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URBAN AIR ENVIRONMENTAL HEALTH INDICATORS: A PRELIMINARY SET FOR CITY OF KUALA LUMPUR

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Abstract

Environmental health as an aspect of concern on healthy environment, involves relationship between environment and human health. It comprises the aspects of human health and diseases that are determined by factors in the environment, as well as the characteristics of environmental conditions which affect the quality of health. Generally, urban ambient air is more polluted than overall atmosphere. It is due to higher concentration of human activities and more rapid urban development in urban areas. Urban areas produced air pollutants with higher rate as compared to less developed areas and natural environment. Furthermore, the atmosphere has always been one of the most convenient places to dispose of unwanted materials, which includes burning activities. It changes the natural combination of gases in the air and causes higher rate of urban air pollution. Besides, the air pollutants are likely to circulate and remain in the urban environment due to the "dust dome" phenomenon. Air pollutants are potentially affecting human health. Epidemiologic and laboratory studies demonstrate that ambient air pollutants contribute to various negative health problems, especially on the respiratory

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and cardiovascular systems, skin, and eyes. Research was carried out in developing a set of environmental health indicators for urban air. The determination of environmental health for urban air involves the identification of air-related health conditions and air quality. The preliminary indicators were formulated to examine the air environmental health conditions and issues in city of Kuala Lumpur. Environmental health indicators are providing useful information for decision-makers, and helping in generating discussion among people of different backgrounds.

Keywords: Municipal solid waste; Local authorities; Waste characteristics; Health Impact; Landfill; Integrated waste management

INTRODUCTION

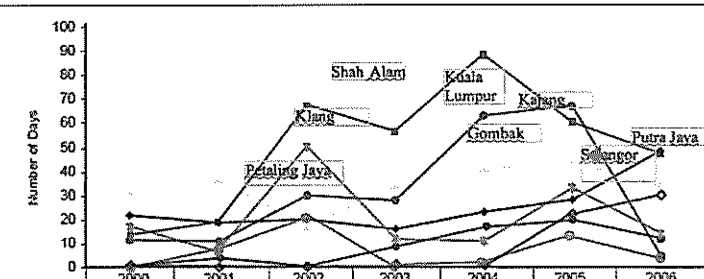
The atmosphere is composed of gas molecules held close to earth's surface by a balance between gravitation and thermal movement of air molecules (Botkin & Keller, 2003). It consists of a number of gases including nitrogen (78%), oxygen (21%), carbon dioxide (0.03%), and less than 1% of argon, neon, helium, cryton and xenon (Koren, 1980). Water vapour is also present in the lower level of atmosphere (Botkin & Keller, 2003). In general, majority of air pollutants are very low in percentage (dry air by volume) in the overall ambient air, which are only 0.00002% of nitrous oxides (N_2O), 0.00001% of carbon monoxide (CO), 0.000002% of ozone (O_3), 0.0000001% of nitrogen dioxide (NO_2), 0.00000006% of nitric oxide (NO), and 0.00000002% of sulphur dioxide (SO_2) (Gupta & Asher, 1998). However, the high growing trend of air pollutant such as carbon dioxide (CO_2) was observed. The concentration of CO_2 in the atmosphere had increased about 10% during the twentieth century (Koren, 1980).

"Urban" in local context, had been defined by JPBD (2006) as, "a gazetted area with its adjacent built-up and consolidated areas located within the urban limits which is including settlement and committed areas that have been approved, with minimum population of 10,000 people, with at least 60% of population are employed (15 years and above) in non-agricultural activities, with estimated population density of 50-60 persons per hectare, and with urban amenities". Urban ambient air is regarded as the most polluted air environment as compared to suburban and rural areas. This was due to higher concentrations of human activities in the urban areas that were capable to produce more pollutants. Study in city of Kuala Lumpur (Ling et al., 2010) with the assistance of Spearman correlation tests indicated a significant and strong positive relationship between the number of unhealthy/hazardous days and urban land uses for the period of 1999/2000 to 2005. The unhealthy/hazardous days were measured by using Air Pollution Index (API) with the five parameters (i.e. PM_{10}, CO, NO_2, O_3 and SO_2). The urban land uses were referred to shopping floor spaces, office floor spaces and industrial units.

