

Assessment of Potential Sources of Marine Pollution in China



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Executive Summary

With the increase in population and the acceleration of industrialization and urbanization, more and more pollutants are created by human activities. The river acts as the conduit to carry the pollution into the ocean.

China has a large land area, and the sea area is also vast. China's marine pollution is relatively serious. However, the government and relevant departments have implemented a series of policies and measures to address the concern, which have been quite effective. This paper summarizes the three main marine pollutants-plastics, oil, and heavy metals, an introduction to each pollution type, the current situation in China, the harm of each pollutant, and the existing effective treatment measures.

The emergence of pollution issues should remind people to reduce pollution at the source. It is very important to prevent and monitor pollution in advance.

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1. Introduction

With the development of the global economy, technology, and science, the world's population is growing rapidly, and the process of urbanization is also accelerating. It is predicted that by 2050, the global population will grow from 7 billion to 9 billion, and more than 3 billion people will live in cities (United Nations, 2018). The increase in pollutants and the increase in population are inseparable. If we do not take action, future pollution will harm the environment to a greater extent and affect our lives, negatively.

This study assessed the main sources of marine pollution in China and suggests preventive and remedial measures as well as suggestions for the protection of marine resources from different types of pollution.

2. Background

2.1 Pollution

Contamination and pollution are two words that have very similar meanings, and we often think that they mean the same thing. However, a careful analysis of the concepts of the two shows that there is a difference.

Concerning the marine environment, pollution refers to the direct or indirect introduction of materials or energy into the environment by humans, thereby destroying biological resources, impacting human health, destroying marine activities including fishing and seawater. (Clark, Frid, & Attrill, 1989).

Contamination means adding foreign materials to an environment that has some damaging effects and is caused by human activities, then it is regarded as pollution.

2.2 Sources of marine pollution

As is known to all, the main problems and activities that affect Marine pollution are mainly human activities. Sewage is discharged from land, industry, household, and other channels.

Figure 1 illustrates the main sources and proportions of marine pollution:

SOURCE	SHARE OF TOTAL (%)
RUNOFF AND DISCHARGES FROM LAND	44
AIRBORNE EMISSIONS FROM LAND	33
SHIPPING AND ACCIDENTAL SPILLS	12
OCEAN DUMPING	10
OFFSHORE MINING, OIL AND GAS DRILLING	1

Figure 1. Sources of marine pollution. (From UN Environment Program)



Figure 2. Different Sources of Marine Pollution

2.3 Classification of marine pollution (Li, 2011)

Organic substances and nutrients -- Includes oil and cellulose discharged from industry, feces in domestic sewage, food residues, detergents, etc.

Solid Waste -- Solid waste includes marine waste, industrial waste, urban waste, and engineering residues that endanger marine resources and destroy coastal landscapes.

Pesticide -- Pesticides include herbicides and insecticides used to grow crops in rural areas that may flow along the river to the sea, causing marine pollution.

Thermal pollution -- Industrial wastewater with heat decreases the concentration of dissolved oxygen in the water, thereby destroying the ecological balance and marine ecosystems.

Oil pollution -- Spilled oil and its products have a large impact on the marine environment and marine life.

Heavy metal and eutrophication – Many elements such as mercury, chromium, copper, pickaxe, sulfur, and phosphorus can also cause both eutrophication and toxicity of water bodies.

2.4 Characteristic of marine pollution

1) Range of pollution sources

All kinds of pollution produced by a human can enter the ocean from the atmosphere, rivers, precipitation, and human waste. The land contains many and complex pollutants, and the ocean is where all the pollutants accumulate.

2) Persistent

The topography of the ocean is low, and it is difficult for pollutants to be transferred out after entering the ocean. Pollutants will spread through the

food chain by bioconcentration and biomagnification and may eventually cause negative effects to humans.

3) Widespread

The world's oceans are an interconnected whole. After a specific area is contaminated, it will spread to the surrounding area or the entire area.

