Assessment of Impact of Oil Spills on Coastal Ecosystem of Uran, Navi Mumbai, India

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Abstract

An oil spill is an escape of oil into the sea or other water body. It is the release of a liquid petroleum hydrocarbon into the marine ecosystem, due to human activity, and is a form of pollution. Oil spill can seriously affect the marine environment by physical smothering as well as toxic effects. The nature and duration of the effects of an oil spill depend on quantity and type of oil spill, its behaviour in the marine environment, the speed with which the oil is diluted or dispersed by the natural processes and biological composition of the affected environment. The present article focuses on the impact of oil spill due to collision of MSC Chitra and MV Khalijia 3 on the coastal ecosystem of Uran with respect to shoreline, sediment, macrobenthos and mangroves. Present study reveals that oil spill is a disaster to the coastal ecosystem and its resources and lead to the adverse effects on the indigenous flora and fauna along with their habitat. Diversity of macrobenthos along Uran coast is threatened by frequent oil spills causing injury and mortality with chronic effects.

Key Words:- Jawaharlal Nehru Port, macrobenthos, mangroves, oil spill, pollution, sediment, shoreline, Uran

Introduction

Marine ecosystem

The marine ecosystem is a home of many life forms from microorganisms, plants and algae, invertebrates to vertebrates (Adzigbli & Yuewen, 2018). The marine environment is a dynamic and diverse network of habitats and species. The ecosystem services received by humans from these habitats and communities include fish, shellfish and other foods that we consume, and the recreational or aesthetic benefits we derive from the sea. Biodiversity is a valuable feature of these ecosystems as it increases the complexity of the food chains and other ecological processes (IPIECA, IOGP, 2015).

- **Ecological role of Macrobenthos**

Benthos refers to the community of organisms that live on, or in, the bottom of a water body and are generally classified according to size. Macrobenthos are the benthic communities with greater than 0.5 mm in size (Pawar and Al-Tawaha, 2017a).

Macrobenthos play various ecological roles in transitional ecosystems like, food source for larger organisms, linking primary production with higher trophic levels, structure and oxygenate the bottom by reworking sediments, break down organic material before bacterial remineralization, food for human, bait for recreational purposes, biological indicators of ecological health and coastal pollution, indicator species for the detection of types and levels of stress, improving and preserving water quality through mineralization and recycling of organic matters, bioindicators of heavy metal pollution in aquatic system, provide shelter and profitable foraging sites for invertebrate feeders, and is useful to assess the fishery production of a particular area (Igborgbor et al., 2004; Harriet et al., 2010; Blackburn et al., 2014; Pawar and Al-Tawaha, 2017b).

- **Pollution due to oil spills**

The rise of energy demand worldwide has resulted in increasing marine exploration, production, and transportation of crude oil, with resulting increases in the risk of oil spills in the marine environment. Petroleum plays an important role in our lives and most transportation vehicles are powered by refined products such as gasoline, diesel, aviation turbine kerosene (ATK) and fuel oil (Michel and Fingas, 2015; Buskey et al., 2016).

The fuels that are derived from petroleum supply more than half of the world's total supply of energy. Gasoline, kerosene, and diesel oil provide fuel for automobiles, tractors, trucks, aircraft, and ships. Fuel oil and natural gas are used to heat homes and commercial buildings, as well as to generate electricity. Petroleum products are the basic materials used for the manufacture of synthetic fibers for clothing and in plastics, paints, fertilizers, insecticides, soaps, and synthetic rubber. The uses of petroleum as a source of raw material in manufacturing are central to the functioning of modern industry (Mansir and Jones, 2012).

Oil pollution of the marine environment has been an issue of considerable national and international concern (Sivadas et al., 2008). In marine ecosystem, oil seeps occur naturally from mineral oils (i.e. petroleum) derived from plant material and animals that are originated millions of years ago, and are modified over time by heat and pressure underground. These underground reservoirs of oil are connected to the surface by geological features and in some areas natural seeps occur through the seabed. These natural oil seeps can be biodegraded and detoxified by the marine micro organisms and is incorporated into the food chain (IPIECA IOGP, 2015; https://en.wikipedia.org/wiki/Oil_spill, 2019).