Urban developments and activities change natural combination of gases in the air, and cause higher contamination of pollutants in the air. For instance, the annual mean concentrations of NO2 were ranged from 0.4 μg/m³ to 9.4 μg/m³ in natural background areas. However, outdoor ambient urban levels had an annual mean ranging from 20 μg/m³ to 90 μg/m³, and hourly maximum concentrations were ranging from 75 μg/m³ to 1,015 μg/m³ (Forastiere et al., 2006). The air pollutants are likely to circulate and remain in the urban environment due to the "urban heat island" and "dust dome" phenomena, and the air pollutants were consistently high as compared to the surrounding areas (Purdom, 1980; Sham, 1989; Kinney & O'Neill, 2006).

In the period of 2000 to 2005, based on API, city of Kuala Lumpur and city of Shah Alam were experiencing high number of unhealthy days. In general, during the six years period, city of Kuala Lumpur was the second top city in term of the number of unhealthy days as compared to the other cities or towns in Klang Valley (Figure 1). However, in 2006, the number of unhealthy days in Kuala Lumpur was decreased significantly to 5 days only as compared to 67 days in 2005 and 63 days in 2004 (DOE, 2007a).

Figure 1: The number of unhealthy days in cities or towns in Klang Valley



	2000	2001	2002	2003	2004	2005	2006
Gombak	22	19	20	16	23	28	48
Shah Alam	14	19	67	56	88	60	47
Kajang	32	37	17	34	41	44	34
Kuala lumpur	12	11	30	28	63	67	5
Klang	17	7	50	12	11	33	14
Petaling Jaya	0	4	0	9	17	20	12
Kuala Selangor	0	8	21	0	2	13	4
Putrajaya	0	0	0	1	1	22	30

In recent years, urban dwellers in Malaysia were voicing out their complaints on the unacceptable air pollutions and the potential health impacts. In 2004, statistics for Kuala Lumpur showed that out of the total 381 environmental complaints received, 70.6% was for air pollution, and 10.5% for bad odour (Iktisas, 2006). The number of complaints on air pollution was further increased in 2006 with 385 complaints out of the total of 498 environmental complaints (77.3%). The number of complaints on bad odour was maintained at 40 cases or 8.03% in 2006 (DOE KL, 2006).

Studies by World Health Organisation (WHO, 2007) in various parts of the world showed that more than 80% of diseases were due to environmental risk factors. Globally, nearly one quarter of all deaths and of the total disease burden can be attributed to the environment. Moreover, slightly more than one-third of the disease burden among children was due to environmental risk factors (WHO, 2007). The estimated annual global burden of disease attributable to urban air pollution is 13 deaths per 100,000 inhabitants, and 7,865,000 Disability Adjusted Life Years (DALYs) or 128 DALYs per 100,000 people (Hambling & Slaney, 2007).

The aspect of concern on healthy environment and the relationship between environment and human health has been called as "environmental health" (CDC, 2006). It comprises the aspects of human health and diseases that are determined by factors in the environment, as well as the characteristics of environmental conditions which affect the quality of health (Purdom, 1980). Determination of environmental health can be defined as combination of identification of "human health conditions" (health effect) and "environmental quality/conditions" *(equation 1).*

$$\textit{Environmental Health} = \textit{Human Health} + \textit{Environmental Conditions} \qquad (1)$$

With the focus on urban air environmental health indication, air-related health indicators were used instead of overall health conditions of general public. Meanwhile, general environmental conditions were replaced by air quality indicators *(equation 2).*

$$\textit{Air Environmental Health indicators} = \begin{array}{c}\textit{Air-related Health}\\ \textit{Indicators}\end{array} + \begin{array}{c}\textit{Air Quality}\\ \textit{Indicators}\end{array} \qquad (2)$$

OBJECTIVE AND METHODS

Study was carried out to develop a preliminary set of urban air environmental health indicators for city of Kuala Lumpur. The process involves a literature review on the impact of air pollution on human health, and review on the existing environmental health indicators established in Malaysia and other parts of the world. The review was not only focusing on the indicators which directly called as "environmental health indicators", but also those listed under the title of "sustainability", "public health", "urban indicators", or "air quality" which were related to the indication of environmental health of the urban air.

IMPACT OF AIR POLLUTION ON HUMAN HEALTH

Clean air is a basic precondition of human health. Generally, cities were engulfed by air pollutant which was identified as one of the main causes of human diseases.

