Sustainable Environment Research xxx (2017) 1–8

Contents lists available at ScienceDirect

Sustainable Environment Research

journal homepage: www.journals.elsevier.com/sustainable-environment-research/

Original Research Article

Modeling PM_{10} in Ho Chi Minh City, Vietnam and evaluation of its impacts on human health

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ARTICLE INFO

Article history:
Received 6 April 2016
Received in revised form
10 August 2016
Accepted 12 October 2016
Available online xxx

Keywords:
Air pollution
Health effects
Mortality
Ho Chi Minh City

ABSTRACT

According to World Health Organization (WHO) and Global Burden of Disease, ambient air pollution is estimated to be responsible for 3.7 million premature deaths in 2012 [1]. Therefore, it is urgent to estimate the impact of air pollution on public health and economic damage. The objectives of this research are: study the distribution of PM_{10} concentration over Ho Chi Minh city (HCMC) and relationship to public health and for proposing solutions of diseases prevention in HCM, Vietnam. EMIssion SENSitivity model was applied to conduct air emission inventory for transportation sector. Then, Finite Volume Model and Transport and Photochemistry Mesoscale Model were used to simulate the meteorology and the spatial distribution of PM_{10} in HCMC. Together with disease data obtained, the US Environmental Benefits Mapping and Analysis Model was applied for calculating the number of deaths and estimating economic losses due to PM_{10} pollution. Finally, solutions to reduce PM_{10} pollution and protect public health are proposed. The results showed that the highest 1-h average concentration of PM_{10} is 240 $\mu g\ m^{-3}$ in North Eastern of HCMC. The concentration of PM_{10} for annual average in District 5 ranged from 17 to 49 $\mu g\ m^{-3}$. There are 12 wards of District 5 with PM_{10} concentration exceeding the WHO guidelines (20 $\mu g\ m^{-3}$ for annual average of PM_{10} and 50 $\mu g\ m^{-3}$ for 24-h average). The high concentration of PM_{10} causes 5 deaths yr^{-1} in District 5 and 204 deaths yr^{-1} in HCMC, and it causes economic losses of 1.84 billion of USD.

1. Introduction

Ho Chi Minh City (HCMC) is the most dynamic area as a social, cultural and economic center of Vietnam. District 5 located at South of HCMC, has an area of 4.27 km^2 with population of 176,890 people and density of 41,426 person km^{-2}. It is one of the most density areas with energetic economic activities. Services, exchange of goods and traffic in this area have been expanded for a long time which drive economic growth. Consequently, environment has become polluted, and the citizens have to face many environmental problems. Especially in traffic jam conditions, air quality becomes worse which directly affects people's health. In a recent study of relationship between air pollution and human health, over 90% children less than 5 years old in HCMC were infected to respiratory disease [2]. According to World Economic Forum in 2012, Vietnam is one of 10 countries which has the worst air pollution in worldwide [3] and in urban area as HCMC, traffic is the major contributor to air pollution [4]. Pollutants emitted from these sources is considered as hazardous pollutants by US Environmental Protection Agency (USEPA), especially particulate matter $PM_{2.5}$ is believed to cause respiratory disease, lung cancer and mortality. In 2012, International Agency for Research on Cancer (IARC) has classified diesel engine emission to Group 1 *Carcinogenic to humans* [1]. The IARC also reported that emissions from diesel engines from trucks, cars, train or boat were one of the major cause of lung and bladder cancer. For those reasons, this study was conducted to clarify the relationship between PM_{10} concentration and mortality in HCMC especially in District 5 and estimate the economic losses.

Many studies related to air quality management in HCMC have been done recently, including “Air pollution forecast for Ho Chi Minh City, Vietnam in 2015 and 2020” [4] to simulate pollutants over HCMC (NO_x, CO, SO_2, O_3, but not PM_{10}); “Optimal Methodology to Generate Road Traffic Emissions for Air Quality Modeling: Application to Ho Chi Minh City” [5] focusing on air emission for

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Peer review under responsibility of Chinese Institute of Environmental Engineering.

http://dx.doi.org/10.1016/j.serj.2017.01.001

road transportation for Optimal Methodology to Generate Road Traffic Emissions for Air Quality Modeling: Application to Ho Chi Minh City; and "Estimation of Road Traffic Emission Factors from a Long Term Tracer Study" focusing on calculating air emission factor for volatile organic compounds and NOx. The previous researches have not focused on PM_{10} and there is no impact study of PM_{10} on human health conducted in Vietnam.

2. Method and data

2.1. Method

In general, the method of this study is described in Fig. 1. First, all information on traffic, industrial activities and household's fuel consumption data were collected for calculation of PM_{10} emission inventory. Then FVM (Finite Volume Model) – a meteorology model and TAPOM (Transport and Photochemistry Mesoscale Model) - a dispersion model were applied to make spatial concentration distribution of PM_{10}. Based on WHO guideline for PM_{10} (20 μg m^{-3} for annual mean), areas with PM_{10} concentration exceeding WHO guideline were made. Finally, applying theory of the Environmental Benefits Mapping and Analysis Program (BenMAP), a GIS computer program developed by USEPA to simulate impact of air pollution change to human health and economic losses and to estimate the mortality cause by PM_{10} in study area.

