

## RW12

# Pollution of marine environment in Bangladesh by shipping and the preventive methods

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**Abstract**—Shipping is one of the most prominent sources of the pollutants that pollute the waterways. Ship can emit different types of emission gases and pollutants that pollute land, water and air. There are various types of adverse effects of these pollutions. These cause the whole ecosystem to be unbalanced and affect on the climate or environment. The types and the rate of the emission gases and the pollutants can be different from place to place and depending on the type of the vessels. This paper outlines the types of emission gases and the pollutants that are emitted from inland vessels, how these can be emitted from vessels in developing countries like Bangladesh, the effects of these emission gases and the pollutants, description of the prevention methods of the pollution especially focused on the prevention of the emissions emitted from ships.

operation of a large number of vessels, operating for inland and merchant shipping.

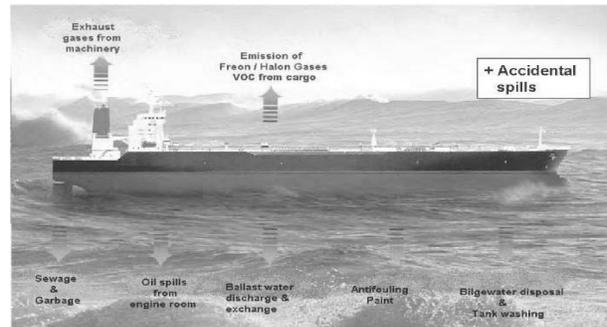


Figure 1: Different forms of pollutants emitted from ships

## INTRODUCTION

In Bangladesh Rivers, canals, creeks and bodies of water occupying about 11 per cent of the total area of the country and only about 6,000 km is currently navigable by larger mechanized vessels. Inland waterways are estimated to carry approximately 14 per cent of the annual passenger volume and 35 per cent of its annual freight volume. About 5,500 different types of registered and many unregistered vessels like passenger vessels, cargo vessels, small size tankers etc. are running for different types of transportation in Bangladesh.

The inland water ways can be polluted in different ways. Different types of pollutants are responsible for this pollution. The vessels that run in different water ways are the most important source of the pollutants that pollute the marine environment. The pollutants can be thrown into river by different ways. The types and rates of these throwing pollutants can be different based on the types and size of vessels. By proper design of the vessels and by proper management of these vessels the significant reduction of the pollutions occurred by shipping can be achieved.

## POLLUTION OF THE MARINE ENVIRONMENT BY SHIPPING

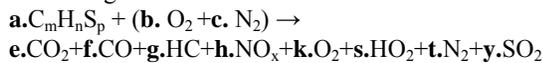
The pollution that can happen by shipping can harm the marine environment. The types of pollution that may originate from ships include oil, chemicals, garbage, sewage, the emissions and the anti-fouling paint on a ship's hull [in figure1]. Marine pests in ship's ballast water or clinging to the ship's hull can also harm the new environments. In the breaking yards during breaking and scrapping the old ships on beaches in Bangladesh can cause pollution unless great care is taken. One of the major sources of marine environmental pollution in Bangladesh is the unregulated

In Bangladesh due to the lax applicable of laws and resource deficiencies of the concerned government departments, pollution by shipping at the ports and at other marine areas has become common incident. For such operation of the vessels, the country has been exposed to massive pollution in the marine environment. Among the various sources of the pollution the most dangerous and unexpected source of pollution of the marine environment in Bangladesh is the unregistered vessels that can pollute the environment but can't account as the sources and always be out of the count of the source of pollution and action. Based on the polluted areas the pollution can be happened into three air pollution, water pollution and land pollution.

*Air pollution by exhaust gases from ships and its effects:* The main sources of air pollution are the emissions of harmful gaseous matters from vehicle, industrial sectors, and construction and open dumping of garbage. The fast growing Asian economies and continued urbanization have increased the demand for mobility and energy in the region, resulting in high levels of air pollution in cities from transport, industry and other sources. Due to increase for demands of transport, energy and other infrastructures that in turn will result in high emission level that can pollute the air.

