Analysis of air quality influenced by traffic density using web based geographic information system (Study case: Central Surabaya)

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Abstract. Central Surabaya is a city center where there are a lot of shopping centre and office buildings which populate the street. High traffic rate increases air pollution caused by motor vehicle, thus resulting in bad air quality for health. Carbon emission that has the biggest effect is CO and CO2, which can amplify global warming rate. The process of air quality monitoring itself, however, lacks a lot of things, especially in keeping data log and information delivery, causing inequal information spread for citizen about air pollution in Surabaya. Geographic Information System (GIS) technology, which is served in web platform, is one way to assist information delivery to Surabaya citizen about the air quality. The result of this study shows that the air quality is still good and doesn’t go beyond the threshold of national ambient air quality. Primary arterial road category, Jalan Diponegoro, has highest emission rate of 1635.64 ton/year CO and 35516.32 ton/year CO2 caused by high volume of vehicle, which is 285388 smp/hour. For secondary arterial road category, Jalan Raya Darmo, has highest emission rate of 1491.72 ton/year CO and 31155.44 ton/year CO2 caused by vehicle 732395 smp/hour vehicle. Result of this study is served in web platform.

Keywords: Air Quality, Web GIS, Central Surabaya

1. Introduction

Surabaya is the biggest city in Indonesia, only second to Jakarta, with the number of citizen reaching 3.105.679 millions people in a 33306,30 Ha wide area which has to cater to the needs of people with various social and economic condition [1]. The development of technology and lifestyle of people creates dynamics to the people’s life pattern in the area, especially true in Surabaya. In social sector urbanization increases people’s growth. This causes the degradation of living environment quality and water as well as air pollution that becomes a problem every year. Air quality suffers great damage in particular, as Central Surabaya, being the centre of the city economics shown by numerous office building, malls, and markets requires streams of vehicles to commute in mass.

The air quality degradation is caused by air pollution (emission) from motor vehicle populating the traffic. the highest influence comes from carbon emission. This is from the usage of fossil fuel in transportation activity. Controlling effort is continuously being done by Surabaya City Government to ensure the pure air quality and to mitigate negative impact towards the health and welfare of human,
animals, plants, and materials. Negative impacts as in thinning of ozone layers, decrease in atmosphere oxidation, and global warming [2].

Currently the air quality monitoring in Surabaya City is done through installation of ambient air quality monitor network. This network will do the measurement directly to various pollutant area. The measurement result will be processed into average value of one day and will be informed to the citizens as value of the day without prediction of the next day’s value. In that process of environment development monitoring, the aspect of data keeping and information delivering about air pollution in Surabaya as hardcopy and analog data still have a lot to improve, as the current method doesn’t deliver the information evenly to the citizens.

One of applicable technology that can be a solution to that shortcoming is Geographic Information System (GIS) served in web form so that the information given will be spread evenly. WebGIS in this study gives information about air quality based on traffic density and pollution rate especially in arterial road. Traffic density is the division result of traffic number to area with unit/area of a certain area [3]. Arterial road is public road to serve main transportation which travels far and can be passed with vehicle with high average velocity and efficiently limited by distribution service for native citizen. Arterial road is divided into primary arterial road and secondary arterial road. Map using is also important in WebGIS for this study to get clear bearing of traffic density and air pollution rate location.

2. Method

2.1. Study Location

The location of this study is Central Surabaya, precisely in 7°12’ - 7°21’ LS and 112°36’ - 112°54’ BT.

![Figure 1. Study Location](image)

Surabaya Central Border
North side : North Surabaya
East side : East Surabaya
South side : South Surabaya
West side : West Surabaya

2.2. Tools

In this Final Project study, tools to process data are required, as such:

a. Hardware
   1. Laptop
   2. Printer
3. GPS Handheld
b. Software
   1. Operation System Windows 7.
   2. Word processor for report documenting.
   3. Number processor for calculation.
   4. Flowchart making programme.
   5. Conversion programme to convert format “.shp” to “.jpeg”.
   6. Map processing Software for spatial data processing, which is digital map editing.

