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A REVIEW OF MARITIME ASSOCIATED POLLUTION

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ABSTRACT

This paper is designed to investigate various sources of marine pollution and to evaluate how maritime transport organizations were able to minimize the volume of marine pollution through rules and regulations designed to face challenges imposed by marine pollution. Results and findings present that marine pollution is not faced in the optimum way so as to prevent or minimize pollution and protect our environment in the perfect way.

KEYWORDS: Marine Pollution, Ports, Maritime Transportation, Shipping, Pollution Control

INTRODUCTION

Safety and environmental protection were the main priorities of the maritime transport organizations, especially after the occurrence of major pollution accident (Giziakis and Bardi-Giziaki, 2002). Water resource is one important resource in the environment. It is always threatened with devastation by industrial wastes. In third world countries, the industrial pollution problems are comparable to those in the industrialized nations (Bichi and Anyata, 1999).

In general, the term pollution refers to the change in the nature of something due to the presence of substances or compounds that are not supposed to be present in it (Akankali and Elenwo, 2015). Another simple definition to the term pollution is that it is the introduction of harmful substances or products into the environment. Moreover, the term pollution was defined as alteration of the environment to its detriment or degradation, which involves an emission, where emission is defined as a discharge of waste, or an emission of noise, odour or electromagnetic radiation. The latter definition was introduced by the Environmental Protection Act, 1986.

Pollution can be classified according to the place where it happens, such as water or aquatic pollution (marine, brackish or fresh water pollution), atmospheric pollution and soil/land pollution. Also, pollution can be classified according to type, such as Chemical pollution and Noise pollution (Akankali and Elenwo, 2015).

The term marine pollution was defined by congress of working group of the United States Marine (and estuarine pollution) as the “introduction by man directly or indirectly of substances or energy into the marine environment resulting in such deleterious effects as harm to living resources, hazard to human health, hindrance to marine activities including fishing, impairment of quality for the use of sea water and reduction of amenities”.

In general, pollution is not a new topic of research as it had been examined in several areas and in different types of research, but unfortunately, pollution still exists and no one can prevent it at all. Yet, studies and researches are designed every now and then to develop new tools and methods that could be helpful in facing new and continuing sources of pollution. This paper is a review of sources of marine pollution and various tools and methods used to face such sources of pollution.

SOURCES OF MARINE POLLUTION

There are several ways to classify pollution according to its sources. It could be classified according to:

Point Source and Non-Point Source Pollution

Sources of pollution in aquatic environment could be broadly classified into “point source” and “non-point source” pollution. The point source pollution is referring to those polluting substances emanating from specific channels. Pollutants emanating from point sources are relatively easy to identify, isolate, contain and therefore manage. Point sources of aquatic pollution are like human activities of pipeline discharges of polluting chemicals fluids such as crude oil, accidents or outright vandalism. Also, point sources are like domestic sewage discharges or industrial wastes. On the other hand, non-point sources pollution resulting from human activities could be defined as those pollutants originating from relatively widespread surface area and gets discharged into the aquatic environment via extensive spheres and channels. Examples of non-point sources of pollution include urban storm run offs, dissolved atmospheric gases and particulates such as acids from gas flaring and volcanic ash being released into the aquatic environment via precipitation. Through this type of non-point source pollution, underground water pollution occurs where the soil capillaries are porous enough to permit downward percolation of significant volumes of water arising from precipitation.

Land Based Pollution Sources

Land-based sources (such as agricultural run-off, discharge of nutrients and pesticides and untreated sewage including plastics) account for approximately 80% of marine pollution, globally. Agricultural practices, coastal tourism, port and harbours developments, damming of rivers, urban development and construction, mining, fisheries, aquaculture, and manufacturing, among others, are all sources of marine pollution threatening coastal and marine habitats.

Household/Domestic Sources of Pollution

It contains virtually all forms of wastes; biodegradable and non-biodegradable solid wastes including metals and plastics, liquid wastes, organics of different classes, chemical wastes etc. In most cases, these wastes are not segregated at source especially in developing countries prior to disposal. Also, indiscriminate dumping of waste into public spaces drains and in waste dumps that are devoid of the impermeable layers of a properly engineered land fill are common practices in developing countries such as Nigeria. The net consequences of this unorganized system of managing domestic waste leads to a high proportion of the waste eventually finding their way into the hydrological cycle via leachates during aquifer recharge.

