ASPECTS OF ENVIRONMENTAL POLLUTION FROM MARITIME TRANSPORTATION IN NIGERIA

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ABSTRACT

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There is no doubt that marine transport is considered one of the main economic development pillars in any nation. The issue of transportation and the environment is paradoxical in nature. The relationships between transport and the environment are multidimensional. The most important impacts of transport on the environment relate to climate change, air quality, noise, water quality, soil quality, biodiversity and land take, algal bloom, anoxic event, anoxic waters, aquatic toxicology, cultural eutrophication, cyanotoxin, environmental impact of shipping: eutrophication, fish diseases and parasites, fish kill, friendly floats, great pacific garbage patch, hypoxia, invasive species, marine debris, mercury in fish, nonpoint source pollution, North Atlantic Garbage Patch, nutrient pollution, Ocean acidification, Ocean deoxygenation, oil spill, particle, plastic particle water pollution, point source pollution, Shutdown of thermohaline circulation, storm water, surface runoff, upwelling, urban runoff and water pollution environmental externalities, environmental externalities assessment, dimensions, the environment link of transport, transport and the environment, affected species, sound pollution, ship impacts, exhaust emission, international regulation, sewages, cleaning, solid waste, bilge water are aspects of environmental pollution from maritime transportation in Nigeria reviewed to enable maritime managers in the country be wary.

Key words: Maritime transport, Environmental pollution, Fate, Effects, Affected species, regulation.

INTRODUCTION

There is no doubt that marine transport is considered one of the main economic development pillars in any country. Most of the world's trade and exactly 75% of it is transported by sea. That is because marine transport has many advantages compared to other means of transportation such as the huge capacity and cheap costs (Vidal, 2009). These advantages have increased the dependence on marine transport and in turn increased the revenues of hard currency. Thus we see how marine transport can serve in improving the balance of these countries, providing jobs for the unemployed and constructing cities (Ward-Geiger et. al., 2005). With the execution of marine projects, such as building ports, docks or starting marine companies, these things lead naturally to opening vacancies for national employment and constructing the cities where the projects are executed (Watson, 2004). The importance of marine transport in the Kingdom lies in its long coast extending for more than 1500 miles, in addition to knowing that 95-90% of the Kingdom's imports and exports are transported through sea (Ward-Geiger et. al., 2005). Based on this fact, the Kingdom has paid great attention to this sector, by constructing modern ports, shipyards, starting marine companies and institutions and modernizing the commercial marine fleet, out of its belief in the role of marine transport in fulfilling the Kingdom's needs. It is known that the commercial marine fleet supports the military fleet at times of peace and war (Vidal, 2009).

Based on all that, decree no. 149 was issued on 28/8/1396 AH announcing the start of the Ministry's under secretariat for transport affairs to be responsible for supervising and organizing all transport means except that through air (Vanderlaan and Taggart, 2007). This is in addition to MOT responsibilities of registering ships and marine units, making sure all the Saudi marine means fulfill the safety and security procedures and issuing safety certificates to sailing ships (Ward-Geiger et. al; 2005). This sector has flourished greatly during the last few years due to its importance to national economy in general and commerce in particular, since most of the goods are transported from other countries to the Kingdom by sea (Vidal, 2007). The Kingdom has been awarded - for the eighth time on a row – the membership of the board of directors in the International Maritime Organization (IMO) in appreciation of its efforts in supporting the Organization and its achievements in the field of marine transport (Vidal, 2009). The Kingdom – represented by MOT – is one of the founders of the Arab Academy for Science and Technology and Maritime Transport (AASTMT). The Kingdom is considered one of the founders of World Maritime University (WMU) in Sweden and has its representative from MOT in the University's board of trustees (Simpson, et a., 2010). The Kingdom participated in 15 international treaties and agreement concerned about marine safety and preservation of maritime environment (Ward-Geiger et. al., 2005).
New research suggests that the impact of shipping on climate change has been seriously underestimated and that the industry is currently churning out greenhouse gases at nearly twice the rate of aviation (Vidal, 2007). Shipping, although traditionally thought of as environmentally friendly, is growing so fast that the pollution it creates is at least 50 per cent higher than previously thought. Maritime emissions are also set to leap by 75 per cent by 2020. The International Maritime Organization, the UN body set up to regulate shipping, has set up a working group due to report this year (Simpson, et al., 2010). Research seen by the group suggests previous calculations, which put the total at about 600 million tonnes per year, are significantly short. The true figure is set to be more than one billion tonnes, according to a confidential report produced for the IMO by Intertanko, the International Association of Independent Tanker Owners (Ward-Geiger et. al., 2005).

In comparison, aviation produces an estimated 650 million tonnes. The old figures were based on 2001 estimates, but shipping has grown by 4.5 per cent on average annually. While other industries have come under pressure to clean up their acts, shipping has so far escaped. Bill Box, from Intertanko, said the industry knows it has been slow to respond (Vidal, 2007). "Shipping has not yet been regulated and for politicians it is the last low hanging fruit," Mr Box said (Simpson, et al., 2010). In California, the Attorney General has launched a petition aimed at forcing the Environmental Protection Agency to curb emissions of climate change gases from shipping in US waters. In the UK, the Government is under pressure to include shipping in emission targets for the Climate Change Bill next month. And new EU regulations come into force in November to compel ship owners to use cleaner fuel in coastal shipping lanes throughout continental waters (Watson, 2004). "Shipping is an invisible industry," said Mr Box. "Ports are away from population centres and many people don't see a ship from one year to another." The industry serves more than 90 per cent of global trade and as commerce has grown, so has the shipping fleet (Vanderlaan and Taggart; 2007). At present it is more efficient to ship a container from Beijing to London than it is to transport it 100km by road. The world fleet of ocean-going vessels stands at 90,000, says Oceana, a US-based ocean protection organization that is part of a coalition of environmental groups that has signed the California petition (Simpson, et al; 2010). The petition claims that the fleet generates emissions equivalent to nearly 190 million cars, all the vehicles in the US. Michael Woods, co-chair of the UK Environmental Law Association's climate change working party, said government curbs on pollution were coming sooner than the industry realizes. He said that shipping could be included in the European Emissions Trading Scheme (Vidal, 2007).

