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Distribution ozone concentration in Klang Valley using GIS approaches

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Abstract. Today, ozone has become one of the main air pollutants in Malaysia. The high ozone precursor concentrations have been encouraging the ozone production. The development of the Klang Valley, Malaysia has many types of physical activities such as urban commercial, industrial area, settlement area and others, which has increased the risk of atmospheric pollution. The purpose of this paper is to determine the spatial distribution between types of land use and ozone concentration that are occurred in the year 2014. The study areas for this paper include Shah Alam, Kajang, Petaling Jaya and Port Klang. Distribution of ozone concentration will be showed via spatial analysis tools in Geographic Information Systems (GIS) approached and the types of land use will be extracted using Remote Sensing technique. The result showed 97 ppb (parts-per-billion, 10^{-9}) and 161 ppb recorded at Port Klang and Shah Alam respectively that are mainly represented by the settlement area. Therefore, the physical land use need to be monitor and controlled by the government in order to make sure the ozone production for daily per hour will not exceed the regulation allowed.

1. Introduction

Nowadays, growth in population and rapid development were absolutely giving the negative impact on the air quality status around the world. Ozone concentration becomes one of the most significant air pollutants due to increasing sources of ozone precursors [1]. Ozone is created in the atmosphere when the sun's rays split oxygen molecules into single atoms. These atoms combine with nearby oxygen to form a three-oxygen molecule. It is known to be a secondary pollutant, photochemical oxidant and the main component of smog [2]. Besides that, the highest ozone formation can be harmful to human health and also air pollution can cause the negative impact on ecosystems, materials, buildings, works of art, vegetation, and visibility [4,5,6].

Based on the previous study that discussed the ozone effects on vegetation area in Europe, ozone concentrations are greater than 40 ppb may be harmful to the crop yield, biomass production, vitality

and stress tolerance of forest trees [3]. In others study, the ozone concentration in the troposphere is highly variable are ranging from 10 ppb over the tropical oceans to 100 ppb over to land and can even exceed in the polluted urban area [5,7]. This variability to the increasing f the ozone concentration is might be dependent on available of solar radiation, temperature, winds, season and altitude or others factors [5,8]. Thus, air pollutants formation, dispersion, transport, and dilution are important roles that are highlighted in an aspect of the meteorology [9,10,11,12]. Based on another study also, average surface ozone level is rapidly increased in developing countries and slowly decreases in developed countries [13,14,17].

Land used are defined as a category land that are covered the physical activities for one place. Based on the previous study, the results on land use and the level of compliance mentioned that some problems in air quality status in the Malaysian peninsular only exist in highly spot on the urbanization areas [15]. According to the Malaysian department of environment and others study stated that motor vehicles getting 82%, power stations 9%, industrial fuel burning 5%, industrial production processes 3% domestic and commercial 0.2% and open burning at solid waste disposal site 0.8% to the total air emission load in the peninsular of Malaysian [15,16].

This paper will highlight the pattern of ozone concentration in Klang valley area. There are 4 areas that are chosen as a potential of high ozone concentration in Klang valley which are Port Klang, Petaling Jaya, Kajang and Shah Alam. The types of land use are defined to illustrate the category of land use. Then, the daily maximums are defined to shows the concentration of formation ozone and analysis high potential of ozone formation also types of category land use that is covered on the higher ozone concentration.

The details of the station are showed in Table 1 and Figure 1 is illustrated the location in 4 monitoring station of ozone data. Based on the Environmental Quality Report released by the Department of Environment in 2011, the status of air quality in Malaysia, especially in some major cities in Klang Valley, namely the Federal Territory of Kuala Lumpur, Shah Alam and Kajang is unhealthy as a whole for that year [18]. This evident can be proved with multiple episodes of air quality decreases and haze phenomenon that become more serious in this area in recent years. This condition can be detected through the Air Pollution Index, which has been recorded by the Department of Environment for a few major urban areas in Klang Valley, which are namely Shah Alam, Petaling Jaya, Gombak, Kajang, Klang and Kuala Lumpur. The status of air quality that is unhealthy level also hit in the Klang Valley area.

The air quality becomes decrease occurs due to the high of concentration levels of pollutants PM_{10} and O_3 become higher than in other pollutant materials [18,19]. Klang Valley had the air quality unhealthy in 2004 where Shah Alam one of the highest recorded air quality to unhealthy, which is 88 days in a year than the Federal Territory of Kuala Lumpur that are recorded air quality unhealthy for 63 days in the same period [18,19]. The air quality in the Klang Valley is influenced by several factors including the vehicle motorized, open burning, industrial and transboundary pollution [20,18]. Urban air pollution that hit several major cities in Klang Valley up resulting in the decreased of air quality, it is also due to the rapid of urbanization and liveliness activities transport in the region.

