ORIGINAL ARTICLE

Metabolism of Shah Alam, Klang and Petaling Jaya: Insights from Material Flow Analysis

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Abstract:

Urbanization is a process of growth for both economic and social activities. Unplanned urbanization lead to negative impacts especially to the environment and human beings living in the city. The aim of this study is to provide an insights on the environmental impacts of Shah Alam, Klang and Petaling Jaya. Materials Flow Analysis (MFA) approach was used to assess the input resources of residential area: electricity usage, water consumption, food consumption and output resources: ambient air quality, wastewater production and solid waste generation. The input-output data were obtained from government agencies and utility providers. The primary data collection was done through a reliability tested questionnaire to the city residents. Any national data obtained were then downscaled to a regional scale. Through the study, the result showed there are significant difference for the water and food expenses between the three cities. Meanwhile, there is no significant different for the electricity use between the cities. Klang has contribute the most in terms of output resource of gases, wastewater and solid waste outcome compared to Shah Alam and Petaling Jaya due to the city's numbers of population. In general, 0.188 kg/cap/day of energy will contribute to about 0.455 kg/cap/day of carbon dioxide emission, 95.3% out of 236.1 kg/cap/day of water usage will become the wastewater and about 0.38 kg/cap/day of food consumption will generate about 4.5 kg/cap/day of solid waste.

Keywords: material flow analysis (MFA), Urban metabolism,

1. INTRODUCTION

Urbanization is a process that involves the transformation of industrial and economic development in the growth of the cities which result in the specific changes of labour division and human behaviours [1,2]. In Malaysia, urbanization processes is expanding rapidly with an average of 11.1% each year [3]. Development without considering the carrying capacity of the city may lead to pollution, traffic jam, brown field areas, short of the inner city attractions, infrastructural decay and insufficient social amenities and vegetation areas [4]. As a result, rapid urbanization has led to more environmental quality degradation mainly to the quality of the water, air and noise [5].

Urban metabolism can simply be defined as the accumulation of the technical and socio-economic processes that took place in cities which result in growth, production of energy, and elimination of waste [6]. In practical, an urban metabolism study is basically a total quantification studies of the inputs, outputs and storage of resources such as energy, water, nutrients, materials and wastes for an urban region [7]. Cities are more like living organisms which required energy and resources consumption such as fuel, air, water or even food as the inputs to sustain their livability and thus ultimately discharged back to the environment as wastes and emissions [8].

2. MATERIALS AND METHODS

2.1 Study location

The study locations were selected from the cities under the Greater Kuala Lumpur or Klang Valley (GKL/KV) which are Shah Alam, Klang and Petaling Jaya (Figure 1).

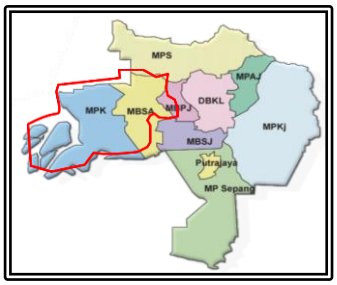

Figure 1. The cities of Shah Alam, Klang and Petaling Jaya

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The number of populations for Shah Alam, Klang and Petaling Jaya is depicted in Table 1.

Table 1. Number of study population

Local Authorities	Numbers of population
Shah Alam	541,306
Klang	744,062
Petaling Jaya	613,977

(Source: Population and Housing Census of Malaysia, 2010)

2.2 Data collection

A set of questionnaire were distributed among the residents of the cities to obtain their electricity, water and food consumption via their monthly utility bills and expenses on food. Secondary data collection on the input and output resources were obtained as follows:

- Electrical usage : Tenaga Nasional Berhad
- Treated water : Syarikat Bekalan Air Selangor
- Food consumption : Ministry of Health
- Gasses emission : Department of Environment
- Wastewater : Indah Water Konsortium
- Solid waste : National Solid Waste Management Department

3.1. Consumption and expenses of city residents

Kruskal Wallis analysis (non-parametric test) were used to analyse the electricity, water and food consumption for the three cities as the data were not normally distributed. Table 3 shows the Kruskal Wallis analysis.

Table 3. Kruskal Wallis analysis

Variables	City	Median (IQR)	X2 Statistic (df)[a]	p-value
Electricity	Shah Alam Klang Petaling Jaya	1.0	2.32 (2)	0.314
Water	Shah Alam Klang Petaling Jaya	1.0 2.0 2.0	8.06 (2)	0.018
Food	Shah Alam Klang Petaling Jaya	2.0 3.0 2.0	76.35 (2)	0.000

Electricity consumption has no significant difference between cities (p-value>0.05). For water and food expenses, there are significant different between the districts (p-value<0.05). Therefore, there is a significant trend between the consumption of water and food consumption except for electricity use.