With land-based polluters already heavily regulated, the shipping industry could provide the most cost-effective way to reduce climate change gases. Since the 1970s, the bulk of commercial vessels have run on heavy "bunker" fuel, a by-product of the oil refining process for higher grade fuels. One industry insider described it as "the crap that comes out the other end that's half way to being asphalt"(Vidal, 2007). It has potentially lethal side effects such as the release of sulphur dioxide, carbon dioxide, nitrogen oxide and sulphuric acid. Recent studies in the US and the Netherlands showed pollutants from ships contribute half of the smog-related sulphur dioxide in Los Angeles. In Rotterdam, North Sea shipping lanes run within 25 miles of the shore, spewing pollution that can travel up to 1,000 miles. "If you want to improve air quality on land, you will have a larger effect from spending one euro at sea than you will have spending one euro on land," said Pieter Hammingh, from the Dutch environment agency (Vanderlaan and Taggart; 2007).

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Transport and the environment
The issue of transportation and the environment is paradoxical in nature. From one side, transportation activities support increasing mobility demands for passengers and freight, and this ranging from urban areas to international trade (Vidal, 2009). On the other side, transport activities have resulted in growing levels of motorization and congestion. As a result, the transportation sector is becoming increasingly linked to environmental problems. With a technology relying heavily on the combustion of hydrocarbons, notably with the internal combustion engine, the impacts of transportation over environmental systems has increased with motorization. This has reached a point
where transportation activities are a dominant factor behind the emission of most pollutants and thus their impacts on the environment (Vanderlaan and Taggart; 2007). These impacts, like all environmental impacts, can fall within three categories:

**Direct impacts:** The immediate consequence of transport activities on the environment where the cause and effect relationship is generally clear and well understood.

**Indirect impacts:** The secondary (or tertiary) effects of transport activities on environmental systems. They are often of higher consequence than direct impacts, but the involved relationships are often misunderstood and difficult to establish.

**Cumulative impacts:** The additive, multiplicative or synergetic consequences of transport activities. They take into account of the varied effects of direct and indirect impacts on an ecosystem, which are often unpredicted.

The complexities of the problems have led to much controversy in environmental policy and in the role of transportation (Vidal, 2009). The transportation sector is often subsidized by the public sector, especially through the construction and maintenance of road infrastructure which tend to be free of access. Sometimes, public stakes in transport modes, terminals and infrastructure (Fig. 1) can be at odd with environmental issues. If the owner and the regulator are the same (different branches of the government), then there is a risk that regulations will not be effectively complied to. It can also lead to another extreme where compliance would lead to inefficient transport systems, but which costs are subsidized (Simpson, et al., 2010).

![Maritime transport terminals and infrastructure](image)

**Fig. 1:** Maritime transport terminals and infrastructure

Total costs incurred by transportation activities, notably environmental damage, are generally not fully assumed by the users. The lack of consideration of the real costs of transportation could explain several environmental problems (Simpson, et al., 2010). Yet, a complex hierarchy of cost is involved, ranging from internal (mostly operations), compliance (abiding to regulations), contingent (risk of an event such as a spill) to external (assumed by the society). For instance, external costs account on average for more than 30% of the estimated automobile costs. If environmental costs are not included in this appraisal, the usage of the car is consequently subsidized by the society and costs accumulate as environmental pollution. This requires due consideration as the number of vehicles, especially automobiles, is steadily increasing (Watson, 2004).

**THE ENVIRONMENT LINK OF TRANSPORT**

The relationships between transport and the environment are multidimensional. Some aspects are unknown and some new findings may lead to drastic changes in environmental policies, as it did in regards of acid rain and chlorofluorocarbons in the 1970s and 1980s. The 1990s were characterized by a realization of global environmental issues, epitomized by the growing concerns between anthropogenic effect and climate change. Transportation also became an important dimension of the concept of sustainability, which is expected to become the prime focus of transport activities in the coming decades, ranging from vehicle emissions to green supply chain management practices (Simpson, et al; 2010). These impending developments require a deep understanding of the reciprocal influence between the physical environment and transport infrastructures and yet this understanding is often lacking. The main factors considered in the physical environment are geographical location, topography, geological structure, climate, hydrology, soil, natural vegetation and animal life.

The main environmental dimensions of transport are related to the causes, the activities, the outputs and the results of transport systems. Establishing linkages between these dimensions is a difficult undertaking. For instance, to what extent carbon monoxide emissions are linked to land use patterns? Furthermore, transportation is
imbedded in environmental cycles, notably over the carbon cycle. The relationships between transport and the
environment are also complicated by two observations: First, transport activities contribute among other
anthropogenic and natural causes, directly, indirectly and cumulatively to environmental problems. In some cases,
they may be a dominant factor, while in others their role is marginal and difficult to establish. Second, transport
activities contribute at different geographical scales to environmental problems, ranging from local (noise and CO
emissions) to global (climate change?). Not forgetting continental / national / regional problems (smog and acid
rain).

Establishing environmental policies for transportation thus have to take account of the level of contribution and
the geographical scale, otherwise some policies may just move the problems elsewhere and have unintended
consequences. A noted example are local / regional policies that have forced the construction of higher chimneys
for coal burning facilities (power plants) and induced the continental diffusion of acid rain. Thus, even if an
administrative division (municipality, county, state/province) have adequate environmental enforcement policies,
the geographical scale of pollutants diffusion (notably air pollutants) obviously goes beyond established
jurisdictions. In addition to the environmental impacts of the network, traffic and modes, economic / industrial
processes sustaining the transport system must be considered. These include the production of fuels, vehicles
and construction materials, some of which are very energy intensive (e.g. aluminum), and the disposal of vehicles,
parts and infrastructure(Simpson, et al; 2010). They all have a life cycle timing their production, utilization and
disposal. Thus, the evaluation of the transport-environment link without the consideration of cycles in the
environment and in the product life alike is likely to convey a limited overview of the situation and may even lead
to incorrect appraisal and policies.

