



Ship disaster threatened environmental security and dwindled down the spirit of maritime Sri Lanka

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Abstract

The MV Xpress-Pearl ship disaster was a maritime environmental security threat that occurred on the Southwest coast of Sri Lanka during this decade. The wreck consists of tonnes of nitric acid, several other chemicals, and oils such as tonnes of bunker fuel oil, gas oil, and tanks full of lubricating oil. Also, several containers occupied with plastic nurdles that escaped have affected the west and southern coastal belt of Sri Lanka. Carcasses of dead endangered turtles, dolphins and various other rare marine organisms washed ashore, such as beaches of Uswetakeiyawa, Panadura, Unawatuna, Wellawatte, Moratuwa, and Induruwa. Besides, experts believe that it may take a long term to completely recover from the impacts including safe plastic nurdle-free seafood. Green peace USA has purported a list of conditions to be updated, such as the implementation of the plastic pallet free water act and placing plastics into the hazardous material category. The study used the qualitative content analysis technique to reconcile plastic pollution caused by the disaster as an environmental problem. Since plastic pollution is also a repercussion of two known keystone environmental problems, such as urbanization and human population increase.

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Introduction

Green peace has continuously urged that 40% of the world's oceans should be declared as natural reserves. But as maritime cargo traffic has been on the hike, the danger of occurrences of disastrous ship accidents causing severe environmental damages has also increased. A container ship 'MV X-Press Pearl' was burning for 13 days off the coast of Sri Lanka since the 20th of May 2021. The wreck sank into the Indian Ocean while trying to tow to the deep sea. The ship contained billions of polyethylene and polypropylene nurdles, 25 tonnes of aqua fortis (nitric acid), 278 tonnes of bunker heating oil, 50 tonnes of fuel oil, and also about 20 containers filled with grease. The spill is amalgamated with the deep ocean waters which are fairly rich in biodiversity. Shores were covered with piles of plastic nurdles as depicted in figures 1 and 2, which were then gathered and cleaned

arduously by navy officials. However, the effects caused by the disaster on the biodiversity appear irreplaceable because it caused injuries and deaths to many endangered turtles, dolphins, and some rare deep-sea creatures that are usually unseen are also among the carcasses that were being washed ashore. Dead turtle carcasses have landed on the coastal beaches of Uswetakeiyawa, Panadura, Unawatuna, Wellawatte, Moratuwa, and Induruwa. Data on the consequences to coral reefs is yet to be confirmed. The government permitted a choice to tug the wreck towards the deep sea further far away from the coast rather than bringing it to the shore for salvaging. This decision to tow the wreck far away from the coast towards the deep sea may further increase the contamination of the shore area with the plastic pellets and unsafe chemicals that remain within the wreck,

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thanks to the ocean currents. However, the other argument also prevails, as some suggest the early decision to maneuver the ship toward the deep sea could have minimized this disaster. Immediately after the incident fishing has been prohibited along the coastal belt from Mannar (South) to Galle. According to local news media (Sri Lanka Broadcasting Cooperation), many families of the fishing communities were affected and they are engaged in an effort to urge compensation from the government. The ultimate purpose of this study is to check whether the main environmental problem caused by the disaster is linked to keystone environmental problems.



Fig. 1. Shore covered with plastic nurdles and burnt remaining



Fig. 2. Naval officers cleaning the plastic nurdles at the beach

Materials and methods

Data collection was done from all reliable sources that are widely available on the internet. Qualitative content analysis methodology was used to detect the root problems of plastic pollution (the environmental problem caused by the disaster). The conceptual framework of the method is depicted in figure 3. Accordingly, the collected data was searched for codes (known environmental issues), and then identified codes were transcribed to discover the root causes, which also keystone environmental issues.

Effects on biodiversity

Nitric acid is a highly oxidizing chemical and very lethal when it contaminates the living cells and tissues causing burns and necrosis. Plastic nurdles block the alimentary canal of the ingested marine organisms and eventually cause death. Plastics also injure soft body parts like eyes, gills, or delicate eggs and young ones. Disintegrating plastics release bisphenol A (BPA) which could harm the genital system, causing less healthy offspring. When absorbed by algae, the algae are ingested by algivorous fishes and accumulate within their tissue. Moving up along the organic phenomenon the chemical can also undergo biomagnification (increase in concentration because the carnivore eats more affected algivorous fishes). Thus, reaching lethal chemical concentrations lead to death among top-level carnivores in the food chain such as sharks, gulls, and even humans when marine products are consumed.

