BAB 1

Chapter 1

Kualiti Udara

Air Quality

BAB 1 / *CHAPTER 1*
PENGAWASAN KUALITI UDARA
AIR QUALITY MONITORING

PENGAWASAN KUALITI UDARA
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Pengawasan status kualiti udara dilaksanakan oleh Jabatan Alam Sekitar (JAS) melalui 52 stesen pengawasan kualiti udara yang ditempatkan di seluruh Negara. Stesen-stesen pengawasan kualiti udara tersebut ditempatkan di lokasi yang strategik iaitu di kawasan bandar, sub-bandar dan perindustrian **(Peta 1.1 dan Peta 1.2)** bertujuan untuk mengesan sebarang perubahan ketara ke atas kualiti udara yang mungkin memberi kesan berbahaya kepada kesihatan dan alam sekitar.

*The Department of Environment (DOE) monitors ambient air quality through a network of 52 continuous monitoring stations. These monitoring stations are strategically located in urban, sub urban and industrial areas **(Map 1.1 and Map 1.2)** to detect any significant change in the air quality which may be harmful to human health and the environment.*

Rangkaian Stesen Pengawasan Kualiti Udara Kebangsaan turut dilengkapi stesen-stesen pengawasan kualiti udara secara manual yang ditempatkan di 14 kawasan yang berbeza. Pengawasan udara di stesen-stesen manual ini melibatkan pengukuran parameter-parameter seperti kumin pepejal, habuk halus bersaiz diameter kurang dari 10 mikron (PM_{10}) dan beberapa logam berat termasuk plumbum. Bagi stesen manual ini, pengukuran dibuat sekali bagi tempoh enam hari dengan menggunakan alat “High Volume Sampler”.

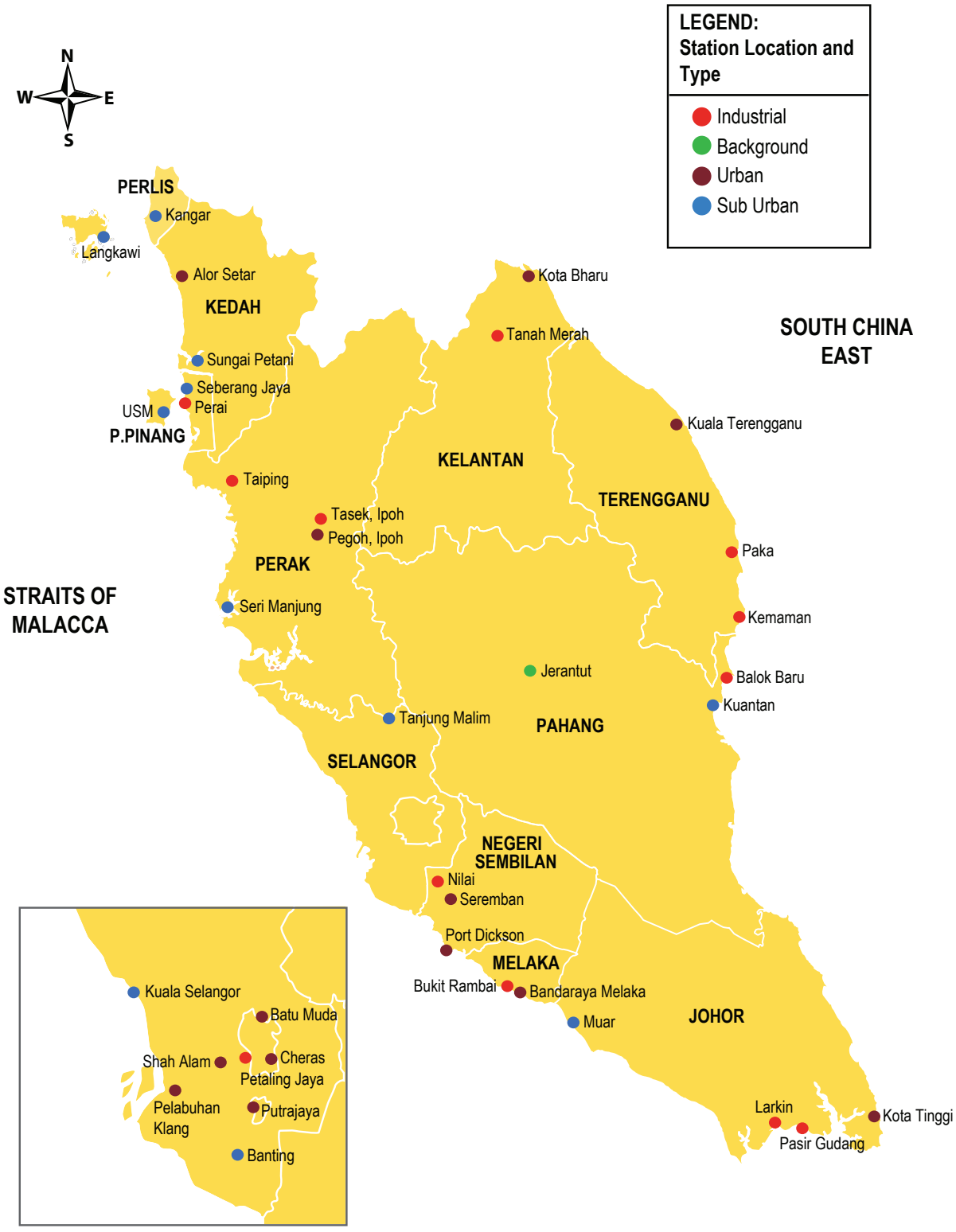
In addition to the 52 stations in the National Continuous Air Quality Monitoring Network manual air quality monitoring stations using High Volume Samplers were also established at 14 different sites for measuring total suspended particulates, particulate matter of less than 10 microns in diameter (PM_{10}) and heavy metals such as lead. The measurement is done once in every 6 days.

