

Evaluation of the Risk Associated with Marine Environment

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Abstract: A hazard identification and risk analysis system can be applied to various activities and processes, including manufacturing, construction, transportation, and other industries. The system helps to identify and address potential hazards before they result in accidents or incidents, which can help to minimize the risk of injury, damage to property, and environmental impacts. This paper provides a research proposal for a hazard identification and risk analysis system to minimize the impacts of shipping on the marine environment, taking the example of the Pearl Harbor Incident.

Index Terms: Hazard Identification, Risk Analysis, Marine Environment, Pearl Harbor.

1 INTRODUCTION

Hazard identification is the process of identifying potential sources of harm or danger that could result in injury, illness, or damage to property or the environment. It is an essential component of risk management, as it helps to identify potential hazards and assess the associated risks in order to develop strategies to mitigate or eliminate them. It can be applied to a wide range of activities and processes, including manufacturing, construction, transportation, environment, and other industries.

The X-Press Pearl incident refers to the catastrophic fire and subsequent sinking of the container ship X-Press Pearl off the coast of Sri Lanka in May-June 2021. Fig. 1 shows the marine environment in Sri Lankan beach. The ship, which was carrying chemicals and other hazardous materials, caught fire on May 20, 2021, while it was anchored near the port of Colombo, the capital of Sri Lanka. The vessel before the occurrence is displayed in Fig. 2 [1].



Fig. 1. Marine environment in Sri Lankan beach

Due to the less Hazard Identification and Risk Analysis, this incident happened, and it took a huge amount of time to solve the damage. The fire burned for several days, causing an extensive amount of damage to the ship and the surrounding environment. The Sri Lankan authorities, as well as international organizations, launched a major effort to contain the fire and prevent an environmental disaster. However, despite their efforts, the ship eventually sank on June 2, 2021, releasing a large number of chemicals and other pollutants into the surrounding waters. The incident had a devastating impact on the marine ecosystem and local fishing communities, as well as causing concerns about the potential long-term effects on the environment and public health.

Our government launched an investigation into the incident, and several parties involved in the ship's

operations and management have faced legal action. The X-Press Pearl incident is considered one of the worst maritime disasters in Sri Lanka's history and has raised broader concerns about the safety and regulation of shipping and the transportation of hazardous materials.



Fig. 2. The ship arrives before the harbor incident

3 BACKGROUND

On May 20, 2021, a fire erupted on X-Press Pearl, a container ship anchored outside of Colombo, the commercial capital and largest city of Sri Lanka. As the world watched the ship burn for 13 days, Sri Lanka braced itself for the inevitable environmental disaster that has later been described as the worst in Sri Lanka's history. Fig. 3 shows the timeline of events starting from February to June [2].

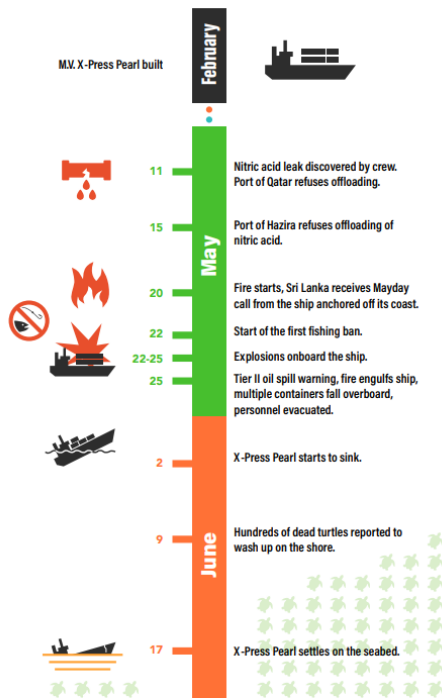


Fig. 3. Dates and events of xpress pearl harbor

Presidential Secretariat and it was decided to tow the ship away to deep sea as a risk of sinking was present.