Oil spill covers the ocean surfaces and reduces the dissolved oxygen in surface waters, additionally, it soaks into the plumage of birds and the fur of mammals, leading to reducing their insulating ability, making them more susceptible to temperature fluctuations and fewer buoyant. Also, it affects flying ability in birds. If ingested, causes irritation to the alimentary canal, liver malfunction, kidney damage, diminish their foraging capacity, and causes dehydration and metabolic imbalance. Thus, birds become more susceptible to predation. The spill also causes fish kills, reduces the taste of the fish, reduces fish growth, and destroys coral reefs, lobsters, crabs, sea stars, sea urchins, etc. Along the coast, the mangroves may perish because mangroves are very sensitive to oil. Pollution also affects corals and shells of the molluscs made from carbonate might be dissolved making them vulnerable.

Loss of keystone species like the plankton population which are the first producers of the oceanic organic phenomenon by the oil may have a cumulative impact of affecting the tiny fish population, reduction within the small fish population subsequently will cause the decline in the large fish

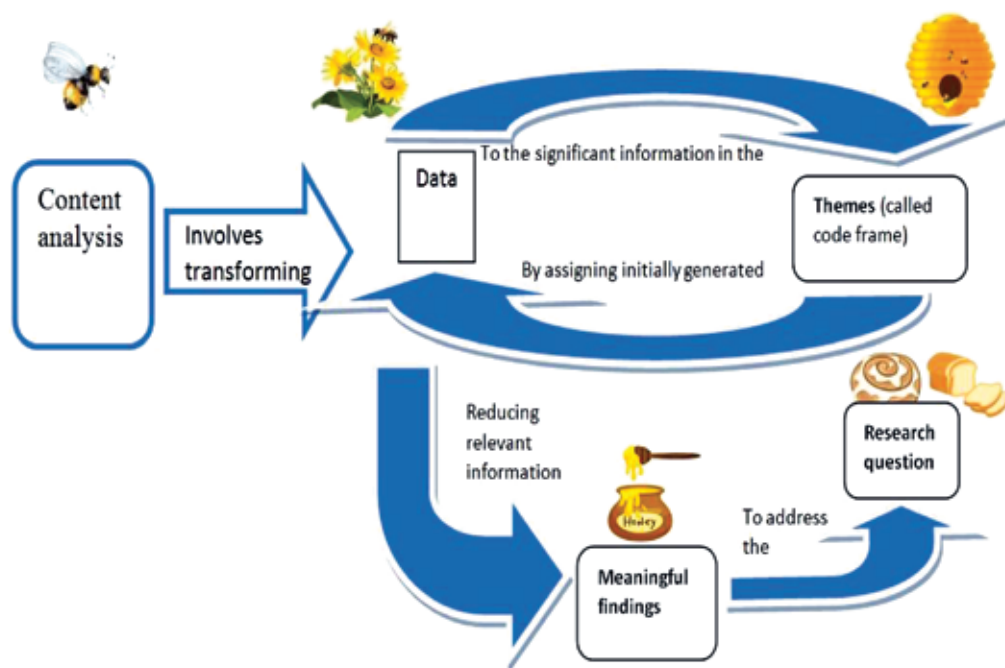


Fig. 3. Qualitative content analysis methodology (Adu, 2017)

population. Heavy metal leachate from the shipwreck burnt and exposed to corrosive acid also results in bioaccumulation and biological magnification of hazardous heavy metal toxins, which finally affect human consumers at lethal concentrations.

Long term effects

Plastic wastes have the ability to attract contaminants like Persistent organic pollutants (POP). These plastics are hydrophobic (do not mix with water) stay long and are transmitted by the natural phenomenon. Van Franeker *et al.* (2011), as cited by the European Commission (2011) reported that fulmars (a seabird) reduce the size of plastic particles in their muscular stomach and excrete them back to the environment within the type of microplastics. These microplastics when entering the food chains can cause severe damage.