Status kualiti udara dilaporkan dalam bentuk Indeks Pencemar Udara (IPU). IPU adalah dikira berdasarkan kepekatan lima bahan pencemar utama iaitu ozon di permukaan bumi (O_3), karbon monoksida (CO), nitrogen dioksida (NO_2), sulfur dioksida (SO_2) dan habuk halus bersaiz kurang dari 10 mikron (PM_{10}) IPU ini dikategorikan sebagai baik , sederhana , tidak sihat, sangat tidak sihat dan berbahaya seperti yang dinyatakan dalam **Jadual 1.1**.

*The air quality status is reported in term of Air Pollution Index (API). The air pollutants used in computing the API are ground level ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter of less than 10 microns in size (PM_{10}). The API is categorized as good, moderate, unhealthy, very unhealthy and hazardous as presented in **Table 1.1**.*

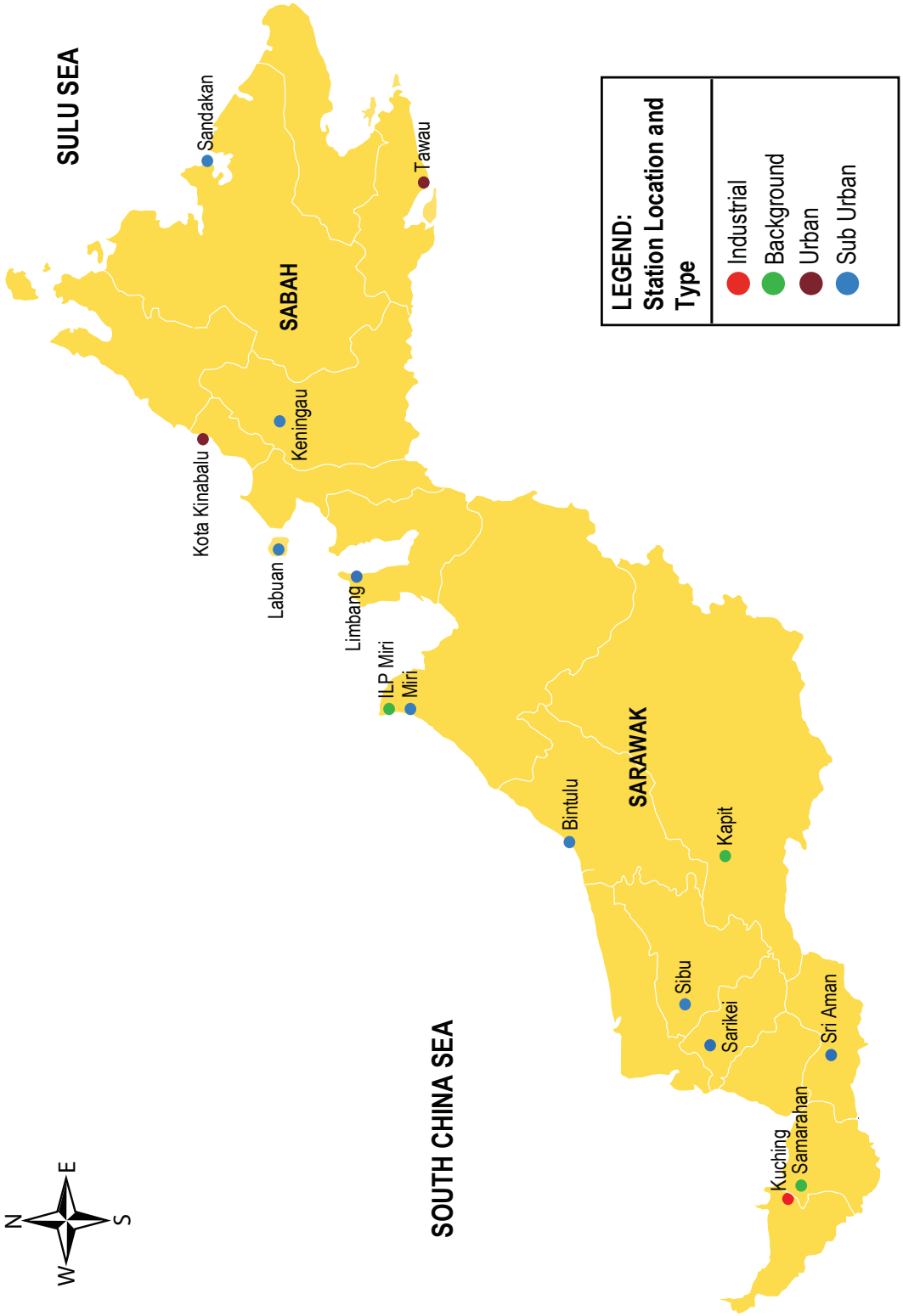
Jadual 1.1 Malaysia : Status Kualiti Udara (IPU)
Table 1.1 Malaysia : Air Pollutant Index (API)

IPU / *API*	STATUS KUALITI UDARA / *AIR QUALITY STATUS*
0 – 50	Baik / Good
51 – 100	Sederhana / *Moderate*
101 – 200	Tidak Sihat / *Unhealthy*
201 – 300	Sangat Tidak Sihat / *Very Unhealthy*
> 300	Berbahaya / *Hazardous*



Peta 1.1 Malaysia: Lokasi Stesen Pengawasan Kualiti Udara Automatik, 2015 di Semenanjung Malaysia

Map 1.1 Malaysia: Location of Automatic Continuous Air Quality Monitoring Stations in Peninsular Malaysia, 2015



Peta 1.2 Malaysia: Lokasi Stesen Pengawasan Kualiti Udara Automatik di Sabah & Sarawak, 2015

Map 1.2 Malaysia: Location of Automatic Continuous Air Quality Monitoring Stations in Sabah and Sarawak, 2015

STATUS KUALITI UDARA
AIR QUALITY STATUS

Berdasarkan Indeks Pencemar Udara (IPU), kualiti udara keseluruhan bagi Malaysia pada tahun 2015 adalah berstatus baik dan sederhana pada kebanyakan masa kecuali terdapat peningkatan bilangan hari yang tidak sihat dicatatkan semasa berlaku jerebu merentas sempadan dari Indonesia.