- 19/ 05/ 2021 – The ship was at an anchorage 9.5 nm (nautical miles) off Colombo Harbor.
- 20/ 05/ 2021 – SL Navy and Sri Lanka Ports Authority (SLPA) are on board to inspect it.
- 21/ 05/ 2021 – Vessel states that all precautionary steps were taken to contain the fire.
- 22/ 05/ 2021 – Marine Environment Protection Authority (MEPA) instructs the vessel to move out of SL waters immediately.
- 24/ 05/ 2021 - National Building Research Organization (NBRO) launches an investigation on air pollution.
- 25/ 05/ 2021 – An explosion was reported in the morning. Crew members are evacuated.
- 27/ 05/ 2021 – Eight people are arrested for collecting debris.
- 28/ 05/ 2021 - National Aquatic Resources Research and Development Agency (NARA) is leading teams to assess damage.
- 29/ 05/ 2021 - Salvage operations are being led by the Dutch company SMIT, which has sent specialist fire-fighting tugs.
- 30/ 05/ 2021 – Police are to question Captain and crew of MV X-Press Pearl.
- 31/ 05/ 2021 – There are fears that this vessel was carrying dangerous mercury, arsenic and lead
- 01/ 06/ 2021 – A special meeting was held at the Presidential Secretariat and it was decided to tow the ship away to deep sea as a risk of sinking was present.
- 02/ 06/ 2021 – The private salvage team had started to tow the ship to deep sea as instructed by the President.

4 HAZARDS IDENTIFICATION OF X-PRESS PEARL INCIDENT

A calamity of this scale and complexity is going to contain many unknowns. It is still unknown what or how much of the cargo has seeped out, and no information on the cargo is accessible. Even if such characteristics were known, the cargo included such a complicated cocktail of toxins that predicting the dangers would be difficult. Yet, this event has had and will continue to have serious, long-term consequences.

A closer look at the marine environment reveals several potential effects on the marine environment. Fig. 4 illustrates the hazards caused by the incident. From this, there is a need in the present times to pay special attention to the dangers posed by shipping. The potential hazards to the marine environment can be categorized into two types:

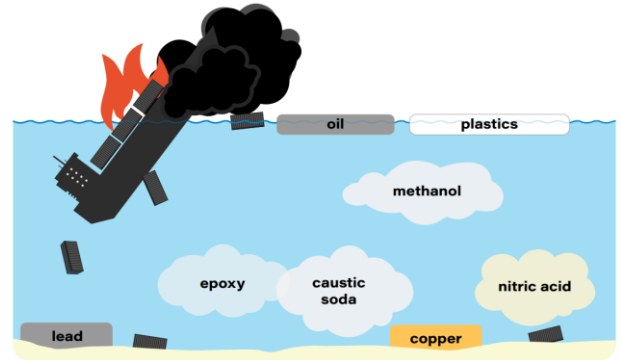


Fig. 4. Hazards caused by the incident

- Potential hazards to the marine environment caused by shipping.
- Risk to the marine environment from accidents during shipping.

It will be clear from the above section that there are several accidents caused by shipping. But here, we discuss the possible hazards of such accidents.

AIR POLLUTION

The first wave of pollution consisted of the smoke plume originating from the burning ship and spreading over Sri Lanka. The smoke plume lasted for approximately ten days.

MARINE AND COASTAL POLLUTION

The second wave of pollution was the cargo that leaked out from the containers and was found along the beaches. On board the ship was a wide array of potentially harmful substances, and although it is not known how much has leaked out. Fig. 5 represents Sri Lanka's wind pattern.