2.5 Oceans in China

The oceans in China are part of the Western Pacific and borders the Asian continent in the south-southeast. (Britannica, 2008). China has a continental coastline of more than 18,000 kilometers, more than 6,500 coastal islands, and a maritime land area of approximately 3 million square kilometers. (Li, 2011). China's four oceans, the Bohai Sea, the Yellow Sea, the East China Sea, and the South China Sea, have a total area of about 4.7 million square kilometers. (China Seas, 2021).



Figure 3. Ocean in China

2.6 Why protect the marine environment?

If you visit a beach, you will see plastic waste floating on the water and accumulating in the ebb and flow of the tide. These wastes are responsible for

the widespread pollution of marine biological communities. (Elliott & Elliott, 2013). In addition, certain organisms in the marine environment are trapped in plastic bags or fishing lines.

Marine pollution affects fisheries, marine food webs, human health, and transboundary (international) movements.

The ocean is the source of many important products to support human society. Pollutants can enter the food chain through bioaccumulation and bioaccumulation, and eventually reach the human body.

3. Project Objectives

The objectives of this project are to:

- 1) Provide the background of China's oceans.
- 2) Assess the main types and sources of marine pollution in China.
- 3) Compare three common marine pollutants (plastic, oil, heavy metals).
- 4) Provide recommendations for remedial measures to address current pollution and preventative measures against continuing pollution.

4. Methods

This paper reviewed and compared published journal articles, case studies, research papers, and books. This research focused on literature and cases of China's marine pollution concerns, including the source, type, and treatment of pollution.

First, through reading types of the literature and the accumulation of information, an assessment of the basic knowledge was synthesized on marine pollution, including pollution classification, source, characteristics of China's seas, and the importance of the ocean.

Second, marine pollution in China was evaluated as to various pollution types and control methods. Third, a prediction of marine pollution that may occur in the future and propose methods to prevent marine pollution was conducted.

5. Three types of marine pollution

This study focused on the three most important pollutants in China.

5.1 Plastic

5.1.1 Plastic Marine Pollution in China

Plastic has a wide range of applications and is not easily degradable, thus plastics are the most important components of marine solid waste. (Nash, 1992). As early as 1970, the problem of marine plastic waste pollutants aroused widespread concern in the world and is considered to be one of the major marine pollution problems. (Cai Zhongli, & Li Xifeng, 1997). We use plastic substances every day. In the early days of this industrial composite material, people were ecstatic about its birth. Bright colors, lightweight, drop resistance, economical and durable, not only brought great convenience to humans, but also greatly promoted the development of the industry. Today, plastic waste is part of our lives, and 80% of plastic waste flows into the ocean through rivers. A report from "Nature Communication" magazine shows that among the world's top 20 estimated plastic inputs from polluted rivers to the ocean, six rivers in mainland China are on the list. The No. 1 Yangtze River contributes about 333,000 tons of plastic waste into the ocean per year, accounting for 23.71% of the world's total input. (Nature Communication, 2017).

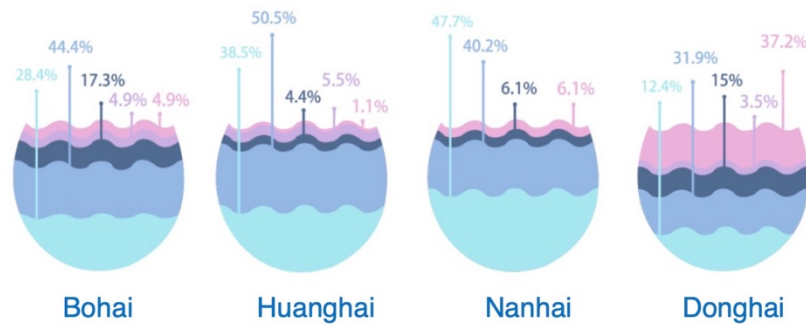


Figure 4. China's Coastal Water Quality. (Communiqué on the Environmental Conditions of China's Coastal Waters,2016)

It can be seen from Figure 5 that in all the marine wastes monitored in China, plastic waste accounts for more than 70%. To a large extent, China's marine plastic waste problem represents China's marine debris problem.