**DIMENSIONS**

Transportation activities support increasing mobility demands for passengers and freight, notably in urban areas.
But transport activities have resulted in growing levels of motorization and congestion. As a result, the
transportation sector is becoming increasingly linked to environmental problems. The most important impacts of
transport on the environment relate to climate change, air quality, noise, water quality, soil quality, biodiversity
and land take:

**Climate change:** The activities of the transport industry release several million tons of gases each year into the
atmosphere. These include lead (Pb), carbon monoxide (CO), carbon dioxide (CO2; not a pollutant), methane
(CH4), nitrogen oxides (NOx), nitrous oxide (N2O), chlorofluorocarbons (CFCs), perfluorocarbons (PFCs),
silicon tetrafluoride (SF6), benzene and volatile components (BTX), heavy metals (zinc, chrome, copper and
cadmium) and particulate matters (ash, dust). There is an ongoing debate to what extent these emissions may be
linked to climate change and the role of anthropogenic factors. Some of these gases, particularly nitrous oxide,
also participate in depleting the stratospheric ozone (O3) layer which naturally screens the earth’s surface from
ultraviolet radiation.

**Air quality:** Highway vehicles, marine engines, locomotives and aircraft are the sources of pollution in the form
of gas and particulate matters emissions that affects air quality causing damage to human health. Toxic air
pollutants are associated with cancer, cardiovascular, respiratory and neurological diseases. Carbon monoxide
(CO) when inhale affects bloodstream, reduces the availability of oxygen and can be extremely harmful to public
health. An emission of nitrogen dioxide (NO2) from transportation sources reduces lung function, affects the
respiratory immune defense system and increases the risk of respiratory problems. The emissions of sulphur
dioxide (SO2) and nitrogen oxides (NOx) in the atmosphere form various acidic compounds that when mixed in
cloud water creates acid rain(Simpson, et al; 2010). Acid precipitation has detrimental effects on the built
environment, reduces agricultural crop yields and causes forest decline. The reduction of natural visibility by
smog has a number of adverse impacts on the quality of life and the attractiveness of tourist sites. Particulate
emissions in the form of dust emanating from vehicle exhaust as well as from non-exhaust sources such as vehicle
and road abrasion have an impact on air quality. The physical and chemical properties of particulates are
associated with health risks such as respiratory problems, skin irritations, eyes inflammations, blood clotting and
various types of allergies.

**Noise:** Noise represents the general effect of irregular and chaotic sounds. It is traumatizing for the hearing organ
and that may affect the quality of life by its unpleasant and disturbing character. Long term exposure to noise
levels above 75dB seriously hampers hearing and affects human physical and psychological wellbeing. Transport
noise emanating from the movement of transport vehicles and the operations of ports, airports and rail yards
affects human health, through an increase in the risk of cardiovascular diseases. Increasing noise levels have a
negative impact on the urban environment reflected in falling land values and loss of productive land uses.

**Water quality:** Transport activities have an impact on hydrological conditions. Fuel, chemical and other
hazardous particulates discarded from aircraft, cars, trucks and trains or from port and airport terminal operations,
such as de-icing, can contaminate rivers, lakes, wetlands and oceans. Because demand for shipping services is increasing, marine transport emissions represent the most important segment of water quality inventory of the transportation sector. The main effects of marine transport operations on water quality predominantly arise from dredging, waste, ballast waters and oil spills. Dredging is the process of deepening harbor channels by removing sediments from the bed of a body of water. Dredging is essential to create and maintain sufficient water depth for shipping operations and port accessibility. Dredging activities have a two-fold negative impact on the marine environment. They modify the hydrology by creating turbidity that can affect the marine biological diversity. The contaminated sediments and water raised by dredging require spoil disposal sites and decontamination techniques. Waste generated by the operations of vessels at sea or at ports cause serious environmental problems, since they can contain a very high level of bacteria that can be hazardous for public health as well as marine ecosystems when discharged in waters. Besides, various types of garbage containing metals and plastic are not easily biodegradable. They can persist on the sea surface for long periods of time and can be a serious impediment for maritime navigation in inland waterways and at sea and affecting as well berthing operations. Ballast waters are required to control ship’s stability and draught and to modify their center of gravity in relation to cargo carried and the variance in weight distribution (Simpson, et al, 2010). Ballast waters acquired in a region may contain invasive aquatic species that, when discharged in another region may thrive in a new marine environment and disrupt the natural marine ecosystem. There are about 100 non-indigenous species recorded in the Baltic Sea. Invasive species have resulted in major changes in near shore ecosystems, especially in coastal lagoons and inlets. Major oil spills from oil cargo vessel accidents are one of the most serious problems of pollution from maritime transport activities.

**Soil quality:** The environmental impact of transportation on soil consists of soil erosion and soil contamination. Coastal transport facilities have significant impacts on soil erosion. Shipping activities are modifying the scale and scope of wave actions leading to serious damage in confined channels such as river banks. The removal of earth’s surface for highway construction or lessening surface grades for port and airport developments have led to important lost of fertile and productive soils. Soil contamination can occur through the use of toxic materials by the transport industry. Fuel and oil spills from motor vehicles are washed on road sides and enter the soil. Chemicals used for the preservation of railroad ties may enter into the soil. Hazardous materials and heavy metals have been found in areas contiguous to railroads, ports and airports.

**Biodiversity:** Transportation also influences natural vegetation. The need for construction materials and the development of land-based transportation has led to deforestation. Many transport routes have required draining land, thus reducing wetland areas and driving-out water plant species. The need to maintain road and rail right-of-way or to stabilize slope along transport facilities has resulted in restricting growth of certain plants or has produced changes in plants with the introduction of new species different from those which originally grew in the areas. Many animal species are becoming extinct as a result of changes in their natural habitats and reduction of ranges (Simpson, et al, 2010).

**Land take:** Transportation facilities have an impact on the urban landscape. The development of port and airport infrastructure is significant features of the urban and peri-urban built environment. Social and economic cohesion can be severed when new transport facilities such as elevated train and highway structures cut across an existing urban community. Arteries or transport terminals can define urban borders and produce segregation. Major transport facilities can affect the quality of urban life by creating physical barriers, increasing noise levels, generating odors, reducing urban aesthetic and affecting the built heritage.

