the world's population highly vulnerable to any changes in the quantity, quality and safety of this food source (Golden *et al*., 2016).

Recreational users of coastlines are exposed more frequently to plastic and experience a range of well-being impacts. Litter on the shore is disliked (Hartley *et al*., 2013), and is often stated as a key reason why visitors will spend less time in these environments or will avoid certain sites if they anticipate they will be littered (Anderson and Brown, 1984; Ballance *et al*., 2000; Tudor and Williams, 2006; WHO, 2003). This has a range of economic costs, from clean-up expenses to loss of tourism revenue.

As well as having economic costs, the presence of litter can also have direct consequences on individuals' physical and mental health. Visitors and maritime workers are susceptible to a range of injuries, such as cutting themselves on sharp debris, getting entangled in nets, and being exposed to unsanitary items (Santos *et al*., 2005). Spending time on littered coastlines has also been demonstrated to be detrimental to their mood and mental wellbeing (Wyles *et al*., 2016). In turn, refraining from going to the coast due to these risks, can also have health implications, inhibiting the opportunity to reap the benefits coastlines typically offer, *e.g.* promoting physical activity, facilitating important social interactions such as strengthening family bonds, and improving physical and mental health (Ashbullby *et al*., 2013; Papathanasopoulou *et al*., 2016).

Beyond the immediate ecological impacts mentioned here, the presence of plastic has the potential to dramatically shift the ecology of marine systems (Galloway *et al*., 2017). An altered environment and shifts in biodiversity can have potentially wide-reaching and unpredictable secondary societal consequences (Worm *et al*., 2006), not least by impairing the ecosystem resilience and recovery potential in a time of global change. Plastics are a stressor, which can act in concert with other environmental stressors such as those arising from other pollutants, changing ocean temperatures, ocean acidification, and the overexploitation of marine resources. The cumulative impacts of these stressors may result in marine plastic causing far greater damage than expected.

In addition, although the results show increased bacterial and algal colonisation and abundance, this might harm the wider ecosystem. Marine plastic is an attractive substrate that is quickly and intensively colonized by a wide range of opportunistic species (Kirstein *et al*., 2016). Natural flotsam such as kelp and wood tend to degrade and sink within a matter of months; conversely, plastic can withstand prolonged exposure to UV radiation and wave action and can remain buoyant for longer periods (decades or even longer) and travel distances of more than 3000 km from source (Barnes and Milner, 2005). The colonization of plastic provides a mechanism for the movement of organisms between biomes, thus potentially increasing their biogeographical range and risking the spread of invasive species and diseases (Lamb *et al*., 2018). Indeed, marine plastic has been linked to increased rates of invasive species and unprecedented rates of species dispersal using man-made flotsam have been documented, including an estimate that marine plastic has doubled organisms' opportunities for dispersal in the tropics (Barnes, 2002). This additional impact is not included in this analysis but has clear potential for causing substantial ecological, social, and economic consequences. The negative ecological, social and economic impacts of plastic pollution will continue to increase into the future.

The ecological effects of pesticides are diverse and often complex. Impacts at the biological or environmental level are usually considered early warning indicators of potential human health effects. Importantly, many of these effects are chronic and often unnoticed by casual observers, but affect the entire food chain. The main effects are the death of organisms, cancer, tumours and lesions of fish and animals, inhibition or disorder of reproduction, suppression of immune system, destruction of the endocrine system, damage of cells and molecules, teratogenic effects, health condition of fish. These effects are not necessarily caused solely by exposure to pesticides and other organic pollutants but may be related to a combination of environmental pressures such as eutrophication and pathogens.

10.10 ECOLOGICAL CONSEQUENCES OF DEEP-SEA MINING

So far, with deep-sea mining being a rather new technology, the ecological consequences are unknown (Glasby, 2000, Yamazuki, 2011). However, many concerns have already been raised:

- Digging up parts of the seafloor disturbs the benthic ecosystems close to the hydrothermal vents. These ecosystems are often teeming with life, containing many species that are unique to the vents and with high primary production. The ecosystems surrounding hydrothermal vents combine superheated and highly mineralized vent fluids with microbes that are capable of using chemicals as a nutritional source. In recent years, such ecosystems have been found to host over 500 species previously unknown to science. In addition, damage to those ecosystems may impact large regions of the benthic zone in the oceans.

