Scientific Research

Promoting Sustainability at the Ports through Knowledge Sharing

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Abstract

Ports are a major source of economic activity and environmental pollution. They use a variety of equipment for loading/unloading and movement of cargo, such as marine vessels, cranes, trucks and railroads. These activities can cause large amounts of pollution to the air, water and soil media. Despite the pollution generated, it also serves as a medium for tourism with its cruise liners. This paper discusses port activities and how it effects the environment. The main focus of this paper is Knowledge Sharing for Sustainability of Ports. Sustainability indicators should help in evaluating port conditions and this knowledge sharing among the proposed 10 major world ports should accelerate economic growth and use of latest technologies for pollution reduction.

1. Introduction

A harbor area such as coastal areas, great lakes and inland river systems where ships load and unload are considered as a port. Ports provide shore side facilities for the transfer of cargo between ships, barges, railroads and trucks. They also have cruise terminals for passengers.

Ports and Its Economic Importance

In the coastal regions, Ports play a major role for economic growth. Port cities have always been at a higher position in the aspect of economic life for many centuries. More infrastructure, employment and associated services are required as the goods and passengers increase with time. This affects the local and regional economy and environment in many ways. Ports are a crucial connection between sea and land transportation. Ports also serve as a social function by providing jobs to people.

Ports provide benefit for international trade. More than 80% of cargoes are transported by sea. They serve as global entry point and source of growth with low trade costs for host ports. At the same time, there are some disadvantages associated with it like reducing the attractiveness of the city due to pollution, traffic and noise (OECD, 2014).

About one third of the total worth of global trade is done by the liner shipping industry which is the most effi-

cient way of goods' transport (WSC, 2014). "In one year, a single large containership might carry over 200,000 container loads of cargo. It would require hundreds of freight aircraft, many miles of railcars, and fleets of trucks to carry the goods that can fit on one large liner ship (WSC, 2014)." In the US (2007) port activity contributed more than $3.15 trillion to the Gross Domestic Product and 13.3 million port related jobs were generated (AAPA, 2014).

Table 1 lists the top 10 container ports of the world (on the basis of the total volume in 2011 and 2012) and **Table 2** lists the top 10 ports of the United States (on the basis of total tons in 2011).

2. Port Activities

The activities and operations carried out at any port depend largely on the type and volume of cargo being shipped. The *operations related activities* are the following:

1) Transportation
2) Cargo handling
3) Building/grounds maintenance
4) Chemical storage and handling
5) Fueling
6) Ship air emissions
7) Painting and paint stripping
8) Rail maintenance
9) Vehicle and equipment maintenance
10) Ship breaking, repair and maintenance

Considering the variety of processes carried by ports and the potential to consume a huge amount of energy and emit large quantities of multi-media pollutants (solid wastes, liquid wastes, and air pollutants), there is a great need for a knowledge-based system to manage environmental affairs of ports around the world. This is particularly important as the mismanagement of port activities and related emissions/waste discharges can impact the community in the immediate vicinity (AAPA, 2014).

2.1. Pollution from Port Operations

Enormous engines running on diesel fuel, diesel trucks, trains, cargo handling equipment, cranes and other equipment at ports cause a tremendous impact on the environment which could affect the health of workers and

Table 1. Top 10 ports in the world (World Shipping Council (WSC), 2013).

Rank	Port, Country	Volume 2012 (Million TEUs)	Volume 2011 (Million TEUs)
1	Shanghai, China	32.53	31.74
2	Singapore, Singapore	31.65	29.94
3	Hong Kong, China	23.1	24.38
4	Shenzhen, China	22.94	22.57
5	Busan, South Korea	17.04	16.18
6	Ningbo-Zhoushan, China	16.83	14.72
7	Guangzhou Harbor, China	14.74	14.42
8	Qingdao, China	14.5	13.02
9	Jebel Ali, Dubai, United Arab Emirates	13.3	13
10	Tianjin, China	12.3	11.59

Table 2. Top 10 ports in the United States (US Department of Transportation, Bureau of Transportation Statistics, 2013).