Table 1. Details of monitoring station ozone data

Station	Coordinates(N)	Coordinates(E)
Pelabuhan Kelang	N 03° 00' 37.02"	E 101° 24' 29"
Petaling Jaya	N 03° 06' 34.16"	E 101° 38' 20"
Kajang	N 02° 59' 38.07"	E 101° 44' 25"
Shah Alam	N 03° 06' 17.22"	E 101° 33' 22"

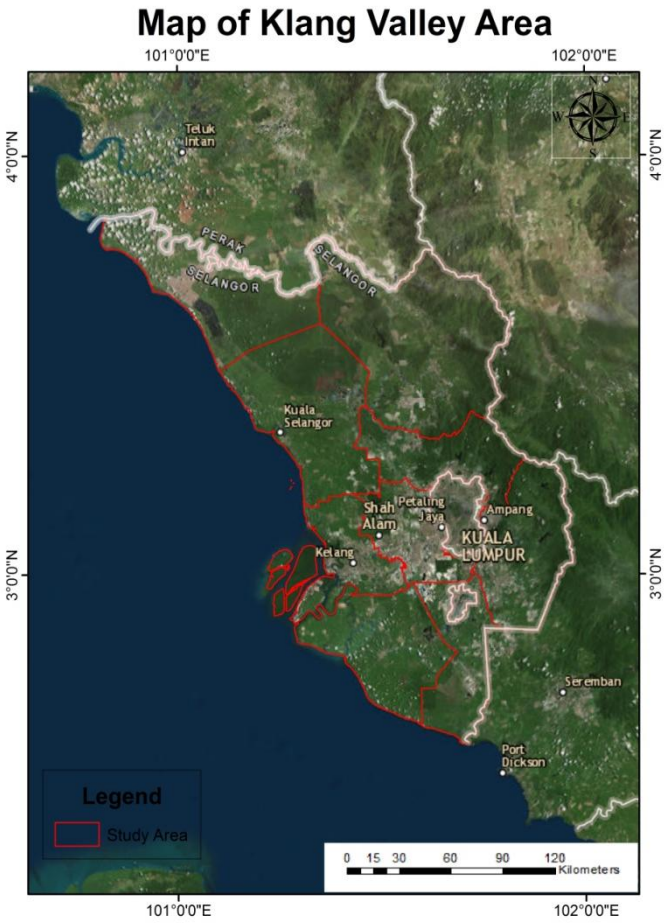

Figure 1. Study area

This study uses two types of data which are land use data and surface ozone concentration. The duration of data is provided for one year period (January 2014 to December 2014). Land use data are provided from the Institute of Climate Changes at University National of Malaysia and hourly surface ozone concentration data are provided from the Malaysian Department of Environment (DOE). The ozone data are given in hourly data for a one year.

2. Methodology

This research focus on the small area in Peninsular Malaysia which is the Klang Valley area. Starting with identifying types of land use for Klang valley area. Then, filtering ozone concentration data obtained from the Department of Environment Malaysia to determine maximum daily and annual maximum daily concentrations for every station in Klang Valley area. Analysis of the spatial distribution of ozone concentration is applying using interpolation techniques which are known as Topo to Raster contained in a GIS. Lastly, analysis using topo to raster is applied on that data to show the distribution of ozone concentration and types of land use that happen in the year 2014.

Arc Map software in version 10.2 is being chosed as the best options and appropriate software for the purposes of the analysis. GIS is a system to store, view and keep a type of information system that can be applied to geographical or spatial data. Other than that, the systems can be combine operating capacity to collect, acquire, store, manage and analyze the data to produce information during the display of spatial data. [21]. While, topo to raster in ArcGIS software that are in spatial interpolation tools or techniques are specially designed for the creation of hydrological correct digital elevation models (DEM). Other than that, these methods are interpolates a hydrologically correct raster surface

from the point, line and polygon data [22]. The best result will be obtained if all input data is stored in the same planar coordinates system and has the same Z units. If more than one input points fall within an output cell, topo to raster will be used the average value for the interpolations (only the first 100 points that fall within a cell will be considered and the rest will be ignored) [22]. In the topo to raster method there have many types of feature data input such as point elevations, stream, lake, contour, sink, boundary, cliff, exclusion and coast.

Based on the other study [18] stated that analysis of the ozone concentration in Klang Valley using GIS techniques appearing the level of the ozone concentration followed by this Table 2 below.

