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Air Emission Inventory

Ho Quoc Bang and Vu Hoang Ngoc Khue

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Abstract

Emission inventory (EI) is a comprehensive listing of pollutants from all sources in a geographical area during a period of time. The development of EI database is very important to air quality management and helps us to find out main sources. In general, to develop a reliable EI for one specific area, the following steps are involved: (i) list the types of sources, (ii) determine the types of air pollutant emission from each of the listed sources, (iii) find out the emission factor (EF) for each of the concerned pollutants, (iv) determine the number and size of specific sources in the area, and (v) multiply the appropriate numbers from step (iii) and (iv) to obtain the total emissions and then sum up the similar emissions to obtain the total for the area. With emission inventory, we can define the main sources in the study area and have the best solution for clean air action. Besides, the result from EIs can be used to study in other sectors related to human health, economic loss from air pollution, etc. This chapter will describe the method for development of an air emission inventory for developing and developed countries.

Keywords: air emission inventory, Can Tho City, point sources, line sources, area sources, air quality management

1. Introduction

In general, air pollutants are defined as substances in the atmosphere, resulting from the activity of humans or from natural processes, causing harm to humans, plants, or animal lives, or damage to man-made materials and structures, or changes in the weather and climate, or interfering with the comfortable enjoyment of life or other human activities (Elsom, 1987).

There are six common air pollutants (criteria pollutants) which are commonly found in air anywhere. These main pollutants should be included in the emission inventory (EI): TSP

(PM₁₀ and PM_{2.5}), NO_x (the sum of NO and NO₂), SO₂, and CO. Other pollutants as VOC and CO₂ will be considered based on the characteristic of the study area and the aim of EI.

2. Design of an emission inventory

2.1. Defined sources

Normally, air emission sources are divided into three main categories: area source, point source, and line source. Each source includes many subcategories based on its distributed characteristic, which was shown in detail in **Figure 1**.

2.1.1. Point sources

Point sources are stationary sources that are typically large manufacturing or production plants that include confined, chimney or stack emission points. Within a given point source, there may be several units of combustion, such as several boilers. The point sources can be hospital incinerators, hospital boilers, hotel boilers, crematorium, and industries.

2.1.2. Area sources

Area sources are defined as sources that are too small and/or too numerous to be considered as point sources (US EPA, 1996). In aggregate, these sources may contribute a significant proportion of the total airshed emissions. Area sources include a wide range of sources, such as residential cooking facilities, rice straw/biomass burning, gas stations, construction activities, printing facilities, auto repair facilities, paint spraying facilities, and so on. They are presented as an area on the map.

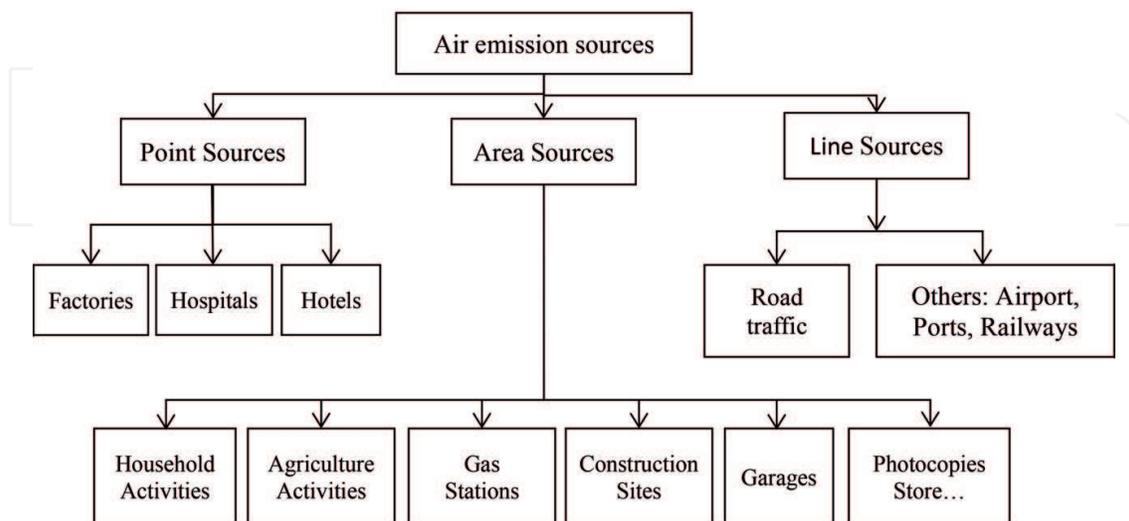


Figure 1. Air emission sources.

