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Study on Air Quality and Influences on Human Respiratory Health Among Residents Who Occupy Buildings at Former Landfill Site

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ABSTRACT

The former landfill site produces various combinations of gases that can cause health problems. The objective of this study was to determine the influence of air quality on the residents' respiratory health that occupy buildings at the former landfill site at Taman Sri Manja, Petaling Jaya, Selangor compared with the control which in PPR Air Panas located at Setapak, Kuala Lumpur. Methods that are used for this study are gas sampling using aeroqual and multi-log gas detector. High-volume sampler (HVS) was used for PM_{10} determination. The open plate method was used to determine total count formed by microorganisms. Questionnaire forms and peak flow meter were used to determine the value of Peak Expiratory Flow Rate (PEFR) of 196 respondents in the case study and 190 respondents in control. Results showed that all the parameters including gases, PM_{10}, heavy metals and total count of microbes under the estimated standard value have no significant difference between the case study and control. There is significant difference ($p=0.031$) of PEFR (L/min) value between respondent at case (347.54 ± 89.50) and control (326.97 ± 97.90). Respiratory symptoms score also showed significant differences ($p=0.04$) between respondents at case (1.38 ± 0.36) and control (1.30 ± 0.37) location. Although there was significant difference ($p<0.05$) between the average value of peak flow meter and the expected value, but the value for both case and control study are between the range of 20% under the expected value which indicated normal respiratory health status. As conclusion, there was a significant difference of PEFR average value in case and control study. The presence of pollutants contributed to the high respiratory symptom score at the case location compared to control.

INTRODUCTION

Landfill sites in Malaysia are mainly in the form of open dumping at-large area whereby the solid wastes are collected and buried in a big hole and covered with soil. It can produce various combinations of gases that can cause health problems. These gases can migrate from one place to another by the factor of weather, wind blowing direction, wind velocity and gas density (Sham 1994). In general, landfill gases (LFG) are produced by three processes, which are bacterial decomposition, volatilization and chemical reaction (ATSDR 2001).

Gases produced from the landfill sites have different chemical and physical characteristics, which give different impact to the human health (Narayana 2008). These gases include methane, carbon dioxide, carbon monoxide, hydrogen sulfide and ozone (ATSDR 2001).

Another contaminant from landfill sites is particulate matter. Particulate matter is an air pollutant that exists in the air either in solid, liquid or gaseous phases. This air pollutant contains various components such as alkaline-acid, organic materials, heavy metals, dusts and also spore (USEPA 2001).

The main health effect caused by the landfill site contaminants is the respiratory system. Symptoms that are shown from the exposure to contaminants are different for each individual, which depends on many factors, for example, age, gender and immune system (Geerling et al. 2009).

Peak flow meter is used to determine peak expiratory flow rate (PEFR) of individuals which is the velocity of the blowing exhalation after taking a deep inhalation. An observed PEFR is compared with the predicted value, which is taken as the mean of PEFR attainable by normal people of the same ethnic origin, gender, age and body build. The aim of this study is to determine the influences of air quality on the resident's respiratory health that occupy buildings at the former landfill site.

MATERIALS AND METHODS

Study location was around a former area dumping site in Taman Sri Manja, Petaling Jaya, Selangor. A former dumping site that is not yet working is 30% from wide dumping site area origin. The balance of 70% was roused by building housing estate and on the staggered method facility for the local community. Housing site at Taman Sri Manja with area of 114 acre was the former dumping site and still having landfill leachate underground this area. This situation is causing the population around complaining about the foul-smelling problem.

Control location, on the other hand, was Projek Perumahan Rakyat (PPR) Air Panas, Setapak, Kuala Lumpur that situated more than 20 kilometres from the case study area but have a same socioeconomic background population with surrounding residents at the former dumping site in Taman Sri Manja. This residential area was not built on dumping site.

There are two types of sampling methodology, which is air quality and respiratory health status determination. For air quality sampling, the parameters involved to include gases, particulate matter and heavy metals and also biological parameters. The gas parameters included methane, nitrogen oxide, hydrogen sulfide, carbon monoxide and ozone. Particulate matter and heavy metal's parameters involved PM_{10}, lead and cadmium. The biological parameters included the total bacterial and fungal counts.

For the gas parameters, methane and ozone gases were measured by using direct reading instrument, Aeroqual for 30 min meanwhile nitrogen oxide, hydrogen sulfide and carbon monoxide gases were measured by using a direct reading instrument also for 30 min. The reading was taken three times to obtain the accurate result.