Oil spill, due to collisions or grounding of ships, is one of the most devastating forms of pollution in the marine environment (Ramakrishnan, 2018). Large number of oil spills happened as a result of accidents of the tanker carrying the crude oil. The world has experienced 10 largest oil spills in the history (Michel and Fingas, 2015).

- **Constituents of crude oil**

Crude oil is a mixture of liquid hydrocarbons containing dissolved gases, water, and salts. Crude oils vary widely from almost solid and heavy that sink in water up to light materials that float on water. They are emulsions-drops of aqueous solution dispersed throughout the continuous hydrocarbon phase. Interstitial or connate water is always present in crudes. Crude oil also contains small amounts of organic compounds containing sulphur, oxygen, nitrogen and metals like vanadium, nickel, iron and copper (Groysman, 2017).

Fate of spilled oil in marine environment

When oil is spilled at sea it initially spreads out and moves on the water surface as a slick. It is a few millimetres thick, moves with the wind and current and undergoes chemical and physical changes. The fate and spreading of marine oil spills is affected by the action of winds, waves, water currents, oil type and temperature. Marine oil spills undergoes weathering, evaporation, oxidation, biodegradation and emulsification by the natural actions present in the aquatic environment (Saadoun, 2015; Michel and Fingas, 2015).

- **Oil spills at Uran coast**

➢ **Collision of Cargo Vessels MSC Chitra and Khalijia**

On 7th August 2010, a oil spill following the collision of cargo vessels impacted the Uran coast. At 9.50 A. M. (local time), collision of Panama-flagged MV MSC Chitra (IMO: 7814838) and MV Khalijia 3 (IMO: 8128690) off the Mumbai coast resulted into spilling of containers and oil along the full coastline. MSC Chitra, which was carrying 1219 containers, 2662 tons of fuel, 283 tons of diesel, and 88040 litres of lubricating oil, capsized and sank into the sea, creating maximum damage to the area. The ship collision sends more than 2 tons of oil pouring into the Arabian sea every hour.

MSC Chitra, which was outbound from South Mumbai's Nava Sheva port, collided with the inbound Khalijia-III, which caused about 200 cargo containers from MSC Chitra to be thrown into the Arabian Sea.

Merchant vessel M V Khalijia 3 ran out of luck again when it collided with another ship of Jawaharlal Nehru Port Trust in the morning. Khalijia 3 collided with a container vessel from MSC line, which was sailing out of the harbour. Eight loaded containers fell into the sea after the collision around 9.30 in the morning.

➢ **Rupture of Mumbai-Uran Trunk oil pipeline**

In January 2011, the Mumbai-Uran Trunk oil pipeline had ruptured causing a major oil spill, about 80 km from the Mumbai coast. The spill had spread to around 4 sq km.

➢ **Oil spill from Oil and Natural Gas Commission (ONGC)**

On Sunday night of 7th October 2013, an oil spill was reported at Uran following a rupture in Oil and Natural Gas Corp's main pipeline that carries crude from the offshore Mumbai High fields to land. The Mumbai-Uran Trunk oil pipeline had a small rupture at its termination point, causing an oil spill. Oil spilling of more than 5,000 litres of crude oil into the Arabian Sea that spread about 10 km along the coastline has caused considerable water pollution.

The grey-black film of oil stretched along the Uran shoreline, from Mora to Karanja villages, adversely affecting local fishermen and raising ecological concerns. The oil seeps into the sand on the shore and it could irreparably damage the soil and the region's flora and fauna.

The water surface and rocks on the shore have become greasy due to the spill. The fishing community in the villages of Mora, Nagaon, Danda and Karanja were greatly affected by the oil spill. The spill has killed many fishes, crustaceans and molluscs.

The oil have spread to the sand on the shore due to tidal activity which will ruin the top layers and also stunt the growth of the plants and animals in the area. Oil spill has affected the growth and productivity of mangroves and other plants from the Uran coast.