2.3. Materials
Materials or data used in this study is spatial data. Spatial data is data with geographical orientation, with base references as certain coordinate system. Spatial data used are as follow:
a. Digital Map of Central Surabaya 1:25,000 from Dinas Cipta Karya Kota Surabaya.
b. Attribute data of CO and CO₂ emission load from Lembaga Penelitian dan Pengabdian Masyarakat (LPPM) ITS.

2.4. Data Processing Step

![Data Processing Flowchart](image)

Figure 2. Data Processing Flowchart
1. Basis data making and normalizing data retrieved from field survey using Microsoft Access to make the emerged data more structurized and appropriate according to GIS standard.
2. Map with .shp format will be formatted as JPEG because it doesn’t use Mapserver. The convert process from shp to jpeg uses C# programming language with software Microsoft Visual Studio. The result of those converts are saved into folder images in server.
3. After the images are converted and saved in folder images in server, the images will be accessed by php programme which will be made at script writing.
4. The script writing process uses Notepad++. If error or failure happen at the application test then the written script needs to be observed to fix the web interface thus ease the user in doing web functions.
5. Interface web making is done to design the desired website appearance.
6. After all the scripts are done and interface web is designed, webGIS can be viewed on localhost (XAMPP).
7. Hosting and domain are needed to publish the web. Hosting is a place to store files that have been made. Domain is a web address. This Final Project uses the domain name www.emisisurabaya.com.

3. Result and analysis

3.1. Attribute data processing
Below is the result of the processing in the form of attribute as followst:

Table 1. CO and CO$_2$ emission load of primary arterial road

| Street Name         | CO (ton/year) | CO$_2$ (ton/year) |
|---------------------|---------------|-------------------|
| Jl. Diponegoro      | 1635.64       | 35516.32          |
| Jl. Kalibutuh       | 296.47        | 6874.86           |
| Jl. Kusuma Bangsa   | 329.32        | 7744.06           |
| Jl. Kapasari        | 185.14        | 4179.5            |
| Jl. Pasar Kembang   | 467.32        | 9690.90           |
| Jl. Raya Gubeng     | 215.61        | 4612.17           |
| **TOTAL**           | **3129.5**    | **68617.82**      |

From Table 1, it can be incurred that the lowest CO$_2$ emission load is on Jalan Kapasari with value of 4179.5 ton/year. The highest emission load is on Jalan Diponegoro with value of 35516.32 ton/year.

![Emission Load 2013 (ton CO$_2$/Year)](image_url)

**Figure 3.** Percentage of CO$_2$ emission load on primary arterial road
From Figure 3 it can be incurred that the biggest percentage is on Jalan Diponegoro lane, 52%, and the smallest is on Jalan Kapasari, 6%.

![Emission Load 2013 (ton CO/Year)](image)

**Figure 4.** Percentage of CO emission load on primary arterial road

From Figure 4 it can be incurred that the biggest percentage is on Jalan Diponegoro lane, 52%, and the smallest is on Jalan Kapasari, 6%. Both CO and CO$_2$ emission load in 2013 shows the same value, with the highest percentage on Jalan Diponegoro and the lowest percentage on Jalan Kapasari.