2.1.3. Line sources (*mobile sources*)

Line sources, also considered as mobile sources, are vehicles, engines, and equipment that generate air pollution and that move or can be moved from place to place. Mobile sources are classified under two smaller sources: on-road and non-road sources. On-road sources include vehicles used on roads for transportation of passengers or freight, such as passenger cars, trucks, and motorcycles that may be fueled with gasoline, diesel fuel, or alternative fuels, such as alcohol or natural gas. Non-road sources include gasoline and diesel powered vehicles, engines, and equipment used for construction, agriculture, transportation, recreation, and many other purposes. For example, non-road sources include marine vessels, aircrafts, railways, tractors, etc. They are presented as line shape on the map.

2.2. Emission inventory methods

2.2.1. Point sources

The aim of point source emission inventory is to give a comprehensive table sheet of sources, their characteristics, and annual emissions. A source which is large enough and contributes a huge amount of emissions can be considered as a point source, such as the hospital boilers, crematoriums, factory's chimneys, hotel boilers, etc. So the first step is to identify all sources in the study area and classify them into categories based on product characterization and combustion process. The list of these sources and emission data can be provided from local Province Officer and Department of Industry. For estimating emission, further process information from each source type needs to be provided directly from questionnaire or inspection. These data are specific for each category and also used for defining activity data, air emission process, and for input of dispersion model. The data normally require: factory type, size, geographical position (coordinates), number of employees, type of industrial activity: what is produced, combustion activities characterized by firing configuration, operating conditions, fuel specification, fuel consumption, raw material used in industrial/manufacturing process, storage of raw material, equipment age, height of stacks (and if available: inner diameter, volume flow in m³/operating hour), hours of operation per year/season, air pollution abatement equipment, and continuous emission monitoring.

Example questionnaire for point source is shown in Appendix A

The emissions for each source category are calculated using Eq. (1) and emission factors. Due to the lack of data monitoring from factories, emission factors are adopted. They can be taken from these following sources, appropriate for production type and process:

- EMEP/EEA Emission Inventory Guidebook (CORINAIR): this technical guidance is for preparation of national emission inventories. The joint European Monitoring and Evaluation Programme/European Environment Agency (EMEP/EEA) air pollutant emission inventory guidebook supports the reporting of emission data under the United Nations Economic Commission for Europe (UNECE) Convention on Long-range trans boundary Air Pollution (CLRTAP) and the European Union National Emission Ceilings Directive. It provides

expert guidance on how to compile an atmospheric emission inventory. The guidebook is published by the EEA with the CLRTAP Task Force on Emission Inventories and Projections responsible for the technical content of the chapters. This guidebook was most recently revised in December 2013, providing a completed emission inventory process. It also contains emission factors for many pollutants, as well as information on emissions from natural and organic sources. It can be accessed at <http://www.eea.europa.eu/publications/emep-eea-guidebook-2013>.

- United States Environmental Protection Agency—Compilation of Air Pollutant Emission Factors (US EPA—AP 42): originally serving the medical public in the United States (US) in 1968, this includes many basic emission factors. The most recent edition was released in January 1995 and has been supplemented since then. Since December 2005, US EPA has given users the opportunity to search and use the latest emission factors on the internet, supporting incorporation of almost any source into EIs. This allows the user to search for the latest and best emission factors for most point and area source categories, including a rating on the quality of the particular emission factor. It can be accessed at <http://cfpub.epa.gov/oarweb/index.cfm?action=fire.main>.
- Intergovernmental Panel on Climate Change (IPCC) 2006—Greenhouse Gases Emission Inventory Guidebook: This guides people to estimate greenhouse gas (GHG) emissions as CO₂ equivalent. IPCC can be used to take emission factors from other combustion activities [2]. The information can be accessed online. The emission factor, which is taken from this guide, should be explained and clearly stated in the report.

2.2.2. Area sources

Area sources are similar to point sources, including small sources with insignificant emissions, evenly distributed in a wide range area. The aggregation of all these sources contributes a considerable emission to air quality. For distributing on the map, emissions from these sources are estimated by each grid cell.

In the beginning, a list of all sources and their information are collected from related local Province Office or other related Departments, as well as the data of inhabitants, the number of households, and the density rate in each ward. These data are used for calculating emission from common sources distributed evenly, such as household cooking, using a top-down approach by which the total emissions for the whole region are calculated, and then they are distributed by each grid cell according to the number of households and the density rate. Sources with the same characteristic are classified under a category, and an appropriate emission estimation method is chosen depending on the source characteristic and the data available. The total emissions of one grid include the emission from household activities and from other sources.

