

Odour Pollution Measurement from Refuse Derive Fuel Operations Using Odour Concentration Meter (OCM) XP-329

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ABSTRACT

Odour perception is subjective and difficult to be accurately measured between individuals. Hence many studies on odour issues are more commonly pertain to its intensity, concentration, types, standards, measurement methods, law and impacts on physical and human environments. Nevertheless, odour analysis can be conducted empirically or based on human sensorial. Among major sources of odour pollution are animal rearing, oil palm and rubber mills, dumpsites, industries and sewage treatments. This study attempted to measure odour pollution generated by Refuse Derived Fuel (RDF) operation. The analysis was conducted at different times of day (morning, evening and night) and weather conditions (normal days and after rains). 10 sampling stations were selected for observations using the Odour Concentration Meter Siri XP-329 III. The results indicated that there existed different level of odour concentrations on normal days and after rains due to the influence of meteorological environment. Distance factors also influenced the odour concentrations, whereby gradually, the stations further from RDF operation recorded higher odour concentrations.

Key words: Odour pollution, Odour concentration, RDF, Meteorological factors.

INTRODUCTION

There has been a dearth on studies of odour pollution in Malaysia due constraints such as lack of measurement equipments, guidelines and legal act for such operational endeavour. Despite the media publication on odour pollution, actions and enforcement were ineffective due to limitations in regulations and operational standards. In particular, scientific studies on odour concentrations and intensity were difficult to be implemented due to lack of equipments for measuring the phenomenon.

Comparatively, researchers in Japan, European Union, Australia and New Zealand have paid serious attention on odour pollutions¹. Their studies not only conducted to measure the odour concentrations, intensity, components, impact on health and people well-being but also involved in

determining the accuracy in the usage of various equipments for such measurements.

There were various measurement methods to measure odour concentrations and intensity in terms of effectiveness in applications, comparative outcomes and systemacity. Studies conducted by²⁻¹² were those focusing on applications of various methods to measure odour pollutions.

There were not many studies on odour pollution conducted in Malaysia. A study on odour concentrations emanated from an open dumpsite was conducted by¹³. Other than that, a study on a population sensory perception was conducted to identify the odour impact, intensity and meteorological factors^{1,14}. This study is therefore aimed to measure the odour intensity from the RDF operation to further highlight issues of odour concentrations measurement in Malaysia. The

measurement was conducted at various times in the morning, evening and night. The differences in odour concentrations were measured according to the prevailing situations of either normal days or after rains. The measurements were conducted at sampling stations per distances from the RDF operation, and also recorded were the meteorological data to identify the other factors involved in influencing the odour concentrations.

MATERIALS AND METHODS

Refuse Derived Fuel (RDF) is a method of power generation involving a process of combustion of solid wastes to produce electricity. The amount of electricity generated depends on the capacity and quantity of wastes being used. The RDF operation in this study was capable to generate electricity at a maximum of 9 megawatt (MW) through utilization of 700 tonnes of solid wastes per day. Parts of the power were used to run its own operation (3.5 MW) and the rest (5.5 MW) was sold to the Tenaga Nasional Berhad. The RDF is located at N 03°00'3.1" and longitude E 101°52'56.6" at 70m above sea level. Figure 1 shows the RDF location and sampling stations per the RDF.

Method for Measuring the Odour Concentration:

The equipment for measuring the odour concentration is Odour Concentration Meter (OCM) XP-329 III. The equipment is also used to measure odour threshold and the measuring unit is stated in odour concentration per cubic meter or ou/m^3 . The OCM has the capacity to measure odour concentration from a minimum concentration of 0 to a maximum of 2000 ou/m^3 .

Malaysian Standards on Odour Pollution and Gas

There have not been specific standards established for regulatory and enforcement guidelines on odour pollution and of gas components. Existing Malaysian guidelines such as the Recommended Malaysian Air Quality Guidelines (RMAQG) have been limited to those pertaining to several gas types: O_3 , CO , NO_2 and SO_2 (Table 1). Based on the table, there is no indication of the H_2S , CH_4 and NH_3 being emitted from the RDF.