Based on the Air Pollutant Index (API), the overall air quality for Malaysia in 2015 was between good to moderate levels most of the time except for a number of unhealthy days recorded during transboundary haze pollution from Indonesia.

Malaysia telah mengalami episod jerebu bermula dari 22 Ogos sehingga 26 Oktober 2015 dan menyebabkan kemerosotan kualiti udara dalam negara. Episod jerebu pada tahun ini merupakan antara yang terburuk semenjak kejadian jerebu pada tahun 1997 dan berlanjutan melebihi tempoh 2 bulan serta mencapai kemuncaknya apabila pada 15 September 2015, sebanyak 34 kawasan telah mencatatkan status kualiti udara 'tidak sihat' iaitu Indeks Pencemar Udara (IPU) melebihi 100. Episod jerebu bertambah buruk pada 4 Oktober 2015 di mana paras IPU meningkat ke paras berbahaya (IPU melebihi 300) iaitu di Shah Alam, Selangor.

Malaysia had experienced the haze episode from 22 August until 26 October 2015. This resulted in deterioration of air quality in the country. This year's haze episode has been referred to as one of the worst episodes since 1997, lasted for more than two months and affected the whole country. It became worse on 15th September when a total of 34 stations in Malaysia recorded unhealthy levels (API more than 100). The haze episode worsened on 4 October 2015 as the API level rose to hazardous level (API reading exceeding 300) in Shah Alam, Selangor.

Semasa jerebu, sejumlah 7,645 buah sekolah terpaksa ditutup (melibatkan 4,080,971 murid sekolah) di kebanyakan negeri antara 15 September 2015 hingga 23 Oktober 2015 berikutan bacaan IPU mencapai paras "sangat tidak sihat" (melebihi 200).

During the haze episodes, a total of 7,645 schools (affecting 4,080,971 students) in most states were closed between 15 September 2015 to 23 October 2015 as the API reached "very unhealthy" level (more than 200).

Antara September hingga Oktober 2015, 4 ribut tropika (taufan) telah melanda rantau ini iaitu "Dujuan", "Mujigae", "Koppu" dan "Champi" yang menyebabkan angin dari arah barat daya berterusan membawa asap kebakaran dari Sumatera dan Kalimantan dan jerebu berlanjutan sehingga Oktober 2015.

Between September to October 2015, the region had been affected by 4 tropical cyclones namely "Dujuan", "Mujigae", "Koppu" and "Champi" that had caused the wind direction to be consistently blowing southwesterly from the burning areas in Sumatra and Kalimantan resulting in a prolonged haze in October 2015.

Terdapat kemerosotan tren kualiti udara yang ketara di kawasan Lembah Klang pada tahun 2015 berbanding pada tahun 2014 akibat daripada jerebu merentas sempadan seperti yang ditunjukkan dalam **Rajah**

*There had been a significant deterioration in the overall trend of air quality in Klang Valley in 2015 as compared to 2014 as shown in **Figure 1.1(a)**. Particulate matter, PM_{10} was the predominant pollutant that had caused*

1.1(a). Kumin pepejal, PM_{10} merupakan pencemar utama semasa Monsun Barat Daya (Mei hingga Oktober). Status kualiti udara tidak sihat di Lembah Klang sepanjang tempoh ini adalah disebabkan oleh kebakaran tanah dan hutan yang berlaku di Sumatera dan Kalimantan, Indonesia. **Rajah 1.1(b)** menunjukkan kepekatan harian PM_{10} bagi Klang adalah lebih tinggi secara keseluruhannya berbanding dengan beberapa stesen terpilih di kawasan sub-bandar dan luar bandar dalam Negara dengan paras PM_{10} yang lazimnya lebih rendah. Walau bagaimanapun, kejadian jerebu pada bulan September hingga Oktober 2015 telah menyebabkan ketiga-tiga kategori stesen tersebut menunjukkan kepekatan harian PM_{10} melebihi had yang ditetapkan.