Source categories are different depending on the feature of the study area, and some common categories for cities in developing countries are: biomass (straw) burning, solid waste open burning, household cooking, smoke for meat and fish curing, gas stations, construction, concrete mixing, garages, commercial/consumer solvent used, and graphic arts.

Normally, within one source category (k), combustion technology and fuel type used are similar so that generalized emission factor and fuel consumption rate (or number of source category k) can be used for estimating emission as in Eq. (1). So the main data collected from survey is fuel consumptions, fuel type, and source type that are included in questionnaires for area sources shown in Appendix A. Though several source categories such as photocopies and gas station emissions are not from combustion but from evaporative VOCs, they are also calculated by using this equation with appropriated emission factors.

$$E_{k,i} = A_k \times EF_{k,i} \quad (1)$$

where

$E_{k,i}$ = total emission from pollutant i in source category k in selected grid cell,

A_k = activity rate: that is, the amount of fuel burnt of source category k in the selected grid cell or surrogate data, and

$EF_{k,i}$ = appropriate average emission factor for pollutant i for source category k.

Emission factors for these sources are taken from USEPA, EMEP/EEA Emission Inventory Guidebook or from studies in the local university.

2.2.3. Line sources (mobile sources)

Line (mobile) sources include on-road sources and non-road sources. On-road sources are the emission from traffic which is distributed all around the area, directly affect human health. It is also the main contributor for this source type due to the huge number of vehicles. Non-road sources are emission from harbors, airports, and railways.

The emission from mobile sources can be estimated based on the fuel consumption in the study area and the average emission factor, with Eq. (2). Vehicle categories to be considered are motorcycles, passenger cars, light duty vehicles, heavy duty vehicles, and busses/coaches in which fuel includes gasoline, diesel, liquid petroleum gas (LPG), and natural gas if available. This method is a top-down approach which is suitable for estimating emission in a huge area. However, top-down approach is high level of uncertainty.

$$E = \sum_{i=1}^n (F C_i \times EF) \quad (2)$$

where

E: total emissions (include emission from each pollutant from each vehicle category and fuel type),

FC_i : fuel consumption (for each vehicle category and each fuel type), and

EF: fuel consumption—specific emission factor (for each pollutant and vehicle category and fuel).

For a more detailed approach, subdivided emission into hot emission, cold-start emission, and extra emission as in Eq. (3) can be applied. Generally, the total emissions are the sum of hot emissions (the emissions when a vehicle is running, with the engine thermally stabilized), cold emissions (the emissions when a vehicle is running, during engine warm-up), and evaporative emissions (the emissions from fuel due to the difference between the temperature of engine and ambient temperature). The equation for total emissions is shown below:

$$E_{\text{total}} = E_{\text{hot}} + E_{\text{cold}} + E_{\text{extra}} \quad (3)$$

where

E_{total} : total emissions of pollutant i ,

E_{hot} : hot emissions,

E_{cold} : cold emissions, and

E_{extra} : evaporation emissions, tyre, and brake wear.

Hot emissions of pollutant i are calculated by the equation below:

$$E_{(\text{hot},i,k,T)} = N_k \times L_{(a,T)} \times e_{(h,i,k,T)} \quad (4)$$

where

$E_{(\text{hot},i,k,T)}$: hot exhausted emissions of pollutant i , produced in the relevant period by vehicles of technology k driven according to traffic situation T (g),

N_k : number of vehicles (veh) of technology k in operation in the period concerned,

$L_{(a,T)}$: length of street section a (in km) with traffic situation T (km), and

$e_{(\text{hot},i,k,T)}$: emission factor in (g/km) for pollutant i , relevant to the vehicle technology k , operated in traffic situation T .

Cold-start emissions are calculated as extra emissions and usually have a small amount compared with hot emissions. Especially in tropical countries with high temperature all year, cold-start emissions are negligible. Eq. (5) is used to calculate cold-start emissions.

$$E_{(\text{cold},i,i)} = \beta_{i,k} \times N_k \times M_k \times e_{\text{hot},i,k} \times (e^{\text{cold}}/e^{\text{hot}}|_{i,k} - 1) \quad (5)$$

where

$E_{(\text{cold},i,i)}$: cold-start emissions of pollutant i , produced by vehicles category j and technology k ,

$\beta_{i,k}$: fraction of mileage driven with a cold engine or the catalyst operated below the light-off temperature for pollutant i and vehicle technology k . β depends upon the ambient temperature,

N_k : number of vehicles of technology k in circulation,

M_k : total mileage per vehicle in vehicle technology k , and

$e^{\text{cold}}/e^{\text{hot}}|_{i,k}$: cold/hot emission quotient for pollutant i and vehicle technology k .