- **Need of the study**

The coastline of Uran is under considerable stress since the onset of Jawaharlal Nehru Port (JN Port), Oil and Natural Gas Commission (ONGC) LPG Distillation Plant, Grindwell Norton Ltd., MSEB Gas Turbine Power Station (GTPS), Bharat Petroleum Corporation

Ltd. (BPCL), DP WORLD, Container Freight Stations (CFS), Naval Armament Depot (NAD), Indian Oil Tanking (IOT), Trawler building workshops, hotels and dhabas, parking areas for vehicles carrying TEU's (Twenty feet equivalent units) (Pawar, 2013).

Jawaharlal Nehru Port (JNP) (18º56'56.00" N & 72º56'57.32" E), an international port, established in 1989 near the Uran creek and is run by JNPT under the control of Government of India. JN Port is one of the busiest ports among 11 Major Indian Ports and handles about 60% of the total National Marine Transport of cargos. JN Port occupies 28th rank among worlds 100 ports and supports a variety of maritime activities; as a result, the area of Uran creek became the ground for hectic activities of Container Freight Stations (CFS) (Pawar and Al-Tawaha, 2017c).

Heavy vessel traffic in and out of JN Port has made the coastline of Uran vulnerable for oil spill incidents posing a potential threat to coastline (Pawar and Al-Tawaha, 2017d; Ramakrishnan, 2018).

The aim of this paper is to assess the impact of oil spill due to collision of MSC Chitra and MV Khalijia 3 on the coastal ecosystem of Uran with respect to shoreline, sediment, macrobenthos and mangroves.

Materials And Methods

- **Study Area**

Uran (18º50'5" to 18º50'20" N, 72º57'5" to 72º57'15" E) with the population of 28,620 is located along the eastern shore of Mumbai harbor opposite to Coloba. Uran is bounded by Mumbai harbor to the northwest, Thane creek to the north, Dharamtar creek and Karanja creek to the south, and the Arabian Sea to the west. Uran is included in the planned metropolis of Navi Mumbai and its port, the Jawaharlal Nehru Port (JNP) (Fig. 1).

The Uran coast is a tide-dominated and the tides are semidiuranal. The average tide amplitude is 2.28 m. The flood period lasts for about 6–7 h and the ebb period lasts for about 5 h. The average annual precipitation is about 3884 mm of which about 80% is received during July to September. The temperature range is 11–37.7ºC, whereas the relative humidity remains between 61% and 86% and is highest in the month of August.

The climate of Uran is typical of that on west coast of India, with plentiful and regular seasonable rainfall, oppressive weather in the hot months and high humidities throughout the year. The summer (pre-monsoon) season from February to May is followed by south-west monsoon season (June to September). October to January form the post-monsoon or the retreating monsoon season. The period from December to February is the cold season.

- **Study Location**

For the present study, three sampling sites, namely Sheva creek, site I (18º 50' 20" N, 72º 57' 5" E), Peerwadi coast, site II (18º 50' 10" N, 72º 57' 1" E) and Dharamtar creek, site III (18º 48' 3" N, 72º 58' 31" E) separated approximately by 10 km were selected. These sites were selected on the basis of their strategic locations for JN Port (an International Port), industries, port related infrastructural facilities and different anthropogenic activities along the entire coastal area.

Sheva creek is characterized by extensive mud flats with sparse mangrove vegetation and less rocky stretches. JN Port and other port related establishments are located in the stretch of the creek. Gharapuri Island (Elephanta caves), a famous tourist spot is present on the north side of the creek. Intertidal region of Peerwadi coast has major portion of rocky substratum. Dharamtar creek is with rocky and coral substratum towards the Dronagiri Mountain whereas remaining part of the creek is dominated by the marshy areas and mud flats. Towards the Revas and Karanja side, the Dharamtar creek has mangrove associated habitats due to presence of dense and natural mangrove habitat. Sheva creek and Dharamtar creek are considered as high anthropogenic pressure zones.