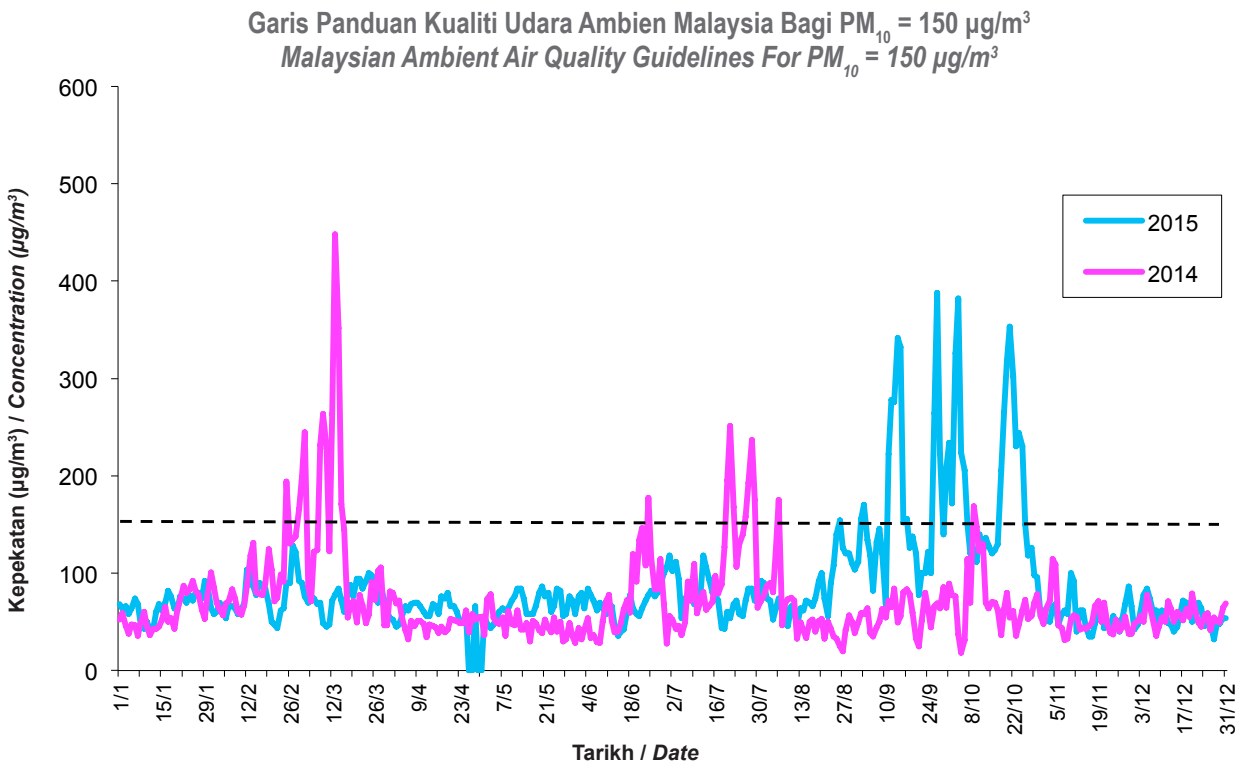
unhealthy conditions during the Southwest Monsoon (May until October). The unhealthy days in Klang Valley during these periods were due to forest and peatland fires occurred in Sumatra and Kalimantan, Indonesia. ***Figure 1.1(b)*** *shows that the daily concentrations of PM_{10} for Klang (urban area) were higher than some selected stations in sub-urban and rural areas in the country, which normally recorded lower levels of PM_{10}. However, the haze incidence that occurred in September till October had resulted in PM_{10} concentrations at those categorized stations to exceed the stipulated limit.*

Selain pencemar PM_{10}, ozon di permukaan bumi (O_3) merupakan pencemar udara yang menjadi perhatian. Ia terhasil akibat tindak balas sebatian-sebatian organik meruap (Volatile Organic Compounds, VOCs) dan oksid-oksid nitrogen (NO_x) dengan kehadiran cahaya matahari. Cuaca panas terik menggalakkan lagi pembentukan pencemar O_3. Punca utama VOCs dan NO_x adalah dari pelepasan industri dan ekzos kenderaan bermotor terutama di bandar-bandar besar. Ini menyebabkan berlakunya beberapa hari yang tidak sihat di beberapa lokasi di Lembah Klang dan di Negeri Perak, Negeri Sembilan, Johor, Kedah dan Pulau Pinang.

Besides PM_{10}, ground level ozone (O_3) remained the pollutant of concern. O_3 pollutant is created by chemical reaction between Volatile Organic Compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight. The formation of O_3 is enhanced during hot and sunny day. Emissions from industries and motor vehicle exhaust are some of the major sources of NO_x and VOC especially in urban areas. These resulted in several unhealthy days recorded at various locations in Klang Valley as well as in Perak, Negeri Sembilan, Johor, Kedah and Pulau Pinang.

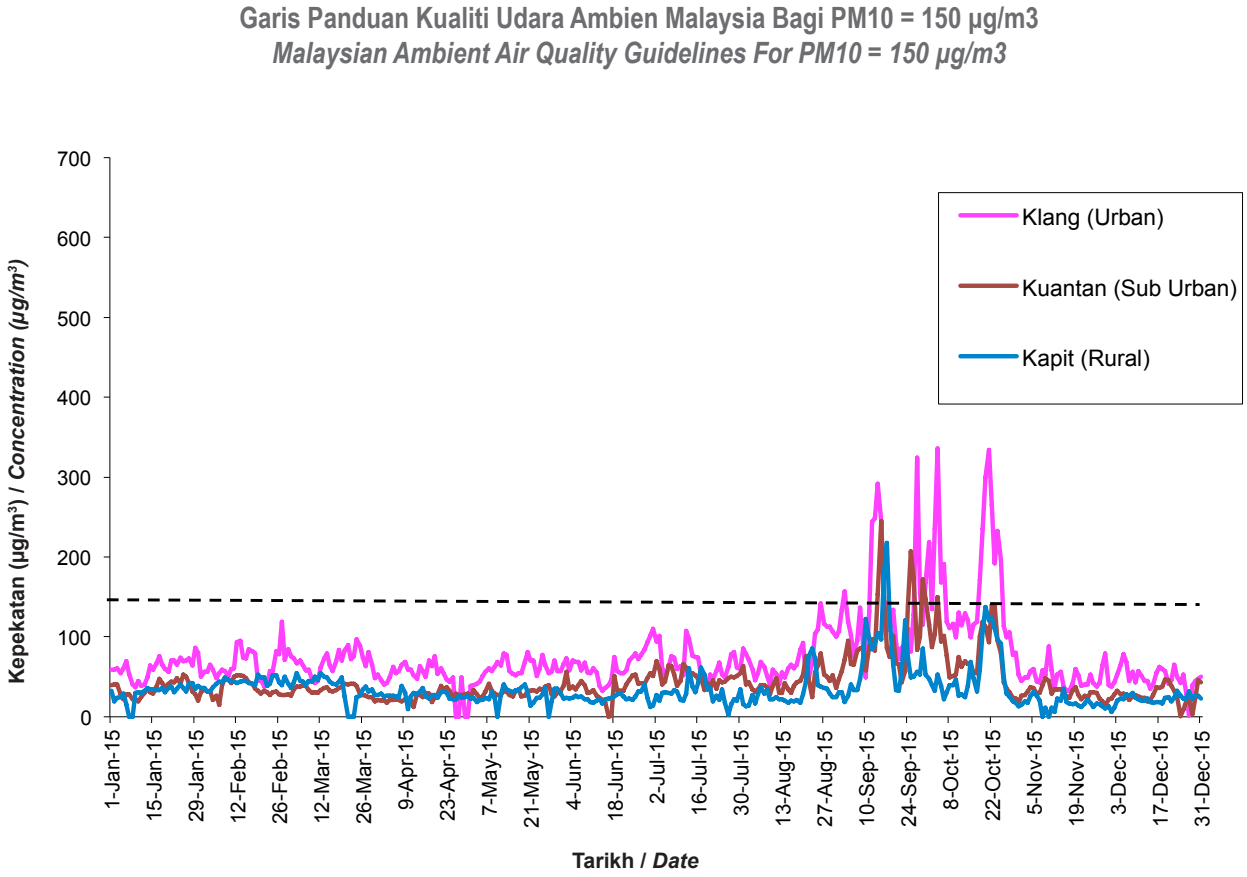
Kadangkala terdapat kepekatan maksimum harian bagi parameter O_3 dalam tempoh 1 jam adalah melebihi Garis Panduan Kualiti Udara Ambien Malaysia terutamanya di beberapa kawasan di Lembah Klang, Negeri Perak, Negeri Sembilan dan Negeri Kedah seperti yang ditunjukkan dalam **Rajah 1.1(c), Rajah 1.1 (d) dan Rajah 1.1 (e)**. Keadaan ini menyebabkan beberapa hari yang tidak sihat dicatatkan terutama di kawasan-kawasan pusat perniagaan yang tinggi dan berkepadatan trafik.

