TRANS-BOUNDARY HAZE: THE ANNUAL EXO-“DUST”

S.M. Saliluddin*

*Department of Community Health, Faculty of Medicine and Health Sciences Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, MALAYSIA.

ABSTRACT

In recent years, this region has experienced an annual occurrence of smoke haze that originate from the activities related to agriculture, where large areas of farming land is burned to clear the way for new crops. This activity has given rise to smoke haze problems that cross borders and cause impacts in surrounding countries. Smoke haze cause disruption to the daily lives of the population as well as being detrimental to their health. Although the causes of pollution in the atmosphere is numerous, the annual activities giving rise to this annual smoke haze generation need to be controlled to prevent increased risk to problems related to smoke haze and other disruption to the countries in the region, both socially and economically.

Key words: smoke haze, trans-boundary haze, haze related health effects, air quality monitoring.

1.0 Introduction

Recent years have seen a period of fast paced economic development in our region. This rapid development spurt has brought with it problems previously afflicting developed regions of the world including from an environmental point of view. The increasing use of fossil fuels as well as other activities related to the process of industrialisation has caused deterioration in the environment. This coupled with the climatic changes of recent years has compounded the effects inflicted on the health of the population.

Malaysia has been indeed lucky as we have experienced one of the least polluted environments in this region despite the rapid pace of development going on. In our efforts to achieve the status of an industrialised country by the year 2020 however, it cannot be denied that the activities have begun to bring with it costs in term of industrial pollution and degradation of the environment. Reducing fishing stock and areas, air as well as water pollution and contamination by industrial wastes have become more widespread in this country. It has also been recognised that air pollution is a major contributor that affects human health, agricultural crops, forest species and the ecosystem in general. Continuous monitoring done by the relevant authorities shows that in some major cities, the level of pollutants in the atmosphere has been seen to be increasing and are not always at levels deemed acceptable by the set national ambient air quality standards.

A recent development seen in the past few years have also seen open biomass burning in our neighbouring country that produces trans-boundary smoke haze. It has become an annual phenomenon that causes deterioration in our local air quality. Severe episodes occurred in April 1983, June 1991, October 1991 and August 1994, with the worst one experienced in
In 1997 when nearly the whole country was choked by thick smog for almost 6 months. During that period, the air pollution index (API) recorded was beyond the hazardous range of 300. Severe smoke haze episode have also occurred in 2005 and 2006; both in the month of August. For this year, the same phenomenon has been experienced between the months of September until now and is only beginning to show improvement.

The full brunt of effects on human health is yet to be fully understood. As an example during the period of “killer smog” occurring over the period of 1 week in London, UK in December 1952, it was found that the smoke which was mainly emitted from coal combustion activities caused approximately 4,000 premature deaths. Conversely, the recent Beijing Marathon took place on 19 October 2014; a day hazy that recorded PM2.5 levels of 344 microgram/m3 with no apparent ill effects on its participants.

2.0 Sources of air pollution

In Malaysia, air pollution is due to three major sources, namely mobile sources, stationary sources and open burning sources. In recent years, it has been observed that emissions from mobile sources e.g. motor vehicles, form a major source of air pollution in the country, contributing to between 70-75 % of total air pollution. Meanwhile emissions from stationary sources form between 20-25 % and open burning or forest fires contribute approximately 3-5 % of air pollution. The Department of Environment has also stated that motor vehicles cause the highest percentage of load into the atmosphere at 82 %, followed by power stations (9 %), industrial fuel burning (5 %), industrial production processes (3 %), domestic and commercial furnaces (0.2 %) and open burning at solid waste disposal sites (0.8 %).

Mobile sources include motor vehicles such as personal cars, commercial vehicles, and motorcycles. Stationary sources are related to industry, power stations, industrial fuel burning processes, and domestic fuel burning. Increased activity from the industrial sector has been accompanied by an increased use of energy and commodities traffic. Open burning sources of air pollution in Malaysia include the burning of solid wastes and forest fires. This is common at some poorly managed disposal sites and results in smoke and fly ash problems. Over the last several years between July and September significant amounts of particle matter have been transported by south-westerly winds from a neighbouring country due to uncontrolled biomass burning activities. As a consequence, serious haze events were recorded in peninsular Malaysia, Sabah, and Sarawak in 1991, in 1994, and, most recently, during September and October of 1997. The cause of the 1997 haze was large-scale forest and plantation fires, particularly in southern Sumatra and central Kalimantan, both in neighbouring Indonesia. Haze conditions are aggravated by local emissions from motor vehicles, industries, and open burning activities. At its worst, the haze limits visibility to less than 500 m and produces respirable particles of concentrations up to 500 g/m³ (five times the level considered “unhealthy”).
3.0 Haze

Haze consists of smog-like tiny suspended solid or liquid particles. It can emanate from domestic or trans-boundary sources. In recent years, the haze episodes in our country have been attributed to forest and peat fires in our neighbouring country, Indonesia. In this regard, the term “smoke haze” is used.