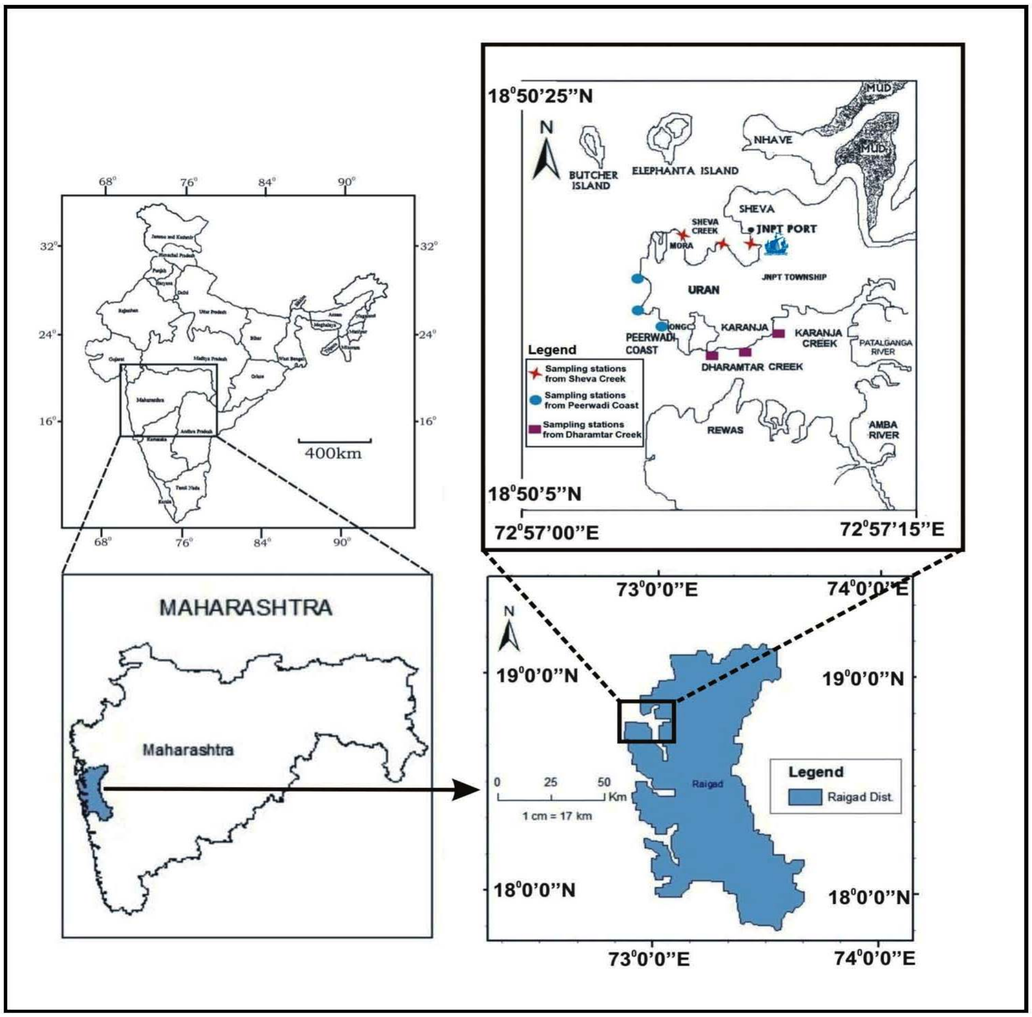

Fig. 1: Map of the Uran coast with sampling substations

- **Field study/Sampling**

The present study was carried out for a period of one month i.e., from 8th August 2010 10th September 2010. The entire intertidal belt of each sampling site was subdivided into upper, middle and lower littoral zones. The species diversity and distribution of macrobenthos in the intertidal belt at each station were studied during the spring low tide. Impact of the oil spill was monitored on shoreline, sediment, macrobenthos and mangroves.

Results and Discussion

- **Shorelines and sediment**

Shorelines comprise a large variety of habitat types such as muddy, rocky and wave-exposed shores. Shoreline habitats and species will be vulnerable to any coastal oil spill. Natural removal of oil from sheltered shorelines is slower and, in locations where the intertidal substrata is muddy and dominated by marsh or mangroves, oil residues can persist for years, causing long-term impacts (IPIECA, IOGP, 2015).

The mud flats and sandy areas of Sheva creek are extensively affected with the spill. The area near NAD jetty shows large quantities of dried and melted tar balls. A stable mousse of crude oil along with floating or bleached oil is reported at shoreline of Sheva creek even after two weeks after the collision. The oil is incorporated into the soft and sub surface sediments, which is more dangerous than the surface oil. Oil is also incorporated through worm burrows and plant stems. Stranded oil is reported even after a month after collision at the sheltered beaches with rocky and coral substratum (Mansir and Jones, 2012).