**Table 2.** Carbon CO and CO$_2$ Emission Load on Secondary Arterial Road

| Street Name          | CO (ton/year) | CO$_2$ (ton/year) |
|----------------------|---------------|-------------------|
| Jl. Blauran          | 89            | 1747,13           |
| Jl. Bubutan          | 989,67        | 28862,64          |
| Jl. Embong Malang    | 86,91         | 2123,16           |
| Jl. Gembongan        | 76,87         | 1365,99           |
| Jl. Gubernur Suryo   | 190,31        | 4570,86           |
| Jl. Jagalan          | 34,19         | 809,51            |
| Jl. Basuki Rahmat    | 428,5         | 10936,21          |
| Jl. Kalianyar        | 45,91         | 884,23            |
| Jl. Kapasari         | 98,42         | 2390,19           |
| Jl. Kramat Gantung   | 67,83         | 1498,69           |
| Jl. Ngaglik          | 96,76         | 1720,33           |
| Jl. Pahlawan         | 126,26        | 2688,33           |
| Jl. Pandegiling      | 113,18        | 1631,09           |
| Jl. Panglima Sudirman| 1099,14       | 28091,98          |
| Jl. Pasar Besar      | 71,03         | 1658,58           |
| Jl. Raya Darmo       | 1491,72       | 31155,44          |
| Jl. Tunjungan        | 192,38        | 4463,07           |
| Jl. Urip Sumoharjo   | 547,4         | 15611,56          |
| **TOTAL**            | **5845,48**   | **142209,00**     |

From Table 2, it can be incurred that the lowest CO$_2$ emission road is on Jalan Jagalan with 809,51 ton/year value. The highest value is on Jalan Raya Darmo with 31155,44 ton/year.
Figure 5. Percentage of CO$_2$ emission load on secondary arterial road

From Figure 5 it can be incurred that the biggest percentage is on Jalan Raya Darmo, 22%, and the lowest is on Jalan Pasar Besar, Blauran, Embong Malang, Kramat Gantung, Jagalan, Kalianyar, Gemblongan, Ngaglik, and Pandegiling with 1%.

Figure 6. Percentage of CO emission load on secondary arterial road

From Figure 6 it can be incurred that the biggest percentage is on Jalan Raya Darmo, 26% and the smallest is on Jalan Pasar Besar, Embong Malang, Kramat Gantung, Jagalan, Kalianyar, and Gemblongan with 1%.

Table 3. Vehicle volume of primary arterial road

| Street Name     | CO (ton/year) | CO$_2$ (ton/year) | Vehicle (smp/hour) |
|-----------------|---------------|-------------------|-------------------|
| Diponegoro      | 1635.64       | 35516.32          | 285388            |
| Kalibutuh       | 296.47        | 6874.86           | 144480            |
| Kusuma Bangsa   | 329.32        | 7744.06           | 100407            |
| Kapasari        | 185.14        | 4179.5            | 98928             |
| Pasar Kembang   | 467.32        | 9690.90           | 284887            |
| Raya Gubeng     | 215.61        | 4612.17           | 43956             |
| **Total**       | **3129.5**    | **68617.82**      | **958046**        |
Table 4. Vehicle volume of secondary arterial road

| Street Name       | CO (ton/year) | CO₂ (ton/year) | Vehicle (smp/hour) |
|-------------------|---------------|----------------|-------------------|
| Blauran           | 89            | 1747.13        | 128400            |
| Bubutan           | 989.67        | 28862.64       | 202563            |
| Embong Malang     | 86.91         | 2123.16        | 59815             |
| Gemblongan        | 76.87         | 1365.99        | 84291             |
| Gubernur Suryo    | 190.31        | 4570.86        | 162700            |
| Jagalan           | 34.19         | 809.51         | 31120             |
| Basuki Rahmat     | 428.5         | 10936.21       | 172443            |
| Kalianyar         | 45.91         | 884.23         | 56840             |
| Kapasan           | 98.42         | 2390.19        | 50080             |
| Kramat Gantung    | 67.83         | 1498.69        | 51162             |
| Ngaglik           | 96.76         | 1720.33        | 54920             |
| Pahlawan          | 126.26        | 2688.33        | 51160             |
| Pandegiling       | 113.18        | 1631.09        | 29920             |
| Panglima Sudirman | 1099.14       | 28091.98       | 265757            |
| Pasar Besar       | 71.03         | 1658.58        | 51920             |
| **Raya Darmo**    | **1491.72**   | **31155.44**   | **732395**        |
| Tunjungan         | 192.38        | 4463.07        | 107800            |
| Urip Sumoharjo    | 547.4         | 15611.56       | 282404            |
| **Total**         | **5845.48**   | **142209.00**  | **2575690**       |

On the primary arterial road table it shows that the street with most traffic is Diponegoro street with vehicle amount 285388 (smp/hour) that it causes it having highest emission value with CO value 1635.64 (ton/year) and CO₂ 35516.32 (ton/year). On the secondary arterial road table it shows that the street with the most traffic is Jalan Raya Darmo with vehicle amount 732395 (smp/hour) that it causes it having highest emission value with CO value 1491.72 (ton/year) and CO₂ 31155.44 (ton/year).