Ports	2011		2010		2001		Percent change 2010-2011	Percent change 2001-2011
	Rank	Total tons (Millions)	Rank	Total tons (Millions)	Rank	Total tons (Millions)		
South Louisiana, LA	1	246.5	1	236.3	1	212.6	4.3%	16.0%
Houston, TX	2	237.8	2	227.1	2	185.1	4.7%	28.5%
New York, NY and NJ	3	139.2	3	139.2	3	137.5	0.0%	1.2%
Long Beach, CA	4	80.3	5	75.4	8	67.6	6.4%	18.7%
New Orleans, LA	5	77.2	7	72.4	4	85.6	6.6%	-9.9%
Beaumont, TX	6	73.7	4	77.0	5	79.1	-4.3%	-6.9%
Corpus Christi, TX	7	70.5	6	73.7	6	77.6	-4.2%	-9.1%
Los Angeles, CA	8	65.0	8	62.4	14	51.4	4.2%	26.5%
Huntington-Tristate	9	58.6	9	61.5	7	76.7	-4.8%	-23.6%
Baton Rouge, LA	10	57.9	13	55.5	10	61.4	4.2%	-5.8%

local communities (NRDC, 2014). All the activities mentioned above may not be performed at every port; also each activity will not generate the same amount of pollution at every port. **Table 4** gives the pollutant information and their pathways for the sub activities mentioned in **Table 3** (Dunn et al., 2011).

2.2. Air Pollution

Major air pollutants from diesel engines at ports are particulate matter (PM), volatile organic compounds (VOCs), nitrogen oxides (NO_x), and sulfur oxides (SO_x). Percentage emissions of NO_x and PM_{10} from various Port activities are shown in **Figure 1**. In addition to these pollutants, there are other air pollutants like carbon monoxide (CO), formaldehyde, heavy metals, dioxins, and pesticides. These pollutants may cause asthma, other respiratory diseases, lung cancer, cardiovascular disease, and premature death. Therefore, reduction of pollutant emissions and improvement of air quality in the vicinity of ports is one of the major environmental concerns and needs to be managed (NRDC, 2014).

2.3. Water Pollution

Dirty water from ships may be directly dumped into the sea or leached into it, which affects the water quality and causes problems to the human health and to the life of marine species. It causes a decrease in oxygen level, accumulation of toxins in fish and degrading aquatic life. At the hull of a ship water gets contaminated with oil called as *Bilge*. It must be cleaned and emptied regularly to prevent contamination by hazardous vapors. Bilge along with other wastes from the ship poses a serious threat to aquatic life. Port water used by ships is called *Ballast* water, stored in tanks. Ballasting is important for cargo loading and unloading activities and improves stability. To prevent the growth of marine organisms on ships, antifouling additives are used in paints. These are mixed with paints and coated on ship surface, which are toxic in nature (NRDC, 2014). AFS Treaty prohibits the use of antifouling agents like organotins and tributyltin (TBT) given the fact that they are harmful to the marine environment (AAPA, 2014).

There are international and national regulations for vessel discharge which need to be followed accurately to prevent irreparable environmental damages.

3. Concept of Knowledge Sharing

The University of New Orleans (UNO) is using the Port of New Orleans as a case study to develop/propose a user friendly intelligent application to promote sustainability at ports. This will be achieved by team work which

Table 3. Typical processes and sub-activities at a typical port (AAPA, 1998).