**ENVIRONMENTAL EXTERNALITIES**

Externalities are an economic concept that refers to activities of a group that have unintended consequences, positive or negative, on other groups and most importantly that those consequences, particularly if they are negative, are not assumed by those causing them. They are therefore “externalized”. A common example of a positive externality concerns technology since it obviously benefits the innovative firm but also the whole economy through various productivity improvements (Simpson, et al., 2010) Negative externalities have a lot of relevance over environmental issues, since many of the negative consequences of pollution are assumed by the whole society. For the environmental externalities of transportation they include the consideration of physical measures of environmental damage and the evaluation of involved costs for the society. The main fallacy underlined by externalities is that the costs attributed to a few sources (e.g. users of cars) must be burdened by many (users and nonusers alike). Knowing the sources of environmental externalities is a relatively easy undertaking, while the evaluation of damage and other costs has not yet reached comparative standards among governmental and non-governmental agencies. The challenge resides over three issues:

**Relationships:** The nature and extent of the relationships between transport and the environment has to be considered. This is particularly complex as most environmental relationships tend to be indirect and cumulative.
Quantification: Relationships have to be quantified and also a value to environmental externalities should be appraised. This is almost out of the possibility as only general figures, much subject to debate, can be assessed. The quantification of economic, social and environmental costs is very difficult but possible if some simplifications and generalizations are assumed.

Policy making: The level and extent of corrective actions that can be taken to alleviate and mitigate environmental externalities linked to transportation in a way where those contributing bear the consequences of their activities. In view of the two above points attempts at regulation, particularly if they involve a comprehensive framework, can be hazardous. The costs of environmental externalities can be considered from economic, social and environmental dimensions. The basic types of transportation externalities attributed to the environment fall within air pollution, water pollution, noise, and hazardous materials. Establishing and quantifying environmental externalities is a complex undertaking. Quantification is only at its preliminary stage and many have used this argument to differ the application of several environmental policies by lobbying governments (e.g. acid rain, CFCs and most importantly, climate change). Additionally, the wider the geographical scale the more complex the environmental problem becomes, mainly due to cross-jurisdictional issues. Recent attempt to reach a consensus about climate change have underlined that multilateral environmental agreements are close to be impossibility.

The sources / emitters of pollutants rarely bear the consequences of their impacts: This has several implications. First, when specific sources are concerned, like road transportation, users only take account of the direct costs of modal ownership like a car (vehicle, fuel, insurance, etc.). Ownership is often the only entry and utilization cost for several transportation modes. The society generally assumes the role of providing and maintaining infrastructure and any indirect costs like damage to structures and infrastructure, losses in productivity (agriculture and labor), cleanup, health services and damage to ecosystems. Second, the geographic separation between sources and recipients is often acute(Simpson, et al; 2010). Acid rains and climate change are obvious examples. On a local level, a community may be affected by noise levels well over its own contribution (notably near major highways), while another (suburbs) may be affected in a very marginal way and still significantly contributes to noise elsewhere during commuting. There is a tendency towards a shift from direct to indirect consequences for environmental externalities, as of total costs involved. For instance, the absolute levels of air pollutants emissions have considerably dropped in developed countries such as the United States. The problem of source reduction by vehicles was addressed because it was a straightforward cause of air pollutants emissions. This has tended to displace problems elsewhere and developed new types of externalities. Thus, the relative share of air pollution impacts is lessening, but not the number of vehicles, investment in infrastructure or noise levels, which have their own externalities. Reductions in the relative importance of one type of externality redirect the focus on other types that were less addressed, but probably as important in the overall impacts of transport over the environment. Transfers and additions of costs are very common attributes of environmental externalities. Trying to lessen economic costs will either lessen or worsen social and environmental costs, depending on the externality. For instance, keeping salt as the main de-icing agent is a cheaper solution for authorities responsible for road maintenance, but this practice transfers economic benefits into environmental costs (damage to the ecosystem). In the context of limited resources, the distribution of economic, social and environmental costs takes an important role as what type of damage is most acceptable and in what proportions. It is clear from past strategies that several economic costs have been minimized, notably for producers and users, while social and environmental consequences were disregarded. This practice is less applicable since the society is less willing to bear the costs and consequences of externalities for various reasons (public awareness, high health costs, etc.).

ENVIRONMENTAL EXTERNALITIES ASSESSMENT

Air pollution is the most important source of environmental externalities for transportation. Although the nature of air pollutants is clearly identified, the scale and scope on how they influence the biosphere are subject to much controversy (see Application 1 for a detailed overview of each air pollutant). On the positive side, emissions of the most harmful air pollutants, such as Carbon Monoxide and Volatile Organic Compounds, have declined in spite of a substantial growth in the number of vehicles an indication of growing levels of environmental compliance of vehicles. Carbon Dioxide emissions have increased proportionally with the growth of transportation usage. Air pollution costs are probably the most extensive of all environmental externalities of transportation, mainly because the atmosphere enables a fast and widespread diffusion of pollutants. As all externalities, costs are very difficult to evaluate because several consequences are not understood, the problems could be at another scale or highly correlated with others and/or a value (monetary or other) cannot be effectively attributed. Two major groups of factors are contributing to air pollution, notably in urban areas. Structural factors are essentially linked to the size and level of consumption of an economy. Factors such and income and education...
tend to be proportional with emissions (Simpson, et al; 2010). Behavioral factors are linked to individualism, consumerism and transportation preferences. Because of convenience and its symbolism, the car is systematically the preferred mode of transportation, even when other modes are available. From a general perspective, the costs of air pollution associated with transportation can be grouped within economic, social and environmental costs. Externalities related to water pollution are almost all indirect consequences. It is thus difficult to evaluate and to appraise the specific contribution of transportation over various environmental issues, which explains that problems tend to be addressed on a modal basis. Noise (air and infrastructure vibration) is an inherent characteristic of transportation. Basically, noise is an undesirable sound. The acoustic measure of the intensity of noise is expressed in decibel, db, with a scale ranging from 1 db to 120 db. Noise emissions can be represented as point (a vehicle), line (a highway) and surface (ambient noise generated by a set of streets) sources (Reilly et. al; 2008). Noise pollution is very different from the two categories of pollutant previously discussed as it is only present as vibrations. The internal combustion engine involves combustion, moving parts and friction on the surface over which a transport mode moves. The impacts of noise are strictly local as vibrations are quickly attenuated by the distance and the nature of the landscape (trees, hills, etc.).