RESULTS AND DISCUSSION

The results can be divided into three major components i.e. the average of odour concentration on normal days; concentration after rains and comparative concentrations on normal days and after rains.

Average Concentrations on Normal Days

Concentrations of odour in the morning, evening and night times are shown in Tables 3, 4 and 5. The highest concentration in the morning was detected at station 5 at 43.0 ou/m^3 . Hot temperatures at 32.7°C and comparative humidity of 79.6 per cent (Table 3) have influenced the odour concentration at that station. The second highest concentration was at station 1 with 38.6 ou/m^3 .

Meanwhile, values of average odour concentration recorded was (53.0 ou/m^3) at Station 7 (Table 4), and maximum values was obtained up to 76.2 ou/m^3 at Station 1. The low average concentrations occurred due to the influence of strong winds at the station, at 3.5 m/s.

Furthermore, the average concentrations at night time on normal days indicated a sequence of higher readings from various directions. The highest odour concentration was from the north east of the RDF location, with 68.0 ou/m^3 (Station 8); followed by the south west direction with 60.6 ou/m^3 (Station 7); and from the western side of the location (56.2 ou/m^3) at Station 3 (Table 5). The average of lowest concentrations on the day was at station 1 with concentration values of 27.8 ou/m^3 . Average of Odour Concentration after Rains:

Meteorological elements, gas and odour concentrations, measured in the morning after rains are indicated in Table 6. Station 7 recorded highest odour concentration at 77.2 ou/m^3 , in addition to Station 6 at 70.8 ou/m^3 . Accordingly, the NO_2 , H_2S and SO_2 gas concentrations measured were at 0.16 ppm, 0.020 ppm dan 20.50 ppm respectively. The three gases recorded highest readings at station 7 compared to that of other stations. This phenomenon occurred due to the influence of high temperatures and humidity; which directly stabilised the atmosphere and thus increased the concentrations of gases and odour.

Table 7 shows concentrations of gas and odour in the evening after rains. Highest odour concentration was measured at station 9 (104 ou/m³), the furthest from the RDF. The combination of temperatures, high humidity, and stable atmosphere of the recorded evenings affected the odour concentration at the station.

Meanwhile, night time after rain concentrations of gas and odour did indicate an uneven pattern (Table 8). The measurement for the night time after rains concentrations indicated high odour concentrations at all stations, with the highest being at station 5 with 42 ou/m³. For gas, night time data indicated the scarce presence of H₂S. Based

Table 1: Gas Standards linked to Air Quality in Malaysia

Air Pollutant	Average Time	Standardppm	Malaysian(ug/m ³)
Ozone	1 hour8 hour	0.100.06	200120
Carbon Monoxide	1 hour8 hours	30.09.00	3510
Nitrogen Dioxide	1 hour24 hours	0.170.04	320
Sulphur Dioxide	1 hour24 hours	0.130.04	350105

Table 2: Gas Standards linked to Odour Pollution

Gas	Standard (ppm)	Description
SO ₂	0.19	Allowed maximum values ¹
NO ₂	0.17	Allowed maximum values ¹
H ₂ S	0.00014	Harmful to adults and children ² Odour threshold ²
	0.13	Allowed maximum values OSHA ²
	10	
NH ₃	17	Odour Threshold ²

Note:

¹Recommended Malaysian Air Quality Guidelines

²EPA standard

Table 3: Meteorological elements, odour concentrations and gas on normal days (morning)