Particulate matter and heavy-metal parameters were measured by using High-Volume Sampler (HVS) that was equipped with filter paper and membrane cellulose acetate 0.8 μm for the 24-hour period. The dust containing heavy metals would trap into the filter paper. The total suspended particles were measured by making a comparison between the original weight of the filter paper and the final weight of the filter paper after sampling, and PM_{10} was calculated by using a formula (USEPA 1999):

$$PM_{10} = B/KM$$

Where;

B = weight of filter paper after sampling – weight of filter paper before sampling

K = air flow rate 1.13 m^3/minute

M = sampling period (24 hrs × 60 min)

For heavy metals determination, the filter paper was analysed in the lab where the acid digestion method (USEPA 1999) was carried out. The filter paper was cut to small pieces and placed into the conical flask. 1.25 mL HCL (70%) was poured into the flask and heated using a hot plate at 95°C for 15 min. Then, the flask was lifted and cooled for 5 min. Later, 1.25 mL HNO_3 (70%) was poured into the flask and heated using the hot plate at 95°C for 15 min. After that, brown fumes are produced; the conical flask was lifted and cooled for 5 min. The liquid obtained was added with deionized water until the final solution of 25 mL was obtained. The final volume was then filtered using membrane cellulose acetate filter paper 0.2 μm. Then, the obtained sample was analysed using ICP-MS method.

The biological parameters, total bacterial and total fungal count was measured by using settle plate method (Pasquarella et al. 2000). The Petri dish containing Trypticase Soy Agar (TSA) was exposed to the air for 10 min and the Petri dish containing Sabouraud Dextrose Agar (SDA) was also exposed to the air for 10 min. After the sampling was over, the Petri dishes were incubated in the incubator for one day (TSA) and three days (SDA) at 100°C. The total colonies formed in the Petri dish were counted using a colony counter.

For health effect in the case study and control area, a questionnaire form was circulated to be filled and peak flow meter to be blown by the residents nearest to every sampling station. The study carried out was a cross-sectional study by using simple random sampling with a total of 195 respondents at Taman Sri Manja that has three blocks of Projek Perumahan Rakyat (PPR), and 190 respondents at PPR Air Panas.

RESULTS AND DISCUSSION

Table 1 shows the average reading to every gas for both the sampling locations. Average reading for nitrogen oxide was higher in case location (0.550 ± 0.217 ppm) compared to control area (0.525 ± 0.106 ppm). There was no reading recorded for carbon monoxide gas, hydrogen sulfide and methane gas in both the sampling locations. O_3 gas reading was higher in case location with an average reading of 0.061 ± 0.094 ppm compared to control location 0.005 ± 0.000 ppm. An unpaired *t*-test was carried out and found that there is no significant difference ($p>0.05$) for case location and control for nitric oxide and ozone gas with $p = 0.894$ for nitric oxide and $p = 0.481$ for ozone gas.

According to EPA (2010), nitrogen oxide gas is a part

Table 1: Different of gas parameter value (ppm) based on sampling location.

Gas parameters	Locations		*t*-value	P value
	Case, Taman Sri Manja (Mean ± SD)	Control, PPR Air Panas (Mean ± SD)		
NO	0.550 ± 0.217	0.525 ± 0.106	0.146	0.894
O_3	0.061 ± 0.094	0.005 ± 0.000	0.803	0.481
CO	0.000 ± 0.000	0.000 ± 0.000	-	-
H_2S	0.000 ± 0.000	0.000 ± 0.000	-	-
CH_4	0.000 ± 0.000	0.000 ± 0.000	-	-

*Significant value for p<0.05

Table 2: Average reading values of dust and heavy metals according to sampling location.

Parameters	Locations		*t*-value	P value
	Case, Taman Sri Manja (Mean ± SD)	Control, PPR Air Panas (Mean ± SD)		
PM_{10}	34.25 ± 5.35	29.77 ± 3.78	1.006	0.389
Plumbum	$6.98 \times 10^{-4} \pm 3.88 \times 10^{-4}$	$1.03 \times 10^{-4} \pm 3.47 \times 10^{-5}$	2.055	0.132
Cadmium	$5.44 \times 10^{-5} \pm 3.50 \times 10^{-5}$	$5.67 \times 10^{-5} \pm 5.68 \times 10^{-5}$	-0.570	0.958

*Significant value for p<0.05

Table 3: Average reading values of biological parameters (CFU) in both the sampling locations.

