Science of the Total Environment 482–483 (2014) 336–348

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Long term assessment of air quality from a background station on the Malaysian Peninsula

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HIGHLIGHTS

- We analysed air quality data recorded at background station on Malaysian Peninsula.
- Principal component regression and sensitivity analysis have been employed.
- Wind direction influences the transport of air pollutants to the background station.
- Diurnal variations of major air pollutants contribute by motor vehicle emissions.

ARTICLE INFO

Article history:
Received 24 November 2013
Received in revised form 6 February 2014
Accepted 27 February 2014
Available online 21 March 2014

Keywords:
Background stations
Major air pollutants
Meteorological factors
Monsoon

ABSTRACT

Rural background stations provide insight into seasonal variations in pollutant concentrations and allow for comparisons to be made with stations closer to anthropogenic emissions. In Malaysia, the designated background station is located in Jerantut, Pahang. A fifteen-year data set focusing on ten major air pollutants and four meteorological variables from this station were analysed. Diurnal, monthly and yearly pollutant concentrations were derived from hourly continuous monitoring data. Statistical methods employed included principal component regression (PCR) and sensitivity analysis. Although only one of the yearly concentrations of the pollutants studied exceeded national and World Health Organisation (WHO) guideline standards, namely PM_{10}, seven of the pollutants (NO, NO_2, NO_x, O_3, PM_{10}, THC and CH_4) showed a positive upward trend over the 15-year period. High concentrations of PM_{10} were recorded during severe haze episodes in this region. Whilst, monthly concentrations of most air pollutants, such as: PM_{10}, O_3, NO_x, NO_2, CO and NmHC were recorded at higher concentrations between June and September, during the southwest monsoon. Such results correspond with the mid-range transport of pollutants from more urbanised and industrial areas. Diurnal patterns, rationed between major air pollutants and sensitivity analysis, indicate the influence of local traffic emissions on air quality at the Jerantut background station. Although the pollutant concentrations have not shown a rapid increase, an alternative background station will need to be assigned within the next decade if development projects in the surrounding area are not halted.

1. Introduction

Background stations can provide invaluable information on pollutant exposure to humans and vegetation at distances from a few km^2 to a few thousand km^2. A rural background station is also useful in providing air quality information on a regional scale (USEPA, 1998; EU, 2005). Such a station must be located in an area with a natural ecosystem, low population density and be a good distance from anthropogenic emission sources (EU, 2005). Hence, continuous air quality monitoring data collected from a rural background station allows the observation of regional trends in air pollutant concentrations with minimal enhancement resulting from local emissions. The expansion of greater urban areas, however, has led to the movement of pollutants from city centres towards suburban areas, which not only affects the level of air pollutant concentrated in the city centres but also that of background areas (Agrawal et al., 2003; Grawe et al., 2013). For example, a study by Donnelly et al. (2011) showed that even cities located more than 50 km away from a background station can influence the NO_2 concentrations at such stations. The concentration of pollutants

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http://dx.doi.org/10.1016/j.scitotenv.2014.02.132
0048-9697/

(for example SO_2) from industrial sources also revealed changes occurring at a rural background station when emission control measures were carried out in industrial and densely populated areas (Lin et al., 2012).

In Malaysia, the central focus of development programmes since its independence in 1957 has been the Klang Valley area where Kuala Lumpur, the capital city, is located. In other parts of the Malaysian Peninsula, the capital of each state is usually the central pollutant emission source, aside from industrial areas located outside the city centre. The movement of air pollutants from the city and industrial areas to rural areas is predominantly dependent on seasonal winds and local conditions. These include land and sea breezes, the valley effect and also the transference of wind from urban to rural areas which results from the urban heat island effect (Sani, 1990; Juneng et al., 2009, 2011). Such developments also result from increases in deforestation and biomass burning through agricultural activities, as soil dust derived from deforestation and smoke from biomass burning contribute to the high amount of particulate matter existing, particularly in suburban and rural areas (Dominick et al., 2012).

The Department of Environment, Malaysia (DOE) had designated Jerantut, Pahang as its site for a rural background station so as to monitor the general background concentrations of selected air pollutants in the Malaysian Peninsula. This continuous monitoring station is located in a rural area close to a national forest reserve. Many studies on air pollutant concentrations in Malaysia have included Jerantut for comparison with observations from other rural, urban and suburban monitoring stations (Azmi et al., 2010; Latif et al., 2012; Banan et al., 2013). However, there are as yet, no studies which focus on the long-term pollutant concentration trends at this station. Although the site was originally chosen because of its distance from local anthropogenic emission sources, there are some concerns regarding its continuing viability as a rural background station in the coming years as a result of increasing development of the surrounding areas. This study aims to fill this gap by analysing continuous monitoring data collected over a period of 15 years and to assess the trends in pollutant concentrations, primarily in terms of local influences on the background pollutant concentrations in the Malaysian Peninsula. Assessments were also undertaken in order to determine the feasibility of this site being used for background data collection in the future, given that rapid industrialisation and urbanisation over the past decade may have introduced significant local or mid-range emission sources to the rural location where the background station is located.