Station	Meteorological elements			Gas Concentration(ppm)			Odour Concentrations (ou/m ³)
	Temp.(°C)	Rh(%)	Wind Speed (m/s)	NO ₂	H ₂ S	SO ₂	
1	30.0	80.3	1.0	0.16	0.014	0.24	38.6
2	28.9	83.4	0.1	0.10	0.026	3.60	27.2
3	29.7	82.6	0.0	0.08	0.024	2.98	4.20
4	30.8	80.4	0.0	0.06	0.012	2.82	12.4
5	32.7	79.6	0.0	0.08	0.018	0.00	43.0
6	31.6	81.5	0.1	0.10	0.010	3.14	5.30
7	33.7	79.0	0.0	0.10	0.004	0.00	30.8
8	28.7	83.9	0.8	0.08	0.016	2.26	22.2
9	31.2	80.1	0.1	0.02	0.004	0.00	24.7
10	30.6	79.8	0.0	0.04	0.014	0.00	25.5

Table 4: Meteorological elements, odour concentrations and gas on normal days (morning)

Station	Meteorological elements			Gas Concentration(ppm)			Odour Concentrations (ou/m ³)
	Temp.(°C)	Rh(%)	Wind Speed (m/s)	NO ₂	H ₂ S	SO ₂	
1	37.6	42.6	1.2	0.24	0.024	5.84	76.2
2	36.1	46.0	0.4	0.12	0.030	0.00	62.4
3	38.0	44.0	1.5	0.14	0.026	10.34	73.2
4	32.3	57.1	1.6	0.16	0.016	7.24	36.8
5	32.0	59.5	1.0	0.14	0.026	7.64	68.6
6	34.6	49.3	1.1	0.10	0.024	6.18	59.7
7	36.0	54.2	3.4	0.10	0.000	0.00	53.0
8	32.3	57.3	1.5	0.12	0.022	3.26	75.6
9	34.4	53.5	1.1	0.22	0.048	24.34	72.8
10	33.1	55.2	1.2	0.16	0.016	15.76	64.6

Table 5: Meteorological elements, odour concentrations, and gas on normal days (night)

Station	Meteorological elements			Gas Concentration(ppm)			Odour Concentrations (ou/m ³)
	Temp.(°C)	Rh(%)	Wind Speed (m/s)	NO ₂	H ₂ S	SO ₂	
1	24.2	85.1	0.3	0.10	0.020	9.06	27.8
2	24.6	84.0	0.2	0.18	0.012	10.44	28.4
3	26.3	83.4	0.1	0.10	0.006	0.00	56.2
4	25.0	83.0	0.1	0.10	0.014	9.18	30.8
5	26.1	84.2	0.1	0.12	0.000	0.38	49.4
6	25.5	87.0	0.1	0.12	0.000	0.14	46.6
7	25.6	92.3	0.1	0.14	0.024	18.36	60.6
8	25.9	83.0	0.4	0.06	0.002	0.56	68.0
9	26.4	82.0	0.2	0.08	0.012	4.68	58.0
10	27.1	81.7	0.2	0.00	0.018	5.94	52.0

Table 6: Meteorological elements, gas and odour concentrations after rains (morning)

Station	Meteorological elements			Gas Concentration(ppm)			Odour Concentrations (ou/m ³)
	Temp.(°C)	Rh(%)	Wind Speed (m/s)	NO ₂	H ₂ S	SO ₂	
1	23.8	83.6	0.3	0.02	0.012	1.00	17.7
2	25.4	77.0	0.1	0.04	0.000	0.00	11.0
3	23.6	85.9	0.0	0.04	0.004	1.52	20.6
4	23.9	87.0	0.0	0.06	0.010	6.24	15.4
5	23.6	82.0	0.0	0.04	0.002	10.20	65.0
6	23.5	80.1	0.6	0.04	0.018	13.80	70.8
7	24.0	84.5	0.3	0.16	0.020	20.50	77.2
8	23.7	87.2	0.1	0.00	0.000	1.90	17.2
9	24.3	81.2	0.1	0.06	0.000	0.00	19.4
10	24.0	85.2	0.2	0.04	0.000	0.00	8.20

on Table 8, it shows that 2/3 of the observation stations could detect the presence of H₂S during the period.