3.2. Spatial data processing

In this study, the spatial data processing uses programme C# because of its usage of HTML, PHP, and Javascript language. This programme can’t read .shp data, however, thus map conversion is done from .shp to JPEG so the map can be viewed on web.

Figure 7. Central Surabaya Map (.shp)
Steps to convert (.shp) map into JPEG form are as follows:
1. Open .shp file from C# programme (Visual studio)
2. Determine the zoom on the picture
3. Save the .shp file in the C# programme into JPEG file type

3.3. Basis Data Design
In this study 6 tables are used, which will be explained in emission information and air quality part to ease the explanation of basis data design.
a. Conceptual Basis Data Design

The conceptual basis data design has table structure as follows:
- Pollution (Id_Pencemaran, Id_Lalulintas, Tanggal, Partikulat) [Id_Pollution, Id_Traffic, Date, Particulate]
- Traffic (Id_Lalulintas, Volume_Kendaraan, Jenis_Kendaraan, Nama_Jalan) [Id_Traffic, Vehicle_Volume, Vehicle_Type, Street_Name]
- District (Id_Kecamatan, Nama_Kec, Nama_Jalan) [Id_District, District_Name, Street_Name]
- Street (Id_Jalan, Nama_Jalan) [Id_Street, Street_Name]
- Emission (Id_Emisi, Nama_Jalan, Jenis_Emisi) [Id_Emission, Street_Name, Emission_Type]
- Air Quality (Id_Kualitas, Jenis_Kualitas, Jenis_Emisi) [Id_Quality, Quality_Type, Emission_Type]

b. Fiscal Basis Data Design

On fiscal basis data design, model basis data is pictured in tabel form as follows:

**Table 5. Fiscal Model Table**

| Entity   | Attribute     | Description                  | Type Data   | Key  |
|----------|---------------|------------------------------|-------------|------|
| Pollution| Id_Pollution  | Pollution code               | numeric     | PK   |
|          | Id_Traffic    | Traffic code                 | numeric     |      |
|          | Date          | Record date                  | varchar     |      |
|          | Particulate   | Pollution parameter          | varchar     |      |
| Traffic  | Id_Traffic    | Traffic code                 | numeric     | PK   |
|          | Vehicle_Volume| The number of vehicles per road | varchar |      |
### Conclusion and Suggestion

a. In this study the basis data design for air quality is divided into 6 tables which are pollution table, traffic table, district table, street table, emission table, and air quality table.

b. WebGIS can give information about street with highest emission load and the impact in Central Surabaya area.

c. As in national ambient threshold in reference to PP No. 41 Tahun 1999, the threshold for CO is: 30,000 µg/m³. The data retrieved from Primary Arterial road holds Jalan Diponegoro as the highest emission load with 1635.64 ton while the lowest being in Jalan Kapasari with 185.14 ton. Thus the air quality of primary arterial road in Surabaya Central is below the threshold, meaning good. For the secondary arterial road, the highest CO emission is on Jalan Raya Darmo with 1491.72 ton CO/year and the lowest is on Jalan Jagalan with 34.18 ton CO/year. Thus, the air quality of secondary arterial road in Surabaya Central is below the threshold, meaning good.

d. The flaw of this web is the inability to answer if the user means to find road with highest emission in Surabaya Central therefore software with multiple query trait is needed.

e. Usage of public transportation can decrease traffic in Surabaya, especially the centre area because this area is the center of Surabaya citizen activity, where there are many shopping malls, hotels, and office building.

### 4. References

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Figure 11. WebGIS of air quality environment of Central Surabaya