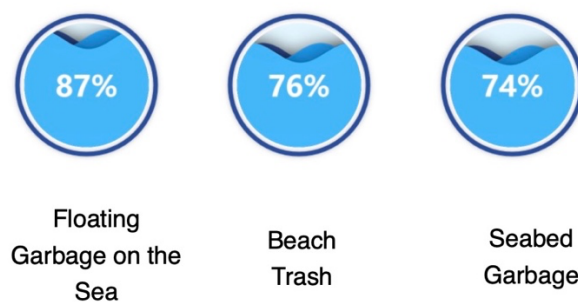


Figure 5. Percentage of marine plastic waste in the monitored area in 2017.
(Communiqué on the Environmental Conditions of China's Coastal Waters,2017)

5.1.2 The Impact of Ocean Plastic Pollution

Marine plastic pollutants may have both short-term or long-term effects on marine animals, the fishery economy, and the environment.

- 1) Because plastics can exist in the environment for a long time and float widely with the waves, the impact of waste plastics on animals is manifested in two aspects: firstly, animals eat plastic and causes the esophagus to pierce resulting in death; secondly, animals are killed by plastic products entanglement which can cause injury or even death. (Cai Zhongli, & Li Xifeng, 1997). Plastic can also cause gastric ulcers in animals, reduce animal appetite, and reduce reproduction rate.

- a) Seabirds: Because the shape and color of some plastics are similar to prey, seabirds often eat plastic by mistake. Although plastic has no direct impact on the health of seabirds, a large number of plastic products have accumulated in the stomach of seabirds. (Moser M & Lee D, 1992). Robards reported that the plastic eaten by seabirds might be passed on to offspring, affect the mother birds as they regurgitate to feed the little birds. (Robards, Piatt & Wohl, 1995).
 - b) Fur seals: The situation of fur seals entanglement by discarded fishing gear is more serious. Entanglement includes trawl nets, packaging bags, gill nets, and ropes. (Jones M, 1995).
- 2) The plastic waste that affects the fishery economy is mainly plastic bottles, plastic bags, and polystyrene foam boards. (Nash, 1992). The possible effects include affecting the normal navigation of vessels; blocking the water inlet channel of the cooling system; staining or even damaging fishing gear; entanglement of the propeller, etc.
- 3) The life of plastic in the ocean may be as long as decades, and its texture generally becomes brittle, then breaks into pieces, and finally turns into powder. (Cai Zhongli, & Li Xifeng, 1997). The plastic itself will also affect the aesthetics of the environment and the local tourism industry and also affect the safety of ships at sea.

5.1.3 Remedy for Marine Plastic Pollution

With the progress of the times and the development of industry, the frequency of use of plastic products has increased year by year throughout the world. The prevention and treatment of plastic pollution in the ocean are urgent. We can prevent and control marine plastic pollution through the following means. (Pearce, 1992).

- 1) Formulate a series of laws to restrict marine plastic pollution and implement with strict means of supervision and implementation.

- 2) Expand publicity and raise the public's awareness of environmental protection through newspapers, magazines, television networks, and publicity brochures. Explain the relevant laws, environmental pollution status, and methods to protect the environment.
- 3) Regularly organize activities for all citizens to clean up beach garbage.
- 4) To systematically investigate the pollution of marine microplastics in the coastal waters, and conduct in-depth research on the transmission pathways, environmental behavior, and biological toxicity of marine microplastics. (Zhu Weiping, 2018)
- 5) Encourage major companies to continue to developing alternatives to plastics or formulating new product formulations to make plastics easier to recycle or easier to degrade. (Wen Yuanyuan, Li Hongtao, Du Yu, & Li Le, 2018)
- 6) Participate in international cooperation and actively participate in international initiatives, activities, and conferences on marine protection organized by the United Nations. (Wen Yuanyuan et al., 2018)

5.2 Oil

5.2.1 Oil Marine Pollution in China

Petroleum and its refined products (gasoline, kerosene, diesel, etc.) invade the marine environment during the process of mining, refining, storage, transportation, and use. At present, it is serious marine pollution worldwide. Its prevention's on global cooperation to be more effective. (Marine oil pollution, 2021).