Evaporation emissions generated by gasoline vehicle are the result of the increase in ambient temperature during the daylight hours and the expansion of the fuel and vapor in the tank. Evaporation emissions are estimated as in Eq. (6).

$$E_{\text{VOC}} = \sum_j N_j \times EF_{\text{VOC},j} \times 365 \quad (6)$$

where

E_{VOC} : emission of VOC (g/year),

N_j : number of vehicles in category j ,

$EF_{\text{VOC},j}$: emission factor of VOC for vehicle in category j (g/veh/day),

j : vehicle category, and

365: number of days per year.

Emissions from tyre and brake wear also considered estimating since they contribute a significant amount of particulate matter (PM), especially those from motorcycles. These are considered as extra emissions and causes from friction between the tyre and the road surface when the vehicle is running. There are many calculation methods for this estimation since it is not complicated and requires simply data, for example, the estimation using Tier 1 emission factors from CORINAIR requires the data of the kilometers the vehicle which has annually traveled in the study area, as in Eq. (7).

$$TE = \sum_{j=1}^n (N_j \times M \times EF) \quad (7)$$

where

TE: total emissions of PM for the defined time period and spatial boundary (g),

N_j : number of vehicle in category j within the define time period,

M : average mileage driven per vehicle in category j during the defined time period (km), and

EF : mass emission factor for pollutant i and vehicle category j (g/km).

Emission factors can be found in emission factor handbooks and research papers such as CORINAIR, EMEP, AP-42, etc. EFs of pollutants depend not only on the generation processes but also on pollution control systems that have been applied. Most of the traffic emission models are intergraded emission factor database with clear reference, and it can also be modified by the user in accordance with the study area.

In general, for urban traffic emission estimation, an emission model is adopted since it can handle a lot of complicated data and consider different fleet compositions and driving conditions in different streets and integrated emission factor database. The advantages of emission models are the time saved, the availability of many estimating options, and the reduction of the calculating uncertainty. There are several emission models available, like COPERT,

MOBILE-5, MOVES, IVE, MOBILEV, EMISENS, etc., but not all emission models are appropriate for calculating traffic emission in single street levels with different traffic situations. Most models were developed for calculations on national or regional level and use, therefore, more aggregated emission factors. An emission model used for an emission inventory on an urban scale with high spatial resolution should fulfill at least the following criteria: highly differentiated emission factor database, a broad selection of street types and traffic situations, an internal module to calculate cold start emissions, a representative and appropriate fleet composition by subsegments for each vehicle category, appropriate default fuel quality parameters, a module to calculate fuel consumption caused by air condition, access to default values in case adoptions are necessary, a user-friendly interface, a user-friendly data input tool, and a comprehensive description of the model.

Input data for emission models usually require the following information which is collected from surveys, previous researches, analysis and observation from the study area: defining main street network/defining road categories, length and width of road, number of lanes, speed limit for each road type/category, define vehicle type/category, average daily traffic, vehicle fleet/composition, vehicle registration database, and vehicle engine type, capacity, emission stage, fuel use, weight, and vehicle traffic curve.

2.2.4. Non-road sources

Non-road sources include gasoline and diesel powered vehicles, engines, and equipment used for construction, agriculture, transportation, recreation, and many other purposes. For example, non-road sources include marine vessels, aircrafts, railways, tractors, etc.

2.2.5. Emission from seaport

There are many different approaches to develop an emission inventory for ports. They vary significantly according to the availability of time, money, and effort. For example, a detailed inventory approach requires detailed data on vessels and land-based equipment characteristics and activities, as well as detailed information on port geography and ship paths within the port. This is the best practice for all ports; however, its applications are limited with available resources. Meanwhile, the streamlined inventory approach requires less input data. The methodology can be tailored to the amount of data available. In some cases, the emission inventory can be developed using extrapolation data.

To calculate air emissions in the port, a streamlined air emission inventory approach was used following US EPA guidelines [3].

2.2.5.1. Ocean going vessels (OGVs)

The available data for some ports in developing countries are not sufficient to develop a detailed inventory by calculating emissions from each vessel. The US EPA guidance [3] proposes a mid-tier approach for calculating air emissions in ports and allows us to calculate emissions from each category using a single representative vessel specification and operating pattern, rather than calculating emissions from every different vessel call. In this case, a detailed or mid-tier approach was selected based on the available data.