A hazardous material is a substance capable of posing an unreasonable risk to health, safety, and property when transported in commerce. Considering the large amounts of freight being shipped through transport systems, hazardous materials have become a concern. Several hazardous materials (hazmat) releases are spectacular events, notably when it involves a supertanker or a train convoy. However, we must consider that maritime transportation only accounts for 0.1% of the total number of hazmat accidents in the United States, although the volume of hazmat released is higher(Simpson, et al; 2010). Other transportation modes are thus important sources of hazmat release in the environment, even if they mostly involve small quantities. Very limited information is available on the nature and consequences of hazmats released during transportation, except for safety regulations. The effects of hazmat release are always punctual, but intense. The nature of the effect is related to the type of accident and the hazmat involved. It can range from a small scale accident where limited quantities of hazmat are spilled, to important accidents requiring prompt intervention and evacuation of population (Reilly et. al., 2008).

Thus, transportation has a wide array of environmental externalities, some of which can be reasonably assessed while others are mostly speculation (often taken as facts by environmentalist groups). Externalities are also occurring at different geographical scales, and some may even overlap over several. The bottom line is that better transport practices, such as a fuel efficient vehicles that reduce environmental externalities are likely to have positive economic, social and environmental consequences. The matter remains about which strategy is the most beneficial as in all environmental matters much subjectivity and often ideology prevails.

ENVIRONMENTAL IMPACT OF SHIPPING

The environmental impact of shipping includes greenhouse gas emissions and oil pollution. Carbon dioxide emissions from shipping is currently estimated at 4 to 5 percent of the global total, and estimated by the International Maritime Organisation (IMO) to rise by up to 72 percent by 2020 if no action is taken(Simpson, et al., 2010). The First Intersessional Meeting of the IMO Working Group on Greenhouse Gas Emissions from Ships took place in Oslo, Norway on 23–27 June 2008. It was tasked with developing the technical basis for the reduction mechanisms that may form part of a future IMO regime to control greenhouse gas emissions from international shipping, and a draft of the actual reduction mechanisms themselves, for further consideration by IMO’s Marine Environment Protection Committee (MEPC).

BALLAST WATER

Ballast water (Fig. 2) discharged by ships can have a negative impact on the marine environment. Cruise ships, large tankers, and bulk cargo carriers use a huge amount of ballast water, which is often taken on in the coastal waters in one region after ships discharge wastewater or unload cargo, and discharged at the next port of call, wherever more cargo is loaded. Ballast water discharge typically contains a variety of biological materials, including plants, animals, viruses, and bacteria. These materials often include non-native, nuisance, exotic species that can cause extensive ecological and economic damage to aquatic ecosystems. When a larger vessel, such as a container ship or an oil tanker unloads cargo, seawater is pumped into compartments in the hull. Similarly, when a larger vessel is being loaded it discharges seawater from these compartments. The sea water is meant to help stabilize and balance a ship. Ballast discharges from ships are responsible for tar balls in the open oceans and seas, and can cause problems navigating tanker routes. Nevertheless, the discharge of ballast water only accounts for a small percentage of oil pollution in the marine environment.
Ships are also responsible for transporting harmful organisms in their ballast water. Meinesz believes that one of the worst cases of a single invasive species causing harm to an ecosystem can be attributed to a seemingly harmless jellyfish. Mnemiopsis leidyi, a species of comb jellyfish that inhabits estuaries from the United States to the Valdés peninsula in Argentina along the Atlantic coast, has caused notable damage in the Black Sea (Simpson, et al; 2010). It was first introduced in 1982, and thought to have been transported to the Black Sea in a ship’s ballast water. The population of the jellyfish shot up exponentially and, by 1988, it was wreaking havoc upon the local fishing industry (Reilly et. al; 2008). “The anchovy catch fell from 204,000 tons in 1984 to 200 tons in 1993; sprat from 24,600 tons in 1984 to 12,000 tons in 1993; horse mackerel from 4,000 tons in 1984 to zero in 1993.” Now that the jellyfish have exhausted the zooplankton, including fish larvae, their numbers have fallen dramatically, yet they continue to maintain a stranglehold on the ecosystem. Recently the jellyfish have been discovered in the Caspian Sea. Invasive species can take over initial occupied areas, facilitate the spread of new diseases, introduce new genetic material, alter landscapes and jeopardize the ability of native species to obtain food. “On land and in the sea, invasive species are responsible for about 137 billion dollars in lost revenue and management costs in the U.S. each year.” This is very significant damage that cannot be ignored. In addition to introducing non native species into new environments, ballast and bilge discharge from ships can spread human pathogens and other harmful diseases and toxins potentially causing health issues for humans and marine life alike.

Discharges into coastal waters along with other sources of marine pollution have the potential to be toxic to marine plants, animals, and microorganisms causing alterations such as changes in growth, disruption of hormone cycles, birth defects, suppression of the immune system, and disorders resulting in cancer, tumors, and genetic abnormalities or even death (Huettel, 2004). They may also have the opposite effect upon some marine life stimulating growth and providing a source of food. Sources of seafood can become contaminated and unhealthy for consumption. Not surprisingly, cholera outbreaks have been attributed to ship operations. “Current research indicates that the bacterium responsible for causing cholera, Vibrio cholerae can spread through attachment to marine organisms in ship ballast water.” Shellfish and drinking water can then be contaminated when the ship discharges its ballast water.

**AFFECTED SPECIES**

There are hundreds of organisms carried in ballast water that cause problematic ecological effects outside of their natural range (Huettel, 2004). The International Maritime Organization list the ten most unwanted species as: Cholera (*Vibrio cholerae*) (various strains), Cladoceran Water Flea (*Cercopagis pengoi*), Mitten Crab (*Eriocheir sinensis*), Toxic algae (red/brown/green tides) (various species), Round Goby (*Neogobius melanostomus*), North American Comb Jelly (*Mnemiopsis leidyi*), North Pacific Seastar (*Asterias amurensis*), Zebra Mussel (*Dreissena polymorpha*), Asian Kelp (*Undaria pinnatifida*) and European Green Crab (*Carcinus maenas*). **New Zealand:** The ballast tanks in New Zealand carry animals and plants that kill ecosystems. Ballast water is controlled under the Bio-security Act 1993 in New Zealand. **Peru:** A form of cholera, *Vibrio cholerae*, previously reported only in Bangladesh apparently arrived via ballast water in Peru in 1991, killing more than 10,000 people over the following three years.
**Mediterranean:** Mediterranean countries have voluntarily implemented Ballast Water Management procedures for vessels entering or trading within MED as from 1st January 2012 according with IMO BWM.2/Circ.35. This is to prevent alien species contaminating Mediterranean waters.