Biological Parameters	Locations		*t*-value	P value
	Case, Taman Sri Manja (Mean ± SD)	Control, PPR Air Panas (Mean ± SD)		
Total fungal count	6.0 ± 1.0	6.0 ± 1.4	0.000	1.000
Total bacterial count	8.0 ± 6.1	4.5 ±0.7	0.769	0.498

*Significant value for p<0.05

Table 4: Comparison of respiratory health level (L/min) of respondents in both sampling locations.

Variable	Locations		*t*-value	P value
	Case, Taman Sri Manja (Mean ± SD)	Control, PPR Air Panas (Mean ± SD)		
Respiratory score	1.38 ± 0.36	1.30 ± 0.37	2.062	*0.040
Peak flow meter reading	347.54 ± 89.50	326.97 ± 90.88	2.163	*0.031

*significant value for p<0.05

of the nitrogen cycle and can be generated through nitrogen degradation in soil by innately bacteria. The nitric oxide gas that exists in control location, which is PPR Air Panas, may have been caused by fuel burning from vehicles in that area. Fuel burning in high temperature can produce N_2O and other nitrogen oxide gas (EPA 2010).

Methane and hydrogen sulfide gas production are the most strenuous during dumping site operating. However, it would be diminished when dumping site is closed and continue to be lacking with time (Chalvatzki et al. 2010). Former dumping site in Taman Sri Manja, which is already closed for over 30 years, may be the reason of too little production of methane and hydrogen sulfide gases that were not detectable by the instrument.

The presence of gases in dumping site is caused by fire in the soil, which will produce toxic gases such as carbon monoxide gas (USFA 2002). This explained the gas reading 0.00 ppm in Taman Sri Manja because probably there is no burning or very less burning occurred which caused very little production of carbon monoxide gas that couldn't be detected by the instrument.

Table 2 shows average reading and difference value according to sampling location for dust (PM_{10}) and also heavy metals. PM_{10} concentration was higher in case of location with an average reading of 34.25 ± 5.35μg/m³ compared to the control location 29.77 ± 3.78μg/m³. Lead concentration was also higher in case location with an average reading of $6.98 \times 10^{-4} \pm 3.88 \times 10^{-4}$μg/m³ compared to control location $1.03 \times 10^{-4} \pm 3.47 \times 10^{-5}$μg/m³. Likewise cadmium concentration was lower in case location with an average reading of $5.44 \times 10^{-5} \pm 3.50 \times 10^{-5}$μg/m³ compared to control location $5.67 \times 10^{-5} \pm 5.68 \times 10^{-5}$μg/m³.

After conducting unpaired *t*-test, there was no significant difference (p>0.05) between case and control locations according to dust parameter (PM_{10}) and the heavy metals namely PM_{10}, p = 0.389, lead, p = 0.132 and cadmium with value p = 0.958.

Concentration of PM_{10} was higher in case location with an average reading of 34.25 ± 5.35μg/m³ compared to control 29.77 ± 3.78μg/m³. Dust which floats in the air and spreads from dumping site depend on the airspeed, surface condition and dust size (Qi et al. 2011). Dust production in dumping site is higher during operation compared after the dumping site is closed. Apart from that, dust also can be produced from vehicles and environment of some areas such as road conditions, construction site and also industry (DERM 2010). Dumping site in Taman Sri Manja that has been closed for a long time showed that PM_{10} in this location has no clear distinction with control location, PPR Air Panas.

Releasing of heavy metals in the environment can occur through volatilization process during combustion from incinerator, open burning or other fires in dumping site (Aucott 2006). Data showed that the increased usage of cadmium in batteries may explain the 70% cadmium that exists in disposal site (Boehme et al. 2003). Lead that exists in disposal site can be originated from battery acid-plumbum, electronic goods, glass, ceramics and plastics (USEPA 1989).

Table 3 shows the average reading and comparison of biological parameters in both the sampling locations in Taman Sri Manja and PPR Air Panas. Average total fungal counts were nearly identical for the both sampling locations which was 6.0 ± 1.0 CFU in case location and 6.0 ± 1.4 CFU in control location. The average total bacterial count was higher in case location with an average count of 8.0 ± 6.1 CFU compared to control location 4.5 ± 0.7 CFU. After unpaired *t*-test was carried out, there was no significant different (p>0.05) between case location and control location concerning total fungal and bacterial counts with p = 1.000 and 0.49, respectively.