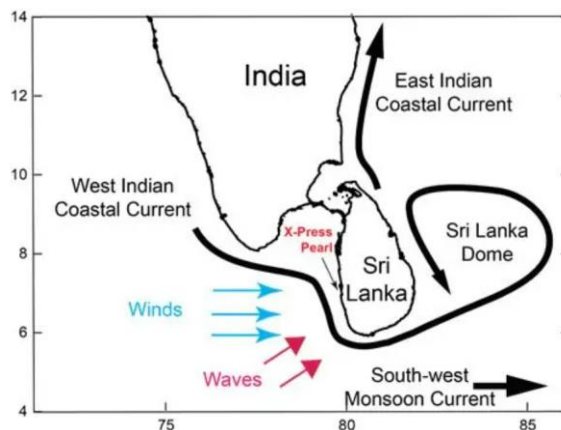


Fig. 5. Sri Lanka's wind pattern

PLASTIC PELLETS

According to the UN environmental advisory mission, the ship carried 1,680 tons of plastic pellets. It can

be inferred that there are approximately 84 billion pellets when considering the weight of each pellet, which is around 0.02 g.

FIREFIGHTING FOAM

Attempts to control the fire on board the ship included using foam, dry chemical powder, and water. The chemical content in the powder and the foam is not known, but it is worth noting that firefighting foams are often associated with adverse effects on human health and the environment.



Fig. 6. Bunker oil filtration

BUNKER FUEL OIL

The X-Press Pearl carried 348 tons of bunker fuel oil [3], and already on May 25, a Tier II oil spill warning was issued. Based on satellite imagery, it was concluded that oil was continuously flowing out of the ship for nearly a month. Fig. 6 and Fig. 7 illustrate the bunker oil filtration and chemical wastages respectively.

NITRIC ACID

The fire started due to a leakage of nitric acid, and it is likely that most of the nitric acid on board was consumed in the fire. However, any nitric acid that may have leaked out into the water remains a cause of concern, especially together with the caustic soda.

CAUSTIC SODA

On board were also 1,040 tons of caustic soda (sodium hydroxide). Caustic soda causes chemical burns, and historical releases into rivers have led to mass deaths of fish and other aquatic organisms.



Fig. 7. Chemical waste

EPOXY RESIN

Almost one-third of the cargo on board was epoxy resin. Epoxy resin is toxic to aquatic life. There is not

enough information in the ship's manifest to assess the risks, but if it leaks out in liquid form, the epoxy resin can sink and create a moving plume on the seafloor.

METHANOL

The 210 tons of methanol from the ship can, if spilled into the sea, float on the subsurface, creating a toxic vapor cloud. This may adversely impact pelagic marine organisms.

METALS

On board were also several metals, including copper, lead, and aluminum, as well as lithium batteries. The ship also carried 474 tons of copper "stuff," further defined as scrap and slag.

5 RISK ANALYSIS OF PEARL INCIDENT IN LOCAL SOCIETY

The impact of the X-Press Pearl incident on the marine environment in Sri Lanka is evident and obvious, but its impact on the lives of everyone in the coastal communities and the livelihood of the fishing community is yet to be identified. Within the fishing community, there are different kinds of livelihoods all being affected, including:

- Boat rentals
- Owners of beach seines
- People sorting fish from nets
- Multi-day boat operators
- One-day boat operators
- Traditional Theppam fishing gear operators
- Lagoon fishermen
- Fish sellers – small scale
- Fish sellers – stocks / large scale
- Tour guides – Snorkelers / Divers
- Ornamental fish sellers

Billions of plastic pellets

These plastic pellets, also called nurdles, are used to make nearly all plastic goods. There were some 46 different chemicals on that ship. A Sri Lankan environmental activist and founder of the Centre for Environmental Justice in the capital Colombo told the BBC that there were tonnes of plastic pellets, and those could take between 500 to 1000 years to decompose and is likely to be carried by ocean currents to shores all around Sri Lanka and even to beaches hundreds of kilometers away from the shipwreck [4].

Stevenses of People

Fishing had been banned in the affected area, meaning that many of them lost their income and livelihood practically overnight. While the government is expecting compensation and insurance money from the Singapore-based owners of the ship, the locals aren't too optimistic that much of that money will be used to help them. However, the fishermen's association told the BBC that they would desperately need help, both the fishermen and the wider community.