Marine Litters/Garbage Sources of Pollution

There are several kinds of marine litters and garbage’s being dumped into the marine environment annually in thousands of tonnages cumulatively. However, plastics appear to be the most noticeable and problematic of marine litters and garbage’s

Operational Sources Such as Fishing Vessels Boats/Ships

Pollution sources at sea or even on inland waters such as Rivers, lagoons, seas, harbours and estuaries constitutes sources of significant pollution to the marine environment. Some of these activities include accidental and deliberate discharges of oil during bunkering operations, operational dumping of garbage (particularly plastics, metallic and non-

metallic objects). Other pollutant sources resulting from operational sources include dredge spoils (mostly routine harbours dredging) and unserviceable equipment. Dredge spoils are often rich in heavy metals (e.g. lead, copper, zinc, mercury, and cadmium), and are dumped at designated sites.

Other sea activities sources

Bunkering activities both legal and illegal of crude oil constitutes a very serious source of pollution into the marine environment.

Another classification of sources of marine pollution is according to:

Port pollution due to ships

Ships moving into a port for berthing or while waiting in the anchorage are potential polluters because of their possible collisions or strandings. Apart from pollution, marine accidents that take place within a port, may cause economic losses to the port through obstructing other ships' use of the port or its berths. State of the art knowledge suggests implementation of the VTMIS system – a newer version of VTS using information/ electronic technology. Ships in ports of course should follow Marpol Convention, where ship's slops should be delivered to slop facilities provided by some ports in the EU. Slops may be identified as coming from ballast water, tank cargo residuals, residuals from the filtering of main engine fuel, oily substances through drainage and carbages. Ships' pollution within a port is highly costly as specialised cleaning companies are called to clean up the quay walls. Can this cost be recovered through high storage costs of pollution-proof ships and cargoes? Ships pollute ports through gas emission from the main engine and hot water, noise from ships' engines and exhaust emissions in the case of passenger ships (Englezou et al., 1993). Ships' maintenance and repair that takes place in floating or grave docks or alongside a port dock create pollution from rust removal, old paints and various chemicals. In the case of tankers, the risk of pollution increases owing to noxious and inflammable substances that may cause sea water pollution or an explosion. Pollution coming from fuel when being delivered to ships within a port is a frequent cause of serious effects on the sea environment. A limited loss of fuel into ports may cost US$7,000 to clean up according to our estimates in a European port (seawater cleaning).

Port pollution Owing to Cargoes: Bulk Cargoes

It is expected that cargoes like coal, iron ore and others, while loaded/unloaded or stored (higher probability) in ports create dust, odour or may be lost. This is because these cargoes are stored in the open. More important is the fact (admitted by transport industry) that 1 per cent of cargoes moved are lost in the transportation and handling procedures from door to door. This is something that technologists should note as 1 per cent of 2.3 billion tons (as shown above) equals 23 million tons per year with a value of $11.5 billion (calculated by assuming the value of a ton as US$500). The dust mentioned above may damage other cargoes stored in the port e.g. cars or may pollute residences near the port and harm residents' health. In major European ports dust nowadays is controlled through special costly equipment.

Port Pollution Owing to Cargoes: Bulk Liquid Cargoes

Research has shown that the main causes of port pollution have been identified as bad maintenance of storage tanks, improper linkages between ship and shore, valve explosion, breaking out the connection of ship with a pipeline. It is expected that when handling oil and the linkage with shore is broken, then 3,000 litres per hour can be poured into the sea. Oil pollution cannot be disconnected from the probability of fire or explosion. Ship maintenance is important to avoid the

above hazards.