Polyethylene under burning conditions and also under the radiation releases of harmful chemicals. When exposed to a temperature above 40°C plastics release harmful chemicals such as Bisphenol A (BPA), Diethylhexyl phthalate (DEHP), and metallic compounds like antimony. Antimony is a toxic compound causing dermatitis in humans, affecting skin cells and the respiratory tract and affecting the immune mechanism (Kim *et al.* 1999). It has also been recognized as a possible carcinogen by International Agency for Research on Cancer

(IARC, 1989). Dioxins another substance that will be released, cause cancer and affect the immune system and cause developmental reproductive disease. Burning of Polyvinyl chloride (PVC) causes air pollution by chlorinated compounds, such as Polychlorinated biphenyls (PCBs). PCB accumulates in fishes and other organisms and undergoes bioaccumulation that ends up in high value in top-level carnivores such as humans. PCB is additionally absorbable via skin, inhalation, or ingestion, causing neurotoxicity, liver damage, tumours, immune suppression, behavioural changes, reproductive disorders, and abnormal sperms (Allsopp *et al.* 1999; Allsopp *et al.* 2000). PAH (Poly aromatic hydrocarbon) is a persistent organic chemical. PAH is formed during the unfinished combustion of coal, oil, gas, garbage, and other organic substances. Prolonged exposure to PAH causes cancers in the lungs, bladder, and gastrointestinal pathways, PAH also causes liver damage, breathing problems, symptoms of asthma and abnormalities in lung functions, and frequent contact with skin may cause skin inflammation (Toxipedia, 2011; European Commission, 2011).

Among plasticizers, phthalates are associated with several health problems. Phthalates in their monomer form, such as DEHP affects the development of testis. Butyl benzyl phthalate (BBP) and dibutyl phthalate (DBP) also affect human reproduction. Exposure to phthalates in pregnancy reduces anogenital index in the male child (distance between anus

and genitals) (Swan *et al.* 2005), DINP and DIDP (diisodecyl phthalate) affect the liver and kidneys. In mammals, chlorobenzene causes acute and chronic effects, such as effects CNS (central nervous system), liver, and thyroid glands. Increasing the degree of chlorination such as tetra chlorobenzenes also affects kidneys. Hexachlorobenzene (HCB) is also categorized under group '2B' carcinogens (agents with limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals), which affects the immune system, liver, thyroid glands, kidney, CNS, and nervous system (Van Birgelen, 1998). It also reported the bioaccumulation of HCB within living tissues.

Polybrominated diphenyl ethers (PBDEs) is an environmentally persistent compound used as flame retardant, which is additionally reported in bioaccumulation, it causes abnormal brain development in the foetus, it is also associated with harmful impacts on learning, memory, behaviour, and thyroid and oestrogen hormone systems and also affects the immune system (Legler and Brouwer, 2003). Burning of PBDEs releases brominated dioxins or furans which are severely hazardous. Triphenyl phosphates (TPP) are known contaminants in human blood (Jonsson *et al.* 2001), and potent inhibitors of an important enzyme (monocyte carboxyl esterase) in the human blood circulatory system (Amini and Crescenzi, 2003). Polycarbonates are plastic 7, many containers are coated with bisphenol A (BPA), which is linked with many health problems including cancer, endocrine disruption, obesity, type-2 diabetes, and miscarriages, and it is an extremely harmful plastic.

Teflon and polytetrafluoroethylene (PTFE) are found in coatings of non-stick pans. When teflon cookware is mistakenly placed on lit at the inner side of pan it may release harmful substances at $\geq 260^{\circ}\text{C}$, Perfluorooctanoic acid (PFOA) is used during the processing PTFE and it may cause cancer. All of these are potential impacts from the burning ship and its substances.