- **Macrobenthos**

Severe impact of oil spill is observed on macrobenthos and high mortality rate of species of fish, oysters, gastropods, shrimps, crabs and indigenous flora and fauna was reported. This could be correlated to the changes in the chemical composition of the water, physical alteration of the habitat and physical smothering due to the exposure to toxic effects of the oil (Neff, 2002; Mansir and Jones, 2012).

Except polychaetes, population of all macrobenthos was found to be affected drastically. This could be due to the impairment of oil with the ability of bivalves and gastropods to attach to the substrate. As a result, these benthos were carried away by currents or consumed by predators (Earth Gauge, 2010). Higher population of polychaetes recorded in present study could be due to more tolerance of these species to oil pollution.

High mortality was recorded for crabs like fiddler crab, mud crab, hermit crabs (Fig. 4) and small oil droplets have been found within the shells of these organisms. Earlier reports also stated that diversity of macrobenthos was significantly reduced as a impact of oil spill (Blackburn et al., 2014; Saadoun, 2015).

According to Sivadas et al. (2008), small-scale but persistent oil spill not only reduce benthic standing stock (abundance and biomass), but also some of the oil-sensitive species were eliminated. Coastal environment of Uran shows rich species diversity of macrobenthos and Pawar and Al-Tawaha (2017e) have reported a total of 170 species of macrobenthos belonging to 119 genera, 83 families, 44 orders and 17 classes. Reports of the present study are in agreement with the work of Crunkilton and Duchrow (1990), Blackburn et al., (2014); Anyadiegwu and Uwaezuoke (2015) and Buskey et al., (2016).

Adzigbli and Yuewen (2018) noted that crustaceans are susceptible to oil through digging into oiled sediments, food ingestion, and direct interaction and are known to be very sensitive to pollutants and experience high mortality after oil spills. Polychaetes are resistant to oil and hence can be used for purification and sanitation of contaminated water and shorelines. Polychaetes also break down and metabolize oil constituents with high tolerance level of hydrocarbons (Grenvald et al., 2013; Castege et al., 2014; Adzigbli and Yuewen, 2018).

- **Mangroves**

One of the biggest extents of wetland mudflats and mangroves in India lie in the vicinity of Uran. The mangroves stretch starts from the northern end of Palm Beach Road in Navi Mumbai and extends up to the Phunde, Mora and Karanja villages. The mangrove ecosystem of Uran is a tide-dominated with average tide amplitude is 2.28 m. Four species of true mangroves representing three genera and three families were recorded (Pawar, 2011; 2013). The dominant species are *Avicennia marina, Avicennia officinalis, Acanthus ilicifolius,* and *Ceriops tagal*. The average tree height is 2.4 m and the canopy coverage is greater than 90%.

Due to oil spill, the leaves, stems, roots, loop-roots and pneumatophores of mangroves were coated with oil. Heavy oil inundation of the root systems is also observed in mangroves of Sheva creek and Peerwadi coast. Large number of tar balls with variable buoyancy and mobility, either intact or melted due to temperature were spotted in Uran mangroves (Fig. 5).

The life of tar balls in the sea varies from 33 to 58 days, however, due to the half yearly changes in surface circulation, these tar balls are deposited along the beaches of India (Sivadas et al., 2008). Poisoning and shading of sea grass beds results in reduced photosynthetic productivity on which a host of creatures depend, and is followed by erosion in coastal waters when sediments are no longer secured by sea grass roots (Ross, 2010).

Results of the study showed that frequent oil spills at Uran coast have impacted the shorelines, sediment, macrobenthos and mangroves. Findings of the study also reflect that oil spill impact causes injury and mortality to many indigenous flora and fauna which could result in the disturbance of the ecosystem.

Conclusion:

Present study reveals that oil spill is a disaster to the coastal ecosystem and its resources which lead to the adverse effects on the indigenous flora and fauna along with their habitat. Diversity along Uran coast is threatened by frequent oil spills causing injury, mortality and chronic effects. It is recommended that long-term monitoring of the impacts of oil spill is necessary to protect the coastal resources as they are the basic livelihood resources of coastal human community.

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