Burned biomass causes an increase in the aerosol loadings as well as smoke in the atmosphere. The burned biomass contains concentrated particulate matter consisting of organic matter, graphitic carbon, toxic metals and acidic species. These are hazardous to health particularly the lungs, heart and circulatory system, and can also cause eye-associated illnesses among susceptible individuals in the community. The health effects can range from health symptoms that lead to treatment seeking behaviour, outpatient and emergency department visits, and hospitalisation for varying levels of severity.

Ambient air quality standards identify individual pollutants and the concentrations at which they become harmful to the public health and the environment. The standards are typically set without a focus on public health, especially the health of “sensitive” populations such as asthmatics, children and the elderly and public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, aquatic resources, and buildings. The Malaysian air pollution index (API) is obtained from the measurement of fine particles (below 10 μm) and several gases namely carbon monoxide, sulfur dioxide, and nitrogen dioxide. Table 1 lists the Malaysian air pollution index while Table 2 gives the recommended Malaysian Air Quality Guidelines (Ambient Standards) and compares them with the National Ambient Air Quality Standards currently enforced in the United States and WHO guidelines. The Malaysian guidelines are fairly consistent with the standards of the United States’.

Table 1: Malaysian Air Pollutant Index (API)

<table>
<thead>
<tr>
<th>API</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 50</td>
<td>Good</td>
</tr>
<tr>
<td>51 - 100</td>
<td>Moderate</td>
</tr>
<tr>
<td>101 - 200</td>
<td>Unhealthy</td>
</tr>
<tr>
<td>201 - 300</td>
<td>Very unhealthy</td>
</tr>
<tr>
<td>301 - 500</td>
<td>Hazardous</td>
</tr>
</tbody>
</table>

Source: DOE

Table 2: Ambient air quality standards - Malaysia vs. United States

<table>
<thead>
<tr>
<th>Air Pollutants</th>
<th>Malaysia (microgram/m3)</th>
<th>USA (microgram/m3)</th>
<th>WHO (microgram/m3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>8 hour average</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>1 hour average</td>
<td>35,000</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>100</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Annual</td>
<td>320</td>
<td>-</td>
<td>400</td>
</tr>
<tr>
<td>1 hour average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ozone</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S.M. Saliluddin
8 hour average 120 - 100
1 hour average 200 240 150
Particulate matter
Annual 90 50 -
24 hour average 150 150 -
Sulfur dioxide
Annual - 80 -
24 hour average 105 365 -

Source: DOE

4.0 Ambient air quality monitoring

Air quality parameters that define the status of air quality in Malaysia are outlined in the established Malaysia Ambient Air Quality Guidelines (MAQG) of 1989 issued by the Department of Environment. The listed concentration values are regarded as being safe for the general population. Subsequently, the air pollution index (API) was introduced as an index system for classifying and reporting ambient air quality in Malaysia. The API reference value of 100 has been set based on the MAQG 1989 ‘safe levels’ values. Further, the API values have been divided into five ranges (i.e. good, moderate, unhealthy, very unhealthy and hazardous) based on possible health effects at each category. The API for a given time period is calculated based on the sub-index values (sub-API) for all five air pollutants included in the Malaysian API system (namely sulfur dioxide or SO$_2$, nitrogen dioxide or NO$_2$, ozone or O$_3$, carbon monoxide or CO, particulate matter below 10 micron in size or PM$_{10}$). The sub-API values are in turn calculated based on the relevant data collected from the Continuous Air Quality Monitoring Stations (CAQMS) operated by Alam Sekitar Malaysia Sdn. Bhd. (ASMA). The air quality data are regularly subjected to standard quality control processes and quality assurance procedures. The reported API value are based on the highest of the five sub-API calculated for that particular time period. The predominant air pollutant parameter contributing towards a particular API value is normally indicated alongside the respective API value. During the 1997 haze episode, the predominant air pollutant parameter was PM$_{10}$ sub-index. A similar approach in monitoring ambient air quality is also commonly adopted worldwide, including the USA and several other countries, thereby promoting a uniform and comparable Air Quality Index system.