Port Pollution Owing to Cargoes: General Cargoes

General cargoes nowadays are transported in boxes (Bruning, 1985), but a considerable percentage of these are dangerous goods. About 51 per cent of all ships calling in the Port of Rotterdam carry dangerous goods. Of these, 64 per cent are packed. Also, 60 per cent of all packed dangerous goods are carried in boxes. Boxes can also be considered as those used to transport liquid or liquified gases. Boxes should not be locked in case of an emergency, and should be treated with care when carrying dangerous goods till these are cleaned out (at which time warning signs and labels should be removed). Boxes (tanks) used to carry dangerous liquids or gasses should comply with the CSC convention for safe container of IMO. This convention assumes frequent testing and inspection of the box. Boxes with liquid cargoes should bear special indications (a proper shipping name), labels (enlarged labels at least 25 by 25 cm) and a special serial number of United Nations (four numbers are used for dangerous goods). Boxes should bear indications and signs on both sides and ends. For the safe transportation and handling of general cargoes international rules and regulations have been imposed for some time now requiring among other things detailed information and documents (Bruning et al., 1990; Heidoloff, 1985; Krause, 1978). The most frequent accidents in the case of general cargoes which create pollution are caused by falls of boxes from the cranes and damage caused by cargo handling equipment. Noxious cargoes of course threaten the health of people working in ports and nearby residents and cause land pollution. Boxes may also cause traffic congestion, noise and pollution as they move by truck from port to hinterland and where the construction of required roads may jeopardise the physical environment. In the case of the Port of Piraeus congestion is caused inside as well as outside the port area owing to car traffic.

Also, a classification of sources of marine pollution refers to types of pollutants as follows:

Energy Pollutants

There are various forms of energy sources available to man either naturally or enhanced and exploited by man as forms of artificial energy. Some of these forms of energy include Noise, Heat, Nuclear, Vibration and solar (Ultraviolet and other forms of radiation). These energy forms are utilizable by man and applied in various forms to drive the various forms of human socioeconomic activities with the exception of noise. Incidentally, a significant portion of these energy sources end up in the aquatic environment as what could be termed as thermal energy residues that eventually constitutes thermal pollutants. Thermal pollution occurs mainly through the creation of a phenomenon known as thermal plume. This creates thermal shock for the aquatic organisms that can lead to either death or other physiologic problems.

Organic or Biological Pollutants

Life processes of organisms leads to the generation of a class of pollutants that inevitably impacts the aquatic environment. Some of these include urine, feaces and various other products of decay process of organics from living or dead organisms. Incidentally, geometric increases in human population and the need to keep up with providing food for the astronomically rising global population has led to corresponding increases in crop and animal productions. This increases the amount of biological pollutants that eventually get into our aquatic environment. Especially in urban areas and in highly industrialized cities that have water bodies, biological pollutants have rendered most municipal water bodies highly toxic. In Lagos Nigeria for example, most of the Lagos lagoon has become so badly polluted from the indiscriminate dumping of untreated human waste and open defecation and urination into the waters among other pollutants. The water

body is perpetually black in colour, with stench like strong ammonia (NH3) odour. This is an indication of heavily polluted waters, mostly from biological pollutants. Aquatic life in such water is reduced to the barest minimum, as the primary producers are completely wiped out. Human wastes in particular generally cause serious problems to the marine environment. The disposal of untreated human waste is one of the largest contributors to the pollution of the marine environment. There is numerous health problems associated with it. Even in places where there are septic tanks and soak away pits they tend to overflow and in many of the coastal villages in rural settings due to lack of proper toilet facilities especially in developing nations like Nigeria. Human waste gets discharged into the sea or coastal waters either directly or through streams, rivers and storm drainages. Furthermore, as human populations grows more and more categories of pollutants impacts both the fresh and brackish waters. One of the most common pollution in this category is the organic pollutant caused by oxygen- demanding wastes as domestic sewage, wood fiber from pulp and paper mills, effluent from food processing plants, and run-off from agricultural areas (especially hay, dairy, and cattle farms). Dissolved oxygen is consumed either through chemical oxidation of these substances or through the respiratory processes of biological decomposition. Decomposition of materials is a normal process in all aquatic ecosystems and is a function of decomposers such as bacteria and fungi. These organisms metabolize the organic matter as an energy and nutrient source and utilize dissolved oxygen in the process. However, serious consequences can result if these natural mechanisms are overloaded by large influxes of organic matter. Severe oxygen depletion can result in the loss of desirable aquatic life and may produce an odorous anaerobic system.