Occasionally, the daily maximum 1-hour concentration of O_3 exceeded the Malaysian Ambient Air Quality Guidelines at several stations in the Klang Valley, Perak, Negeri Sembilan and Kedah as shown in ***Figure 1.1(c), Figure 1.1(d) and Figure 1.1(e)****. These conditions led to a number of unhealthy days recorded in some areas especially those of central business with heavy traffic volumes.*



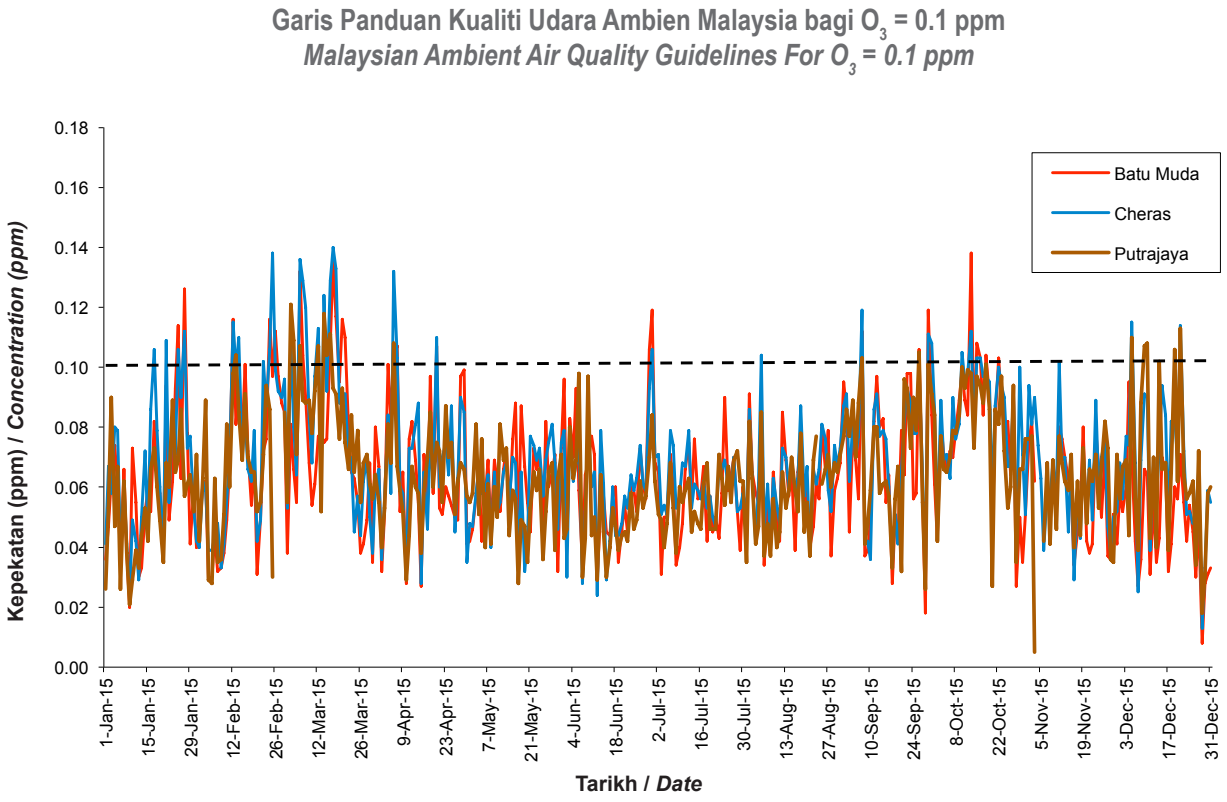
Rajah 1.1 (a) : Tren Kepekatan 24 jam bagi Pepejal Terampai (PM_{10}), Klang, 2014 dan 2015

Figure 1.1 (a) : Trend of 24-hour Concentration of Particulate Matter (PM_{10}), Klang, 2014 and 2015