| Major Process	Sub Activity Numbers[*]
CONSTRUCTION ACTIVITIES	
Building Demolition	D2, O5,O6, O7, O11, O12
Building Renovation	D1, D2, O5,O6, O7, O11, O12
Bulkhead Installation	D1, D3, O5,O6, O7, O9, O11, O12
Contamination Remediation	D1, O5,O6, O7, O11, O12
Dredge Material Disposal	O5,O6, O7, O9, O11, O12, O13, O14
Dredging	O5,O6, O7, O9, O11, O12, O13, O14
Landfilling	D1, O5,O6, O7, O11, O12
New Building Construction	D1, O5,O6, O7, O11, O12
Pavement Installation	D1, O5,O6, O7, O11, O12
Pavement Removal	D1, O5,O6, O7, O11, O12
Pier & Dock Construction	D1, D3, O5,O6, O7, O9, O11, O12
Site Clearing	D1, O5,O6, O7, O11, O12
Utility Construction	D1, O5,O6, O7, O11, O12
OPERATIONS ACTIVITIES	
Automobile Transport Operations	
- Offloading	O1, O2, O6, O11
- Storage	O1, O2, O6, O11, O12
Building and Grounds Maintenance/Landscaping	D1,D2, O2, O5, O6, O7, O8, O11, O12
Cargo Handling	
- Dry Bulk	O3, O14
- Liquid Bulk	O4,O5, O6, O14
- General Cargo	O3, O5, O14
- Containers	O3, O5, O14
- Breakbulk	O3, O5, O14
Chemical Storage and Handling	O4, O5, O6
Fueling	
- On-Loading	O4, O6
- Storage	O4, O6
- Off-Loading	O4, O6
Painting	
- Anti-Fouling-Building	O2, O5
- Service Vehicles	O2, O5
Paint Stripping	O2, O5, O13, O15
Public Access and Recreation	
- Cruise Lines	O5, O6, O7, O9, O10, O13, O14
- Fishing Piers	O5, O6, O7, O9, O10, O13, O14
- Moorings/Slips	O5, O6, O7, O9, O10, O13, O14
- Public Recreational Access	D1, O5, O6, O7, O9, O10, O13, O14
Rail Maintenance	D1, D2, D3, O2, O5, O6, O11, O12
Ship liquid discharges	
- Ballast Water	O5, O8, O9, O11, O13

Continued

- Tank Cleaning	O5, O8, O9, O11, O13
- Bilge Water	O5, O8, O9, O11, O13
- Sewage	O5, O8, O9, O11, O13
Solid Waste	
- Ship-Generated	O8, O9
- Shore-Generated	O8, O9
Vehicle and Equipment Maintenance	O5, O6, O7, O8, O10, O11, O12, O13
Vessel Repair and Maintenance	D2, O5, O6, O7, O8, O10, O11, O12, O13
Ship Breaking	D2, O5, O7, O8, O15

*Table 4 contains details of sub activity numbers.

Table 4. List of sub activities and potential pollutants (AAPA, 1998).

No.	Sub Activity Name	Potential Pollutants	Target Pathways
D1	Sediment and Erosion Control	Sediments, Dust	Surface water, Air
D2	Buildings Renovation and Demolition	Asbestos, Lead, Dust, Sediments, Petroleum Hydrocarbons, PCBs	Surface water, Air, Soil, Groundwater
D3	Bulkhead, Pier, and Dock Construction	Sediments	Surface water
O1	Automobile Storage and Transport	Oil, Grease, Sediments, Soaps, Combustion By-Products	Air, Surface water
O2	Building and Grounds Maintenance	Pesticides/Herbicides/Fertilizers, Oil and Grease, Sediments	Groundwater, Surface water, Air, Soil
O3	Bulk Storage and Handling—Dry	Dust, Sediment, Metals, Hydrocarbons, Salts	Surface water, Air, Soil
O4	Bulk Storage and Handling—Liquid	Oil and Grease, Fuels, Organic Chemicals, Inorganic Chemicals	Air, Surface water, Groundwater, Soil
O5	Chemical Storage and Handling—Non Bulk	Organic Chemicals, Inorganic Chemicals, Metal, Oil and Grease	Surface water, Air, Groundwater, Soil
O6	Fueling	Petroleum Hydrocarbons	Groundwater, Surface water, Air
O7	Vessel and Equipment Painting and Paint Stripping	Paints, Solvents/Hydrocarbons, Metals, Solids	Surface water, Soil, Air
O8	Ship and Shore generated Solid Waste Handling	Oils and Grease, Petroleum Hydrocarbons, Metals, Solvents, Paints	Surface water, Soil
O9	Protection of Marine Mammals and Sensitive Aquatic Habitats		
O10	Public Access and Recreation	Solvents, Petroleum Hydrocarbons, Metals, Solid Waste	Surface water
O11	Vehicle and Equipment Maintenance	Oils and Grease, Petroleum Hydrocarbons, Coolants, Solvents	Surface water, Air, Soil
O12	Vehicle and Equipment Washing	Oils and Grease, Petroleum Hydrocarbons, Surfactants/soaps	Surface water
O13	Vessel Repair and Maintenance	Oils and Grease, Paints, Solvents, Fuels, Sediments	Surface water, Air
O14	Ship Air Emissions	NO_x, SO_2, Particulates, HAPs	Air
O15	Ship Breaking	Oils and Grease, Heavy Metals, Suspended Solids, PCBs, Asbestos	Surface water, Soils, Air
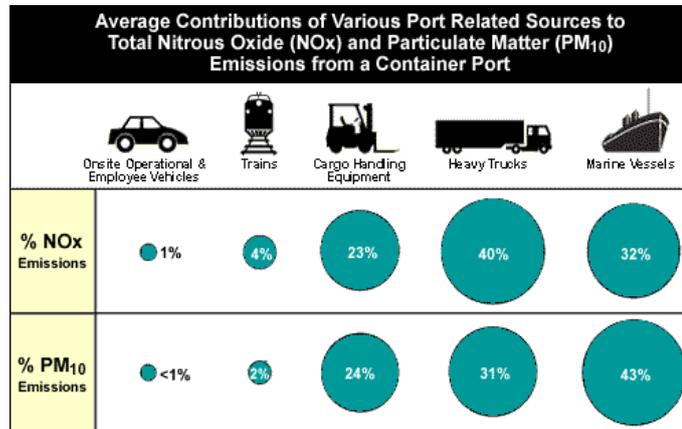
Figure 1. NO$_x$ and PM$_{10}$ emissions from various port related activities.