The primary emissions of sulphur oxides (SO_x), nitrogen oxides (NO_x), CO, respirable particulates (PM), and metals (such as lead and cadmium) were severely polluting cities and towns in Asia, Africa, Latin America, and Eastern Europe (Christiani & Woodin, 2002).

Respiratory and cardiovascular diseases are especially relevant to air pollution susceptibility worldwide (Kinney & O'Neill, 2006). Research had shown that many air pollutants especially CO, O3 and fine particulate matter ($PM_{2.5}$) may contribute to the onset or aggravation of heart diseases (US EPA, 2003; Utell et al., 2006; Samet et al., 2006). Studies on the laboratory animals and human populations showed significant association between acute cardiovascular system effects (such as heart rate variability, HRV) and air pollutant levels (such as PM_{10} and O_3) (Saldiva et al., 2006).

Furthermore, epidemiologic and laboratory studies demonstrated that ambient air pollutants (e.g. PM, O_3, SO_2 and NO_2) contributed to various respiratory problems including bronchitis, emphysema, and asthma (Romieu, 1999; Botkin & Keller, 2003; US EPA, 2007; WHO, 2005a; Forastiere et al., 2006; Utell et al., 2006). People suffering from respiratory diseases (e.g. asthma) are the most likely to be affected by air pollution (Botkin & Keller, 2003).

For instance, a long term study on residents of six US cities (in 1974, involving 8000 subjects over a period of 14–16 years) showed that subjects living in the more polluted cities have a higher risk of hospitalisation and early death from pulmonary and heart diseases as compared to those living in the less polluted cities. The relationship between air pollution and mortality was much stronger for the fine particle component than for the gaseous pollutants (NIEHS, 2007). In Asian cities, a study of the relationship between PM10 concentrations and the number of patients (2005/2006 in Korea) showed positive correlation coefficients in the eight cities except for Busan, for 2005 (Dong et al., 2007).

In Malaysia, there are a very limited number of studies that relate air pollution to the impact on health. A few studies have examined possible health effects of the 1997 forest fires in this country. Besides, data on health impact during 2005 haze episode was also collected. During the haze episodes, there were a high increased number of asthma, acute respiratory infection (ARI) and conjunctivitis cases in both West Malaysia and East Malaysia (Rafia et al., 2003; Norela et al., 2008). For example, during the 1997 haze episode, the number of respiratory disease outpatients visited the Kuala Lumpur General Hospital increased from 250 to 800 per day. In Selangor, asthma cases increased from only 912 in June to more than 5,000 in September, 1997. The total number of ARI cases increased from about 6,000 to more than 30,000 during the same period (Rafia et al., 2003).

Another study in Malaysia was carried out to identify risk factors in childhood asthma through case studies at Ipoh General Hospital (Shamarina, 1998) via self-administered questionnaires (among 32 parents / guardians of patients who were 1 to 16 years old). The study found that common risk factors among the patients include family history of asthma (65.7%), allergic to dust (53.1), location of house (37.5% near factories; 34.4% near main roads), and the presence of smoker or ex-smoker in the house (65.7%; father 53.1%, mother 6.3%). It showed that majority of young asthmatic patients were allergic to air pollutants (dust) and a high percentage of them lived near to the source of air pollution (factories and main roads). Shamarina (1998) explained that asthmatics patients who lived in areas located in the vicinity of factories or main roads were three times as likely to be severe asthmatics compared to asthmatics who did not live in such areas.

Exposure to air pollution is not limiting to inhalation alone, it is referring to contact with any part of the human body (Janssen & Mehta, 2006). Therefore, beside the respiratory and cardiovascular effects occurring due to inhalation, it also can result in eye or skin irritation (Janssen & Mehta, 2006; Botkin & Keller, 2003), such as conjunctivitis (MOH, 2004; Rafia et al., 2003). Besides, exposure to O3 also increased the risks of skin cancer (DOS, 2001). Besides, the effects of air pollutants on human health are also depending on the doses or concentrations of the air pollutants, and other factors including the individual susceptibility (Botkin & Keller, 2003).