Emissions were then calculated using Eq. (8):

$$E = P \times LF \times A \times EF \quad (8)$$

where

E = emissions (g),

P = maximum continuous power rating (kW),

LF = load factor (%),

A = activity (hours), and

EF = emission factor (g/kWh). Emission factors were taken from US EPA [3].

Main engine load factors were calculated using Eq. (9):

$$LF = (AS/MS)^3 \quad (9)$$

where

LF = load factor (%),

AS = actual speed (knots), and

MS = maximum speed (knots).

2.2.5.2. Cargo-handling equipment (CHE)

Emissions were calculated for each category using Eq. (10):

$$E = N \times P \times LF \times A \times EF \quad (10)$$

where

E = emissions (g),

N = number of items,

P = maximum continuous power rating (kW),

LF = load factor (%),

A = activity (hours), and

EF = emission factor (g/kWh).

2.2.6. Emission from airport

Emissions from this type of sources are often overlooked since it is not a typical source. For estimating emission, the following data are required:

- Fuel consumption for each flight phases (landing and taking-off (LTO), cruise phase...)
- Emission factor for each flight phases and aircraft type

- Type of aircraft available
- Number of landing and taking off for domestic aviation and international aviation per aircraft type

Basically, emissions are calculated from aircraft type, fuel type used, and emission factor related. Based on the data available, a simple or detail approach can be applied. Typically, Tier 2 approach from EMEP/EEA emission inventory guidebook 2013 is applied as in Eq. (11) since there are no sufficient data for higher tier. Related emission factors are also taken from this document.

$$E_{\text{pollutant}} = \sum_{\text{aircraft types}} \left(AR_{\text{fuel consumption, aircraft type}} \times EF_{\text{pollutant, aircraft type}} \right) \quad (11)$$

where

$E_{\text{pollutant}}$: annual emission of pollutant for each of the LTO and cruise phases of domestic and international flights,

$AR_{\text{fuel consumption, aircraft type}}$: activity rate by fuel consumption for each of the flight phases and trip types, for each aircraft type, and

$EF_{\text{pollutant, aircraft type}}$: emission factor of pollutant for the respective flight phase and trip type, for each aircraft type.

Calculation steps for this approach are as the following:

- Obtain the total amount of fuel sold for all aviation (in ktonnes).
- Obtain the total amount of fuel used for domestic aviation (in ktonnes).
- Calculate the amount of fuel used for international aviation by subtracting the domestic aviation (step 2) from the total fuel sold (step 1) (in ktonnes).
- Obtain the total number of landing and taking off carried out per aircraft type for domestic aviation.
- Calculate the fuel use for landing and taking off activities per aircraft type for domestic aviation.
- Calculate the total fuel use for domestic cruise by subtracting the total amount of fuel for LTO activities found in step 6 from the total in step 2.
- Estimate the emissions from domestic LTO activities per aircraft type. The number of landing and taking off for each aircraft type is multiplied by the emission factor related to the particular aircraft type and pollutant.
- Estimate the emission from domestic cruise activities. Use the domestic cruise fuel use and the corresponding emission factor for the most common aircraft type used for domestic cruise activities.
- Calculate the total emission for landing and taking off activities for domestic aviation.

- Calculate the total emission for cruise activities for domestic aviation.
- Do the same for calculating for international aviation.

Data on the aircraft types and the number of flights were collected directly from the airport and from the Department of Transportation (DOT).

2.2.7. Emission from railway

Emissions from railway are mainly from locomotives which generally are one of the three types: diesel, electric, or steam. Like other sources, emissions are the product of fuel combustion with CO, NO_x, SO₂, PM, hydrocarbons, and other heavy metals. According to EMEP/EEA, the locomotives fall into three categories: shunting locomotives—used for shunting wagons whose power output is typically in the range of 200–2000 kW, railcars—used for short distance rail traction with power output about 150–1000 kW, and line haul locomotives—used for long distance rail traction both for freight and passengers with power output around 400–4000 kW.

The methodology to estimate the emission for railway is from the total fuel type used and related emission factors as in Eq. (12) as follows:

$$E_i = \sum_m \sum_j (FC_{j,m} \times EF_{i,j,m}) \quad (12)$$

where

E_i : emission of pollutant i for the period concerned in the inventory (kg or g),

$FC_{j,m}$: fuel consumption of fuel type m used by category j for the period and area considered (tonnes),

$EF_{i,j,m}$: emission factor of pollutant i for each unit of fuel type m used by category j (kg/tonnes),

m : fuel type (diesel and gas oil), and

j : locomotive category (shunting, rail-car, and line haul).

