Study on pollutant emission inventory of port

Xu Guo 1*, Da Xu 2

1Key Laboratory of Environmental Protection in Water Transport Engineering Ministry of Communications, Tianjin Research Institute of Water Transport Engineering, Tianjin 300456, China
2Ningbo Zhoushan Port Group co. Ltd
*Corresponding author’s e-mail: 18630836305@163.com

Abstract. With the frequent exchanges of Global trade, ports play an increasingly important role in economic development. However, the environmental problems caused by the port are also increasing. As the most basic, comprehensive and practical information, emission inventory is the premise of scientifically formulating and improving the control measures and policies of pollutants from ships and ports. In this study, some terminals in coastal ports are taken as an example to provide technical support for port pollutant emission estimation and pollution control by compiling pollutant emission inventory.

1. Introduction
With the frequent exchanges of Global trade, ports play an increasingly important role in economic development. However, the environmental problems caused by the port are also increasing. As the most basic, comprehensive and practical information, emission inventory is the premise of scientifically formulating and improving the control measures and policies of pollutants from ships and ports.

At present, China's air pollutant emission control work is still in its infancy, many problems have not been solved reasonably, and the basic work related to the air pollutant emission of port area needs to be carried out urgently [1-8].

2. Research status of emission inventory
The quantitative estimation methods of pollutant emission inventory mainly include material balance method, actual measurement method, model estimation method and emission factor method. The emission factor method is the most widely used method because it is easy to obtain data, which is suitable for the estimation of regional pollution source inventory without local measurement, and relatively saves manpower and material resources.

The work of emission source inventory estimation in foreign countries is earlier and more perfect. Among them, the U.S. Environmental Protection Agency (U.S. EPA) began to study the emission factors of pollutants since the 1960s. After years of testing the emission factors, it summarized and released the AP-42 Manual of air pollutant emission factors, which is also the most widely used emission factor database in the world.

The development of emission inventories in Europe is mainly carried out through intergovernmental cooperation. The European Environment Agency (EEA) has carried out a lot of emission factor tests. On this basis, it organized the compilation of inventory development guidelines in 2009, and constantly updated and improved them.
The National Environmental Research Institute of Japan has developed a new 1980-2020 emission inventory for Asia (regional emission inventory for Asia Version 1.1). Reas inherits the historical, present and future pollutant emission data, and provides the emission in 2000, the historical emission in 1980-2003 and the expected emission in 2010-2020, involving NOx, SO2, etc. of fuel combustion and industrial sources, and establishes a spatial grid for the emission of these pollutants.

3. Compilation of Air Pollutant Inventory of port non road mobile sources

3.1. Introduction of compilation method

According to the technical guide for compiling the emission inventory of air pollutants from non road mobile sources, three methods can be used in view of the different levels of available activities. Users can choose the appropriate method based on the relevant information of emission sources. The accuracy of the three methods from high to low is method 3, method 2 and method 1.

3.1.1. Method 1

The calculation formula of air pollutant emission of non road mobile machinery is as follows

\[ E = (Y \times EF) \times 10^{-6} \]  

*E*: Emissions of CO, HC, NOx, PM2.5 and PM10 in tons;  
*Y*: the fuel consumption, in kg;  
*EF*: the emission factor, in g / kg fuel.

3.1.2. Method 2

The calculation formula of air pollutant emission from transport vehicles is as follows

\[ E = \sum_j \sum_k (P_{j,k} \times EF_{j,k} \times M_{j,k}) \times 10^{-6} \]  

*E*: The emissions of CO, HC, NOx, PM2.5 and PM10 of transport vehicles, in tons;  
*j*: K is the emission stage;  
*P*: the number of vehicles, and the unit is vehicles;  
*EF*: pollutant emission coefficient, unit: g / km;  
*M*: Annual average mileage, unit: km / (vehicle / year).

For other non road mobile machinery emissions, the calculation formula of air pollutant emissions is as follows:

\[ E = \sum_j \sum_k \sum_n (Y_{j,k,n} \times EF_{j,k,n}) \times 10^{-6} \]  

*E*: Emissions of CO, HC, NOx, PM2.5 and PM10 from non road mobile machinery, in tons;  
*j*: Category of non road mobile machinery;  
*k*: Emission stage;  
*n*: Fuel consumption in kg;  
*EF*: emission factor, unit: g / kg fuel.

3.1.3. Method 3

For the vehicle emissions, the calculation formula of air pollutant emissions is the same as method; For other non road mobile machinery emissions, the calculation formula of air pollutant emissions is as follows:

\[ E = \sum_j \sum_k \sum_n (P_{j,k,n} \times G_{j,k,n} \times LF_{j,k,n} \times EF_{j,k,n} \times hr_{j,k,n}) \times 10^{-6} \]  

*E*: Emissions of CO, HC, NOx, PM2.5 and PM10 from non road mobile machinery, in tons;  
*j*: Category of non road mobile machinery;  
*K*: the emission stage;  
*N*: the power section;  
*P*: The unit is vehicle;  
*G*: Average rated net power, unit: kW / set;
LF: the load factor;
HR: annual service hours, in hours;
EF: pollutant emission coefficient, unit: g / kWh.