Different from traditional pollutants, when petroleum pollutants enter the water body or the food chain, they are not easy to be destroyed after invading the human body. They maintain their persistence, accumulation, fluidity, and high toxicity, and threaten human health. (Wang Chuanyuan et al., 2009).

According to statistics, about 390,000 tons of oil are spilled into the ocean due to tanker accidents in the world each year. As of 2006, there have been 2,635

oil spills from large and small ships along the coast of China, with a total oil spill volume of 37,077 tons. (Wang Chuanyuan et al., 2009). The average mass concentration of oil in China's offshore waters has reached 0.055 mg/L, and pollution is increasing daily. (Chen Yao, 2003).



Figure 6. Marine oil pollution in China. (By Feng Hao, 2018)

Compared with 2006, the average concentration of seawater oil in coastal waters and the proportion of samples exceeding the standard are the same. Except for the increase in the Yellow Sea, the over-standard rate in other regions has slightly decreased. (Wang Chuanyuan et al., 2009).

Year	Bohai Sea	Huanghai Sea	Donghai Sea	Nanhai Sea	Nationwide
2006	6.2	2.5	4.8	1.4	6.2
2007	5.1	5.1	5.1	5.1	6.8

Table 1. Surpassing times of petroleum pollution in the four major marine regions during 2006-2007 in China

5.2.2 The Impact of Marine Oil Pollution

Oil spills will cause varying degrees of short-term and long-term damage to the environment. From a short-term perspective, the leakage of oil will directly cause pollution of the ocean, land, and air environment, leading to a large number of deaths of animals and plants. At the same time, it will have a direct

impact on local scientific research experiments.

From a long-term perspective, a series of problems will arise:

- 1) Oil covers the surface of the ocean, destroying the CO₂ absorption mechanism, affecting normal photosynthesis, and blocking the exchange of gases such as O₂ and CO₂. The oxidation of oil will also consume dissolved oxygen in the water, leading to a lack of oxygen in the water body, and causing suffocation of animals and plants in the ocean. (Prince et al., 2003).
- 2) After oil spills into the sea, a photochemical reaction takes place within a few hours to produce a series of toxic chemical substances. Among them, aromatic hydrocarbons (PAHs) are the most serious organic pollutants. Their potential toxicity, carcinogenicity, and teratogenic effects, combined with hydrocarbons through biological enrichment and food chain transmission, further aggravates the negative impacts, which have great potential effects on human health and the ecological environment. (Huang Jianping, 2014).
- 3) The leaked oil brings some chronic problems to marine life, including changes in eating and reproductive patterns, abnormal behavior, and growth, and may also interrupt the chemical communication between the organs used for migration between animals. (Chen Guifeng et al., 1997).
- 4) Oil pollution will aggravate the greenhouse effect and will have varying degrees of impact on local fisheries, industry, agriculture, and tourism.

5.3.3 Remedy for Oil Marine Pollution

At present, China's countermeasures against marine oil pollution are divided into the following steps: prevention, monitoring, and comprehensive management, and strengthening international cooperation. Governance is mainly divided into physical treatment and chemical treatment. The more commonly used methods are as follows:

- 1) The coagulation method refers to the use of an oil condensing agent to rapidly increase the viscosity of the oil to make the slick oil agglomerate for

easy recovery. The coagulation method is not as common as the dispersant method, but the coagulation method can recover the oil without causing secondary pollution, but the solidification method requires a relatively high temperature, and the procedure to recover the solidified oil, a problem to be studied.