2.2. Data for PM_{10} emission inventory

The PM_{10} emission inventory was carried out for HCMC for the year of 2012.

2.2.1. Traffic source

EMISENS (EMIssion SENSitivity model) model was used to calculate emissions of PM_{10} from traffic; the model combined two approaches of Bottom-up and Top-down. This model is appropriate for developing countries as Vietnam with lack of information. Traffic data were collected from survey for road type, vehicle shares, vehicle age, annual daily traffic, etc. which was from previous study for calculating traffic emission for HCMC conducted by the author [4].

2.2.2. Industrial source

For industrial sources/point sources, PM_{10} was estimated from 282 major sources (such as Iron, Steel, Cokes, Refinery, and Cement, among others) in boilers, chimneys, generators, etc. in HCMC. Activity data for each source were collected as fuel consumption, fuel

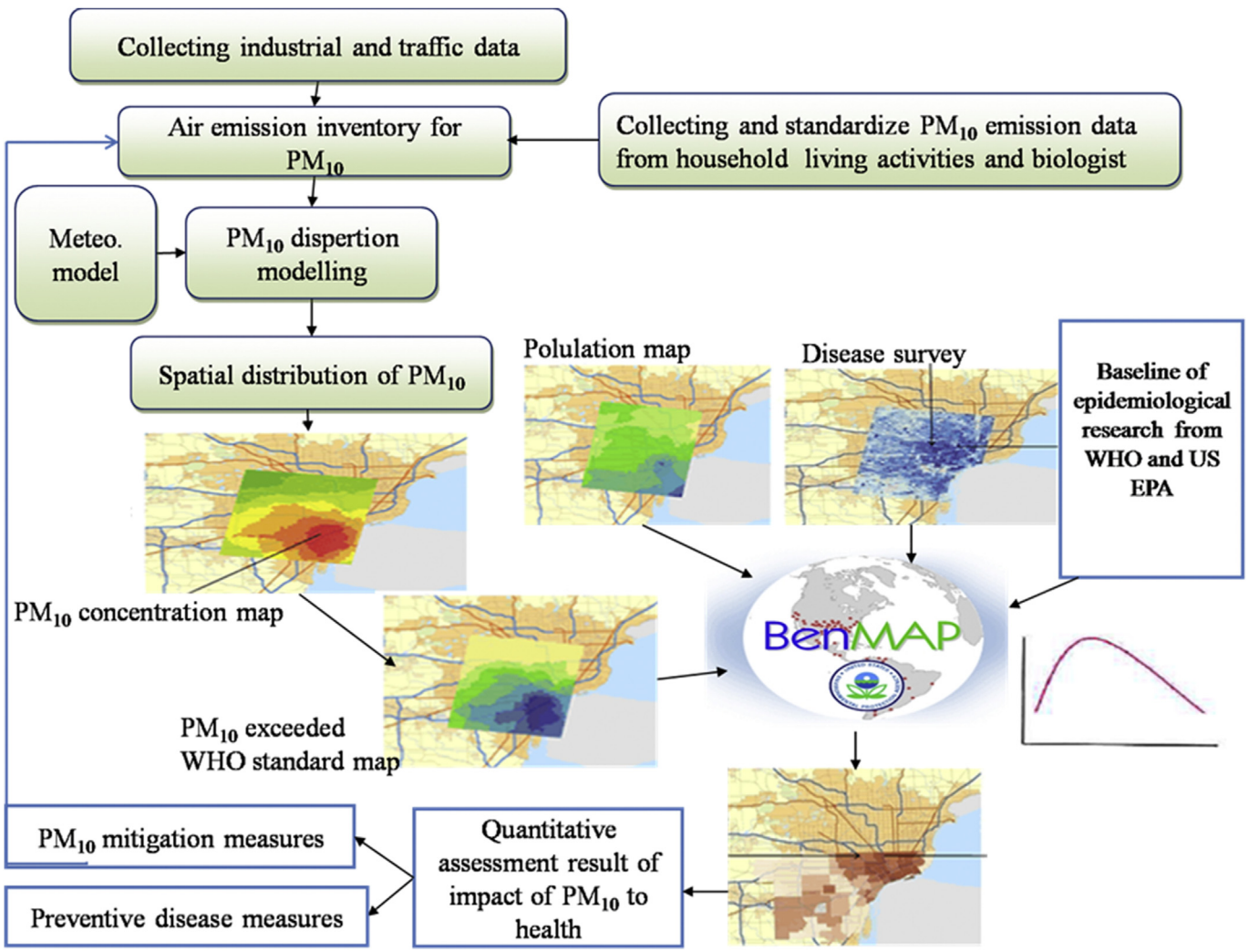

Fig. 1. Research flow chart.

Please cite this article in press as: Ho BQ, Modeling PM_{10} in Ho Chi Minh City, Vietnam and evaluation of its impacts on human health, Sustainable Environment Research (2017), http://dx.doi.org/10.1016/j.serj.2017.01.001