In 1997, the generally good quality air prevailing throughout the country was adversely affected largely due to the forest and peat fires in the region. During that period, all 29 (CAQMS) stations, except for the one in Miri, Sarawak recorded hourly measurements of PM$_{10}$ exceeding the MAQG of 150 μg/m$^3$, up to 15% of the time for the year or about 1300 total number of hours as recorded in Kuala Lumpur, as well as two other areas most adversely affected in Klang (12%), and Gombak (10%). In Kuching, although the measurements exceeding the acceptable level was captured for a shorter duration compared to the Klang valley (about 8%), it registered the highest API ever recorded in the country which was 839 over a period of 24 hours on 23 September 1997. The maximum API values registered at other places in the country were less than 460. At least five of the 22 locations monitored for sulfur dioxide were burdened not only by the dust and the minute particulate hanging over the lower atmosphere but also adversely affected by this contaminant, up to
16% of the time at the Prai Industrial Estate in Pulau Pinang as well as four other affected locations in Pasir Gudang, Johor (2%), Kajang, Selangor (0.4%), Johor Bharu, Johor (0.2%), and Shah Alam, Selangor (0.1%).

During the haze episode, the authorities and the public were concerned over the synergistic effects of pollutants. Particulate combined with SO₂ could be fatal, as demonstrated in the London smog of early December 1952, with 4000 deaths when the concentrations of sulfur dioxide exceeded 0.10 p.p.m. and reached almost 0.75 p.p.m. Fortunately, such an episode did not develop in Malaysia. The formation of ozone (O₃), a secondary pollutant did however, affect highly urbanized areas, namely Selayang, Gombak (1.3%), Kajang (0.7%), Shah Alam (0.6%), Kuala Lumpur (0.2%), Klang (0.1%) as well as Johor Bharu (0.1%), Ipoh (0.01%) and Pasir Gudang (0.01%). In Kuala Lumpur the measurements of CO and NO₂ levels exceeded the acceptable levels for 0.2 and 0.01% of the time, respectively. These were due to motor vehicle emissions. As the effects of El Nino weaned off, the overall conditions improved in 1998, except at some places during the early parts of the year, due to local peat-forest fires in Miri, Sarawak (30% of the time, the measurements of PM₁₀ exceeded the acceptable concentrations of 150 μg/m³), Kota Kinabalu (0.4%), Sibu (0.3%), Seberang Jaya (0.3%), Gombak (0.3%), Pengkalan Chepa (0.1%) and Kota Bahru (0.02%). Other locations, although not adversely affected by the particulate, continued to register SO₂ measurements exceeding the acceptable level of 0.04 p.p.m. for 24 h, namely, Prai Industrial Estate (5.1%), Prai Seberang Jaya (3.1%), Johor Bharu (2.35%), Pasir Gudang (2.0%) and Nilai (0.2%); all in percentage of total monitored time.

5.0 Health impacts of air pollution in Malaysia

There have been a number of possible short-term and long-term health effects of exposure to air pollution identified. In the short term, high levels of air pollution may lead to acute health effects. Blockage of sunlight may promote the proliferation of harmful bacteria and viruses that would otherwise be killed by ultraviolet B. The possible long-term health effects of exposure to air pollution are mostly unknown and difficult to detect. Components of smoke haze, including polycyclic aromatic hydrocarbons, are known carcinogens, of which the effects may not be apparent for years. The consequences may be more severe for children, for whom the particulates inhaled are high relative to body size.