ENVIRONMENTAL HEALTH INDICATORS

Indicators are measurements selected to represent a large phenomenon of interest. An indicator points to certain issue or certain condition in certain city. It provides useful information for decision makers, not just data (Peterson et al., 1999), and can generate discussion among people with different backgrounds and viewpoints (Andrew, 1998).

Environmental indicators evolved during the 1970s when the environment became a mainstream issue and governments responded with environmental assessment legislation and processes. In the 1980s, two approaches arrived, which were sustainable development and healthy communities. Sustainable development indicators are now commonly used at the national, regional and local levels in many nations. The healthy community model continues to frame analysis, although it seems to have been eclipsed since the late 1990s by the quality of life model (Seasons, 2005). In the past 20 years, some of the most interesting theoretical advances in broad-based indicator development have been the promotion of a capabilities approach; the synthesis of economic, quality of life and environmental indicators under the banner of sustainability; and experimentation with participatory methodologies (Keough, 2005).

Besides the broad-based sustainable indicators and quality of life indicators, there are also more specified or focused indicators which have been developed and used for the issues of environmental health, such as Environmental Health Indicator by WHO, the adaptation by WHO-Europe and New Zealand, and the Environmental Public Health Indicators by Atlanta.

In this study, preliminary set of environmental health indicators was developed for the aspect of urban air. It includes two major components which are air quality indicators and air-related health indicators. In selecting and proposing environmental health indicators, the following points were taken into consideration:

i. The link between the proposed indicator and the human health issue, and the ability to determine the impact on health when using the proposed indicator.
ii. The feasibility of using the proposed indicator. After the formation of preliminary indicators, the indicators are tested in Kuala Lumpur before being refined. However, this paper is not aimed to discuss on this matter.
iii. Scientific basis.

The explanation of the formation of preliminary indicators was divided into two major parts which were "air quality indicators" and "air-related health indicators".

Air Quality Indicators

A review of existing air quality indicators for environmental health

In general, for the purpose of indicating urban air quality level for environmental health or sustainability, the five pollutants (PM, O_3, CO, SO_2, NO_2) and API (or Air Quality Index, AQI) are usually selected. For example, an indicator of ambient air quality as proposed by WHO Environmental Health Indicators (Briggs, 1999) is "mean annual or percentile concentration of six major ambient air pollutants", which are covering O3, CO, particulate matter (PM_{10}, $PM_{2.5}$, SPM), SO_2, NO_2 and lead (Pb). Indicators have been proposed by Briggs (1999) and Gosselin et al. (2001) as "number of days/hours in excess of air pollution standard". They are similar to the New Zealand, Seattle, US and other indicators, such as:

a. New Zealand: number of days exceeding WHO guidelines for the major five pollutants, which are PM_{10}, O_3, SO_2, NO_2, and CO (Hambling & Slaney, 2007);
b. Seattle, Washington, US: number of "good" air quality days in the calendar year (Peralta, 2003);
c. Atlanta: annual high levels of criteria pollutants: PM_{10}, O_3, SO_2, NO_2, CO and Pb (CDC, 2006);

d. US EPA (2003): number and percentage of days that metropolitan statistical areas have Air Quality Index (AQI) values greater than 100 (under 100, the air quality is considered good or moderate); number of people living in areas with O_3 (8 hour average) and $PM_{2.5}$ levels above the National Ambient Air Quality Standards (NAAQS);
e. Gosselin et al. (2001) for the US-Mexico region: percentage of children living in counties in which concentrations of air pollutants are exceeded air quality standards;
f. Kuching Healthy City (Malaysia): number of pollution free days in a month; number of areas with air pollution in a month (Andrew, 1998);
g. Selangor Sustainable Development Indicators: total number of days with API exceeding an unhealthy level; SO & NO pollution levels in Petaling Jaya & Shah Alam; small particulate matter & PM_{10} concentrations (Selangor State Government, 2001);
h. Malaysian Sustainable City Award ('Bandar Lestari' Environment Award): number of days exceeding standards for CO and NO_x concentrations in ambient air, for selected year (Tan et al., 2006);
i. Malaysian Urban Indicators Network (MURNInet): average API value in a year (Kamalruddin, 2005).

In KL, environmental targets and indicators were proposed by the Kuala Lumpur Local Plan's study team in its Finding Report (AJM, 2006). There was only one indicator which measured the "state" of urban air environmental health, and none for the measurement of health effects. API was suggested as an indicator, to achieve the following target: "strive for API to be within the good range for 20% of the year and within the moderate range for the remaining 80% of the year".