Table 2. Level of patterns spatial distribution in the Klang Valley [20]

Level	Ozone Concentration (O_3)
1	0-50 ppb
2	50-100 ppb
3	100-150 ppb
4	150-200 ppb
5	200-250 ppb

3. Results and Discussion

Based on the analysis, by using satellite images and GIS techniques, the pattern distribution ozone concentration will be shown in a map. The types of land use categories will be shown in Table 3. The total areas for the land use classification on Klang Valley are 433479 hectares. The types of classification are covered by 7 types which are croplands, forestlands, grassland, mangrove, settlement area, wetlands and others. The types of land use are covered on that range are 48.26% of cropland area, 25.08% for forestland, 0.75% for grassland, 0.98% for mangrove, 20.24% for settlement area, 2.19% wetlands and 1.70% for others. According to Intergovernmental Panel on Climate Change (IPCC), 2006 [23] others lands category include bare soil, rock, ice, and all land areas that do not fall into any of the other five categories like cropland, forestland, mangrove, settlement, and wetlands. Figure 2 shows the types of land use in Klang Valley area.

Table 3. Types of land use in Klang Valley

Land Use Types	Area (ha)	Percentage (%)
Cropland	209191	48.26
Forestland	112192	25.08
Grassland	3251	0.75
Mangrove	4257	0.98
Settlement	87735	20.24
Others	7381	1.70
Wetlands	9471	2.19
Total	**433479**	**100**

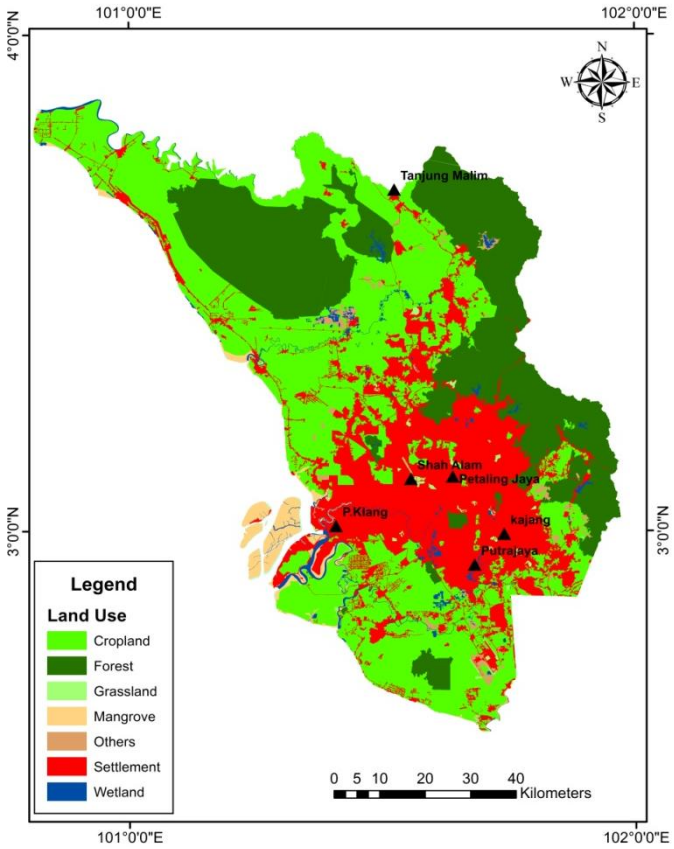

Figure 2. Types Of Land Use in Klang Valley

Figure 3 represent the graph of monthly maximum values for 4 selected areas that are in Klang Valley. Distribution of ozone concentration is different for every month from January until December 2014. The concentrations of ozone for the all sampling station are in the range between 40 ppb until 161 ppb. The red line shows the level of ambient ozone concentration of 100 ppb that is suggested by Malaysia Air Quality Guidelines (Department of Environment Malaysia) which is also discussed in other studies [24].