Threat to environmental security

In 1994 U.S. president Bill Clinton stated that "We must prevent further environmental degradation if we fail these problems will cause terrorism, tension, and war". Environmental security was identified as a component of regional and national security in step with the U.S. department of state (2001). "Environmental security refers to the mitigation and prevention of energy threats, threats to energy sources and provides lines, and potential environmental risks and related issues that directly lead to political financial instability or conflict in foreign countries or regions of importance to the country of concern". Furthermore, it includes selected

energy, environmental, and related national security concerns that cause a direct conflict with country's foreign policies. Environmental security threats indirectly affect the country of concerned and its allies thanks to its adverse effects on global financial set-up, e.g., nuclear contamination, spent fuel and waste, threats to energy resources, contamination, degradation or depletion of essential natural resources U.S. department of state (2001). Within the year 1991, President Bush declared the role of environmental security within the national security strategy of the U.S. Following statement was found in the U.S national security report of the year 2000, "Decisions today regarding the environment and natural resources can affect our security for generations. Environmental threats do not heed national borders; environmental hazards overseas confound long-term dangers to U.S. security and well-being" US department of state (2001). Furthermore, Environmental Security Initiative (ESI) framework was established in July 1996 and was actively engaged in the departments of defence, energy, and environmental protection agency (U.S. EPA, 1996) ("Memorandum of Understanding among the Environmental Protection Agency, the Department of Energy and also the Department of Defence Concerning Cooperation in Environmental Security", 1996; U.S. Department of State, 2001). Additionally, the millennium project has revealed that environmental security as environmental variability for all times support with three sub-elements, such as 1) preventing or repairing military damage to the environment, 2) preventing or responding to environmentally caused conflicts, and 3) protecting the environment because of its inherent moral value (Millennium project, 2006). In line with Mignonne Chan (Chan, 2011), the transboundary movement of hazardous waste is additionally a threat associated with environmental security, e.g. shipment of electronic waste (E-waste) from Europe to Africa (Ghana).

Legislations and prevention

Key legislations about marine pollution are the convention on the prevention of marine pollution by dumping of wastes and other Matter (1972) which is also known as the London Protocol, the International Convention for the Prevention of Pollution from Ships (1973), modified by the protocol of 1978 relating thereto referred as MARPOL 73/78, and the international convention on oil pollution preparedness, response, and co-operation 1990 (OPRC) adapted from USEPA (1996).

MARPOL convention has two protocols coping respectively with reports on incidents involving harmful substances and arbitration and five annexes which contain regulations for the prevention of various forms of pollution, such as oil (EIF

2/10/83), noxious liquid substances transported in bulk (EIF 06/04/87), harmful substances transported in packages, portable tanks, freight containers, or road or rail tank wagons, etc. (EIF 01/07/92), sewage from ships (EIF not yet), and garbage from ships (EIF 31/12/98t) adapted from USEPA (1996).

Convention on the prevention of marine pollution by dumping of wastes and other Matters, 1972 (known as the London Protocol) which is an inter-governmental conference on the convention on the dumping of wastes at sea. The protocol restricts all kinds of dumping except for a permitted list of wastes, the allowed contents include dredged material, sewage sludge, bycatch wastes, wastes from industrial fish processing activities, vessels, and platforms or various other man-made structures at sea, inert, inorganic geological material, organic material of natural origin, bulky items mainly comprising iron, steel, concrete and similar harmless materials for which the primary concern is physical impact and limited to those circumstances, where such wastes are generated at locations, such as small islands with isolated communities, having no feasible access to disposal options aside from dumping adapted from USEPA (1996).

A conference of leading industrial nations held in July 1989 in Paris called upon IMO (International Maritime Organization) to develop further strategies to prevent pollution from ships. This request was considered by the IMO assembly in November of the same year and work began on a draft convention aimed toward providing a worldwide framework for international cooperation in handling major accidents or threats of marine pollution.

Delegates to the international convention on oil pollution preparedness, response, and co-operation (OPRC) are required to determine ways or strategies for handling pollution incidents, either nationally or in cooperation with other countries.

It is mandatory for ships to hold a shipboard oil pollution emergency plan. Offshore operators under the jurisdiction of delegates also are required to have oil pollution emergency plans or similar systems which must be coordinated with national frameworks for responding immediately and effectively to oil pollution incidents adapted from USEPA (1996).