includes Civil & Environmental Engineering graduate students, faculty, Computer Science students, and the personnel of the Port of New Orleans. The results and products of this research and application can be applied to all ports to improve and manage environmental quality in our surroundings in a better way. **Figure 2** depicts the concept of this research.

4. Methodology of Building a Knowledge-Based (KB) System for Promoting Sustainability at Ports

Process being used by UNO Researchers to quantify the pollution load from the ports and create a knowledge-base for promoting sustainability:
- Collaborate with the Port of New Orleans to understand the processes in detail.
- Benchmark pollution loads (multimedia pollutants (air, water, solid).
- Identify sustainability indicators important for the Ports.
- Calculate the real time values for the identified indicators for The Port of New Orleans.
- Survey ten major ports to understand the indicators for other ports using the online system.
- Design and develop knowledge-sharing methodology to improve performance of participating ports.

Different environmental indicators should be considered for ports sustainability such as energy consumption, water consumption and discharge from vessels, sanitary wastewater from cruise liners and offices, solid and hazardous wastes, air pollution, diesel power, fueling, painting, and welding. Other indicators like employment potential, secondary economic impacts and tertiary economic impacts will be considered as cost indicators which have a critical role for managing and quality improvement. The UNO application or knowledge-based system will use data from participating ports on a 5 - 10 year scale in computing indicators in useful units. For instance, energy consumption can be calculated as Energy used/100,000 tons of cargo, Energy used/100,000 barrels of crude, or Energy used/1000 ft^2 of the building space (office or warehouse). In the same way, other indicators can be calculated and analyzed. In addition, UNO application aims to adopt EPA and international regulations/guidelines to evaluate participating Ports and provide rational recommendations that are environmentally—sensible, economically-viable, and socially-responsible.

Authors believe that the proposed Knowledge-Based (KB) System (Web-Based) can be accessed by the consortium of ports under the leadership of MERIC, which will promote "sustainability" by reducing pollution load, increasing profitability, and improving social relevance.