Comparison Between the Averages of Odour Concentrations on Normal Days and after Rains:

Figure 2 shows odour concentration recorded around the RDF. Based on the figure, it shows that concentrations vary per day and time variances, with indications of the concentrations exceeded the limit set by the [15]. According to the standards, the allowable concentration was set at 10 ou/m³. However, the analyses showed that the average concentration of the three sessions of

measurements on normal days and after rains exceeded the limit allowable under the standards

Minimum and maximum concentrations recorded on normal days was at 23.39 ou/m³ (morning) dan 64.29 ou/m³ (evening) respectively. After rains recording saw a maximum reading of 54.21 ou/m³ (evening); while minimum concentration was 31.26 ou/m³ at (night). The high concentration could adversely effect routine outdoor activities and wellbeing of the local population.

Comparison of The Averages of H₂S, SO₂ and NO₂ Gas Concentrations on Normal Days and After Rains:

Table 7: Meteorological elements, gas and odour concentrations after rains (evening)

Station	Meteorological elements			Gas Concentration(ppm)			Odour Concentrations (ou/m ³)
	Temp.(°C)	Rh(%)	Wind Speed (m/s)	NO ₂	H ₂ S	SO ₂	
1	26.2	100	2.4	0.12	0.026	29.46	31.8
2	26.7	98.8	2.0	0.12	0.020	18.36	30.8
3	26.5	100	2.4	0.14	0.014	14.46	43.6
4	27.1	79.1	0.2	0.22	0.006	7.50	64.6
5	27.4	80.2	0.0	0.22	0.006	8.56	80.2
6	27.6	80.7	0.0	0.26	0.012	8.43	34.3
7	25.1	90.2	0.5	0.14	0.012	13.04	30.4
8	26.2	98.8	1.3	0.14	0.004	8.52	27.0
9	26.6	85.6	0.2	0.14	0.000	1.96	104.4
10	26.4	83.3	0.1	0.16	0.000	1.72	95.0

Table 8: Meteorological elements, gas and odour concentrations after rains (night)

Station	Meteorological elements			Gas Concentration(ppm)			Odour Concentrations (ou/m ³)
	Temp.(°C)	Rh(%)	Wind Speed (m/s)	NO ₂	H ₂ S	SO ₂	
1	24.7	86.4	0.1	0.12	0.000	1.32	34.8
2	24.6	86.0	0.2	0.16	0.000	0.58	28.0
3	24.5	85.3	0.1	0.16	0.000	2.40	25.6
4	24.7	80.8	0.2	0.16	0.000	0.24	33.8
5	24.7	86.2	0.0	0.10	0.000	0.00	42.0
6	24.7	97.4	0.2	0.10	0.000	0.02	28.6
7	25.3	97.3	4.0	0.12	0.016	14.04	25.6
8	24.5	92.5	0.3	0.10	0.000	3.52	35.2
9	24.7	91.1	0.1	0.10	0.002	9.22	24.2
10	25.1	93.8	0.1	0.16	0.014	13.94	34.8