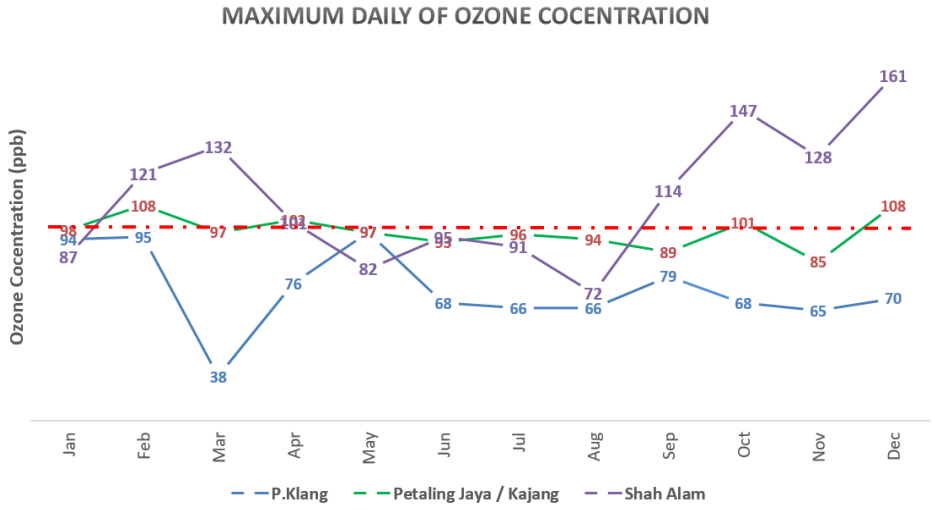

Figure 3. Monthly maximum daily of ozone concentrations at Klang Valley

The highest annual maximum value of surface ozone concentration at the 4 stations which are Port Klang, Petaling Jaya, Kajang, and Shah Alam. The annual maximum value per year at Port Klang is the maximum value is 97 ppb, Petaling Jaya and Kajang getting 108 ppb and Shah Alam recording highest valueof 161 ppb among the stations. This is because Shah Alam has many industrial areas and development where activities that are created by human-like industrial, lodging and others impact to the formation of the ozone. The level of ozone concentration illustrated by using GIS techniques as shown in Figure 4. The distribution annual maximum for the year 2014 illustrated using topo to raster method. The level of ozone concentration is shown by color. Shah Alam represents the level of highest ozone concentration in the Klang Valley starting from September until December in the year 2014. Other than that, Shah Alam is the place that has many physical activities like industrial, development and other man made that can be polluted air pollution.

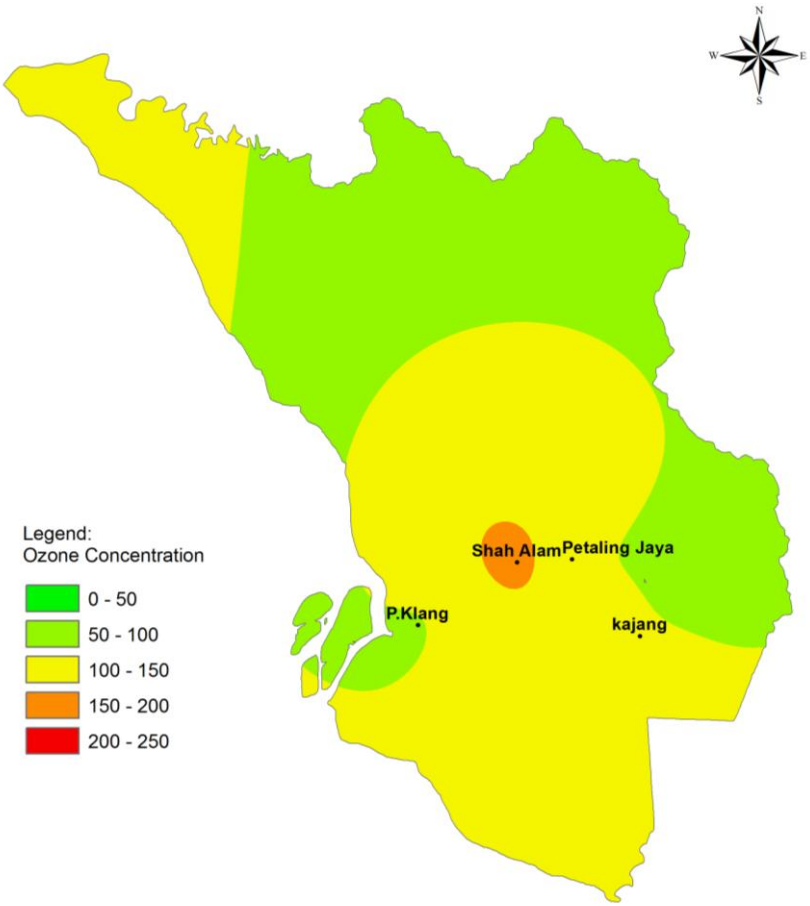

Figure 4. Distribution of annual maximum ozone concentration in the year 2014 at Klang Valley

4. Conclusion

In conclusion, ozone concentration recorded in Klang Valley area affected because of seasonal variations and physical activity that are happening in that area. Other than that, the effect from the types of land use also gives impact to the concentration of ozone. Klang Valley is the areas that have a many settlements and development land. The development is increasing, and hence it can be the effect population and physical activity in that area. This is indicated by analysis spatial distribution of ozone pattern by applying interpolation techniques topo to raster. The results also show Shah Alam area has exceeded the maximum allowable concentration of New Malaysian Air Quality Standard The

concentration of ozone and others pollutants and also types of land use need to be controlled and planned. This paper attempts to understand the distribution of ozone concentration in Klang Valley and further research is required to find the relationship between ozone concentration and types of land use changes in Klang Valley area. This study also can be carried out by the interested parties by introducing green technologies to prevent the air pollution are archived to the dangerous level. Lastly, the government can do an adaptation to control strategies of future planning for physical activities and development that are happening for future in Klang Valley area as a proactive mitigation measures to reduce the level concentrations and emissions in that areas.

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