**United States:** Ballast water discharges are believed to be the leading source of invasive species in US marine waters, thus posing public health and environmental risks, as well as significant economic cost to industries such as water and power utilities, commercial and recreational fisheries, agriculture, and tourism. Studies suggest that the economic cost just from introduction of pest mollusks (zebra mussels, the Asian clam, and others) to US aquatic ecosystems is more than $6 billion per year. These problems are not limited to cruise ships, but there is little cruise-industry specific data on the issue, and further study is needed to determine cruise ships’ role in the overall problem of introduction of non-native species by vessels (Huettel, 2004). The zebra mussel, native to the Caspian and Black Seas arrived in Lake St. Clair in the ballast water of a transatlantic freighter in 1988 and within 10 years spread to all of the five neighboring Great Lakes (Huettel, 2004). The economic cost of this introduction has been estimated by the U.S. Fish and Wildlife Service (FWS) at about $5 billion. Congress enacted the National Invasive Species Act of 1996 (NISA) to control aquatic nuisance species. It amended the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990, and authorizes regulation of ballast water; funding for prevention and control research; regional involvement with the Aquatic Nuisance Species Task Force; and education and technical assistance programs to promote compliance with the new regulations. NISA also includes specific actions for certain geographical locations, such as the Great Lakes, Chesapeake Bay, the Gulf of Mexico, and San Francisco Bay (Reilly et. al; 2008).

**REGULATION**

US Clean Water Act (CWA) regulations currently exempt ballast water discharges incidental to the normal operation of cruise ships and other vessels from NPDES discharge permit requirements (see above discussions concerning sewage and gray water). Because of the growing problem of introduction of invasive species into US waters via ballast water, in January 1999, a number of conservation organizations, fishing groups, native American tribes, and water agencies petitioned the Environmental Protection Agency (EPA) to repeal its 1973 regulation exempting ballast water discharge, arguing that ballast water should be regulated as the “discharge of a pollutant” under the NPDES program (Schmidt and Olicker., 2004). EPA rejected the petition in September 2003, saying that the “normal operation” exclusion is long-standing agency policy, to which Congress has acquiesced twice (in 1979 and 1996) when it considered the issue of aquatic nuisance species in ballast water and did not alter the EPA’s CWA interpretation. Further, EPA said that other ongoing federal activities related to control of invasive species in ballast water are likely to be more effective than changing the NPDES rules. Until recently, these efforts to limit ballast water discharges by cruise ships and other vessels were primarily voluntary, except in the Great Lakes. Since 2004, all vessels equipped with ballast water tanks must have a ballast water management plan (Meinesz, 2003).

After the denial of their administrative petition, the environmental groups filed a lawsuit seeking to force EPA to rescind the regulation that exempts ballast water discharges from CWA permitting (Huettel, 2004). In March 2005, a federal district court ruled in favor of the groups, and in September 2006, the court remanded the matter to EPA with an order that the challenged regulation be set aside by September 30, 2008. The court rejected EPA’s contention that Congress had previously acquiesced in exempting the “normal operation” of vessels from CWA permitting and disagreed with EPA’s argument that the court’s two-year deadline creates practical difficulties for the agency and the affected industry (Meinesz, 2003). Significantly, while the focus of the environmental groups’ challenge was principally to EPA’s permitting exemption for ballast water discharges, the court’s ruling — and its mandate to EPA to rescind the exemption in 40 C.F.R. 122.3a — applies fully to other types of vessel discharges that are covered by the regulatory exemption, including gray water and bilge water. The government has appealed the district court’s ruling, and the parties are waiting for a ruling from the appeals court. However, in June 2007, EPA also initiated steps seeking public comment on regulating ballast water discharges from ships, an information-gathering prelude to a potential rulemaking in response to the district court’s order (Schmidt and Olicker., 2004). The 110th Congress has considered ballast water discharge issues, specifically legislation to provide a uniform national approach for addressing aquatic nuisance species from ballast water under a program administered by the Coast Guard. Some groups opposed the bills because they would have preempted states from enacting ballast water management programs more stringent than Coast Guard requirements, while the CWA does allow states to adopt requirements more stringent than in federal rules (Meinesz, 2003). Also, while the CWA permits citizen suits to enforce the law, the proposed legislation included no citizen suit provisions. The US government has set up voluntary guidelines for vessels operating within US waters (Reilly et. al; 2008). These guidelines are for implementing the provisions of NISA. The guidelines are as follows:

- Avoid ballast operations in or near marine sanctuaries, marine preserves, marine parks, or coral reefs.
Avoid taking on ballast water:
- with harmful organisms and pathogens, such as toxic algal blooms.
- near sewage outfalls.
- near dredging operations.
- where tidal flushing is poor or when a tidal stream is known to be more turbid.
- in darkness when organisms may rise up in the water column.
- in shallow water or where propellers may stir up the sediment.
- Clean ballast tanks regularly.
- Discharge minimal amounts of ballast water in coastal and internal waters.
- Rinse anchors during retrieval to remove organisms and sediments at their place of origin.
- Remove fouling organisms from hull, piping, and tanks on a regular basis and dispose of any removed
  substances in accordance with local, state, and federal regulations.
- Maintain a vessel-specific ballast water management plan.
- Train vessel personnel in ballast water management and treatment procedures.
- States can impose stricter guidelines and it is unlawful to ballast within national marine monuments.

There are additional guidelines, mandatory log keeping, and mandatory reporting for any vessel that plans to enter
US waters after being outside the Exclusive Economic Zone. The log keeping and reporting information is as
follows:
- Ballast water management plan (Each ship must have one)
- Copy of IMO guidelines.
- Vessel’s name, type, IMO number, flag, owner, gross tonnage, call sign, and agent.
- Last port, next port, arrival port, and date.
- Total volume of ballast water capacity.
- Total volume of ballast water on board.
- Total number of tanks in ballast.
- Total number of tanks on board that are used for ballast, will be discharged, have undergone exchange,
  or have undergone alternative management.
- Location, date, volume, and temperature of ballast when each tank was loaded.
- Location, date, volume, and salinity of ballast water to be discharged for each tank.
- Particulars of exchange if conducted, including volume exchanged, location, date, percent of tank
  volume exchanged, and sea height at time of exchange.
- Description of alternative management method, if used.
- Reasons if no ballast treatment method was used.