From the questionnaire, on average Shah Alam resident spent less than RM100 for their electricity bill, less than RM10 for their water bill and less than RM400 for food. A Klang resident on average spent less than RM100 for their electricity bill, less than RM20 for their water bill and more than RM400 for food. For Petaling Jaya, a resident spent spend less than RM100 for their electricity bill, less than RM20 for the water bill and less than RM400 for food.

3.2. Residential electricity consumption

Figure 2 indicates that Klang residential areas have the highest usage of electricity every year. On average, Klang residential areas have consumed about 663,728,458.8 kWh per year followed by Petaling Jaya with about 623,142,087.7 kWh per year, and Shah Alam with about 406,242,796.6 kWh per year. The electricity use of each city recorded increment every year. The electricity use is influenced by the size of the district population itself.

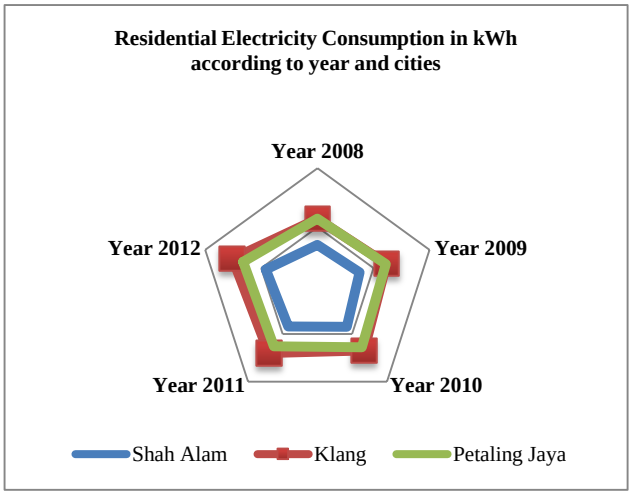


Figure 2. Residential electricity consumption according to year and cities

3.3. Ambient air quality

Figure 3 depicts Air Pollution Index (API) for the three cities. Shah Alam led the unhealthy status days followed by Klang with only two days of with unhealthy status and Petaling Jaya with a single record on unhealthy status.

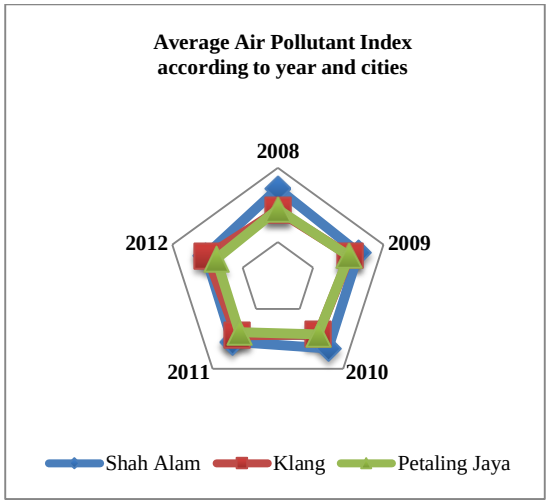


Figure 3. Average Air Pollutant Index according to year and cities

API for Shah Alam and Petaling Jaya shows improvement year by year. API for Klang however increased from year 2009 until 2012. Based on the gross land area, Klang has the largest area with 573 km^2 followed by Shah Alam with 293 km^2 and Petaling Jaya with 97.2 km^2. By referring to the total gross land area for each city, it shows that Petaling Jaya has contributed the highest air pollutants based on per land area.

3.4 Sulphur Dioxide (SO_2)

Figure 4 illustrates the highest record in 2011 for Shah Alam and Klang with the record of 0.014 ppm. All the readings still met the acceptable limit by the Malaysian Ambient Air Quality Guidelines which is 0.04 ppm. SO_2 slightly increased every year except for Petaling Jaya where the reading was not consistent. It is important to monitor the exposure to SO_2 since the side effect of a single exposure may cause immediate bronchial constriction, narrowing of the airways, increased pulmonary resistance, and increased airway reactivity [10].