Ships are required to report incidents of pollution to coastal authorities and thus the convention details the actions that are then to be taken. The convention also involves the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises, and also the development of detailed plans for handling pollution

accidents. Delegates to the convention are required to supply assistance to others in the event of a pollution emergency and provision is generated for the reimbursement of any given assistance. The convention facilitates IMO to coordinate of an important role adapted from USEPA (1996).

A protocol referring to hazardous and noxious substances (OPRC-HNS Protocol) was adopted in 2000. In addition to these, there are many other internationally accepted laws and protocols currently active. In addition, some internal laws are prevailing according to the needs of a particular maritime environment and are governed by states and governments adapted from USEPA (1996).

Green peace USA has postulated the following demands in order to prevent similar disasters in the future (Greenpeace, 2021).

A. The plastic pallet free waters act (introduced in May 2021) should be passed by the U.S. Congress.

B. All cargo ships should use mandatory location systems for containers carrying dangerous goods. Unless the ship meets the security requirements, containers in the ship should be reduced to an acceptable level before granting clearance. All cargo vessels should be required to inform authorities including the public about lost or damaged cargo containers.

C. Authorities should be informed about any damaged containers in the cargo, this is a mandatory requirement for all cargo ships without any bias (at present, this information is required only when claiming insurance money).

D. Plastic should be classified as an environmentally hazardous material and allocated appropriate IMDG codes.

E. And the most important demand: consumer goods companies MUST stop propping up the fossil fuel industry by using single-use plastics.

Keystone environmental problems

When solving a man-made environmental problem, if it results in the permanent disappearance of one or more man-made environmental problems, then that mitigated problem can be considered as a keystone environmental problem. For instance, air pollution can be considered a keystone problem because if air pollution (SO_x , NO_x , and CFC) gets solved, the resulting acid rain and ozone depletion can also come to a halt. Similarly, eutrophication is caused by water pollution. When water pollution through nitrate and phosphate is prevented, then cultural eutrophication and

subsequent biodiversity loss can be abated. Thus, water pollution is a keystone environmental issue.

However, if more than one environmental factor causes an environmental problem, then none of the causative environmental problems can be considered the keystone. For instance, biodiversity loss is caused by land degradation and competition with invasive species. Here, land degradation is not a keystone environmental problem because even if land degradation is mitigated, competition impact from invasive species continues to fuel biodiversity loss.

Based on the aforesaid definition eight environmental problems are considered the keystone environmental problems, such as population explosion (population growth), deforestation, air pollution, intensive farming, urbanization-urban sprawl-settlements, global energy crisis, water pollution-water scarcity, and overexploitation of natural resources.

In this case, plastic pollution is not a keystone environmental problem but it is caused by urbanization and human population increase (keystone environmental problems). The following figures 4 and 5 illustrate how urbanization and population explosion endure as a keystone environmental problem, respectively.

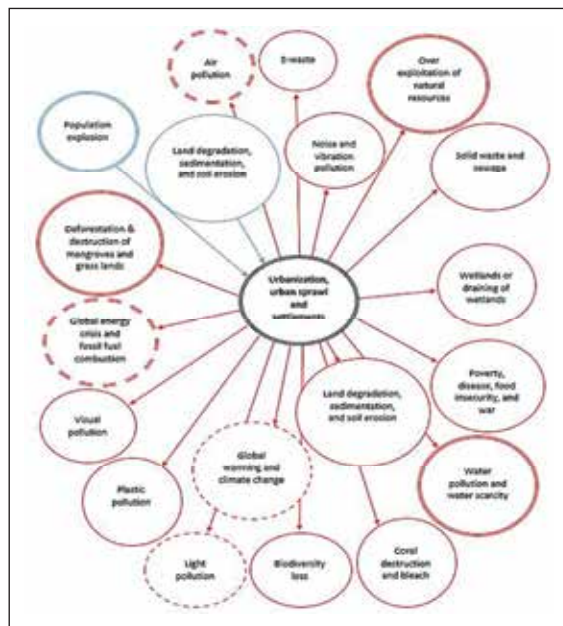


Fig. 4. Urbanization-urban sprawl-settlements as keystone environmental problems with the disappearance of air pollution, global energy crisis, and light pollution on its mitigation (hypothetical diagram)