- 2) The adsorption method refers to the use of oil-absorbing materials to absorb oil, which is the fundamental method to solve oil pollution, and is usually used in conjunction with the fence method. As for the oil-absorbing material, it must have a fast-enough oil absorption rate, it must be able to float on the water for a long time, and it must not be toxic, otherwise, it will cause secondary pollution. (Chen Guifeng et al., 1997).
- 3) An oil skimmer can also be used to treat spilled oil. The oil skimmer recovers oil without changing the physical and chemical properties of the oil. (Huang Jianping, 2014).
- 4) The best way is to use bioremediation, but this method is slower than other methods. The process is to add nutrients, natural or genetically modified compositions, and oxygenated compounds to polluted water bodies. Some oleaginous microorganisms can degrade petroleum hydrocarbons in the natural environment. These oleaginous microorganisms may be artificially selected, cultivated, or even improved, and then placed into the contaminated sea area for artificial petroleum hydrocarbon biodegradation. Bacteria and yeasts are the main degraders in the ocean. The advantages of using biodegradation methods are that they are rapid, have no residual toxicity, and are low cost. (Huang Jianping, 2014). (Christopher L& Bryony A, 2017).

5.3 Heavy Metal

5.3.1 Heavy Metal Marine Pollution in China

Heavy metals generally refer to metals and metalloids with a density greater than 5.0 g/cm³, such as lead (Pb), zinc (Zn), cadmium (Cd), mercury (Hg), and

chromium (Cr). (Yu et al., 2017). Due to their special chemical, geochemical properties, and toxic effects, heavy metals which are highly toxic and difficult to manage are considered to be potentially hazardous and important pollutants in the environment. Natural sources of heavy metal pollution include weathering of metal-bearing rocks and volcanic eruptions, while man-made sources include mining and various industrial and agricultural activities.

The water samples of 50 locations (including coasts, estuaries, sea channels, and adjacent waters) and seven typical geographic locations in three hydrological seasons (rain, flat, and dry) in the past 5 years (2010-2014) were analyzed for eight common metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg). Among these metals, Zn has the highest concentration ($10.42 \pm 9.07 \mu\text{g/L}$). This may be the result of the release of antifouling coatings to the estuary from many ships and other man-made resources (such as industrial wastewater). The mercury concentration in the seven sampling periods ($0.0063 \pm 0.0038 \mu\text{g/L}$) was the lowest among all metals. (Yu et al., 2017).

5.3.2 The Impact of Heavy Metal Marine Pollution

There are many impacts of heavy metal pollution, long residence time, not easy to decompose, difficult to find after pollution, difficult to recover, and the ease at which they move and concentrate along the food chain. They act directly or indirectly on the DNA of organisms, causing mutations in the genetic material of organisms, leading to problems such as slow growth, abnormal growth, and reduced larval viability. (Tian Jin et al., 2009).

Different metals have different toxicities. For example, lead can affect the body, and is especially harmful to the growth of young children. Lead is stored mainly in teeth and bones, and accumulates over time, affecting the brain, liver, and bones.

5.3.3 Remedy for Heavy Metal Marine Pollution

Cleaning (or remediation) techniques that can be used to reduce the harmful effects of heavy metal contaminated sites include drilling and excavation

(physical removal of pollutants), stabilizing metals in the marine environment, and preventing proliferation and extracting heavy metals from polluted sediment (e.g., phytoremediation). (M. Lambert, 2000).

6. Recommendations

Based on the major categories of marine pollution and the main source of pollution caused by human activities-industry, agriculture, mining, rivers act as the conduit to transfer pollutants to the ocean, causing marine pollution on a global scale.