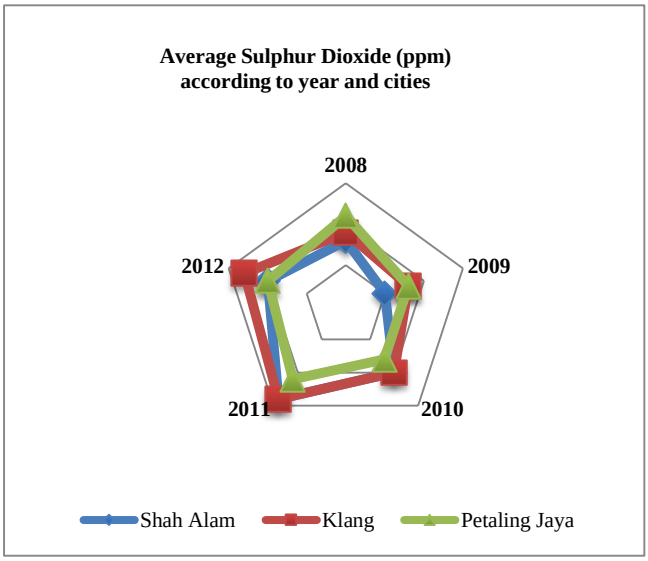


Figure 4. Average Sulphur Dioxide according to year and cities

3.5 Nitrogen Dioxide (NO_2)

Figure 5 depicts the reading on nitrogen dioxide for each city where the reading slightly decreased from 2008 until 2012. From 2008 until 2012, Petaling Jaya recorded the highest concentration. This could be explained by its proximity to the busiest city in Malaysia, Kuala Lumpur. Even though the readings show a decreasing trend, the concentration still contravened the acceptable limit which is not exceeding 0.04 ppm. It is crucial to monitor and attempt to reduce the reading to the acceptable limit since it is life-threatening to human. NO_2 can irritate airways in the human respiratory system and lead to wheezing, coughing, colds, flu and bronchitis.

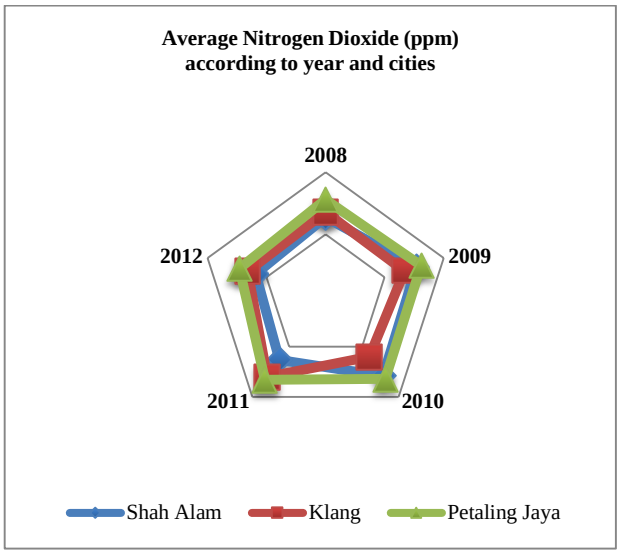


Figure 5. Average Nitrogen Dioxide according to year and cities

3.6 Ozone (O_3)

Ozone concentration in the three cities (Figure 6) shows that the results were above the acceptable limit by Malaysia Ambient Air Quality Standard at 0.06 ppm. Shah Alam has the highest reading followed by Klang and Petaling Jaya. However, the reading decrease from year to year which indicate improvement in managing the emission of ozone to the environment. The formation of ozone may lead to decrease in lung function, lung inflammation and permeability, respiratory symptoms and even death.

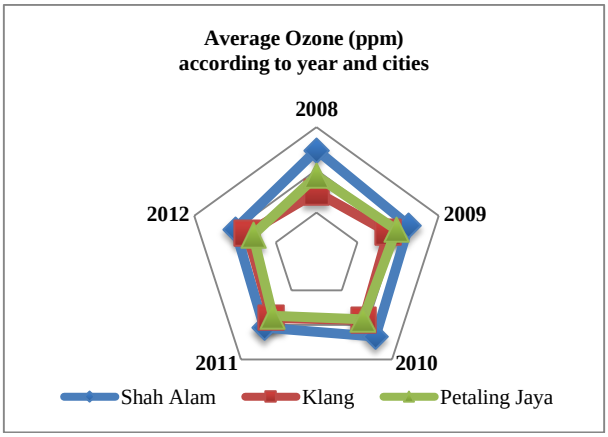


Figure 6. Average Ozone according to year and cities

3.7 Carbon Monoxide (CO)

Figure 7 displays the concentration of carbon monoxide in the three cities. Klang recorded the highest reading. All the concentration did not exceed the acceptable limit of 9.00 ppm. All cities show increase from year 2008 until 2012. Carbon monoxide production is proportionate to the increase of motor vehicles. The increase of motor vehicles may be associated to the population growth where city mobility is essential.

