

Human-Induced Ecological Imbalances: Effect on Ocean and Life

Review Article

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Article Information: Submission: 13/05/2014; Accepted: 07/06/2014; Published: 08/06/2014

Abstract

Healthy and balanced environment supports different organisms on earth, and the human population depends on these organisms for a comfortable and healthy living. The natural and anthropogenic factors cause disturbance to the ecosystem. The natural disturbances to the ecosystems cannot be prevented; however, the ecosystems are resilient and return to the normalcy. The human-induced disturbances can be prevented by taking conscious efforts to adopt ecologically sound management measures. Society derives food, feed, fuel and drugs by exploiting marine ecosystem. The mainstay of coastal communities for their livelihood is ocean. The human-induced disturbances such as overexploitation, habitat destruction, pollution, bio-invasion and climate change affect the livelihood of fishers. The pressure on the marine resources is increasing steadily resulting in overexploitation. The resources of oceans are considered as common property resources and this consideration forms one of the major reasons for depletion of resources and degradation of the environment. Accidental and intentional discharges of pollutants especially persistent pollutants may pose greater ecological risks such as bio-magnification. Invasion of alien species results in loss of biodiversity and restructure the food-web. The climate change results in acidification, sea-level rise, and affect the marine ecosystem, which in turn affect the society. The human-induced or the accelerated ecological imbalance should be prevented by arousing the consciousness of human beings and proper implementation of national and international regulations. Educating the coastal and ocean user communities on the problems of imbalance in marine ecosystem and on how to ensure ecosystem sustainability is needed at this juncture. The conservation efforts will be successful only when user communities cooperate in this endeavour. Hence, encouraging co-management and the community participation of fishers should be made in marine resource management. This paper deals with the causes of ecological imbalance in ocean and its effect on ecosystem and the society.

Keywords: Marine Ecosystem; Ecological Disturbances; Biodiversity; Co-management; Environmental Awareness

Introduction

India has a coastline of 8129 km and has immense potential for developing and producing a good variety of sea foods, demanded highly throughout the world and this has made fishing as a commercial industry. It is also an important sector which is contributing to the nation's economy and supporting the livelihood of millions of fisher-folk. The total potential yield of the marine fishery resources of the Indian EEZ is revalidated as 3.93 million tonnes. The marine fish production during 2009-10 was 3.07 million tonnes [1]. The export of marine products has steadily grown over the years from a mere Rs. 3.92 crore in 1961-62 to Rs. 16,597.23 crore in 2011-12 [2]. Since marine fishery is considered as a million dollar business, pressure on the open access resources is increasing day-by-day resulting in overexploitation of marine resources. During recent years, global concerns in conservation and management of marine resources have

been visualized and discussed by considerable number of agencies, particularly aiming at conservation of marine species. The living and non-living resources of oceans are considered as common property resources and this consideration forms one of the major reasons for depletion of resources and degradation of the environment.

Overexploitation of the resources would not only have negative impact on environment but also lead to their exhaustion. According to FAO estimate, in 2009 nearly 57.4% of the world fish species were fully exploited. The increase of destructive fishing techniques worldwide destroys marine mammals and the ecosystem. FAO reports that illegal, unreported and unregulated fishing worldwide appears to be increasing, as fishermen seek to avoid strict rules in many places in response to shrinking catches and declining fish stocks. Enormous fishing by mechanized sector leads to large-scale destruction of egg-bearing and juvenile fish leading to the destruction of the marine

ecosystem [3]. According to the marine fisheries census conducted in 2010 by Central Marine Fisheries Research Institute, there are about 3288 marine fishing villages with a total population of 8,64,550 fishermen families [4]. Increase in population and the indiscriminate dumping of garbage along the Indian coast have destroyed over 50% of the mangroves. At least one species is on the verge of extinction every day according to certain estimates [5]. There are many laws for protecting the marine resources in India; however, the authorities concerned are constrained to implement the policies and the related laws. If this prevailing condition exists, there could be the possibility of "Too many fishers catching too few fishes".