To minimize the spread of invasive species in U.S. waterways, the Environmental Protection Agency and the U.S.
Coast Guard are developing plans to regulate the concentration of living organisms discharged in the ballast water
of ships (Schmidt and Olicker., 2004). A June 2011 National Research Council study provided advice on the
process of setting these limits. The study found that determining the exact number of organisms that could be
expected to launch a new population is complex. It suggested an initial step of establishing a benchmark for the
concentrations of organisms in ballast water below current levels, and then using models to analyze experimental
and field-based data to help inform future decisions about ballast water discharge standards (Meinesz, 2003).

Sound pollution
Noise pollution caused by shipping and other human enterprises has increased in recent history. The noise
produced by ships can travel long distances, and marine species that may rely on sound for their orientation,
communication, and feeding, can be harmed by this sound pollution.

The Convention on the Conservation of Migratory Species has identified ocean noise as a potential threat to
marine life (Schmidt and Olicker., 2004).

Ship impacts
Marine mammals, such a whales and manatees, risk being struck by ships, causing injury and death. For example,
if a ship is traveling at a speed of only 15 knots, there is a 79 percent chance of a collision being lethal to a whale
(Huetel, 2004). One notable example of the impact of ship collisions is the endangered North Atlantic right
whale, of which 400 or less remain. The greatest danger to the North Atlantic right whale is injury sustained from
ship strikes. Between 1970 and 1999, 35.5 percent of recorded deaths were attributed to collisions. During 1999 to
2003, incidents of mortality and serious injury attributed to ship strikes averaged one per year. In 2004 to 2006,
that number increased to 2.6. Deaths from collisions have become an extinction threat (Watson, 2004).
Exhaust emissions

Exhaust emissions from ships are considered to be a significant source of air pollution, with 18 to 30 percent of all nitrogen oxide and 9 percent of sulphur oxide pollution. The 15 biggest ships emit about as much sulphur oxide pollution as all cars combined. "By 2010, up to 40 percent of air pollution over land could come from ships.” Sulfur in the air creates acid rain which damages crops and buildings (Schmidt and Olicker., 2004). When inhaled the sulfur is known to cause respiratory problems and even increase the risk of a heart attack. According to Irene Blooming, a spokeswoman for the European environmental coalition Seas at Risk, the fuel used in oil tankers and container ships is high in sulfur and cheaper to buy compared to the fuel used for domestic land use. "A ship lets out around 50 times more sulfur than a lorry per metric tonne of cargo carried.” Cities in the U.S. like Long Beach, Los Angeles, Houston, Galveston, and Pittsburgh see some of the heaviest shipping traffic in the nation and have left local officials desperately trying to clean up the air (Meinesz, 2003). Increasing trade between the U.S. and China is helping to increase the number of vessels navigating the Pacific and exacerbating many of the environmental problems. To maintain the level of growth China is currently experiencing, large amounts of grain are being shipped to China by the boat load. The numbers of voyages are expected to continue increasing (Ward-Geiger et. al., 2005).

Shipping causes 3.5 to 4 percent of all climate change emissions. Air pollution from cruise ships is generated by diesel engines that burn high sulfur content fuel oil, also known as bunker oil, producing sulfur dioxide, nitrogen oxide and particulate, in addition to carbon monoxide, carbon dioxide, and hydrocarbons (Huettel, 2004). Diesel exhaust has been classified by EPA as a likely human carcinogen. EPA recognizes that these emissions from marine diesel engines contribute to ozone and carbon monoxide nonattainment (i.e., failure to meet air quality standards), as well as adverse health effects associated with ambient concentrations of particulate matter and visibility, haze, acid deposition, and eutrophication and nitrification of water (Meinesz, 2003). EPA estimates that large marine diesel engines accounted for about 1.6 percent of mobile source nitrogen oxide emissions and 2.8 percent of mobile source particulate emissions in the United States in 2000. Contributions of marine diesel engines can be higher on a port-specific basis. Ultra-low sulfur diesel (ULSD) (also spelled “sulphur”) is a term used to describe a standard for defining diesel fuel with substantially lowered sulfur contents. As of 2006, almost all of the petroleum-based diesel fuel available in Europe and North America is of a ULSD type (Vidal, 2009). As one way to reduce the impact of greenhouse gas emissions from shipping, vetting agency Right Ship has developed an online “GHG Emissions Rating” as a systematic way for the industry to compare a ship’s CO2 emissions to peer vessels of a similar size and type. Using higher rated ships can deliver significantly lower CO2 emissions across the voyage length (Vidal, 2007).

One source of environmental pressures on maritime vessels recently has come from states and localities, as they assess the contribution of commercial marine vessels to regional air quality problems when ships are docked in port (Meinesz, 2003). For instance, large marine diesel engines are believed to contribute 7 percent of mobile source nitrogen oxide emissions in Baton Rouge/New Orleans. Ships can also have a significant impact in areas without large commercial ports: they contribute about 37 percent of total area nitrogen oxide emissions in the Santa Barbara area, and that percentage is expected to increase to 61 percent by 2015 (Vanderlaan and Taggart; 2007). Again, there is little cruise-industry specific data on this issue. They comprise only a small fraction of the world shipping fleet, but cruise ship emissions may exert significant impacts on a local scale in specific coastal areas that are visited repeatedly (Meinesz, 2003). Shipboard incinerators also burn large volumes of garbage, plastics, and other waste, producing ash that must be disposed of. Incinerators may release toxic emissions as well. In 2005 MARPOL Annex VI came into force to combat this problem. As such cruise ships now employ cctv monitoring on the smoke stacks as well as recorded measuring via opacity meter with some also using clean burning gas turbines for electrical loads and propulsion in sensitive areas (Simpson, et al; 2010).

Oil spills

Most commonly associated with ship pollution are oil spills. While less frequent than the pollution that occurs from daily operations, oil spills have devastating effects (Meinesz, 2003). While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), the components in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment. Marine species constantly exposed to PAHs can exhibit developmental problems, susceptibility to disease, and abnormal reproductive cycles (Schmidt and Olicker., 2004). One of the more widely known spills was the Exxon Valdez incident in Alaska. The ship ran aground and dumped a massive amount of oil into the ocean in March 1989. Despite efforts of scientists, managers, and volunteers over 400,000 seabirds, about 1,000 sea otters, and immense numbers of fish were killed.