4. Air pollutant emission inventory of port and wharf

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used.

4.1. Style and spacing

Due to the limitation of activity level data statistics, this paper uses mode 1 to compile the pollutant emission inventory. According to the survey data of some terminals in a coastal port, the emission inventory is obtained as follows:

| Wharf A | 3.40 | 3.40 | 5.51 | 53.30 | 17.42 | 1.14 |
|---------|------|------|------|-------|-------|------|
| Wharf B | 3.71 | 3.71 | 6.02 | 58.26 | 19.05 | 1.24 |
| Wharf C | 10.28| 10.28| 16.68| 161.32| 52.74 | 3.44 |
| Wharf D | 5.21 | 5.21 | 8.44 | 81.68 | 26.70 | 1.74 |

The specific conditions of each wharf are as follows as follows:

| Equipment name | PM<sub>10</sub> | PM<sub>2.5</sub> | HC | NO<sub>x</sub> | CO | SO<sub>2</sub> |
|----------------|----------------|----------------|----|-------------|----|------------|
| Gantry crane   | 1.91           | 1.91           | 3.10| 29.94      | 9.79| 0.64       |
| Forklift       | 0.07           | 0.07           | 0.12| 1.17       | 0.38| 0.02       |
| Frontal crane  | 0.15           | 0.15           | 0.24| 2.33       | 0.76| 0.05       |
| Stacker        | 1.27           | 1.27           | 2.05| 19.85      | 6.49| 0.42       |

| Equipment name | PM<sub>10</sub> | PM<sub>2.5</sub> | HC | NO<sub>x</sub> | CO | SO<sub>2</sub> |
|----------------|----------------|----------------|----|-------------|----|------------|
| Gantry crane   | 2.50           | 2.50           | 4.05| 39.21      | 12.82| 0.84     |
| Forklift       | 0.06           | 0.06           | 0.10| 0.97       | 0.32| 0.02      |
| Frontal crane  | 0.12           | 0.12           | 0.20| 1.94       | 0.64| 0.04      |
| Stacker        | 1.03           | 1.03           | 1.67| 16.14      | 5.28| 0.34      |

| Equipment name | PM<sub>10</sub> | PM<sub>2.5</sub> | HC | NO<sub>x</sub> | CO | SO<sub>2</sub> |
|----------------|----------------|----------------|----|-------------|----|------------|
| Gantry crane   | 5.73           | 5.73           | 9.29| 89.88      | 29.38| 1.92    |
| Forklift       | 0.23           | 0.23           | 0.37| 3.58       | 1.17| 0.08     |
Frontal crane & 0.46 & 0.46 & 0.74 & 7.16 & 2.34 & 0.15 \\
stacker & 3.87 & 3.87 & 6.27 & 60.69 & 19.84 & 1.30 \\

Table 5. Pollutant discharge list of Wharf D (unit: ton)

| Equipment name     | PM$_{10}$ | PM$_{2.5}$ | HC   | NO$_x$ | CO   | SO$_2$ |
|--------------------|-----------|------------|------|--------|------|--------|
| Gantry crane       | 1.37      | 1.37       | 2.22 | 21.45  | 7.01 | 0.46   |
| Forklift           | 0.05      | 0.05       | 0.09 | 0.83   | 0.27 | 0.02   |
| Frontal crane      | 0.11      | 0.11       | 0.18 | 1.77   | 0.58 | 0.04   |
| Stacker            | 0.98      | 0.98       | 1.59 | 15.42  | 5.04 | 0.33   |

5. Conclusion
In this study, some terminals in coastal ports are taken as an example to provide technical support for port pollutant emission estimation and pollution control by compiling pollutant emission inventory.

References
[1] Liu L L etc, Study on methodology of voluntary emission reduction of greenhouse gases from shore power projects (journal of waterway and harbor), 445-449, 2019,40(4).
[2] Guo X etc, Research on construction technology of energy consumption onlinemonitoring system for port energy equipment. (journal of waterway and harbor), 746-752,2018,39(6).
[3] Guo X, Improved multifractal algorithm based on image gray value distribution and its application in oil spill monitoring. (journal of waterway and harbor), 619-624,2020,41(5).
[4] Wang q, Liu X J Yan C J, Emergency material dispatch in the early stage of emergency response to oil spill [J]. Journal of Shanghai Maritime University, 2019,40 (4): 27-32
[5] Ma Q J,Liu X. Countermeasures for the development of China's voluntary carbon emission reduction market(economic review) 58-61,2011,(11).
[6] WANG C Y etc, Components of regional emergency linkage system for ship pollution accidents, (journal of waterway and harbor), 340-346,2020,41(3).
[7] XIONG H X etc. Enlightenments of Tokyo bay revitalization action plan (2003 ～2012) in Janpan to Bohai bay in China. (journal of waterway and harbor) 119-124 ,2020,41(1).
[8] Lin Y, Comparison and reference between domestic and foreign green port evaluation systems. (journal of waterway and harbor), 613-618,2020,41(5).