Ecological studies play an important role in maintaining the balance among the different ecosystems. It deals with various scientific principles that govern the relationship between organisms and their environment. More than 70% of the earth is covered by water, and the marine ecosystem contributes both directly and indirectly for the growth of the economy. Marine ecosystem includes the whole biotic community in a marine area and its abiotic environment. Marine ecosystem is complex and dynamic in nature. It is affected by natural and human-induced factors. It produces organic matter, and decomposes natural and artificial substances (self-purification capacity) in a way to maintain a balanced ecosystem. Every ecosystem has resilience to overcome the disturbances and maintain stability, and if the disturbance is beyond the resilient power, ecological imbalances set in. The disturbances may be biological or non-biological and may be major or minor. Although the economic development resulted in improved standards of living of the human beings, it did indeed impact the ecosystem. The balance state of the ecosystem is regarded as an indication of harmonious interaction between human economic activity and marine environment.

McKay and Mulvaney [6] reviewed the major marine ecological disturbances and reported the concern over human impacts on the marine environment which is visible with the apparent increase in marine morbidity and mass mortality, emergence of new diseases across a range of taxa, increases in harmful algal blooms, and the declines of wildlife populations. The public health, economic activity and biodiversity are threatened along various coastal regions as a result of natural and anthropogenic factors driving minor and major disturbances [7]. The accidental discharge of untreated domestic sewage into the coastal waters is a minor disturbance and it disturbs the ecosystem for a shorter period and the ecosystem recovers immediately. The major ones such as continuous release of pollutants to the marine ecosystem are catastrophic and cause irreversible change in the ecosystem. The marine ecosystems are threatened by anthropogenic disturbances such as overexploitation, habitat destruction, pollution, bio-invasion and climate change. The natural disturbances include cyclones, volcanic activity, El Nino events and disease outbreaks.

Overexploitation

Overexploitation of both living and non-living marine resources leads to unstable ecosystem. The human population derives food from ocean, damaged marine habitats and overfished marine organisms for millennia even by using less-developed pre-industrial fishing technologies [8]. The marine ecosystem could recover

from such disturbances. However, in the last hundred years, the percentage of marine waters fished, the sheer volume of marine biomass removed from the sea, and the pervasiveness of habitat-altering fishing techniques have cumulatively eroded the capacity of marine ecosystems to withstand either human-induced or natural disturbances. The problem is further compounded by pollution, climate change and invasive species [9,10]. The rate of harvesting has exceeded the natural rate of renewal, resulting in biological overfishing. Such overexploitation leads to stock collapse or severe depletion. The overexploitation of living marine resources for both commercial and recreational purpose affects the marine ecosystem leading to altered ecosystem structure and function. Harvest mortality and incidental mortality are the immediate consequences of fishing. Overfishing, directly affects the target species by reducing their abundance, growth, maturation and reproduction, and also the dependent and associated species. Indirectly, overfishing affects marine biodiversity and ecosystems, through physical disturbances caused by fishing gear, bycatch, habitat degradation and biological interactions. As commercial fishery declines, people begin fishing down the food-web, resulting in a decline in the mean trophic level of the world catch [11-15]. The proportion of marine fish stocks estimated to be overexploited, depleted or recovering stocks increased from 10% in 1974 to 32% in 2008 [5]. The overexploitation of tiger shrimp (*Penaeus monodon*) to use as seed for shrimp culture and molluscan shell for poultry feed and edible lime is evident in the north-eastern coast of India and resulted in reduction in these species as well the associated species [16]. The exploitation of marine non-living resources such as oil and gas, minerals, sand and gravel causes habitat destruction, which in turn, disturbs the ecological balance.

Habitat destruction

The inappropriate agricultural and forestry land-use practices, destructive fishing practices, unregulated coastal developmental activities, and mining and dredging activities limit the suitability of coastal and marine habitats for the organisms to thrive and sustain. Habitat destruction is observed in coral, sea grass, mangrove, saltmarsh and estuarine ecosystems. Many of the world's tropical coral reefs have been in decline or have been destroyed over the last decades, typically the result of fisheries, land-use changes increasing sedimentation and nutrient pollution [17]. Similarly, the world's area of mangrove forests has been reduced by about 35% on a worldwide scale since 1980s, and 2.1% of the existing worldwide mangrove area is lost each year [18]. The land-use practices that lead to habitat destruction include deforestation, cultivation along the slopes and mining. Destructive fishing methods such as bottom trawling, dynamiting or using poisons like cyanide and indiscriminate netting can destroy target as well as non-target organisms such as benthos and corals. In addition, the modification of coastline for developmental activities such as industry, tourism, aquaculture, agriculture and urbanization accelerates the process of habitat destruction. Many animal species depend on these ecosystems as their feeding, breeding and nursery grounds. Destruction of such grounds directly affects these organisms and thereby the ecosystem. The erosion and sedimentation result in increased turbidity, which prevents the penetration of sunlight and so the primary production eventually alters the food-web. The agricultural runoff loaded with chemicals