As a reference to the various air quality indicators chosen by various organisations at local and international levels, the indicator and target proposed by AJM (2006) for KL are the most appropriate to be adopted for this study. This is because they were designed based on a target for better air environment for KL city. The indicator is an accumulative of other individual indicators to form a target oriented indicator. By choosing API to form air quality indicators, PM10, CO, NO2, O3 and SO2 were chosen as air quality parameters. These five pollutants have the potential to affect human health.

The target is not too high as compared to the previous air quality level. KL's air quality level (2000 to 2003) with an unhealthy API level was only 10% or less, and the remaining days were moderate or good. It was not too far from the targeted standard (good range for 20% of the year and within the moderate range for the remaining 80% of the year). This is a reasonable target for KL. As compared to Singapore (a neighbouring city-country), for the period of 2000 to 2003, Singapore city's ambient air had already experienced 88% (or about 320 days) "good days", while KL city had only about 12% (or 42 days) "good days". In terms of unhealthy days, KL experienced about 9% or 20 days while Singapore did not experience any unhealthy days (AJM, 2006).

A review of urban air quality

The formation of air quality indicators for Kuala Lumpur should take into consideration the common air pollution in urban areas. Based on the ambient air quality data for 2000 and 2006 (DOE, 2007b), the more significant ambient air pollutant in Kuala Lumpur were NO_2 and O_3, followed by PM and CO. Majority of air pollutants in urban areas were contributed by mobile sources (transportation) and stationery sources (power stations, industrial fuel burning process, domestic fuel burning) (Sivertsen, 2006; Harrison, 2006). In Malaysia, about 80% of air pollutants were contributed by mobile sources (Table 1). Transportation (mobile sources) and stationery sources contribute to the high percentage of total pollutant emissions in urban areas for PM, CO, NO_2, O_3 and SO_2. Therefore, the concentrations of these pollutants were higher in urban as compared to rural areas.

In United Kingdom (UK), the United States (US), Belgium, Germany, Finland and Italy, transportation sector along had contributed to more than half of the total emissions of CO and NO_2 (Harrison, 2006). Actually, the principal sources of CO and NO_2 were traffic (EPU, 2006), and to a lesser extent industries, shipping and households (Sivertsen, 2006) and power generation (DO_S, 2001). For SO_2, majority were contributed by power plants followed by industries, and others such as hotels and commercial premises (EPU, 2006; Harrison , 2006).

Table 1: Emissions of air pollutants by sources in Malaysia, 1995, 1998, 1999 & 2005.

Sources	1995		1998		1999		2005	
	'000 tonnes	%	'000 tonnes	%	'000 tonnes	%	'000 tonnes	%
Mobile sources	3,386.00	84.30	2,402.80	73.80	2,563.10	81.66	1,537.98	82.37
Stationery sources	477.57	11.89	706.50	21.70	461.40	14.70	329.21	17.63
Burning of wastes	153.14	3.81	146.50	4.50	114.20	3.64		
Total	**4,016.71**	**100.00**	**3,255.80**	**100.00**	**3,138.70**	**100.00**	**1,867.19**	**100.00**

Note:
Mobile sources : *vehicles*
Stationary sources : *power stations, industrial fuel burning process, & domestic fuel burning*
Burning of wastes : *burning of municipal & industrial wastes*
Source : DOS, 2001; 2006

Proposed air quality indicators for Kuala Lumpur

The proposed preliminary air quality indicators for Kuala Lumpur are explained as follows:

i. Trends of average concentrations of air pollutants (SO_2, NO_2, O_3, PM_{10}, CO), in order to observe the change of air quality during the whole period of the study as well as in the dry and wet seasons.

ii. Total number (or percentage) of good, moderate, unhealthy, very unhealthy, hazardous or emergency API days in the dry and wet seasons, as well as during the whole period of the study. The percentage of good, moderate, unhealthy, very unhealthy, hazardous or emergency days would determine the level of air quality for a period. The proposed KL's environmental target for air quality is to be used to indicate the "excellent" air quality level, which is a good range of API for 20% of the year (or a period) and within the moderate range for the remaining 80% of the year (or a period). The proposed classifications of air quality levels for this indicator are shown in Table 2.