Marine Biodiversity Damage

The most long-lasting impact, likely to affect the country for decades, is that of chemical pollution. Among the most dangerous elements on board the ship are nitric acid, sodium dioxide, copper, and lead. Once in the water, these chemicals made their way into the bellies of the local marine life; then the Small fish dead quickly as a result of poisoning, but bigger ones were less likely to. Instead of feeding on smaller fish, the toxins slowly build up in their bodies over time. Also, fish, turtles, and dolphins had already washed up dead on the beaches. Some of those had turned a greenish color, suggesting contamination with metals and chemicals.

Pollution

While there have been shipwrecks before, Sri Lanka has never faced one with such poisonous cargo - and the country is not well prepared for a difficult job like this. Activists urge that international experts will be crucial. The shipping company that owns the X-Press Pearl has already commissioned an international firm to respond to the crisis and says its specialists are on the ground in Sri Lanka to determine whether a profit-driven firm will do its utmost to help the situation. The shipwreck has become a high-profile insurance case, and the idea of a large payout could trump the concern for marine life. The Centre for Environmental Justice has sued both the Sri Lankan government and the shipping company over the situation [5].

The incident occurred during a period of strong winds and high waves, which resulted in the onshore movement of the nurdles and high accumulation on the beaches directly onshore of the ship location (e.g., at Pamunugama). Subsequently, nurdles were found along an ~300-km stretch of the coastline along the west and southwest coasts transported by the prevailing currents: initially to the south and then to the north. As the southwest monsoon becomes established, the nurdles could be transported around the Sri Lanka dome and impact the east coast of Sri Lanka.

Some of the nurdles will be transported to the east and impact Indonesia. When the monsoon currents reverse, the nurdles will be transported to the west and may beach in the Maldives and Somalia. The volume of chemicals released was small, and it is unlikely that they will have a major effect on the marine environment. There is a potential for an oil spill to occur, although it is uncertain how much oil is currently on the ship. Irrespective of the oil spill, it is the worst man-made maritime disaster in Sri Lankan history to date.

6 REASONS CAUSES THE X-PRESS PEARL HARBOR

Along with uncertainties of cascading environmental damage, the incident's complexity stems from the range of pollutants involved - oil, hazardous chemicals, and plastics – and the lack of clarity regarding the nature and status of a substantial part of the vessel's cargo. Moreover, the growing geographic extent of the plastic spill - the largest on record - is expected to have transboundary impacts, further compounding the problem.

There are two immediate risks from the incident that needs to be eliminated as soon as possible:

- a sudden major spill of fuel oil aboard the ship; and
- Pollution and navigational hazards from the wreck and lost containers.

Proactive and vigilant surveillance is required to mitigate these risks. With the development of offshore and shoreline clean-up plans, as well as the deployment of response equipment, key actors are now relatively

well-pre-positioned to deal with a possible oil spill. Action to contain and recover the limited but continuous release of oil from the wreck should be taken as soon as conditions allow.

Nevertheless, several key actions need to be carried out to enhance its effectiveness, including:

- i. Contamination analysis of the plastic waste to determine if it is hazardous or not;
- ii. Refining and scaling-up clean-up techniques that minimize sand abstraction and recover small burnt particles; and
- iii. Establish technical specifications for the completion of microplastic clean-up operations while minimizing inadvertent environmental damage.

Environmental assessment of the incident needs to focus on pollution 'hot spots,' namely the area of the wreck and impacted shoreline sites, and the Risk Analysis should have directed at resolving several key factors with significant socio-economic implications and allaying public concerns, notably:

- i. Fishing area safety Protocols
- ii. The moratorium on fishing
- iii. Spike in turtle and marine mammal living

A biomonitoring programmer should have been recommended as a relatively simple and cost-effective option to monitor the situation around the wreck, including the status of sensitive marine ecosystems in the wider incident area.