Domestic Pollutants

For decades, communities, settlements and municipalities have utilized water courses for domestic chores, transportation and as the sink for waste. However sewage depletes the much needed dissolved oxygen and contains high concentration of bacterial and viral life forms, some of which could be pathogenic. In addition, effluent from municipal domestic waste treatment plants, with unknown and unusual chemicals contained in the industrial process because of trade secrets, find their way into water courses. These substances affect both the pelagic and benthic organisms and impair water quality for fish spawning and breeding, ultimately in the coastal aquatic environments.

Synthetic Pollutants

Synthetic pollution involves pollutants from substances that are manufactured or synthesized by man from factories and laboratories. In other words they are artificially formulated compounds, which man utilizes as raw materials, drugs, herbicides and pesticides. Depending on the nature of the active ingredients of the synthetic pollutants, irrespective of where they are used, the residues may persist in the aquatic environment and have long lasting impacts as they may not easily be biodegradable. Pesticides constitute very good examples of synthetic pollutants. There are two major categories of synthetic products, the organo-chlorine and organo-phosphorous groups. The organo-chlorine based compounds include pesticides, pharmaceuticals and cosmetics products and plastics. For example, some pesticides like DDT are not only biologically active but stable and persist for a long time in the aquatic environment. Some organo-phosphorous based compounds are less stable and therefore of lesser persistence and impact in the aquatic environment. Although most pesticides are often used on land in agricultural estates, the aquatic environment becomes the ultimate recipients of the residues. The heavy metals in them may be in very trace quantities, but aquatic organisms such as mollusks and crustaceans are able to raise the level of concentrations through their filter feeding habits. When these substances bio-accumulate in such aquatic organisms and are consumed by man it biomagnifies the adverse health hazards of the

pollutants. It has been reported that over 90% of the detergents which are the commonest in use today are biodegradable; many new pesticides such as the organo-phosphorous group break down readily in water, although not necessarily to simple inorganic salts. Even where a substance is biodegradable, it does not mean that it poses no problems as the products of its breakdown may be toxic or bio-accumulated to levels at which it becomes hazardous.

Crude Oil Pollutants

Crude oil pollution, a type of chemical pollutant, deserve specific discuss as a pollutant type. This is because it has become one of the most important pollutants of the marine environment. Several factors make crude oil a top polluting substance of aquatic environment. Top among these factors include the global economic importance of crude oil as a product that drives most economies all over the world. Hence, the global demand and production of it has steadily been on the increase, thereby leading to development of numerous oil fields all over the world. Some of the major oil producing facilities around the globe are located either onshore, near shore or offshore facilities. Thirdly, most oil refining and transportation facilities are sited close to and carried on water respectively.

Industrial Pollutants

Industrial pollution focuses mainly on industrial wastewater, even though thermal heat (such as from gas flaring), radiation and other forms of industrial pollutant impacts negatively on the aquatic environment. Industrial waste water is given priority as a fundamental type of water pollutant due to its serious impact on the aquatic environment. In virtually all industrial processes, water is required as an important catalyst ingredient and as coolant etc. The excess of such waters are often released into the environment, especially into the aquatic environment with all the dissolved constituents. Most of the constituents include organics and in-organics. Undesirable Industrial wastewater may be characterized based on the nature of the industry and the projected uses of the waters of the receiving stream. These undesirable wastewater characteristics (pollutants) according to include Soluble organics, Suspended solids, Heavy metals, cyanide and toxic organics, Colour and turbidity, Nitrogen and phosphorous, Refractory substances, Volatile materials oil and floating material, and aquatic toxins.

Precipitation Pollutants

Liquid precipitation such as rainfall constitutes a fundamental source of marine pollutant. This is because, the processes that leads to the formation of precipitation is based on crystallization of moisture around suspended particulate matter. The particulate sources ranging from salt particles from the field, ash emitted from volcanic eruption, dust particles such as chromium, asbestos, particulates from smokestacks, crystals of salt, pollens in air or combustion by-products of coal or fossil fuel. The increasing concentration of greenhouse gases containing carbon dioxide, oxides of nitrogen and sulphure, beyond threshold levels, are responsible for acid rain which adversely affects fisheries and aquaculture, forestry and agricultural soil fertility in coastal environments.