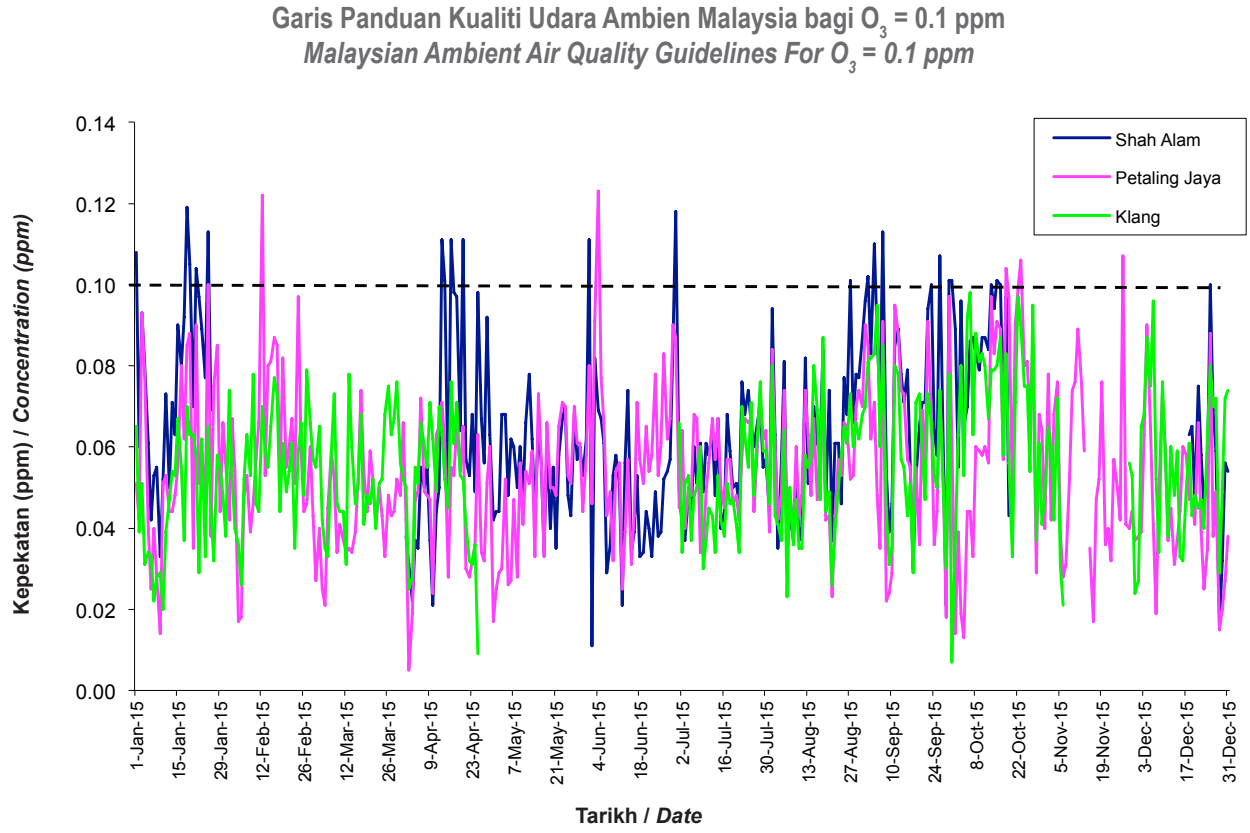
Rajah 1.1 (b) : Tren Kepekatan 24 Jam Pepejal Terampai (PM_{10}), Malaysia, 2015

Figure 1.1 (b) Malaysia : Trend of 24 Hours Concentration of Particulate Matter (PM_{10}), Malaysia, 2015



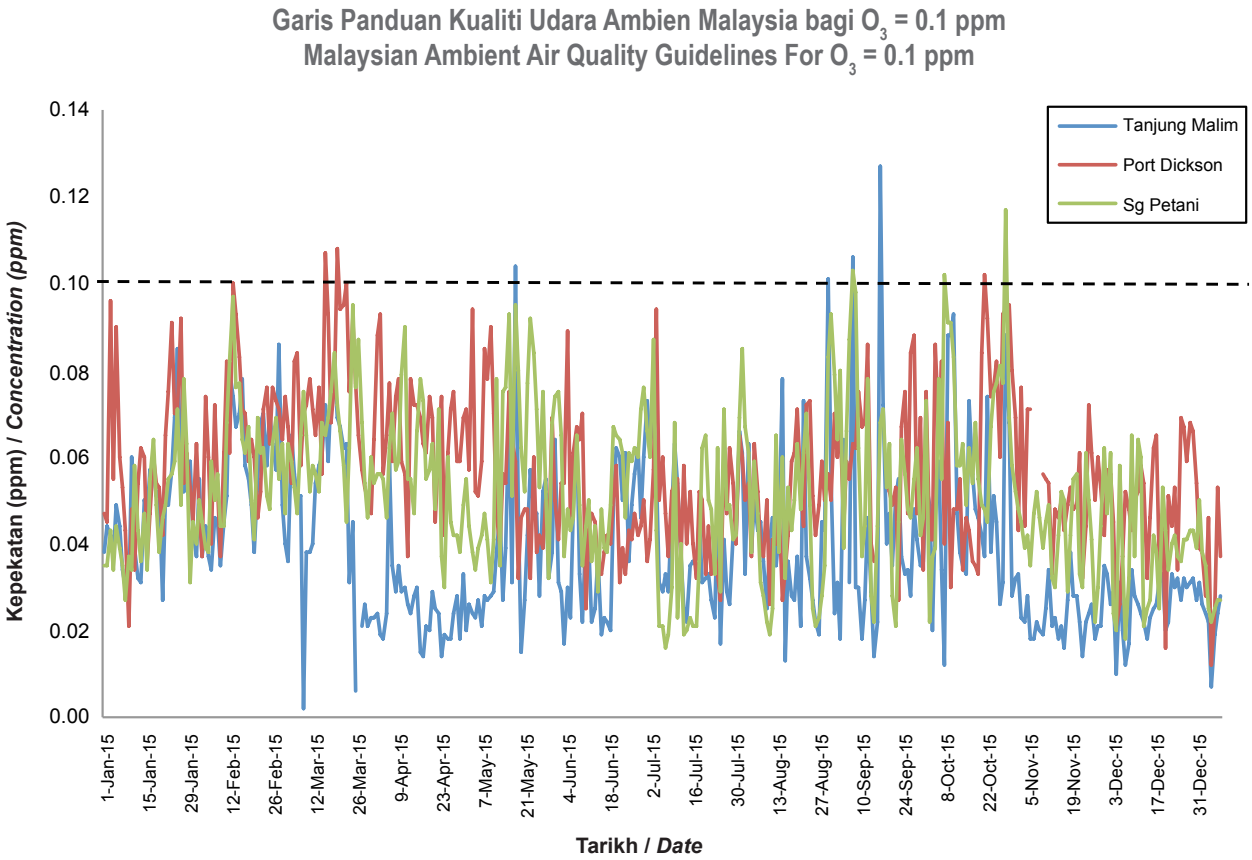
Rajah 1.1 (c) Malaysia :Tren Kepekatan Maksimum Harian Ozon (O_3)1 Jam, Lembah Klang, 2015