2.3. Case study

2.3.1. Can Tho City

2.3.1.1. Overview

In this section, the process to apply the above theory for conducting an air emission inventory Can Tho City (CTC) is described. The emission inventory includes basic information about the dispersion of air pollutants, such as location, sources, and emission rates. The emission inventory assessment is necessary because it helps businesses implement effective policies to control their emissions, while it also helps the administration assess the current emissions and construct air quality management strategies in the future.

Can Tho is the fourth largest city in Vietnam and the largest city in the Mekong Delta. It is noted for its floating market, rice paper-making village, and picturesque rural canals. In 2013, in an area of 140,894.9 ha, the city had 1,232,260 inhabitants. Can Tho city is located on the south bank of the Hau River, a branch of the Mekong River. The city is located at N 9055'08"–10,019'38"; E 105013'38"–105,050'35". It consists of five urban districts (Thot Not, O Mon, Binh Thuy, Ninh Kieu, and Cai Rang) and four suburban districts (Vinh Thanh, Thoi Lai, Co Do, and Phong Dien). Can Tho City was administratively formed on 1st January, 2004, when the old province of Can Tho was divided into Hau Giang province and Can Tho City; Can Tho City then directly belongs to the Central Committee (City Profile, 2013).

In general, there are four main types of emission sources: point, area, and on-road, and non-road mobile sources. **Figure 2** shows the locations of emission sources in the study domain. Different symbols represent various kinds of point and area sources including gas stations, garages, construction sites, industrial factories, hospitals, hotels, etc.

2.3.1.2. Collecting data and calculating

EI was conducted for two districts: Ninh Kieu and Binh Thuy (NKBT) (**Table 1**).

2.3.1.2.1. Total emission from area sources

The highest area emission source type for all pollutants in NKBT is burning fuel activities from households/residential activities (**Table 2**).

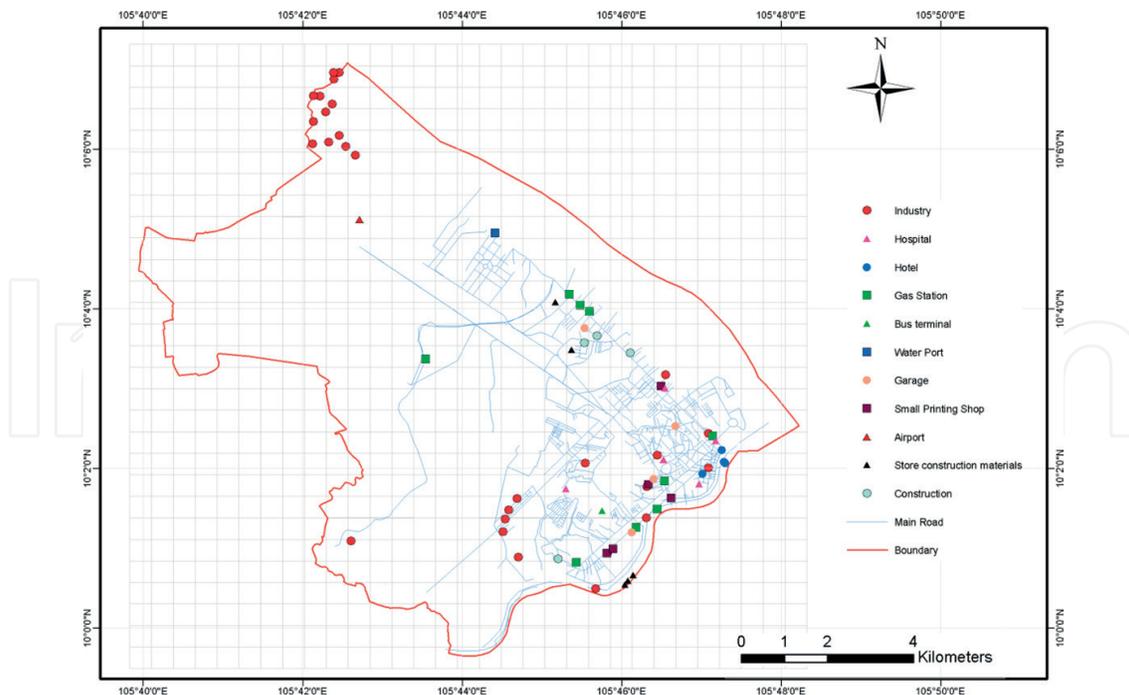


Figure 2. The locations of point, mobile, and some area emission sources that have been visited/interviewed by the data collection team.