- Mining these deposits may result in leakage of the toxic sulfides, altering the composition of the water column.

- Deep-sea mining can have the biggest influence on sediment plumes. When mining tailings are discharged into the sea, a cloud of particles floats on the surface by forming plumes. There are two distinct sorts of plumes:

  (1) Seafloor plumes, which will affect the local turbidity and clog the feeding apparatus of the benthic organisms down below, and

  (2) Surface plumes, which could affect light penetration in the water near the ocean surface, threatening primary production by the phytoplankton, and alter the chemical composition near the surface, affecting all planktonic life forms.

Most marine pollution is simply by accident when it comes to the amount of pollution that goes into the water, it needs to be said that most of it are simply by accident. As there are a good number of international regulations that forbid the express dumping of all different kinds of waste above certain levels. For example, garbage has to be either delivered to shore or burnt in incinerators onboard. Incineration is prohibited in special areas. The quantitatively largest aquatic form of accidental pollution caused by the maritime sector is also the one that has been highlighted the most, oil spills. As crude oil consists of a wide range of different hydrocarbon molecules with different molecular weights and properties, it is not easy to give a concise view of the total damage that is done by an accidental spill. Apart from the highly visible heavy oil that covers the water, the animals and the shores, a large number of lighter components are present as well. These lighter components are likely to do even more damage in the long run, as they are stored in the adipose tissue of different animals in the food chain. Examples of these lighter components comprise the monocyclic and polycyclic aromatic hydrocarbons, which are difficult to clean up, and bound to cause cancer and other health problems after a few years of continuous exposure.

CHECK YOUR PROGRESS 2

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the unit.

1. Discuss beach debris and benthic marine debris.

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2. What are the ecological consequences of deep-sea mining?

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10.11 MANAGEMENT AND POLICY

Several international conventions, treaties, and agreements have been established by the United Nations to regulate the use and exploitation of the oceans, especially coastal seas. The United Nations Convention on the Law of the Sea, which governed all uses of the oceans and their resources from 1973 to 1982, established a global framework of law and order in the world's oceans and seas. It establishes the idea that all marine issues are intertwined and must be addressed as a whole.

In 1972, the Convention for the Prevention of Pollution from Waste and Other Substances Disposal (London Disposal Convention) was signed. It aimed to avoid marine pollution caused by the intentional dumping of rubbish or other chemicals at sea, including in places beyond the country's jurisdiction. The 1996 Protocol accepted the changes and included stricter terms. The United Nations Environment Program (UNEP) is committed to protecting the oceans and promoting the environmentally sound use of marine resources, especially through its regional ocean programs. The International Maritime Organization (IMO) develops and/or manages various treaties with a particular focus on the prevention of sea and sea pollution.

Apart from this, every country, including India, has its own marine environmental monitoring program to understand and assess the status of the marine environment. For this purpose, seawater, sediments and fish tissue samples are being regularly collected and analyzed to estimate the concentrations of pollutants.

At present, the disposal or dumping of land-derived effluent, sewage and waste into the marine environment is controlled and regulated. Each country has its environmental standards and guidelines for controlling the discharge or dumping of pollutants into the sea. It is also mandatory to conduct an Environmental Impact Assessment (EIA) before starting construction and/or operation of any industrial activities in the coastal areas. In India, the Central Pollution Control Board (CPCB), a statutory organization under the Ministry of Environment and Forest, formulates environmental standards and guidelines for protecting the marine environment. Every industry must treat their effluent to comply with the standards before discharging it into the coastal waters.

The ocean's self-cleaning capacity is finite, and if human pollution exceeds the limitations of the ocean's self-cleaning capacity, marine pollution will undoubtedly have a catastrophic effect on the entire globe. The following methods and guidelines must be considered to regulate and manage marine pollution.