Figure 1.1 (c) Malaysia : Trend of Daily Maximum 1-hour Concentration of Ozone (O_3), Klang Valley, 2015



Rajah 1.1 (d) Malaysia : Tren Kepekatan Maksimum Harian Ozon (O_3) 1 Jam, Lembah Klang, 2015

Figure 1.1 (d) Malaysia : Trend of Daily Maximum 1-hour Concentration of Ozone (O_3), Klang Valley, 2015



Rajah 1.1 (e) Malaysia : Tren Kepekatan Maksimum Harian Ozon (O_3) 1 Jam, Malaysia 2015
Figure 1.1 (e) Malaysia : Trend of Daily Maximum 1-hour Concentration of Ozone (O_3), Malaysia 2015

Status Kualiti Udara di Pantai Barat

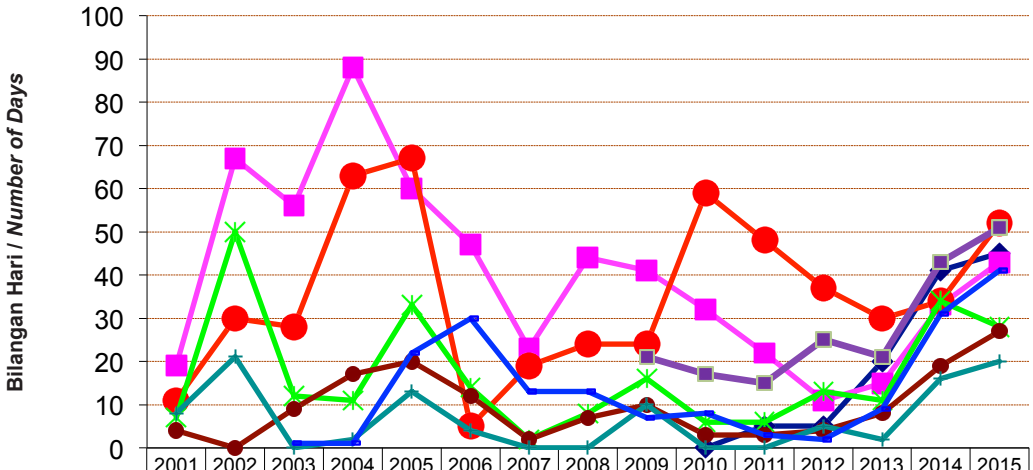
Lembah Klang

Pada tahun 2015, status kualiti udara di Lembah Klang mencatatkan 21 peratus baik, 68 peratus sederhana, sepuluh (10) peratus tidak sihat dan satu (1) peratus pada tahap sangat tidak sihat. Bilangan hari di mana status kualiti udara mencatatkan paras tidak sihat yang tertinggi adalah di Cheras, Kuala Lumpur (52 hari) **(Rajah 1.1)**. Status kualiti udara tidak sihat yang dicatatkan adalah disebabkan punca utama kumin pepejal (PM_{10}) daripada kebakaran tanah dan hutan di peringkat tempatan dan pencemaran jerebu merentas sempadan. Status kualiti udara di Lembah Klang secara keseluruhannya ditunjukkan seperti di **Rajah 1.2**.

Air Quality Status in the West Coast

Klang Valley

*In 2015, the air quality in the Klang Valley was good 21 percent of the time, moderate 68 percent, ten (10) percent at an unhealthy level and one (1) percent at a very unhealthy level. The highest number of unhealthy days was recorded in Cheras, Kuala Lumpur (52 days) **(Figure 1.1)**. The unhealthy days recorded were mainly due to PM_{10} from forest and peatland fires that occurred locally and transboundary haze pollution. The overall air quality status in Klang Valley is shown in **Figure 1.2**.*