Extraneous Pollutants

There are pollutant types in the aquatic marine environment that are not easily recognizable and may not be easily classified. Consequently, they are termed as extraneous pollutants. When large tracts of land are plowed, the exposed soil can erode during rainstorms. Much of this runoff flows to the sea, carrying with it loose earth material that may be contaminated. In the process of sedimentation, a considerable portion of such earth material may constitute silt pollutants. Extraneous pollutants occur mainly through the non-point source of pollution, which occurs as a result of runoff. Other

extraneous pollutants include minor leakages from many small sources, like septic tanks, cars, trucks, and boats, plus larger sources, such as farms, ranches, and forest areas. Millions of motor vehicle engines drop small amounts of oil each day onto roads and parking lots. Much of these oil droplets make its way to the water bodies or seas. Some water pollution actually starts as air pollution, which settles into waterways and oceans. Dirt and dust from road construction during dry weather also constitutes extraneous pollutants, which impacts the aquatic marine environment. Silt from fields or construction sites can run off into waterways, harming fish and wildlife habitats.

Previous Studies on Marine Pollution

It should be highlighted that one of the studies showed that on-board garbage disposal accounted for the highest source of pollution (2,120.9; 97.13 per cent). This study showed that different transport activities, like bunkering, accidental discharge of ships effluent, deliberate discharge of ships effluent, dumping, fishing trawlers and other activities cause severe pollution through oil, bilge water, oily ballast water, plastics, garbage and heat (Ogbuagu et al., 2013)

An important study examined the effect of trade and institutional quality on the level of CO_2 emissions in the Arab countries. A reduced form equation is tested for a sample of 13 Arab countries using emissions data for the 2003-2008 periods. Statistics reveal that in 2008, CO_2 emissions (metric tons per capita) by the Arab countries averaged 10.2 compared to 12.5 in the high-income countries; 3.3 in the middle-income countries; and 0.28 in the low-income countries (The World Bank, 2011). These statistics indicate that the level of emissions are considerably higher for the Arab countries as not all of them fall in the high-income category of countries and so poses a serious cause of concern in terms of environmental damage. The analytical procedures based on fixed effects estimation provide strong evidence that trade and industrial activity are positively and statistically significantly correlated with emissions. Across the Arab countries, a positive correlation of income is established with emission levels. The results also provide strong evidence that regulatory quality is negatively and statistically significantly correlated with the emission levels. Based on the empirical findings, it can be concluded that better achievements in a country's regulatory quality including environmental regulations can translate into lower levels of pollution. The Arab countries should continue to reform their regulations relating to environmental pollution by strengthening it. Economic activity is likely to expand in most of the Arab countries and so the levels of trade and industrial expansion. Associated with growing economic output is the high likelihood of rising CO_2 emissions in years to come. Rising population also places pressures for many governments to create more economic opportunities and so one way to improve the economic opportunities is to allow more domestic investment including foreign investment. The Arab countries are experiencing rising economic growth and with expansion of their economic activities signals future increases in CO_2 emissions, thus, contributing to a rise in average per capita CO_2 emission levels. Hence, the issue relating to the pollution control through targeting environmental regulations demands urgent attention so as to institute mechanisms to strengthen them at the industry as well as the country level (Gani, 2013).

REGULATIONS FACING POLLUTION

One of the proposed solutions was the UK's Environmental Protection Act 1990, which established a regulatory regime for the control of pollution. It proposed an integrated solution through the integrated pollution control (IPC) which embraces the release of pollution to all three environmental media of air, water and land. It was made the responsibility of Her Majesty's Inspectorate of Pollution (HMIP). The need for such a regime was first recognized in the fifth report of the Royal Commission on Environmental Pollution. It proposed a system that deliberately takes the interrelation of environmental media into account. The "cross-media" dimension of pollution is addressed by the use of the best

practicable environmental option (BPEO). The processes involved are generally those which are most complex and potentially polluting (Wills and Jones, 1996).