*Emissions from Marine vehicles:* Emissions can take place by natural or unnatural processes. Unnatural emissions have increased significantly as the rapid development of the industrial activities, electricity infrastructure, transportation etc. The significant amounts of emission gases are produced from the transportation system about 28% of the global emissions [3] and the shipping sector is responsible for nearly 3% of the global emissions [2]. The exhaust emissions from marine engines comprise the following groups: NO<sub>x</sub> (nitrogen oxides), SO<sub>x</sub> (sulphur oxides), CO<sub>2</sub> (carbon dioxide) and HC, CO, particulates. CO<sub>2</sub> emissions are directly proportional to the

quantity of fuel burned. All of these gases are related to engine processes. The function of the engine as the producer of the emission gases is shown in Figure 1. The exhaust gases and the amount of the exhaust gases are also included in this figure. The chemical reaction of the production of the emission gases is as follows:



Where,  $C_mH_nS_p$  is an equivalent diesel composition established by PETROBRAS (Brazilian oil company); a, e, f, g, h, k, s, t and y are determined from chemical reaction mass balance and the air compositions b and c will be also determined by mass balance.

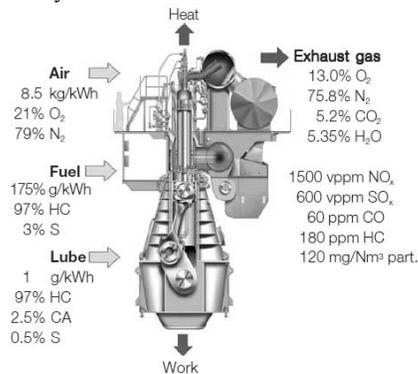


Figure 2: Exhaust gases compositions

Marine diesel engines are used for propulsion power on the different vessels such as container ships, oil tankers, bulk carriers, and cruise ships. Emission control technologies which can be used on these engines are limited. The residual fuel that is used in marine engines is the by-product of distilling crude oil to produce lighter petroleum products.

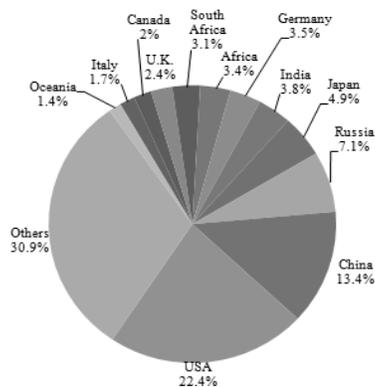


Figure 3: CO<sub>2</sub> Emission statistics of the world (1994) [4]

It possesses high viscosity and density, which affects ignition quality. Typically it has high ash, sulfur and nitrogen contents in comparison to marine distillate fuels. Residual fuel can increase engine NO<sub>x</sub> emissions from 20-50% and sulfate product 750% to 1250% when compared to distillate fuel. One average barrel of crude oil will produce the minimum of 317kg of CO<sub>2</sub> by burning. [1 American barrel = 0.136 tonne (approx)]. The global emissions have been increased dramatically since World

War II and still now high level of emissions can be observed showing in figure 2.

*Water pollution by exhausts from ships:* The vessels are the major source of the oil that pollutes the water pollution in Bangladesh. This type of water pollution is happened in marine areas mainly from the tankers and other vessels transiting through the busy sea transportation routes of the southern Bay of Bengal. Around 3.5 million tons of crude and refined oil are imported in Bangladesh and Bangladesh contributes around six thousand tons of oil to the four hundred thousand tons of annual oil pollution in the Bay of Bengal. During transfer process some oil escapes into the waterways and also from the engine room the oil substances are thrown into water with ballast water. The chemical wastes generated from noxious liquid substances carried in bulk. These chemical wastages are potentially more harmful than oil for the marine environment.

Another cause of the water pollution in marine environment is the oil spill. Repeated oil spills from foreign and local ships which call in to the Mongla Port are creating a severe threat to the world's largest tidal halophytic mangrove forest, the Sundarbans. The Sundarbans is the main spawning ground of major commercially important marine species including prawn and fish. In August 1994, the oil spill happened from a vessel of Panama's flag which capsized near the Sundarbans. It caused the immediate mortality of a great number of fauna and flora in the Sundarbans mangrove forest and adjacent sea area. It posed a severe threat to the existence of fish, shrimp and other marine living resources. The other occurrence that pollutes the water is dumping of garbage and sewage from ships. In Bangladesh the garbage and sewage from the vessels are usually dumped into the sea and rivers. Compared to the volume of these types of wastes from the land, the amount of garbage and sewage from vessels are not so much but the most dangerous factor is that the foreign and local ships find the marine area of Bangladesh as a safe place for throwing away their garbage and sewage.