Table 2: Proposed classifications of air quality level

Classification	Criteria (air quality condition)
Excellent	Good API days for 20% or more of a year (or any period) and the remaining days are moderate. No unhealthy/hazardous/emergency days.
Good	Good API days for 10 to <20% of a year (or any period) and the remaining days are moderate. No unhealthy/hazardous/emergency days.
Moderate	Good API days for <10% of a year (or any period) and the remaining days are moderate; or Unhealthy API days for <10% of a year (or any period) and the remaining days are moderate or good.
Unhealthy	Unhealthy API days for 10 to <20% of a year (or any period) and the remaining days are moderate or good.
Hazardous	Unhealthy API days for 20% or more of a year (or any period) and the remaining days are moderate or good; or any very unhealthy, hazardous or emergency API days in a period.

iii. Total number (or percentage) of good, moderate, unhealthy, very unhealthy, hazardous or emergency API days for every single pollutant (i.e. SO_2, NO_2, O_3, PM_{10}, CO) in the dry and wet season, as well as during the whole period of the study. The percentage of good, moderate, unhealthy, very unhealthy, hazardous or emergency days would determine the level of air quality for a period. The same methodology and classification as in "indicator ii" is to be used. The reason for "indicator iii" in addition to "indicator ii" is to assist the discussion of the potential source and factors of air pollution which are related to the urban development and activities.

iv. Percentage of the city's population living in areas where the air quality outside the housing is experiencing unhealthy, very unhealthy, hazardous or emergency API levels.

v. Percentage of people frequently exposed to air pollution (as self-reported) in relation to the total population.

Air-related Health Indicators

A review of existing air-related health indicators

International indicators such as Environmental Health Indicators for the WHO European Region (WHO-Europe, 2002) had been formulated with limited parameters which were using common readily available data for international comparison. However, it also consisted of indicators for individual countries. Other than Europe, there are Environmental Health Indicators in various countries, such as New Zealand (Hambling & Slaney, 2007), Atlanta (US) and Seattle (US). The localised environmental health indicators were also formulated with readily available data especially from hospital records for the purpose of monitoring environmental health conditions. Summary of the air-related health indicators are shown in Table 3 (first and second columns).

Preclinical health conditions or ill-symptoms as health indicator

For a good health indicator, the measurement should not only focus on the diagnosed illnesses (clinical), but also the preclinical health conditions or ill-symptoms. The total impact of air pollution on the population is likely to be dominated by the less severe health effects such as sub-clinical (preclinical) and symptomatic events (Gouveia & Maisonet, 2006). The proportion of the exposed population affected by these outcomes is much larger than those affected by more severe events such as emergency admissions to hospitals and deaths. It is important to consider that some of the less severe effects may lead to chronic effects later in life (Gouveia & Maisonet, 2006). Hence, health indicators should include the identification of ill-symptoms (preclinical) besides the frequency of medication use, and the rates of hospitalisation and visits to hospitals/ clinics (clinical).

According to the Disease Spectrum (Figure 2), patients will enter the stage 4 (preclinical) before they are diagnosed with any illness. In stage 4, as the symptoms become gradually more marked and perhaps troublesome, the patient decides that something is wrong and seeks medical advice (the 'surrender point'). With that, the stage of recognised ill-health (stage 5 – clinical disease) has been reached, but that is a relatively late stage in the total process and opportunities for prevention have been lost (Rowland and Cooper, 1983).

Figure 2: The Disease Spectrum

Time

Surrender point

1	2	3	4	5	6
People with no disease	People with no disease but in susceptible high-risk category	Pre-disease	Preclinical (with symptom)	Clinical disease	Death

Source: Rowland and Cooper, 1983

Proposed air-related health indicators for Kuala Lumpur

By referring to the proven relationship between air pollution and human health and the established related international and local indicators, preliminary air-related health indicators were formulated in this study. However, one of the major differences (improvement) in the newly formulated indicators (for this study in KL) as compared to other indicators was that the indicators did not only focus on the diagnosed disease (clinical), but also covered the preclinical health conditions or illness symptoms. Table 3 shows the proposed preliminary set of air-related health indicators (third column of Table 3), and the indicators proposed by others (first and second columns of Table 3).