There are limited numbers of studies that relate air pollution to its health impact in Malaysia. The lack of data available for environmental epidemiological analysis makes it difficult to estimate the health impact of air pollution. Recent studies in this country have attempted to elicit possible health effects of the 1997 forest fires. Outpatient visits in Kuching, Sarawak increased between two and three fold during the peak period of smoke haze and outpatient visits to Kuala Lumpur General Hospital due to respiratory causes increased from 250 to 800 per day. Data assembled indicated an increase in cases of asthma, acute respiratory infection, and conjunctivitis during August–September 1997 at a number of hospitals in Kuala Lumpur. For respiratory diseases, Selangor recorded a significant increase in the total number of cases during the September haze. Asthma cases increased from 912 in June the same year to more than 5000 in September. The total number of acute respiratory infection cases increased from about 6000 to more than 30,000 during the same period. Apart from respiratory diseases, the
number of conjunctivitis cases increased significantly during the haze period. In Selangor, the total number increased from 207 cases in June to 3496 in October. The same trend was observed in Sarawak where the daily incidence of conjunctivitis during September was found to have a positive correlation with the API reading (representing PM$_{10}$ concentration). The number of cases gradually decreased toward June figures as the concentration of PM$_{10}$ began to decrease after September. When the air quality was almost back to the values of a non-haze period in October, the number of cases returned to normal. The trend indicated that short-term exposure to high levels of PM$_{10}$ was detrimental to human health. Effects were found to be greatest in children, the elderly, and people with pre-existing respiratory problem; while youngsters are among the most resistant. A preliminary survey carried out among secondary school children in Kuala Lumpur and Klang revealed that less than 50% of these school children sought medical treatment each time they fell sick.

A study conducted also suggested that in the 1997 haze episode the total health effects were estimated to include 285,227 asthma attacks, 118,804 cases of bronchitis in children, 3889 cases of chronic bronchitis in adults, 2003 respiratory hospital admission, 26,864 emergency room visits, and 5,000,760 restricted activity days. Population from all states was at risk except for those in Perlis, Kelantan, and Sabah. The total health damage cost was significantly high due to the long duration of the haze. The results show that restricted activity days accounted for about 79.3% of the health damage cost while asthma attacks contributed 10.7% to the total health damage cost. The contributions of the other three health effects such as respiratory, hospital admission, emergency room visits, and chronic bronchitis were insignificant. Each of the above-mentioned effects actually contributed less than 1% of the total health damage costs. The estimated health effects for Kuala Lumpur and Selangor during the haze were also high, since both states recorded an average PM$_{10}$ of 170.6 and 131.22 μg/m$^3$, respectively.

Another study conducted revealed that in the 1997 haze episode the population at risk was from all states of the country except Kelantan, Terengganu, and Pahang; this population is estimated to be 18 million people. But the incidence of risk varied among states in terms of intensity and length of the haze. The increased cost incurred by the population at risk for treatment of haze-related illnesses from both public and private clinics and hospitals and for self-treatment (mainly for the purchase of medicine) was estimated to be RM 5.02 million during the period of August–October 1997. The incremental cost incurred for hospital admissions was estimated to be RM 1.18 million during the same period. This study also revealed that the country experienced productivity losses as a result of haze-related illnesses. These productivity losses occurred in missed production opportunities during the idled workdays when workers were in hospital or on sick leave. Those not hospitalized and not granted sick leave, who managed to continue working are believed to have experienced reduced activity days arising from the haze-related illnesses they suffered. These sources of haze-related productivity losses are estimated to be RM 4.3 million.

The major air contaminant during the 1997 haze in Malaysia was suspended particles, while gaseous pollutants were not significantly different compared with normal days. During the period, PM$_{10}$ concentration rose beyond the MAQG (1989) level in almost all areas.
monitored. It increased fourfold higher in Klang Valley, and up to 20-fold in Kuching. In reflecting the scenario, Hospital Kuala Lumpur recorded an increase in cases of upper respiratory tract infections, asthma and conjunctivitis; three diseases directly caused by the haze. The increase in asthma cases was found to have a 2 day lag behind the Malaysian API as reported by the Ministry of Health Malaysia in 1998. However, no change was observed for mortality figures.

Apart from respiratory diseases there was also a significant increase in conjunctivitis during the haze period. In Selangor, the total number of cases increased from only 207 cases in June 1997 to as high as 3496 cases in October 1997. The same trend was also observed in Sarawak. In addition, the daily incidence of conjunctivitis in Sarawak during September was found to have a positive correlation with the API (representing PM$_{10}$ concentration).

The data suggest that the adverse effect of haze on human health could be attributed to the elevated PM$_{10}$ levels in the ambient air and not likely to be due to other pollutants. Despite the reversibility of the acute effects observed, it is believed that exposure to haze might also lead to long-term effects on the community. This calls for more vigorous long-term studies. Besides the health data, a spirometry study done on 16-year-old schoolchildren in Kuala Lumpur also revealed that long-term exposure to a relatively higher PM$_{10}$ concentration led to decreased lung functions and increased prevalence of respiratory symptoms. The schoolchildren in Kuala Lumpur had been exposed to 103.27 μg/m$^3$ ambient PM$_{10}$, while the control group (matched for age, gender, height, weight and smoking habits) was exposed to only 47.35 μg/m PM$_{10}$. A significant reduction in spirometry parameters such as the vital capacity (VC), forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV$_1$) was observed among the Kuala Lumpur schoolchildren.