Type of source	Pollutants (tonne/year)					
	NO _x	CO	SO ₂	VOC	CO ₂	PM ₁₀
Construction sites	0.08	0.02	0.00	0.01	—	6.93
Photocopy stores	—	—	—	0.84	—	—
Construction material vendors	—	—	—	—	—	8.73
Gas stations	—	—	—	0.11	—	—
Restaurants—Cooking	0.62	23.98	3.65	2.92	695.61	2.33
Burning rice straw	8.39	342.39	0.66	25.77	4333.26	33.50
Households	77.28	2678.05	161.50	429.82	88,162.37	328.77
Car garages	—	—	—	1.41	—	—
Total	86.37	3044.44	165.81	460.88	93,191.24	380.26

Table 1. Total emissions from area sources in NKBT.

Activity	Emission rate (tonne/year)					
	NO _x	CO	SO ₂	VOC	CO ₂	PM ₁₀
Hotels	47.35	9.71	3.21	5.90	16,560	1.46
Hospital	3.41	0.44	0.31	0.17	492.52	0.13
Industry	1006	2620	30.67	795.25	643,070	8.56
Total	1057	2630	34.19	801.32	660,123	10.15

Table 2. Total emissions for point source in CTC.

2.3.1.2.2. Point source

Point sources in CTC also include emissions from industries, hospital incinerators, and hotel boilers. The total emission for this source is presented in **Table 3**.

Air pollution emissions that are NO_x, SO₂, CO, CO₂, and VOC (NMVOC) from industrial activities are the largest among the three categories of point source emitters.

2.3.1.2.3. Mobile source

2.3.1.2.3.1. On-road mobile source

EI for mobile sources in CTC was implemented using Mobilev model, as in the case of Bac Ninh City. It shows that the main pollutant from this source is CO with the main contributor, motorcycle. The emission from side street generated from small street in residential (include alleyways and passageways) also contributes a significant amount of emissions.

Source type	CO	CO ₂	HC	NO _x	PM	SO ₂
Motor	5843.931	47,371.67	495.577	132.99	75.835 ^a	15.936
Car	146.33	7481.723	26.531	25.827	7.011	2.619
Bus	10.168	3572.496	3.715	42.449	1.547	1.262
LDV	63.97	1926.505	7.945	8.623	1.621	0.677
HDV	22.112	6782.04	8.23	82.085	3.33	2.396
Bus terminal	0.72	300.85	0.17 ^b	2.56	0.11	0.05
Side streets	6964.53	75,908	923.82	421.91	97.49	23.66
Tyre and brake wear	—	—	—	—	80.671	—
Diurnal evaporation	—	—	1035.46 ^c	—	—	—
Total	13,051.76	143,343.28	2501.45	716.44	267.62	46.60

Note: ^a is emissions of PM₁₀; ^b is emissions of NMVOC; ^c is VOC; and HC is hydrocarbon.

Table 3. Total emissions from on-road sources (tonne/year).

2.3.1.2.3.2. Non-road mobile source

2.3.1.2.3.2.1. Emissions from Hoang Dieu Port

We conducted a survey with an emission declaration table. For ocean going vessels: in general, anchorage areas for OGVs meet the standard, and the activity data are used in calculation including: name of OGVs, arrived day, leaving day, good categories (container, roll-on/roll-off, package, etc.), gross register tonnage (GRT), dead weight tonnage (DWT), power, etc. Some information included: time and speed in reduced speed zone (RSZ) (transit) mode, in maneuver mode, etc.

For CHE, there are details about the number, type, capacity, and equipment life, allowing the preparation of a basic inventory.

Emissions from Hoang Dieu Port in 2014 are from 22 OGVs and 11 CHE (including cranes and forklift trucks) shown in **Table 4**.

As you can see, the total emissions are mainly generated from CHE, except for SO₂ from OGVs. This is the result of using fuel with a high content of sulfur. 73.3% of PM₁₀, 74.4% of PM_{2.5}, and 77.3% of CO₂ come from CHE.

2.3.1.2.3.2.2. Emissions from Can Tho airport

Can Tho International Airport (CTIA) is located in Binh Thuy district, and emissions from this source can affect people living in CTC. The numbers of flights from CTIA are shown in **Table 5**.

Emission factors for air plane are referred in the documents:

EMEP/EEA Emission Inventory Guidebook 2009, Section 2, **Tables 3–5, page 8.