Table 3: Air-related health indicators

Existing established indicators	**Organisation / source**	**Proposed preliminary indicators for KL**
Number of cases & number of deaths for acute respiratory infections (ARI) in a year.	WHO (2005b) for Singapore	1. ARI rate (incidence, hospitalisation, outpatient visit or deaths) per 10,000 people (all age).
Incidence of morbidity due to the ARI in children under 5 years, & the elderly.	WHO Environmental Health Indicators (Briggs, 1999)	2. ARI incidence, hospitalisation or outpatient visits rate among children below the age of 5, & 13 (per 10,000; children) 3. ARI incidence, hospitalisation or outpatient visits rate among the elderly (age 65 & above) per 10,000 people;
Incidence of mortality due to the ARI in children under 5 years, or disease-specific mortality.	WHO Environmental Health Indicators (Briggs, 1999)	4. ARI mortality rate among children below the age of 5, & 13; 5. Asthmatic mortality rate among children below the age of 5, & 13;
Number of asthma case to 10,000 population.	MURNInet, (Kamalruddin 2005)	6. Hospitalisation, outpatient visits or emergency unit visits rate for asthma cases (per 10,000 people);
Rate of hospitalization of children for asthma (children 0-14).	Seattle's Environmental health indicators (Peralta, 2003); Gosselin et al. (2001)	7. Hospitalisation, outpatient visits or emergency unit visits rate among children due to asthma (below the age of 5, & 13) and the elderly (aged 65 & above) per 10,000 children or people;
Hospitalisation / occurrence of morbidity or mortality due to: - Carbon monoxide poisoning - Lead poisoning (in children). Consultation / emergency department visits for possible poisoning in a child, including lead poisoning.	Atlanta's Environmental Public Health Indicators (Centers for Disease Control and Prevention, 2006)	*This indicator focuses on impact on health from specific sources of pollution, which has been included in other indicators for ambient air. Lead concentration in Malaysian urban areas (ambient air) is far lower than standard (DOS 2006). Besides, primary sources of lead exposure (for most US children) are deteriorating lead-based paint & lead-contaminated*

Existing established indicators	**Organisation / source**	**Proposed preliminary indicators for KL**
		dust & soil; others were child-oriented products & possible drinking water (US EPA 2007)
Number of asthma-related deaths.		8. Asthma-related death rate (per 10,000 people);
Incidence of asthma.		
Rates of hospitalisation & emergency department visits for acute asthma events.		*Taken into account in constructing indicators (emergency unit visits).*
Number of work days missed because of asthma.		9. Number of work days missed per patient due to asthma; 10. Rate of work days missed due to asthm a (per 10,000 people);
Number of school days missed because of asthma.		11. Number of school days missed per patient due to asthma; 12. Rate of school days missed due to asthma per 10,000 school children;
Proportion of population filling prescription for asthma medication.		13. Increase of severity of chronic respiratory/cardiac illness due to air pollution (or haze), as measured by increase in intake of medicine (%)
Number of admissions for coronary heart disease.	Kuching Healthy City (Andrew, 1998)	*Combined with other indicators*
Incidents of cardiovascular & respiratory events (unusual event, outdoor air standards are exceeded).	Atlanta's Environmental Public Health Indicators (CDC, 2006)	*Combined with other indicators*
Acute cardiovascular & respiratory events.		
Cancer incidence & mortality rates, lung cancer in non-smokers, etc.		15. Rate of lung cancer patients among non-smokers, and rate of mortality;

Existing established indicators	Organisation / source	Proposed preliminary indicators for KL
Number of peoples visit to hospital due to asthma, upper respiratory infections (URI) & conjunctivitis.	Malaysian Government (Norlela et al., 2005)	16. Incidence, hospitalisation or outpatient visits rate due to conjunctivitis (per 10,000 people).
Emergency consultations for asthma, bronchitis, cardio-pulmonary disease	Gosselin et al. (2001)	17. Non-asthmatic chronic respiratory rate for hospitalisation, outpatient visits or emergency visits (per 10,000 people). 18. Hospitalisation, outpatient visits or emergency visits rate due to cardiac diseases (per 10,000 people).
Annual number of hospital admissions for respiratory diseases (per 100,000 population)	Environmental Health Indicators for New Zealand (Hambling & Slaney, 2007)	
Annual number of hospital admissions for diseases of the circulatory system (per 100k. p.)		
Annual number of hospital admissions for asthma (per 100k. p.)		*Combined with other indicators*
Annual mortality rate due to respiratory diseases; or cardiovascular diseases (per 100,000 population)	Environmental Health Indicators for New Zealand (Hambling & Slaney, 2007)	20. Mortality rate due to respiratory diseases *(bronchitis, emphysema, COPD, etc)*; and cardiac diseases.
Annual prescription rate for asthma medication (per 100k. p.)		*Combined with other indicators*