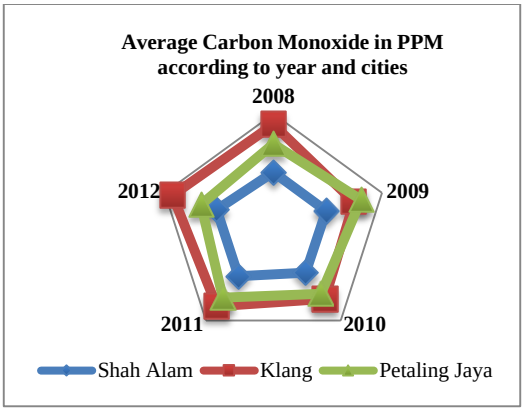


Figure 7. Average Carbon Monoxide in PPM according to year and cities

3.8 Particulate Matter 10 (PM_{10})

Figure 8 depicts that PM_{10} concentration exceed the acceptable limit which is 50 ug/m^3. Shah Alam shows increase from 2008 with 85.833 ug/m^3 and 2012 with 89.167 ug/m^3. This pattern also can be observed for Petaling Jaya record where the record for year 2008 is 67.083 ug/m^3 and 93.167 for year 2012. Klang shows a decrease in the record unlike the other two cities. This is associated with the city activities which includes urban development. PM_{10} reading should be monitored and reduced to avoid from inconvertibility of the nearby areas.

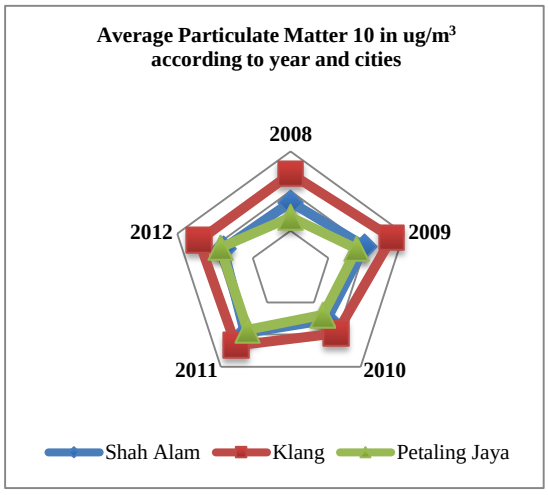
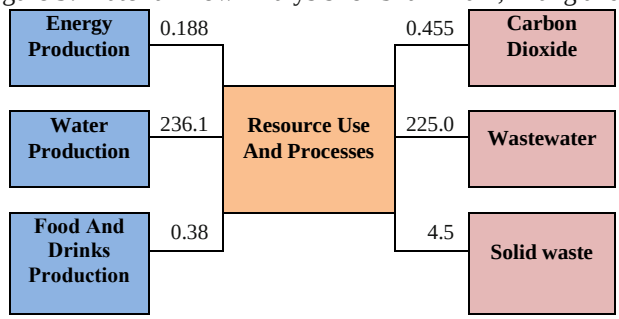


Figure 8. Average Particulate Matter 10 in ug/m3 according to year and cities

3.9 Material Flow Analysis

The insights of the city metabolism is presented by using Material Flow Analysis (Figure 9). National data has been downscaled for three cities/capita/day. All data are in unit of kg/capital/day except for energy which is in koe/capital/day.

Figure 9. Material Flow Analysis for Shah Alam, Klang and



Units in kg/capital/day
*Energy in koe/capital/day
(kg of oil equivalent for energy)

Petaling Jaya

In general, 0.188 kg/cap/day of energy will contribute to about 0.455 kg/cap/day of carbon dioxide emission, 95.3% out of 236.1 kg/cap/day of water usage will become the wastewater and about 0.38 kg/cap/day of food consumption will generate about 4.5 kg/cap/day of solid waste.

4. CONCLUSION

Material Flow Analysis is a good tool in visualizing the overall input and output components that run through from a city. It shows that the environmental impact from human daily activities for each city are very much depending on the number of population. Klang had the most input and output variable in which it had the highest electricity consumption based on the questionnaire. It can be assumed that Klang may contribute more than other city on the output in term of emission and waste.

In general, there are many urban practices that can be improved to achieve sustainable development. By managing the resources such choosing more energy efficient products and implementing as good practices and establishment of rainwater harvesting may help in preparing a sustainable future for the city.

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