ILLUSTRATED EXAMPLE OF POLLUTION

The data used was obtained from the Transport Operations (Marine Pollution) Act 1995 and regulations protect Queensland's marine and coastal environment by minimizing deliberate and negligent discharges of ship-sourced pollutants into coastal waters. Under the Transport Operations (Marine Pollution) Act 1995 the master of a ship must report a discharge or probable discharge of any pollutant without delay to Maritime Safety Queensland or the Australian Maritime Safety Authority. Pollutants are defined as harmful substances and include oil, chemicals, and sewage and garbage. Even minor instances of marine pollution must be reported. The marine pollution data records issued for the years 2002 till 2015 were used to imagine the volume of pollution faced by the environment till now.

It could be observed from figure 1 that the number of events recorded had been decreased through the years 2005 till 2011, then it shows an increase again. Generally, it could be claimed that events of marine pollution are fluctuating in their records abd it could not be claimed that they are being controlled.

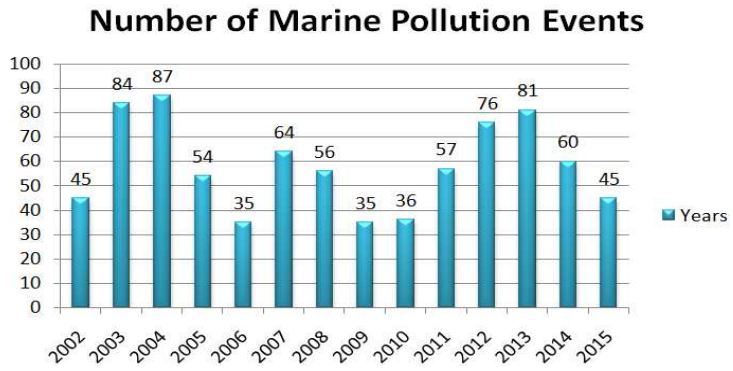

Figure 1: Number of Marine Pollution Events through 2002 - 2015

Regarding figure 2, it could be observed that sources of marine pollution are ships, Aircraft or land through the years 2005 till 2011.

It could be observed that the highest source of pollution is ships with a percentage of around 60%, while the second source of pollution is aircraft with around 29% of marine pollution events, while the least in pollution is land with around 11% of total events of marine pollution.

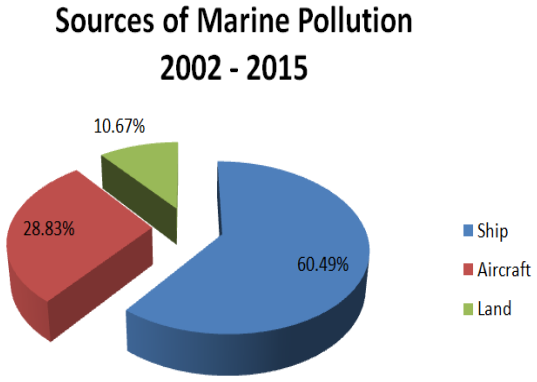

Figure 2: Sources of Marine Pollution through 2002 - 2015

CONCLUSIONS

Pollution is still present with a huge volume in many regions and the known tools and regulations established till now are not really enough to face the challenges imposed by various types of pollution on our environment. Thus, people should be aware enough of the problems they are facing by pollution to be able to develop strict rules and regulation to be applied on marine pollution to reach the minimum level of pollution we can.

It should be highlighted that it was so difficult for the researcher to find records of data for events of pollution for any of the developing countries. This means that pollution might be happening and with higher percentages while it is not recorded and by that it could not be even faced or treated by any means. An important question that still arises is how to control, face and treat pollution happening while it is known to the environment but a much more important question that should find a critical answer is how to control pollution that is not even know or recorded to the environment.

REFERENCES

1. Akankli, J.A. and Oronsaye, J.A.O. (2012) Fundamentals of Water Pollution. Manuscript as Submitted in 2012 for Publication Assessment to Tertiary Education Fund, Abuja.
2. Alexander M. Goulielmos Angeliki Pardali, (1998),"The framework protecting ports and ships from fire and pollution", Disaster Prevention and Management: An International Journal, Vol. 7 Iss 3 pp. 188 – 194
3. Alexander M. Goulielmos Kostas Giziakis, (1998),"Treatment of uncompensated cost of marine accidents in a model of welfare economics", Disaster Prevention and Management: An International Journal, Vol. 7 Iss 3 pp. 183 – 187
4. Alexander M. Goulielmos, (2001),"Maritime safety: facts and proposals for the European OPA", Disaster Prevention and Management: An International Journal, Vol. 10 Iss 4 pp. 278 – 285
5. Azmat Gani, (2013),"The effect of trade and institutions on pollution in the Arab countries", Journal of International Trade Law and Policy, Vol. 12 Iss 2 pp. 154 - 168