International regulation

Some of the major international efforts in the form of treaties are the Marine Pollution Treaty, Honolulu, which deals with regulating marine pollution from ships, and the UN Convention on Law of the Sea, which deals with marine species and pollution (Meinesz, 2003). While plenty of local and international regulations have been introduced throughout maritime history, much of the current regulations are considered inadequate. “In general, the treaties tend to emphasize the technical features of safety and pollution control measures without going to the
root causes of sub-standard shipping, the absence of incentives for compliance and the lack of enforceability of measures.” Cruise ships, for example, are exempt from regulation under the US discharge permit system (NPDES, under the Clean Water Act) that requires compliance with technology-based standards. In the Caribbean, many ports lack proper waste disposal facilities, and many ships dump their waste at sea (Schmidt and Olicker., 2004).

**Sewage**

The cruise line industry dumps 255,000 US gallons (970 m3) of grey water and 30,000 US gallons (110 m3) of black water into the sea every day. Black water is sewage, wastewater from toilets and medical facilities, which can contain harmful bacteria, pathogens, viruses, intestinal parasites, and harmful nutrients(Reilly et al, 2008). Discharges of untreated or inadequately treated sewage can cause bacterial and viral contamination of fisheries and shellfish beds, producing risks to public health. Nutrients in sewage, such as nitrogen and phosphorus, promote excessive algal blooms, which consumes oxygen in the water and can lead to fish kills and destruction of other aquatic life. A large cruise ship (3,000 passengers and crew) generates an estimated 55,000 to 110,000 liters per day of black water waste. Due to the environmental impact of shipping, and sewage in particular marpol annex IV was brought into force September 2003 strictly limiting untreated waste discharge. Modern cruise ships are most commonly installed with a membrane bioreactor type treatment plant for all black water and grey water, such as Zenon or Rochem which produce near drinkable quality effluent to be re-used in the machinery spaces as technical water (Meinesz, 2003).

**Cleaning**

Grey water is wastewater from the sinks, showers, galleys, laundry, and cleaning activities aboard a ship. It can contain a variety of pollutant substances, including fecal coliforms, detergents, oil and grease, metals, organic compounds, petroleum hydrocarbons, nutrients, food waste, medical and dental waste. Sampling done by the EPA and the state of Alaska found that untreated grey water from cruise ships can contain pollutants at variable strengths and that it can contain levels of fecal coliform bacteria several times greater than is typically found in untreated domestic wastewater. Grey water has potential to cause adverse environmental effects because of concentrations of nutrients and other oxygen-demanding materials, in particular. Grey water is typically the largest source of liquid waste generated by cruise ships (90 to 95 percent of the total). Estimates of grey water range from 110 to 320 liters per day per person, or 330,000 to 960,000 million liters per day for a 3,000-person cruise ship (Huettel, 2004).

**Solid waste**

Solid waste generated on a ship includes glass, paper, cardboard, aluminum and steel cans, and plastics. It can be either non-hazardous or hazardous in nature. Solid waste that enters the ocean may become marine debris, and can then pose a threat to marine organisms, humans, coastal communities, and industries that utilize marine waters. Cruise ships typically manage solid waste by a combination of source reduction, waste minimization, and recycling. However, as much as 75 percent of solid waste is incinerated on board, and the ash typically is discharged at sea, although some is landed ashore for disposal or recycling. Marine mammals, fish, sea turtles, and birds can be injured or killed from entanglement with plastics and other solid waste that may be released or disposed off of cruise ships. On average, each cruise ship passenger generates at least two pounds of non-hazardous solid waste per day (Reilly et al., 2008). With large cruise ships carrying several thousand passengers, the amount of waste generated in a day can be massive. For a large cruise ship, about 8 tons of solid wastes are generated during a one-week cruise. It has been estimated that 24 percent of the solid waste generated by vessels worldwide (by weight) comes from cruise ships. Most cruise ship garbage is treated on board (incinerated, pulped, or ground up) for discharge overboard. When garbage must be off-loaded (for example, because glass and aluminum cannot be incinerated), cruise ships can put a strain on port reception facilities, which are rarely adequate to the task of serving a large passenger vessel (Harrabin, 2003).

**Bilge water**

On a ship, oil often leaks from engine and machinery spaces or from engine maintenance activities and mixes with water in the bilge, the lowest part of the hull of the ship. Oil, gasoline, and by-products from the biological breakdown of petroleum products can harm fish and wildlife and pose threats to human health if ingested. Oil in even minute concentrations can kill fish or have various sub-lethal chronic effects. Bilge water also may contain solid wastes and pollutants containing high amounts of oxygen-demanding material, oil and other chemicals. A typical large cruise ship (Fig.3) will generate an average of 8 metric tons of oily bilge water for each 24 hours of operation (Copeland, 2008).
To maintain ship stability and eliminate potentially hazardous conditions from oil vapors in these areas, the bilge spaces need to be flushed and periodically pumped dry. However, before a bilge can be cleared out and the water discharged, the oil that has been accumulated needs to be extracted from the bilge water, after which the extracted oil can be reused, incinerated, and/or offloaded in port. If a separator, which is normally used to extract the oil, is faulty or is deliberately bypassed, untreated oily bilge water could be discharged directly into the ocean, where it can damage marine life. A number of cruise lines have been charged with environmental violations related to this issue in recent year (Adams, 2002).

CONCLUSION

- There is no doubt that marine transport is considered one of the main economic development pillars in any nation.
- The issue of transportation and the environment is paradoxical in nature. The relationships between transport and the environment are multidimensional.
- The aspects of environmental pollution from maritime transport on the environment relate to climate change, air quality, noise, water quality, soil quality, biodiversity and land take, algal bloom, anoxic event, anoxic waters, aquatic toxicology, cultural eutrophication, cyanotoxin, environmental impact of shipping: eutrophication, fish diseases and parasites, fish kill, friendly floaters, great pacific garbage patch, hypoxia, invasive species, marine debris, mercury in fish,
- Adequate knowledge of the effects and fate of these environmental pollutants from maritime transportation in Nigeria enable maritime managers and other stake holders in the country wary.

REFERENCES