5. Conclusion

Every country has its national and international sector of transportation, in which a major role is played by ocean-going and inland waterways. They are classified as cargo and passenger vessels. As mentioned in this paper, Ports have potential to produce large amounts of pollution. The amount of pollution can be a function of the amount of fuel consumed; work done, quantity of materials handled, types of materials handled, design of the Port and its logistics, Port equipment, and more. Different ports around the world have various technologies,
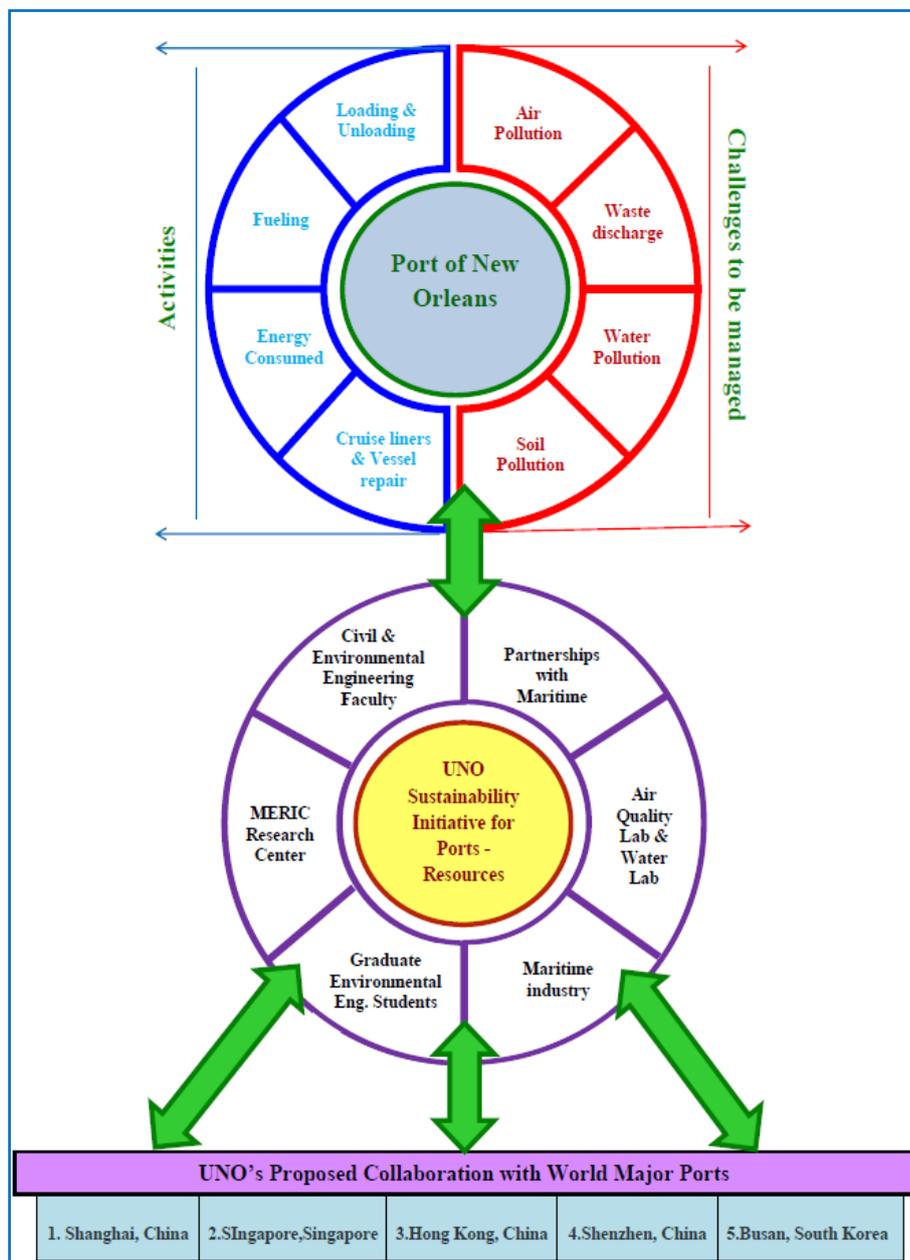
Figure 2. Knowledge sharing using KB system for promoting sustainability at ports.

equipment and logistics for their day-to-day operations and pollution control. The goal of this project is to combine the knowledge available at MERIC-UNO and the World Ports on a single platform, like a web-based application (KB System) which will be accessible to users to implement technologies and strategies to reach the goals of sustainability in an efficient manner. This is achieved by identification of sustainability indicators for ports and benchmarking them. The study will use and compare these indicators with other major ports in the world to attain sustainability through knowledge-sharing to promote growth. The KB System to be developed is aimed to improve Port performance, reduce costs, improve profitability, and protect the public health & the environment.

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