The following are some of the reasons behind shipwrecks

- Natural occurrences such as strong winds and high tides are examples of natural conditions.
- The ship has some technical flaws.
- Errors in shipping due to poor road conditions.
- Human error causes accidents.
- Cargo-related accidents (Weights and dangerous objects are included).

The factors that must be included in a risk assessment are as follows.

- Identify things that may contribute to a
- Review of acceptable health and safety information
- Assessing the magnitude of the hazard
- Evaluate how a threat can cause harm
- The probability of damage is determined in advance
- Identify measures to eliminate or control the hazard.
- Records to be kept ensuring risk elimination or control
- Reasonable range of conditions, the risk assessment process is carried out by reviewing any available information about the accident.

7 RECOMMENDATIONS

- Ensure that proper information dissemination and clear communication channels are established.
- Take a precautionary approach to any debris on the beach potentially originating from the ship
- Develop both preventive and mitigation strategies to respond to future spills/accidents within your exclusive economic zone and ensure that each port has designated persons with adequate knowledge of hazardous and noxious substances.
- Develop strategies on fishing zone bans, when to start, what parameters to measure to decide the extent in time and space, and what are suitable communication channels for them.
- Ratify the hazardous and noxious spills convention (HNS convention).
- Determine how to best support the affected local communities as soon as possible.
- Safety of life at seas (the SOLAS Convention) is adequately adapted to today's large container ships.
- There is a clear responsibility for harbors involved in handling dangerous goods to help prevent accidents and that there are designated persons with adequate knowledge of hazardous and noxious substances in the harbor.
- A compensation program for spills of plastics and chemicals is put into place, and the HNS convention is ratified.
- Set up strategies for monitoring pollutants after spills of plastics and chemicals spills to make it possible to provide early advice on suitable restrictions for different activities such as fishing.
- A system for reporting lost containers and their content is adopted to facilitate mitigation and prevention strategies.
- Plastic pellets are classified as hazardous substances.
- Sri Lanka receives support in investigating the consequences of the accident, as well as the issues related to responsibility and accountability.
- Sri Lanka receives support in mitigating the effects of the accident on human health and the environment.

8 CONCLUSION

As a country, we haven't done a proper study of the marine ecosystems around the island; as of now, we only have information on a few studies that have been done in a few smaller regions. So, understanding the changes that have resulted from this shipping disaster is itself a challenge, as we don't have data on how those ecosystems actually were before the incident. So, during these investigations, we collected whatever data we had about these affected environments, and also, we have been collecting scientific information from different locations, different time frames, and different sources (Biological and Physical), and these collected data will be subjected to a proper laboratory and statistical analysis. "

"During the ongoing investigations, different components are considered,

- Biodiversity – Biology, Ecology, Life Cycle Changes, Population Dynamics, and economic importance
- Different ecosystems – Shore, Corel Reefs, Lagoons, Mangroves, Estuarine
- Chemical compositions of Water, Sand, Sediments, and Animal tissues
- Impact of weather and other environmental factors on the dispersal of pollutants and movement of affected organisms

The marine environment is harmed not only by shipping accidents, collisions, and oil spills but also by ship bilge water, ballast water, and solid waste discharged into the sea, all of which pose environmental risks and result in irreversible marine pollution. Shipping accidents have become an increasing environmental problem in recent years, with the consequences being critical for all parties in terms of human lives, the marine environment, trade, and financial losses.

Even though pollution-related regulations have reduced the number of accidents and incidents, ships continue to pollute the oceans worldwide. Some of the cases result from human error, while others are the result of physical factors. Whatever happens, people will not be able to change the fact that ship-caused "environmental disasters" devastate habitat and marine life, endanger the survival of marine flora and fauna, cause severe ecosystem distress, and harm people's livelihoods and quality of life. From hazard identification and risk analysis systems, some solutions are proposed in this paper to address some of the marine environmental problems.

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