Average total bacterial count, which was higher in Taman Sri Manja, may be attributed from innately bacterial existence on the ground because Taman Sri Manja was the former dumping site. Bacteria in the disposal site responsible to disentangle organic waste that existed in disposal site and change into gas form such as methane, carbon dioxide and nitrogen gas (ATSDR 2001).

Table 4 shows a comparison of the respondents' respiratory health level in both sampling locations. Respiratory score was categorized into two, which score 1-3 has no respiratory illness symptom, and score 4-5 have the respiratory illness symptoms. Mean respiratory score for the respondents in both the sampling locations did not exceed score 3. Nevertheless, case location had a score of 1.38 ± 0.36, which was higher compared to control with the average respiratory score of 1.30 ± 0.37. For the average reading of peak flow meter, case study location recorded higher average reading of 347.54 ± 156.56 L/min compared to control location with an average reading of 326.97 ± 157.37 L/min. The unpaired *t*-test showed that there is a significant difference (p<0.05) between the two sampling locations for respiratory score and also peak flow meter value.

Table 5 shows a comparison between socio-demographic factors according to sampling location. Chi-square test result found that there are several socio-demographic factors that have a significant mean difference value between case locations in Taman Sri Manja and control location in PPR Air Panas. Among the socio-demographic factors; races came out with value p = 0.000 and stay period with value p = 0.000.

Table 5: Comparison between socio-demographic factors according to sampling location.

Socio-demography factors	Locations: Case, Taman Sri Manja n (%)	Locations: Control, PPR Air Panas n (%)	χ^2 value	P value
Gender				
Male	88 (47.6)	100 (57.1)	3.305	0.069
Female	97 (52.4)	75 (42.9)		
Race				
Malay	142 (76.8)	97 (55.4)	24.941	*0.000
Non-Malay	43 (23.2)	78 (44.6)		
Education level				
Lower education	161 (87.1)	151 (86.3)	2.077	0.557
Higher education	24 (12.9)	24 (13.7)		
Stay period				
1-5 years	32 (17.3)	66 (37.7)	39.324	*0.000
≤ 6-10 years	106 (57.3)	101 (57.7)		
> 10 years	47 (25.4)	8 (4.6)		

*Significant value at p<0.05

Table 6 shows a comparison between respiratory illness symptoms according to sampling location in Taman Sri Manja and PPR Air Panas. Chi-square test result found that the only symptom of snoring that is significantly different (p<0.05) between sampling locations with value p = 0.015.

The comparison of peak flow meter values according to age group in both the sampling locations are given in Table 7. The unpaired *t*-test revealed that there is no significant difference (p>0.05) between the age group in the case and control study. Table 8 gives a comparison of peak flow meter value according to gender in both the sampling locations. The unpaired *t*-test revealed that there is a significant difference (p = 0.01) between the male gender in the case and control study. Table 9 depicts a comparison of peak flow meter value according to stay period in both the sampling locations. The unpaired *t*-test revealed that there is no significant difference (p>0.05) between the stay period in the case and control study. Table 10 showed the relationship between peak flow meter and some factors. Pearson correlation tests revealed that peak flow meter has a significant correlation with the height factor which is p = 0.000 even the relationship is categorized as weak, r = 0.056. There was also a correlation that is weak and inversely proportional between peak flow meter value and age with r = -0.048 and p = 0.512 which is not significant correlation. The relationship between peak flow meter value and respiratory score was weak and inversely proportional with r = -0.089 and p = 0.231 which is not significant correlation.

Increase of age can reduce human breathing system capacity (Watsford et al. 2007). Unpaired *t*-test revealed that there is a significant difference between male gender where

Table 6: Comparison between respiratory illness symptoms according to sampling location in Taman Sri Manja and PPR Air Panas.