A higher prevalence of respiratory symptoms was observed in the Kuala Lumpur group; the most commonly reported symptoms being chest tightness, followed by breathing difficulties, morning phlegm and coughs. In both groups, females were found to be more susceptible to develop ailments, showing a higher percentage in the prevalence of the respiratory symptoms. Therefore, it was concluded that prolonged exposure to a relatively high concentration of PM$_{10}$ (even though below the set safety limit) is associated with reduced lung function and increased respiratory symptoms in schoolchildren.

There is ample evidence that the most susceptible groups to exposure to air pollutants are the elderly and very young children, while youngsters are among the most resistant. However, the study done clearly indicates adverse effects due to the exposure on the 16 year olds, hitherto assumed as the most resistant age group.

In addition, a preliminary survey carried out among secondary schoolchildren in Kuala Lumpur and Klang revealed that less than 50% of these school-children sought medical treatment each time they fell sick. Therefore, the total number of respiratory cases reported in the clinical health data may actually be lower than the exact figure of adverse effects caused by the haze on the community. However, despite this bias, the researchers still observed significant increases in haze-related diseases.

Although analysis of the health and spirometry data revealed that short-term exposure to very high PM$_{10}$ led to increased cases of related diseases, the effect was apparently reversible.

S.M. Saliluddin
Nevertheless, prolonged exposure to PM\(_{10}\) even below the MAQG could reduce the lung function and increase the prevalence of respiratory symptoms. Therefore, it was concluded that the concentration of PM\(_{10}\) and the period of exposure might determine the nature of the adverse effect on humans.

### 6.0 Continuous air quality monitoring network and value added data

Under the privatization program of the government of Malaysia, a network of 50 CAQM is being built and has been established for its first 5-year period (1995–2000). It will be operated and owned by ASMA for a 20-year period (1995–2015). As of 30 September 1998, 37 CAQMS have been commissioned and are effectively in operation.

The DOE receives the data through electronic means, on-line, 24 h a day for at least 85% of the time in a month. Subject to DOE concurrence, such data are also accessible to other environment-related authorities, researchers, and concerned private citizens, especially those whose health may be sensitive to air pollution.

The data, other than to help establish the status of air quality in Malaysia, are invaluable to both the regulator, in particular the DOE, and the industry at large. To the DOE, any regulatory action has its scientific basis, and should not be construed as an exercise of ‘whim and fancy’. To the industry, and other polluting sectors of the economy, the same credible and timely data should provide the early signal for self-regulation as promoted by the Government of Malaysia as part of the 1998 Budget strategy for the environment. Other than relying on stricter enforcement, the private sector can also play an important role in promoting new mechanisms for protecting the environment. One that offers considerable promise is a series of environmental management standards, known as ISO 14000, developed and introduced under the monitoring of the International Organization for Standardization in Geneva. The adoption and implementation of such a standard where there is a clear and positive stake in participating, hold more promise for change than the traditional top-down political approaches we have seen.

Based on assessment, the emissions of unburnt hydrocarbons from motor vehicles and other oil and gas works remain the most serious source of air pollution in Malaysia. Equally serious are the emissions of SO\(_2\) due to high-sulfur fuel dependency for industrial production and electric power generation, as found in Prai, Pasir Gudang, Johor Bahru, and the Klang Valley. In addition to biomass burning within the country or beyond national boundaries, much of the dust and fine particulate was contributed by the inefficiency of diesel-powered vehicles, on and off the road.

The annual trends do not appear encouraging. However, these trends can be reversed through several means- increasing environmental awareness and stopping open burning activities. The responsibility to ensure that our air is clean rests with one and all. Greater provisions of public rather than private transportation by polluting motor vehicles; using less sulfur fuel and more gas; using natural gas for vehicles and not diesel; saving electricity and power; planning holiday breaks and school holidays during the month of September may help toward this end.

S.M. Saliluddin
In addition, vigorous research and development efforts should be geared toward establishing long-term effects of air pollution despite its apparent reversible acute impact on human health.

References:


Department of the Environment, Malaysia, 1996. Malaysia Environmental Quality Report. Department of the Environment, Ministry of Science, Technology and Environment, Malaysia