10.11.1 Oil Pollution Control Measures

1. **To improve legislative oversight and increase law enforcement actions**

   All countries should accelerate the formulation and implementation of special laws on offshore oil pollution as per their national conditions, ratify the International Convention on Oil Pollution Preparedness, Response, and Cooperation as soon as possible, pollution control, strengthen the management of oil tankers, and crew training as per the UN Convention on the Law of the Sea and other international laws and regulations.

2. **Controlling industrial contaminants in the environment that pollute coastal waterways**

   To begin with, bring changes in the economic growth mechanism by altering the industrial structure and product mix, culminating in the formation of a circular economy. Steps to improve the management of major industrial pollution sources, as well as the production process as a whole, should be implemented. Professional treatment and in situ treatment limit industrial pollution sources of toxic and hazardous material emissions, in accordance with the "who is contaminated, who bears the" concept. Lastly, implementation of environmental impact assessments and the creation of a comprehensive pollution control and sewage permit system must be made compulsory.

3. **Controlling pollution of coastal cities**

   Coastal wetlands conservation, urban coastal sewage collecting pipe network and sewage treatment plant construction, urban sewage collection and treatment capacity improvement, and urban wastewater treatment facilities are all examples of irrational city planning coordination. Denitrification and dephosphorylation improvements have to be introduced.

4. **Controlling the pollution of marine pollutants**

   Construction of large-scale port wastewater, waste oil, waste recycling and treatment systems, as well as transportation and fishing vessels, to meet pollutant discharge criteria that prioritize recycling, shore treatment, and discharge regulations.

5. **Reducing the occurrence of pollution accidents**

   The preparation of contingency plans for maritime oil spills and toxic chemical spills, as well as disaster contingency plans and an emergency response system for port environmental pollution disasters, should be in place.

10.11.2 Measures to Reduce Heavy Metal Pollution

Heavy metal pollution is difficult to regulate, which is closely tied to its characteristics, but there is also an increasing focus on the causes, so its characteristics must be properly studied for the prevention of heavy metal pollution as heavy metal pollutants are persistent pollutants that can't be completely removed from the environment, only their position or form can be altered.

1. **Source Governance**

   Heavy metal pollution incident information should be submitted in the event of a problem; it is necessary to report and properly handle and assist the local government in doing a good job of information disclosure, publicity, and education, and earnestly safeguarding the environmental rights and interests of the masses. Strict checks must be carried out regularly to ensure that the heavy metal emissions laws are not violated. Improve the enterprise waste treatment system so that it may reduce pollution and improve working conditions to protect worker health.

2. **Cleaner Production**

   Heavy metal emissions from new and enlarged large-scale smelting projects should be closely regulated. A fair deployment of enterprise production water is essential to encourage the cascade usage of water technologies. Improve industrial wastewater treatment technology and reintroduce wastewater into the processing system. To accelerate the industry's technological advancement and improve the quality and efficiency of its development, strengthen research on key technologies related to clean production, as well as disseminate and implement existing advanced technologies.

3. **Improved Technology**

   Reduce the amount of heavy metal pollution via improving industrial technology and equipment, automation, and mechanization. Strengthen resource use across the board and encourage industrial upgrading. Improve the industrial structure, and promote the development of energy-saving emission-reduction technologies vigorously. Improve industrial technology and equipment, automation and mechanization to reduce heavy metal pollution.

10.11.3 Measures to Reduce Ship Pollution

Increasing the effectiveness of ship pollution prevention and control legislation, establishing and improving the global marine environmental law system, adhering to ship pollution prevention and control legislation and the uniformity of the environmental legal system, particularly the marine environmental legal system, and properly handling ship pollution prevention and control are all important goals. A comprehensive and systematic review of existing ship pollution control legislation based on necessary amendments and additions should be carried out. Make national norms and regulations for the prevention and control of inland water pollution. Modern international law relies heavily on international treaties. The state has an international obligation under international treaties in international relations. It has a responsibility to align its domestic laws with its international obligations. As a result, the maritime environmental protection law is based on the relevant international treaties. To increase awareness of maritime environmental protection and limit or eradicate pollution-causing human activities and raise anti-pollution consciousness, increase public awareness and education. Increase the penalty for unlawful operations and pollution of re-incorruptible vessels, as well as those who fail to take steps to improve the industry.