A. Goulielmos E. Tzannatos, (1997),"Management information system for the promotion of safety in shipping", Disaster Prevention and Management: An International Journal, Vol. 6 Iss 4 pp. 252 – 262

6. Browne, M.A., et al. (2011) Accumulations of Microplastic on Shorelines Worldwide: Sources and Sinks. Environmental Science and Technology, 45, 9175-9179.
7. Cambridge Water Co. Ltd v. Eastern Counties Leather plc [1994] 1 All ER 53.
8. Daria Gritsenko , (2015),"Quality governance in maritime oil transportation: the case of the Baltic Sea", Management of Environmental Quality: An International Journal, Vol. 26 Iss 5 pp. 701 – 720
9. Dike Henry Ogbuagu Grace Chidiogo Okoli Nasiru Asuenime Agbonikhena, (2013),"Seaport-associated pollutions in Ogu waterway near Port Harcourt", Management of Environmental Quality: An International Journal, Vol. 24 Iss 4 pp. 512 – 525
10. Environmental Data Services (ENDS) Report 231, Environmental Data Services, London.
11. Environmental Data Services (ENDS) Report 227, Environmental Data Services, London, pp. 3-4.

12. E.S. Tzannatos, (2003),"A decision support system for the promotion of security in shipping", Disaster Prevention and Management: An International Journal, Vol. 12 Iss 3 pp. 222 – 229

13. Gholamreza Emad Wolff Michael Roth, (2008),"Contradictions in the practices of training for and assessment of competency", Education + Training, Vol. 50 Iss 3 pp. 260 – 272

14. Helena Palmquist Jörgen Hanæus, (2004),"A Swedish overview of selecting hazardous substances as pollution indicators in wastewater", Management of Environmental Quality: An International Journal, Vol. 15 Iss 2 pp. 186 – 203

15. How Sing Sii Jin Wang Tom Ruxton, (2001),"Novel risk assessment techniques for maritime safety management system", International Journal of Quality & Reliability Management, Vol. 18 Iss 9 pp. 982 - 1000

16. Julian Wills C.J.F.P. Jones, (1996),"Pollution control designs in continuous improvement", Environmental Management and Health, Vol. 7 Iss 1 pp. 5 - 8

17. J. A. Akankali1, E. I. Elenwo, 2015. Sources of Marine Pollution on Nigerian Coastal Resources: An Overview. Open Journal of Marine Science, 2015, 5, 226-236.

18. Kiriaki Mitroussi, (2004),"Quality in shipping: IMO's role and problems of implementation", Disaster Prevention and Management: An International Journal, Vol. 13 Iss 1 pp. 50 – 58

19. Konstantinos GiziakisErnestini Bardi-Giziaki, (2002),"Assessing the risk of pollution from ship accidents", Disaster Prevention and Management: An International Journal, Vol. 11 Iss 2 pp. 109 - 114

20. M.H. Bichi B.U. Anyata, (1999), "Industrial waste pollution in the Kano river basin", Environmental Management and Health, Vol. 10 Iss 2 pp. 112 - 116

21. Rosa Duarte Pac Julio Sánchez-Chóliz, (1999),"Regional productive structure and water pollution in the Ebro Valley (Spain)", Environmental Management and Health, Vol. 10 Iss 3 pp. 143 – 154

22. The Environmental Protection (Prescribed Processes and Substances) Regulations 1991.

23. (The) World Bank (2011), World Development Indicators CDROM, The World Bank, Washington, DC.

24. (The) World Bank (2012a), World Development Indicators CD ROM, The World Bank, Washington, DC.

25. (The) World Bank (2012b), Worldwide Governance Indicators, The World Bank, Washington, DC, available at: www.worldbank.org/governance/wgi2010.