Source	NO _x	PM ₁₀	PM _{2.5}	VOC	CO	SO ₂	CO ₂
OGV	0.97	0.12	0.11	0.04	0.09	0.96	182.01
CHE	9.82	0.33	0.32	0.80	3.16	0.13	618.28
Total	10.79	0.45	0.43	0.84	3.25	1.09	800.29

Table 4. Total emissions from OGVs and CHE in 2014 (tonne/year).

Type of plane	Number of flights		Total flight (flight/year)
	Domestic (flight/year)	International (flight/year)	
A321	1460	10	1470
A320	450	0	450
AT72	730	0	730
Total			2650

Table 5. Number of flights in CTIA (2014).

*S. Caserini. M. Monguzzi. A. Fraccaroli. M. Moretti. E. Angelino, *Emission inventory in Lombardy Airport (Italy): Methodology and result*, **Table 4**, page 8.

Emissions from airports can be generated through airplanes taking off and landing. Air emissions from this source are estimated by using the number of flights per year and emission factors related (kg/flight) for each type of airplane. **Table 6**, which contains the emission from airport, shows that the emission rates of NO_x, SO₂, CO, CO₂, VOC, and PM₁₀ are 14.41, 1.02, 23.79, 3048, 2.31, and 0.22 tonne/year, respectively.

2.3.1.2.3.3. Total non-road mobile emissions

Emissions of CO, VOC, and CO₂ from the airport are much higher than the marine port within the non-road mobile emission source category (**Table 6**).

2.3.1.2.3.4. Total emissions in CTC

Air emissions in NKBT, Can Tho City, are dominated by emissions from on-road mobile sources (mainly from motorcycles) for CO and VOC, by area sources (mainly from household energy consumption) for SO₂ and PM10, and dominated by point sources (mainly from

Pollutant	NO _x	CO	SO ₂	VOC	CO ₂	PM ₁₀
Airport	14.41	23.788	1.021	2.308	3048.369	0.224
Marine port	10.790	3.243	1.088	0.838	800.284	0.452
Total	25.200	27.031	2.109	3.146	3848.653	0.676

Table 6. Total emissions from non-road mobile sources in NKBT (tonne/year).

Source	Emission parameters (tonne/year)					
	NO _x	CO	SO ₂	VOC	CO ₂	PM ₁₀ *
On-road mobile sources	716.45	12,173.02	45.78	2178.91	134,268.86	183.52
Non-road mobile sources	27.76	27.75	2.16	3.32	4149.50	0.79
Point sources	1057.47	2630.90	34.19	801.32	660,124.38	10.14
Area sources	86.38	3044.44	165.82	460.88	93,191.24	380.26
Total	1888.06	17,876.11	247.95	3444.43	891,733.98	574.71

Note: * Only emission from on-road mobile source is for PM, and in Table 7 considers it as PM₁₀.

Table 7. Total emissions from all sources in NKBT in 2014 (ton/year).

industrial activities) for NO_x and CO₂. It was found that on-road traffic emitted a significant amount of pollutants into the atmosphere. Also, household activities, which were classified as area sources, played an important role [1].

Point sources are the biggest emitters of NO_x and CO₂; area sources are the main emitters of SO₂ and PM₁₀; and on-road mobile sources are the main emitters of CO and VOC (Table 7).

3. Conclusions

Emission inventory is a basic step of air quality management. There are several approaches of EI as described above, and based on each study area, considered using EI approaches consistent with the available data. High accuracy in EI is proportional to time consuming and costly and inversely. In general, less time and low cost are proportional with inaccuracy. And in general, an EI should be done annually or at least every 5 years to update the air emission status and to observe the trend of major air pollution sources and evaluate the effectiveness of air quality control.

A. Restaurants/households/street cookings

1. General Information:

Restaurant/Households-Residential/Street cooking name:

Address:.....

Phone:

Fax:

Coordination:.....N.....E

2. Fuel use:

2.1 LPG

Size. Capacity.....kg
Amount of useday/tank.
Operating period.....hour/day.
Period of time:hour/day.

2.2. Charcoal:

Types:
Amount of use.....kg (day/month/year)
Operating period.....hour/day.
Period of time.....hour/day.

2.3. Electric stove/ Microwave

Electric power.....W
Amount of use.....day.

2.4. Other types

Day.....month....year...

Informant

Interviewer

Author details

Ho Quoc Bang* and Vu Hoang Ngoc Khue

*Address all correspondence to: bangquoc@yahoo.com

Air Pollution and Climate Change Department, Institute of Environment and Resources (IER), Viet Nam National University Ho Chi Minh City (VNUHCM), Vietnam

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