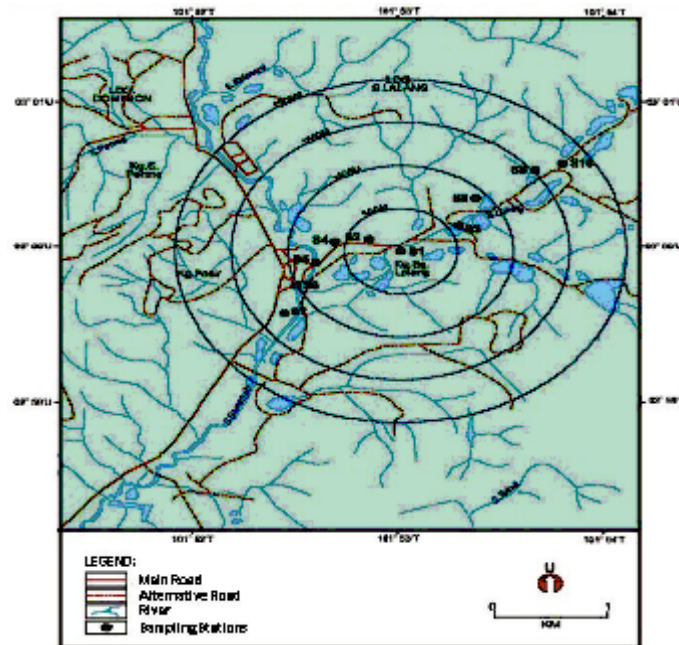


Fig.1: Sampling stations from the RDF Operation

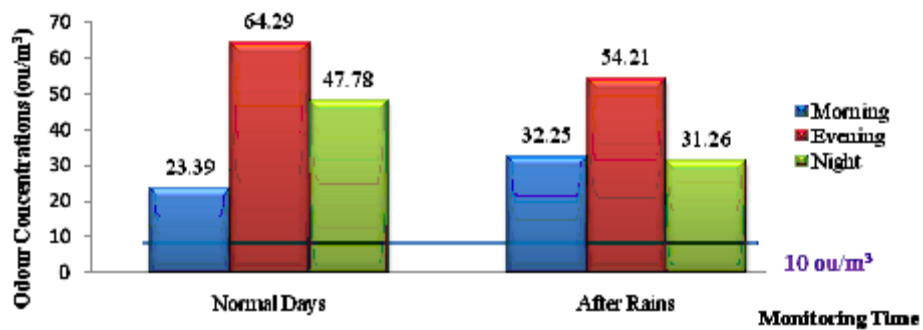


Fig. 2: Comparison of odour concentrations in the morning, evening and night on normal days and after rains

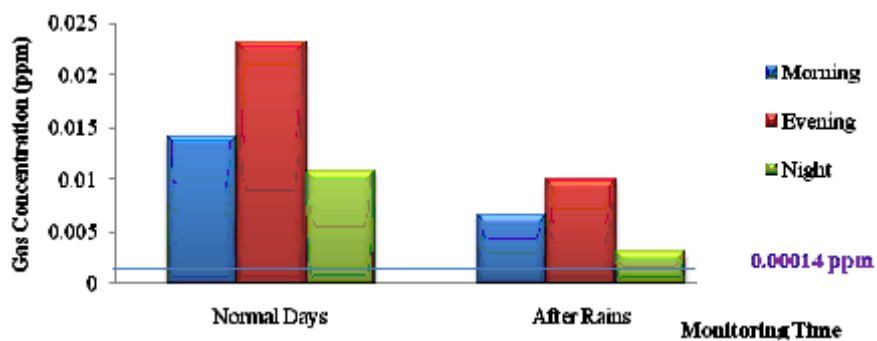


Fig. 3: Comparison of H₂S concentrations in the morning, evening and night on normal days and after rains

Generally, based on figure 3, figure 4 and figure 5, the gas concentrations were the highest in the evening and after rains. For example, the concentration of SO₂ and NO₂ reached highest reading after rains, whilst the H₂S registered highest concentration on normal days.

Table 3 indicated that the presence of H₂S around the studied area exceeded the standard limit set by the EPA. The exceeded presence could give an impact on the health of sensitive receptors. For example, the maximum presence of H₂S at 0.0232 ppm on normal days and at 0.01 ppm after rains are extremely hazardous to the surrounding population. Exposure to a concentration of 0.00014 ppm could give adverse effect on the health of the elderly and children (Table 2).

The analysis of SO₂ (Table 4) indicated that the concentrations exceeded the limit set by JAS. The rate of maximum gas concentration on normal days (8.06 ppm) and after rains (11.201 ppm) exceeded the standard limit by 0.19 ppm (Table 2). These gases extended exposure to human beings could damage not only their health but also their properties¹⁶. An indication is ruinous effect on human skins and deterioration of buildings walls and paintwork.