2. Materials and methods

2.1. Location of sampling station

The air quality data used in this research was collected from Batu Embun, Jerantut, Pahang Station, which has been established as a background air monitoring station by the Department of the Environment (DOE), Malaysia. This station is located near the middle of the Malaysian Peninsula with coordinates N03° 58.238′, E102° 20.863′ (Fig. 1) and is surrounded by natural forest and agricultural areas, as well as traditional Malaysian villages. It lies within a 2 km radius of Sungai Pahang, one of the longest rivers in Malaysia, and its confluence, Sungai Teh. The nearest town is Jerantut, which is about 7 km from Batu Embun. Some short-term studies have shown that the air quality level at this monitoring station is influenced by local open burning, soil dust and a low number of motor vehicles (Azmi et al., 2010; Banan et al., 2013). This may be due to the presence of a two-lane paved road close to the sampling site (<1 km) and villages, as well as modern housing areas within a 10 km radius south of the station.

2.2. Data collection

The air quality data for the analysis period, January 1997 to December 2011, was obtained from the Air Quality Division of the DOE; the Ministry of Natural Resources and Environment of Malaysia. A total of 1,368,715 hourly observations from the 15-year (1997–2011) dataset, which consisted of 14 variables, were initially arranged based on month and year. The 14 variables studied were divided into three groups: major air pollutants, organic pollutants and meteorological parameters. The major air pollutant group consisted of ground level ozone (O_3), carbon monoxide (CO), nitrogen oxide (NO), nitrogen dioxide (NO_2), oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and particulate matter with a diameter size of less than 10 μm (PM_{10}). The organic pollutant group consisted of methane (CH_4), total hydrocarbon (THC) and non-methane hydrocarbon (NmHC) while the meteorological parameter group consisted of wind speed, ambient temperature, relative

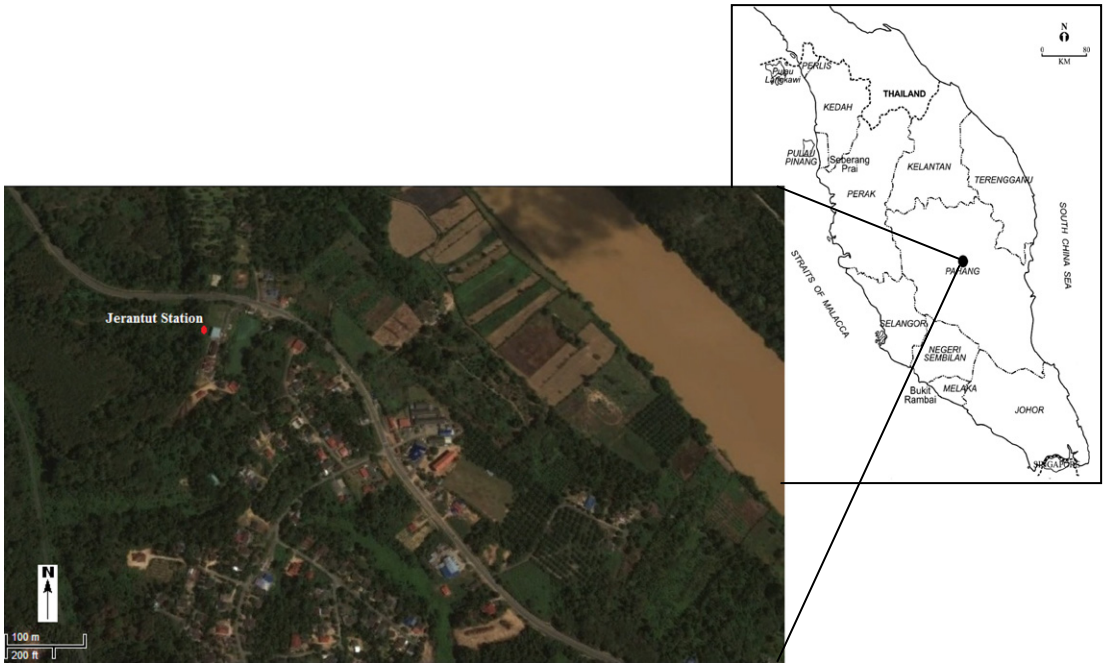

Fig. 1. Location of the Jerantut air monitoring station.