Respiratory illness symptoms	Locations				χ^2 value	P value
	Case, Taman Sri Manja (%)		Control, PPR Air Panas (%)			
	Low score	High score	Low score	High score		
Snoring	162(87.6)	23(12.4)	166(94.9)	9(5.1)	5.901	*0.015
Sneezing and coughing when I wake up	171(92.4)	14(7.6)	168(94.9)	7(4.0)	2.084	0.149
Cough	177(95.7)	8(4.3)	170(97.1)	5(2.9)	0.556	0.456
Often breathless and stopped for a while when walking	175(94.6)	10(5.4)	163(93.1)	12(6.9)	0.330	0.565
Fatigue when climbing stairs	164(88.6)	21(11.4)	158(90.3)	17(19.7)	0.255	0.613
Asthma	183(98.9)	2(1.1)	169(96.6)	6(3.4)	2.281	0.131
Pharyngitis	181(97.8)	4(2.2)	173(98.9)	2(1.1)	0.570	0.450
Persistent cough	180(97.3)	5(2.7)	172(98.3)	3(1.7)	0.404	0.525
Breathless	185(100)	0(0)	172(98.3)	3(1.7)	3.198	0.074
Breath whistling sound	185(100)	0(0)	174(99.4)	1(0.6)	1.060	0.303

*Significant value for p<0.05

Table 7: Comparison of Peak Flow Meter values (L/min) in the case and control locations based on the age group.

Age (yr)	Taman Sri Manja		PPR Air Panas		*t*-value	P value
	n	Peak Flow Meter value (Mean ± SD)	*n*	Peak Flow Meter value(Mean ± SD)		
7-15	26	301.15 ± 69.40	50	284.40 ± 56.93	1.128	0.263
16-25	56	376.34 ± 91.47	33	376.36 ± 90.132	-0.001	0.999
26-35	43	340.70 ± 86.06	26	370.77 ± 92.43	-1.368	0.176
36-45	34	359.41 ± 94.74	16	334.38 ± 103.92	0.845	0.402
46-55	13	335.38 ± 80.38	23	339.13 ± 91.80	-0.123	0.903
56-65	10	343.00 ± 84.47	19	310.00 ± 78.10	1.052	0.302
66-75	3	243.33 ± 15.28	5	198.00 ± 29.50	2.420	0.052

*Significant value for p<0.05

Table 8: Comparison of Peak Flow Meter values (L/min) according to gender in both sampling locations.

Gender	Taman Sri Manja		PPR Air Panas		T value	P value
	n	Peak Flow Meter value (Mean ± SD)	n	Peak Flow Meter value(Mean ± SD)		
Male	88	404.77 ± 81.97	100	357.60 ± 99.363	3.522	*0.001
Female	97	295.62 ± 59.48	75	286.13 ± 57.04	1.056	0.293

*Significant value for p<0.05

p = 0.001. According to Ebomoyi and Iyawe (2005), there are differences between peak expiratory flow rate (PEFR) among adult males and females where this association can be probably described by physical strength and muscle in adult males compared to adult females. The stay period in study location is important to know. Previous researchers reported that duration of exposure influences some of the disease symptoms in individuals (Kang et al. 2005).

Pearson correlation showed that peak flow meter and respiratory symptom scores were weak and inversely proportional with r = -0.089 and p = 0.231 where there was no significant correlation. This case explained the average value of peak flow meter that was lower at control but had a lower respiratory symptom score compared to case location, which had a higher respiratory symptom score; even the average value of peak flow meter was also higher because of the correlation factor that is weak and not significant.

Although there was a significant difference between the respiratory illness symptom score in case and control locations, the symptom score was low, which did not show any critical respiratory illness symptom. The pollutant values presented in case location were higher compared to control even though all the values were still below the permissible

Table 9: Comparison of Peak Flow Meter values (L/min) according to stay period in both sampling locations.

Stayperiod	Taman Sri Manja		PPR Air Panas		T value	P value
	n	Peak Flow Meter value (Mean ± SD)	n	Peak Flow Meter value(Mean ± SD)		
1-5	32	369.69 ± 95.19	66	332.27 ± 89.34	1.903	0.060
6-10	106	340.52 ± 92.55	101	325.05 ± 91.45	1.209	0.228
>10	47	348.30 ± 77.01	8	307.50 ± 104.71	1.313	0.195

*Significant value for p<0.05

Table 10: Correlation between peak flow meter and height, age and respiratory score.

		Height	Age	Respiratory score
Peak Flow	R value	0.056**	-0.048	-0.089
Meter value	P value	0.000	0.512	0.231

*Significant value for p<0.05

limit. Therefore, the presence of pollutants such as NO, O_3, PM_{10}, Cd and Pb and bacteria and fungi, which were higher in the former dumping site area compared to control location, contributed to higher symptom score in case location compared to control location.

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