Based on the RMAQG standards, the overall observations indicated that the NO₂ presence were below the standard limit allowable (Figure 5). The figure shows that the NO₂ concentration was at maximum on normal days and the lowest after rains at 0.15 ppm and 0.16 ppm respectively (Table 2).

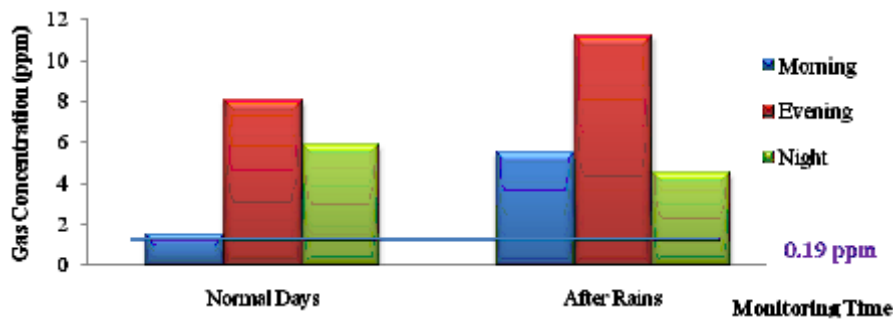


Fig. 4: Comparison of SO₂ concentrations in the morning, evening and night on normal days and after rains

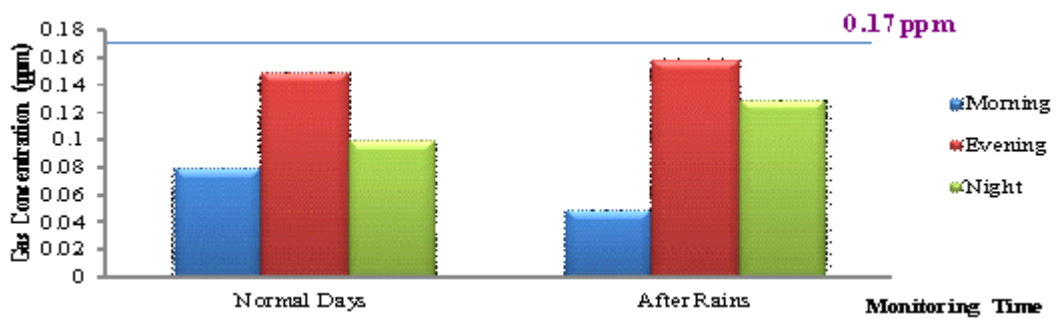


Fig. 5: Comparison of NO₂ concentrations in the morning, evening and night on normal days and after rains

CONCLUSION

This study has indicated that concentrations of odour produced from the RDF

operation could be influenced by meteorological factors such as temperatures, relative humidity and wind speed. On normal days, the concentration of odour indicated high readings

in the evening that was at 76.0 ou/m³ followed by night readings at 68.0 ou/m³ and mornings at 43.0 ou/m³. After rains, the concentrations in the evening also shown highest reading at 104 ou/m³. However, the second highest reading was recorded in the morning at 77.2 ou/m³. While for the night time, concentration was at the lowest at 42 ou/m³.

In addition to that, this study also revealed the concentrations of odour generated by the RDF operation have exceeded the standard limit set by the DEC at 10 ou/m³, either on normal days or after rains. It was also revealed that odour pollution was also due to the release of H₂S, SO₂, and NO₂ concentrations. SO₂ and NO₂ were detected at high concentrations after rains; whilst the H₂S attained high concentrations on normal days.

The exposure to odour concentrations and the gases for an extended period may be harmful to wellbeing and quality of the environment of sensitive receptors. Close monitoring and penalty enforcement by the authorities need to be enhanced to minimize the potential harms of odour and gas pollutions to human beings and the larger environment.

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