Note:

1. Any illness experienced and lasting for a period within 14 days was considered as an episode/ case of acute event, such as ARI. This is similar to the definition used by the Institute of Public Health, Malaysia. The majority of ARI episodes lasted within a duration of 14 days and was an acute, self limiting condition (IPH, 2008).
2. Rates of illness in these indicators are calculated as ratios of illness cases among respondents to total number of respondents (or any segment of respondents) which may consist of repeated cases of the same respondent. Thus, these indicators are not aimed at reflecting the prevalence rate of disease.

In the establishment of air-related health indicators, children (< age of five and 13) and the elderly (≥ age of 65) were given special attention with specific indicators for them, such as ARI rate and asthmatic rate. This was because, these groups of children and the elderly were observed to have higher rate (or higher risk) of respiratory illness as compared to others in Malaysia and abroad. For instance, in Malaysia, the highest incidence of ARI as per NHMS III (in 2006) was in the age group of 1 to 4 years with 29.7%, followed by infants (< 1 year) with 24.9% (IPH, 2008). However, the age group of 55 to 64 years and above 65 years were identified with the lowest ARI incidence rate (10.7% and 11.7% respectively in 2006). Besides, a study in 1997 showed that the estimated average prevalence rate of asthma (self-reported) in Malaysia was between 3.9% and 4.4% (mean 4.2%). However, for children under 5 years it was 4.5% (higher rate than average), and for adults it was 4.1% (Rozlan et al., 1999).

Furthermore, as compared to some countries as stated in Table 4, Malaysian children under 5 years are at a higher risk of getting ARI. In countries abroad, every year, around 150 000 children under-5 in countries in the Americas die from pneumonia (80%-90% of all deaths from ARI) (Benguigui, no date). Among the children under five years, in all developing countries (in 1995), the second largest cause of death after "neonatal" causes (32%), was ARI (24% of the 10.7 million deaths) (WHO-NHD, 2000).

Table 4: ARI prevalence among children under five years

Country	% of children < 5 years with ARI (2 weeks prior to survey)	Year (study conducted)
Nepal	34.1	1996
India	19.3	1999
Bangladesh	18.3	2000
Philippine	16.2	1999
Vietnam	9.3	2000
Indonesia	9.0	1999
Malaysia (MHNS)	28.0	1986/87
Malaysia (MHNS II)	39.3	1996
Malaysia (MHNS III)	28.8	2006

Source: IPH, 2008

In a study of respiratory effects from haze episodes in Malaysia (based on Melaka and Klang government hospitals data), Norela et al. (2008) found that the most affected age in the haze episode were the children aged under 12 years. Besides, survival analyses indicated that for persons over the age of 65, prior hospitalisations for respiratory diseases were significantly more likely than others to be re-hospitalised (Norela et al. 2008). Therefore, even though the elderly ($\geq$ 65 years old) were identified to have a lower ARI incidence rate in Malaysia, they were more susceptible to respiratory infections, partly because of an age-related decline in specific immune responsiveness (Utell et al. 2006).

CONCLUSION

Preliminary urban air environmental health indicators were developed based on the relationship between environment and human health. It consists of two major groups of indicators which are air quality indicators and air-related health indicators. Related indicators proposed locally and internationally were reviewed together with research findings on the subject matter. However, the proposed preliminary set of indicators required a wide range of health data which are not 100% readily available in our country. For the purpose of the comprehensive identification of urban air environmental health, questionnaire survey from house to house is necessary to be carried out. Environmental health indicators are believed to be an important measurement tool to provide quantified and summarised information for decision makers, politicians, planners, and public to understand the environmental health conditions of a particular area. It helps for continuous improvement of human living environment especially in the urban environment.

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