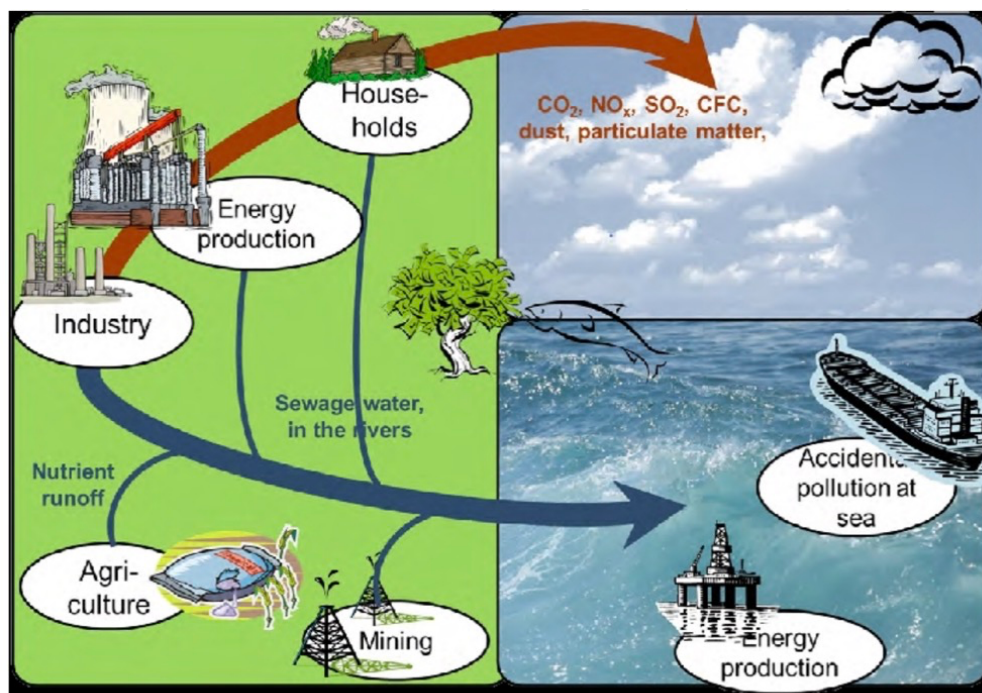


Figure 7. Inputs of Pollution into the Marine Environment. (By Clark, R. B, 2002).

For each type of pollutant, this report summarized some commonly used and effective treatment measures. But instead of treating problems when they arise, it is better to prevent them before they happen.

- 1) All countries should further strengthen the monitoring and evaluation of the marine environment, gradually establishing a regulatory mechanism for the marine environment, and a real-time marine ecological environment

classification management system and carry out symptomatic monitoring for typical rare marine ecological areas, damaged marine ecological areas, and other typical ecological areas. (Du Yuncai et al., 2014).

- 2) Take measures to control land-based pollution. Strengthen the prevention and control of land-sourced pollutants, to contain the source of the continuous deterioration of the environment in the coastal waters. (Du Yuncai et al., 2014).
- 3) Generally, the density of population, economic development, and the degree of environmental pollution are directly proportional. Therefore, it is necessary to concentrate on monitoring the pollution situation in industrially developed areas and densely populated areas and do a good job in publicity and education to solve the problem fundamentally.

7. Innovation

Since Norway is a country that relies on the ocean for its livelihood, plastic pollution in the ocean has had a great impact on the development of the Norwegian country and the daily lives of its residents. (The Explorer, 2020) Norwegian companies focus on materials, ocean clean technology, resource reuse, and value chain improvement, and have made significant progress in developing solutions and technologies that help eliminate ocean plastic pollution and plastic waste.

- 1) Use offshore technology to collect plastic pollution

Plastic fragments should be picked up before they sink into the seabed, or the plastic decomposes. Norwegian *Spill Tech* is using its knowledge of oil skimming technology to develop solutions for collecting floating marine debris. *Clean Sea Solutions* has developed a marine cleaning robot. With the help of computer vision and remote sensing, this electric waterborne drone can "clean up." The wreckage on the sea will be returned to its

dedicated docking station, emptied when the equipment is full and cleaned for the next time.

2) Reduce emissions by recycling plastic waste

Plastic has the unique attribute that is simple to produce and low cost, so many plastics are thrown away after they are used, causing a lot of pollution. *Quantafuel* chemically recycles mixed plastic waste and converts it into raw materials for new plastic products.

3) Encourage plastic recycling

When it comes to plastic recycling, Norway is the champion. *Empower* designed a system that allows people to put plastic waste into a recycling station and exchange it for tokens.

8. Discussion & Conclusion

China's sea area is wide and large, and it is difficult to monitor and manage it. As the ocean circulates continuously on a global scale, the whole world must be vigilant and work together to manage the marine environment. Through the analysis of the three main types of marine pollution in China's waters, pollution exists and is relatively serious, but China realized this problem early and has started to improve it. To control pollution is also important to raise people's awareness to reduce pollution from its root causes; for us, and the next generation.

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