and nutrients also affects the organisms and ecosystem productivity. Thus, habitat destruction can impair and destroy productive marine ecosystems. Habitat destruction apart from affecting the marine animals, can also get affect the plant communities and result in loss of biodiversity. Ultimately, habitat destruction would not only affect the plant and animals, but also the economic activities such as tourism, recreation and aesthetic value, and human health [19].

Pollution

The oceans are the ultimate sink for pollutants and the marine ecological balance is disturbed by pollutants. The marine ecosystems are polluted by sewage from industrial and urban discharges, waste discharged during the extraction of minerals, oil and gas, sea transport activities, accidental spill of oil and other transported material, accumulation of plastic debris, etc. Organic and inorganic pollutants are discharged into the ocean waters. Some of the simple organic pollutants are degraded to less toxic material in the ocean. However, the persistent organic pollutants such as polycyclic aromatic hydrocarbons (crude and refined petroleum hydrocarbons), organo-chlorine pesticides and poly-chlorinated biphenyls pose greater threat to marine life. Heavy metals such as mercury, lead, cadmium and arsenic are also deleterious to marine organisms. These organic and inorganic pollutants have the tendency to accumulate along the food chain and affect the ecosystem in its entirety. Robards et al. [20] have documented the dangers to marine mammals and birds caused by the entanglement in and ingestion of marine litter. Plastics are one of the most common and persistent pollutants in ocean waters and beaches worldwide [21]; particularly the micro-plastic particles (less than 5 mm in size) are potentially dangerous to marine species due to the risk of magnification over the food chain [22]. Micro-plastics have higher potential for the adsorption of hydrophobic organic pollutants due to the high surface area. These hydrophobic substances can be readily ingested by invertebrates at the base of the food-web [23]. Top predators in the Arctic food web are prime examples of organisms that are at risk of high exposure due to these lifestyle factors. High levels of organo-chlorine contaminants are found in seals and polar bears in the Barents Sea region [24]. The effect of environmental factors on human health requires better attention in time with the international awareness on the issue. Health hazards due to the consumption of fish harvested from contaminated water are also becoming a matter of great concern internationally. The agencies involved in formulating legislation on environmental pollution need to implement them more precisely and stringently so that the impact of pollution on fisheries can be minimized. All solid, liquid and radioactive wastes reach the sea and fishers as the main stakeholder of the marine environment have to be sensitized against land-based pollution besides educating them on responsible fishing practices, which would reduce the imbalance in the marine ecosystem including mangroves.

Bio-invasion

Bio-invasion is the introduction of species that is not native to the ecosystem by natural expansion or human assistance. Bio-invasion in marine ecosystem is one of the major threats for ecosystem stability. The human-assisted species introduction in marine ecosystem takes place intentionally or unintentionally. The vectors for introduction include fouling organisms in ships, discharge of ballast water, dry-

docking, drilling platforms, floats, floating debris, activities of aquarium, fisheries, research and education, etc. At least 7,000 different species of marine life are likely transported each day around the world [25]. The transport vessels can carry living aquatic organisms in their larval or dispersal stages, becoming bottom-dwelling organisms as adults. These include sea anemones, worms, barnacles, crabs, snails, clams, mussels, oysters, bryozoans, sea urchins, sea squirts, seaweeds and many others. Other species live permanently as adult organisms in the water. These include diatoms, dinoflagellates, copepods, jellyfish, etc. Certain viruses and the bacteria that cause human epidemic (e.g., cholera) have also been detected in ballast waters [26]. Apart from introduction through ballast water, fouling organisms attached to the outside of vessels form another important mode of introduction. Barnacles, mussels, hydroids, seaweeds and varieties of other marine life form fouling assemblages and these assemblages, harbour free-living species such as crabs and fish. Introduction of non-native species with the intent of starting a new fishery to harness the commercial value is a common practice. Accidental escape of organism transported for direct consumption as live seafood or use as live bait for fishing also result in invasion. The fate of live organisms purchased for aquarium, research and education is in the hands of public or researchers with little or no regulatory measures. Bio-invasions affect the biodiversity and restructure the food-web in the ecosystem. The bio-invasions impact human society directly by affecting fisheries and causing health hazards.