*Land pollution:* Sometimes in shipyard the old ships are repaired and the wastage from these ships pollute the yard environment and also in shipyard various types of the activities such as the open air sand blasting, the painting works pollute the air and the land of the shipyard. The ship breaking yards and sometimes the shipyards can pollute the land around their positions.

In ship breaking yards different types of refuse and disposable materials are discharged and spilled from scrapped ships and often get mixed with the land of the yard area. These ship breaking activities are the threat to both the terrestrial and marine environment as well as to public health. The ship breaking yard discharges various kinds of pollutants like as liquid, metal, gaseous and solid pollutants. Depending on their size and function, scrapped ships have an unladen weight about 95% of which is steel and also other substances like coated with paint containing lead, cadmium, organotins, arsenic, zinc and chromium. Ships also contain a wide range of other hazardous wastes, sealants containing PCBs, various types of asbestos and several thousands liters of oil such as engine oil, bilge oil, hydraulic and lubricants oils and grease. Tankers

additionally hold residual oil. In Bangladesh, the scrapped ships containing these materials are being cut up by hand, on open beaches, with no consideration given to safe and environmentally friendly waste management practices. The substances that are thrown from ships into water deposit on the river bed or on the underwater land or beside the waterways. These deposited substances pollute the river bed and underwater land and make harmful effects on environment.

*Impacts of the pollution of marine environments:* There are various types of adverse effects of these pollutions. These cause the whole ecosystem to be unbalanced and affect the bad impact on the climate or environment. Fishing is a profession for a large number of people in Bangladesh and due to pollution the living places of the fishes are destroying and so reducing the amount of fishes in water that makes more unemployed people. In broad sense about these effects the global temperature is increasing and so the sea level is increasing. Besides due to unbalance ecosystem influences the unbalance natural activities which give rise to frequent flooding, storms occurrences and also the low level lands go under water, sometimes for emissions the acid rains can be happened and nowadays all of these harmful events are happened frequently. The World Health Organization estimates that ambient air pollution causes over half a million premature deaths per year, leaving the urban poor particularly vulnerable since they live in air pollution hotspots, have low respiratory resistance due to bad nutrition, and lack access to quality health care.

#### PREVENTION OF THE POLLUTION FROM SHIPPING

In the coastal and marine areas of Bangladesh the wastage and sewage of the ships contribute a lot in polluting the environment. Proper management of the wastages is needed to minimize and ultimately reduce the pollution. Government, non-Governmental shipping organizations, intergovernmental shipping agencies should come forward and mobilize communities so that they will be inclined to adapt techniques and activities that are sustainable. The awareness of the crew is the most important factor in order to reduce the pollutions that could be happened by throwing the pollutants from ships. This awareness can be increased by the proper training of the crews. Besides the marine laws must apply very strictly that can promote to increase awareness of the crews as a result the pollution can be reduced. In order to prevent the oil spills and oil leakage from the unfitted vessels must be banned that can save the marine environment from the unexpected pollution. The rates of pollution from the unregistered vessels are more than the registered vessels. So these unregistered vessels must take in laws and the avoidance of the laws should be huge punishable and must be applicable in field.

*Methods of reduction of the Emissions:* The emissions from ship can be reduced by two methods- reduction of the produced emissions or by counter action method that is more expensive with more hazardous and the reduction of the production of the emissions or preventive method that can be done by reducing the fuel consumption. The preventive method is more efficient but not easy task like as

counter action methods. The produced emissions can be reduced by absorbing the emissions and the absorption tasks can be done by various ways such as by using special types of chimney that can absorb and convert the emissions. This method is relatively expensive task than preventive method.

The fuel consumption can be reduced by optimizing the ship design and hull maintenances so the emissions can be reduced that produce by burning fuel from ship [1]. Principle flow chart of the emission reduction method by design optimization as follows:

Design optimization → Resistance Reduction → Less effective power required → Reduced fuel consumption → Reduced emission gases production

The ship effective power is directly proportion to the resistance. As Yasukawa states [8] for hull optimization (using Rankine source method) the wave resistance reduces 30% and for the attachment of the bulb the wave resistance reduces about 50% when the Froude number is 0.3. For high speed vessel about 8% fuel consumption can be reduced by hull optimization [1].