10.11.4 Suggestions and Prospects

Human life is greatly influenced by the sea environment. Global warming as well as rising sea levels pose a serious threat to humanity. Marine oil contamination, which is caused by a biological chain breakdown, as well as environmental degradation and other issues, are all major concerns. Heavy metal contamination of the water is a direct result of human activity; heavy metals move through the natural cycle and into the biological chain, finally reaching the human body and having a substantial impact on human health.

Each of us has a responsibility and obligation to protect the marine environment, and the marine ecosystem is now being put to the test, and the results are not encouraging. However, as people's environmental awareness has grown in recent years, maritime environmental preservation has received increased attention. There is optimism for maritime environmental protection as newer environmentally friendly energy is employed, and environmental monitoring efforts to improve the discharge of industrial wastewater discharge requirements are made.

With the advancement of humans, it is reasonable to expect that marine environmental issues will be addressed in the future.

CHECK YOUR PROGRESS 3

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the unit.

1. Differentiate between natural and anthropogenic marine pollution.

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2. What are the effects of marine pollution?

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10.12 LET US SUM UP

Aquatic pollution is expected to worsen in the coming years, providing a significant ecological and public health threat, especially in developing countries.

Coastal and marine pollution has already changed the structure and function of phytoplankton, zooplankton, benthic, and fish communities across large areas, posing a health risk to humans. The impact of pollution on fisheries and other commercial uses of coastal and marine environments is of special relevance. The majority of the world's main fisheries have now been harmed to varying degrees; the situation is considerably graver in those fisheries that are already overexploited or otherwise susceptible, and hence require rapid intervention. Effective and long-term management of the coastal and marine environment should begin at the local level and work its way up to the international and global levels to ensure the most efficient and effective use of resources for the greater good of humanity. Ocean pollution is a worldwide issue. It comes from a variety of places and crosses national borders. It's getting worse, and most countries don't have a good handle on it. Land-based sources account for more than 80% of the total.

Plastic trash is the most visible kind of water pollution, and it has deservedly earned a lot of attention. It kills seabirds, fish, whales, and dolphins, among others. It breaks down into plastic micro-and nanoparticles, as well as fibres, all of which include a variety of dangerous and carcinogenic chemicals.

Fish and shellfish consume these chemical-laden particles, which then enter the marine food chain and eventually reach people. It is only now that the dangers they bring to human health are being assessed. The gross domestic product and never-ending economic expansion are the obsessions of this linear economic worldview. Natural resources and human capital are viewed as plentiful and disposable, with little regard for the consequences of their indiscriminate exploitation. It goes against the norms of environmental stewardship. It isn't going to last long. Controlling ocean pollution and preventing pollution-related illness would necessitate leaders at all levels of government as well as continual international and civil society engagement.

10.13 KEY WORDS

Marine Pollution: Marine pollution is defined as the intentional or unintentional introduction of substances or energy into the marine environment (including estuaries) by humans, causing damage to living resources and risks to human health. People, interfere with marine activities such as fishing, degrade seawater quality, and reduce amenities. When substances used by humans, such as industrial, agricultural and residential waste, particles, noise, excess carbon dioxide or invasive organisms, reach the water and cause harm, it is called marine pollution.

Marine Debris: Marine debris, is defined as any persistent, manufactured or processed solid material made or used by humans and either deliberately or accidentally discarded, disposed of, or abandoned in the marine and coastal environment. Marine debris, also known as marine litter, is human-created waste that has deliberately or accidentally been released into a sea or ocean. Floating oceanic debris tends to accumulate at the centre of gyres and on coastlines, frequently washing aground, when it is known as beach debris or litter.

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10.15 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Please refer to section 10.3
2. Please refer to section 10.4

Check Your Progress 2

1. Please refer to section 10.6
2. Please refer to section 10.10

Check Your Progress 3

1. Please refer to section 10.4
2. Please refer to section 10.5