Climate change

Climate change is the change in earth's temperature and weather pattern naturally over a period of time. There are evidences for climate change in the geological time scale. The ground for the concern now is the accelerated climate change. The rapid growth in population and economic development led to increased emission of greenhouse gases. Greenhouse gases include carbon dioxide, methane, nitrous oxide and chlorofluorocarbons. These gases cover the lower atmosphere like a blanket, absorb the long-wave radiation (infrared) and do not allow the radiation to escape. This results in warming of earth's surface and lower atmosphere. In marine ecosystem, the global climate change is projected to increase sea-surface temperature, sea level rise and ocean acidification. The increase in sea surface temperature would change the current and precipitation patterns. These affect the ocean circulation and cause frequent cyclones and storms. The warm water results in coral bleaching. Corals depend on single-cell algae as their major food source. Bleaching is the expulsion of these algae due to warming. Subsequently, reef-building corals die due to lack of food. Changes in circulation pattern affect the migratory behaviour of marine animals. Rise in sea-level would inundate coastal areas and affect coastal communities. Sea level rise would affect coral atolls and low-lying coastal regions with wetlands, sea-grass beds, mangroves and shallow reefs, thereby impairing many ecosystems. Decrease in pH due to increase in carbon dioxide in seawater would disturb the organisms that have calcium skeleton. The acidification will dissolve calcium carbonate skeleton and the organisms become soft-boned and weak. In the long run, survival and perpetuation of these organisms might get affected along with the ecosystem structure and functioning.

Summary

The ecological imbalances in marine ecosystem will jeopardise the world. As the marine explorer and oceanographer Jacques Cousteau warned, "The very survival of the human species depends upon the maintenance of an ocean clean and alive, spreading all around the world. The ocean is our planet's life belt". Hence, the life belt should be secured properly. The human-induced or the accelerated ecological imbalance should be prevented by arousing the consciousness of human beings. People should offer whole-hearted cooperation with the concern to protect the marine ecosystem. Awareness among coastal and ocean user communities on the effect of overexploitation, habitat destruction, pollution, bio-invasion and climate change on the marine ecosystem should be created. There are national and international regulations to prevent the activities that cause imbalances to the marine ecosystem. However, proper implementation of these regulations is lacking in many parts of the world. Many governmental and non-governmental agencies are striving to protect the marine environment and maintain the ecological balance but their efforts will be successful only when user communities cooperate in this endeavour. Co-management and the community participation of fishers should be made effective in marine resource management. The need for proper management and conservation of aquatic diversity is very vital as it is directly linked with the livelihoods of the small-scale fishermen. The protection of marine biodiversity is a community-based activity which also needs the cooperation of research, policy making and other line departments involved in fisheries management.

Marine fishing policies need to be drafted to provide fishermen the right to own and manage coastal water bodies. In addition to environmental factors, coastal biodiversity conservation needs to include the socio-economic and cultural aspects of the coastal population. Integrated policy approaches, which involve scientific disciplines to address the complexity of the interaction between the social and natural systems in the coastal and marine environment, have to be developed. Destructive gear which sweeps and damages the sea bottom requires immediate attention to improve the selectivity of the gear and should be made eco-friendly. Pollution is causing alarming damage to the coastal resources to a greater extent and this could be controlled by promulgating pollution control acts/legislations by the pollution control boards and also the big industrialists/entrepreneurs should be made known about the toxic effect of the effluent on the marine animals and the loss due to the inflow of untreated effluent. Coastal development plans should be shaped in a comprehensive way without affecting the fishing activities of the coastal inhabitants and the planning should involve the grass-root level people who are the managers of the resources. Co-management and self-regulation initiatives and drives from the fishermen community are well appreciated and proven methods for resource conservation as they, the partners, impose self-regulation within their own community. Voluntary action leads to better output and exerts control over the emerging issues. Opportunities for diversified fisheries activities and alternate livelihood options should be opened before the fishermen with financial and credit support so that the mounting pressure on the resources could be minimized without any threat to the lives of the fishermen community.

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