In Bangladesh most of the inland vessels run with the limited speed 8-12knots. At 13 knots ship speed the wave resistance is about 2.5% and the frictional resistance is about 97.5% [1] and at lower speed the wave resistance will be reduced gradually. By hull shape optimization and by dimensions optimization the wave resistance can be reduced significantly. These optimization methods are relatively hard and require skilled ship designers that are so expensive for the shipyards in Bangladesh. But for the vessels whose speed is around 10 knots normally the wave resistance is low and so it will not be efficient method for reducing the engine power by reducing the wave resistance. For the slow speed vessel the most important factor in order to reduce the engine power is the frictional resistance.

The frictional resistance can be reduced by reducing the wetted surface and by smoothing the underwater hull surface. The wetted surface is related with the ship capacity and ship stability. So smoothing the hull surface is the most efficient and easy way for reducing the frictional resistance or total resistance of the slow speed inland vessels in Bangladesh.

Significant amount of frictional resistance can be reduced by smoothing the wetted surface and so the effective power and engine power can be reduced significantly. When the surface roughness is low, the frictional force between the hull surface and the water will be low and therefore frictional resistance will be reduced. By frequently cleaning the hull the frictional resistance can be reduced and so the total fuel consumption and CO<sub>2</sub> can be mitigated as shown in table1. For inland vessels in Bangladesh in most cases the maintenances of the hull surface are always neglected, but by the hull maintenance the fuel consumption can be reduced on the other hand the emissions and also the operating cost also can be reduced. In figure 4 the comparison between the smooth and the rough hull surface is shown and this hull smoothness can be possible by regular maintenance of the hull.

Table 1: Reduced fuel consumption by cleaning the hull [11]

Vessel type	Reduced fuel consumption and CO <sub>2</sub> emission
Tanker	3%
Ferry	2%
Container	2%

The roughness can be minimized by selecting anti-fouling paints, flush welding and good paintwork. Silicone anti-fouling paints offer a very low average hull roughness (ARH) down to about 65 microns and standard value of model basins ARH about 150 microns[9]. However ARH-values exceeding 200 microns[9] have been reported. By using special type of coating which makes the surface smooth, will reduce about 6% in total resistance[9] and also same percentage of the effective power can be reduced.

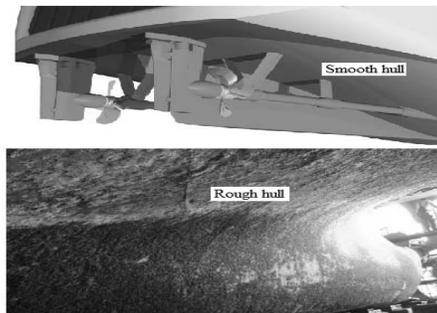


Figure 4: Hull surfaces comparison

Now the delivery power of the engine is about 1.35 times of the effective power of the ship [1], so the delivery power of the engine can be reduced about 4.4 % of the total power by using this special type of painting. By reducing the engine power the fuel consumption and the production of the emission gas, CO<sub>2</sub> will be reduced about 4%. Similarly the production of the other components of the emission gases will also be reduced. So for the low speed inland vessels the hull smoothness is more important than the vessel design optimization. By using this method the fuel consumption can be reduced significantly and on the other hand the emissions also can be reduced. The emissions also depend on the quality of the fuel; especially the production of SO<sub>x</sub> and NO<sub>x</sub> by burning fuel depends on the amount of the sulfur and nitrogen components in fuel.

### CONCLUSION

In Bangladesh the most important factor for the pollutants emitted from the inland vessels is the unconsciousness of the people and the staffs about the effects of the pollution and the proper management of the pollutants. By increasing the consciousness of the people and the staffs and by applying strictly the marine laws, significant reduction of pollutions can be achieved in Bangladesh. For low speed ships like inland vessels in Bangladesh the ship design optimization can contribute very little for reduction of the fuel consumption and also emissions that produced by burning fuel but the proper maintenance of the vessels and the hull surface significant

amount of fuel consumption about 4% can be reduced and also the emissions produced by burning fuel can be mitigated. The fuel cost is about 50% of the total operating cost, the reduction in operating cost for the vessel design due to fuel saving is about 2% of the total operating cost.

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