In the figure black circle is the problem being examined, blue circles are cause man-made environmental problems, red circles are effect man-made environmental problems, double lined circles are keystone man-made environmental problems, and circles with dashed lines (either single or double lined) are the man-made environmental problems that disappear when the problem being examined (black circle) is mitigated

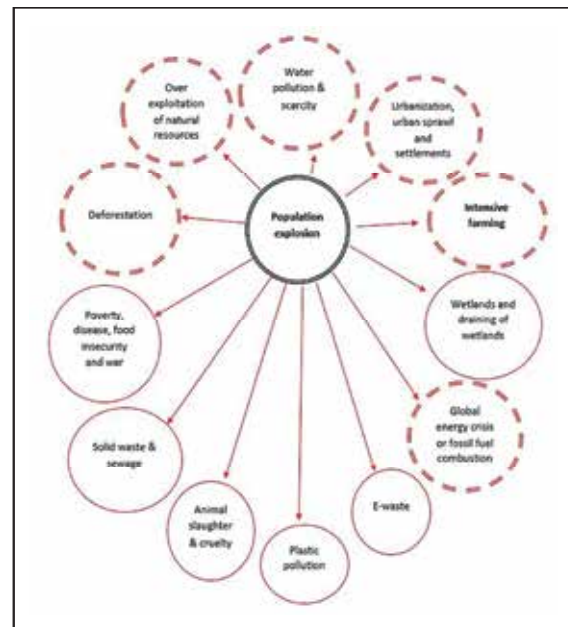


Fig. 5. Population explosion as keystone environmental problem with the disappearance of intensive farming, deforestation, urbanization, water pollution-water scarcity, and overexploitation of natural resources on its mitigation (hypothetical diagram)

In the figure black circle is the problem being examined, blue circles are cause man-made environmental problems, red circles are effect man-made environmental problems, double lined circles are keystone man-made environmental problems, and circles with dashed lines (either single or double lined) are the man-made environmental problems that disappear when the problem being examined (black circle) is mitigated

Thus, plastic pollution has two root problems such as urbanization and population explosion, both of which are known keystone environmental issues.

Conclusion

Actions taken during environmental disasters have to consider the long-term effects. Many criticize the late decision to take the ship to the deep sea, as it should have been taken earlier, as soon as the smoke was identified. But on the other hand, taking the hazardous chemical and plastic source towards the deep sea may increase the impact on the shoreline and sea surface by the contaminant spreading widely due to ocean currents and tides. However, now that the ship is almost completely sunk, and the remaining packs containing possibly more plastic pellets, other chemicals along with bunker oil is still a threat to the deep-sea biota and existing coastal environment. Thus, the secure removal of the remaining containers is the most environmentally friendly path to handling this problem. Also, possible bioremediation techniques and temporary shifting of non-sedentary creatures from the site can be examined in the region along with physical cleaning. It is believed demands postulated by the Greenpeace USA in order to prevent similar disasters in the future have also created a vibe of sympathy towards awakening on the same. This paper highlighted the main problem created by the disaster is plastic pollution, which has two keystone roots (keystone environmental problems), such as urbanization and human population explosion.

Abbreviations

IMDG: International Maritime Dangerous Goods; OPRC: Protocol on Preparedness, Response and Co-operation to pollution Incidents; HNS: Hazardous and Noxious Substances; IMO: International Maritime Organization; MARPOL: International Convention for the Prevention of Pollution from; ESI: Environmental Security Initiative; PVC: Polyvinyl chloride; PFOA: Perfluorooctanoic acid; PTFE: polytetrafluoroethylene; BPA: bisphenol A; PBDE: Polybrominated diphenyl ethers; HCB: Hexachlorobenzene; CNS: Central Nervous System; PAH: Polyaromatic hydrocarbon; BBP: Butyl benzyl phthalate; DBP: dibutyl phthalate; DINP: Diisononyl phthalate; DIDP: diisodecyl phthalate; HCB: Hexachlorobenzene; TPP: Triphenyl phosphates; U.S. EPA: The United States Environmental Protection Agency.

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