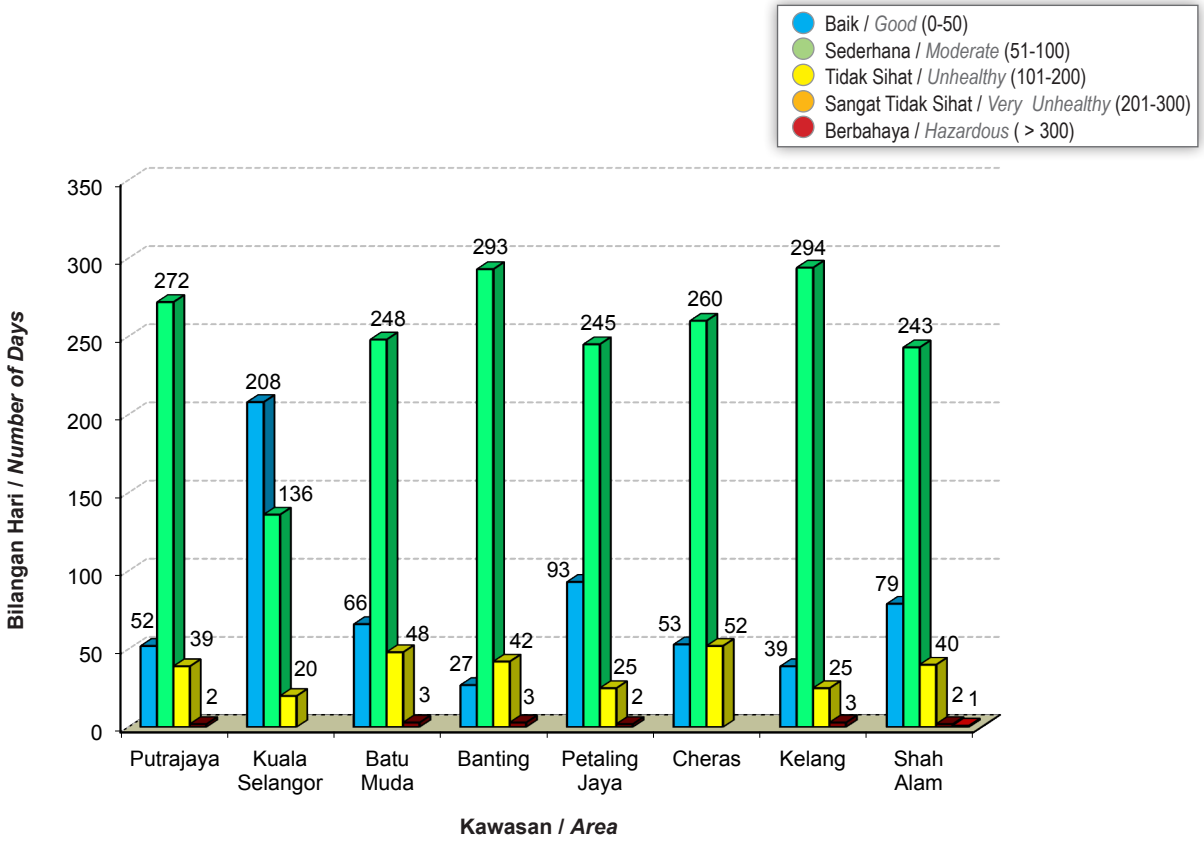
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Banting										0	5	5	20	41	45
Shah Alam	19	67	56	88	60	47	23	44	41	32	22	11	15	33	43
Cheras	11	30	28	63	67	5	19	24	24	59	48	37	30	34	52
Klang	7	50	12	11	33	14	2	8	16	6	6	13	11	34	28
Petaling Jaya	4	0	9	17	20	12	2	7	10	3	3	4	8	19	27
Kuala Selangor	8	21	0	2	13	4	0	0	10	0	0	5	2	16	20
Putrajaya			1	1	22	30	13	13	7	8	3	2	9	31	41
Batu Muda									21	17	15	25	21	43	51

Rajah 1.1 Malaysia : Bilangan Hari Tidak Sihat, Lembah Klang, 2001-2015
Figure 1.1 Malaysia : Number of Unhealthy Days, Klang Valley, 2001 - 2015

Nota 1 : Bacaan adalah berdasarkan IPU Maksimum Harian
Note 1 : Readings were based on Daily Maximum API

Nota 2 : Stesen di Putrajaya , Batu Muda dan Banting mula beroperasi masing-masingnya pada 2003, 2009 dan 2010
Note 2 : Stations in Putrajaya , Batu Muda and Banting had started operation since 2003, 2009 & 2010, respectively

Nota 3 : Stesen di Kajang tidak lagi beroperasi semenjak 2011
Note 3 : Station in Kajang had stopped operating since 2011



Rajah 1.2 Malaysia : Lembah Klang, Status Kualiti Udara, 2015
Figure 1.2 Malaysia : Klang Valley Air Quality Status, 2015

Nota : Bacaan adalah berdasarkan IPU Maksimum Harian
Note : Reading based on daily Maximum API

Wilayah Utara

Secara keseluruhan, status kualiti udara di utara Pantai Barat Semenanjung Malaysia yang meliputi Negeri Perlis, Negeri Kedah, Negeri Pulau Pinang dan Negeri Perak adalah baik dan sederhana sepanjang masa. Walau bagaimanapun, Kangar, Langkawi, Alor Setar, Sungai Petani, USM dan Seberang Jaya masing-masing mencatatkan satu (1) hari status kualiti udara sangat tidak sihat disebabkan pencemaran jerebu merentas sempadan. Stesen lain yang mencatatkan status kualiti udara tidak sihat adalah Tasek, Ipoh dan Manjung (masing-masing 18 hari), Tanjung Malim (14 hari), Perai (12 hari), dan Taiping (13 hari). Status kualiti udara tidak sihat di kawasan-kawasan berkenaan adalah disebabkan oleh pencemar $PM_{10.}$

Rajah 1.3 menunjukkan status kualiti udara keseluruhan bagi wilayah utara di Pantai Barat Semenanjung Malaysia.

Northern Region

The overall air quality of the northern region of the West Coast of Peninsular Malaysia (Perlis, Kedah, Pulau Pinang and Perak) was between good to moderate most of the time. However, Kangar, Langkawi, Alor Setar, Sungai Petani, USM and Seberang Jaya recorded one (1) very unhealthy day respectively due to transboundary haze pollution. Unhealthy days were also recorded in other stations namely Tasek, Ipoh and Manjung (18 days), Tanjung Malim (14 days), Perai (12 days), and Taiping (13 days). Unhealthy days recorded in these areas were mainly due to PM_{10} pollutants.

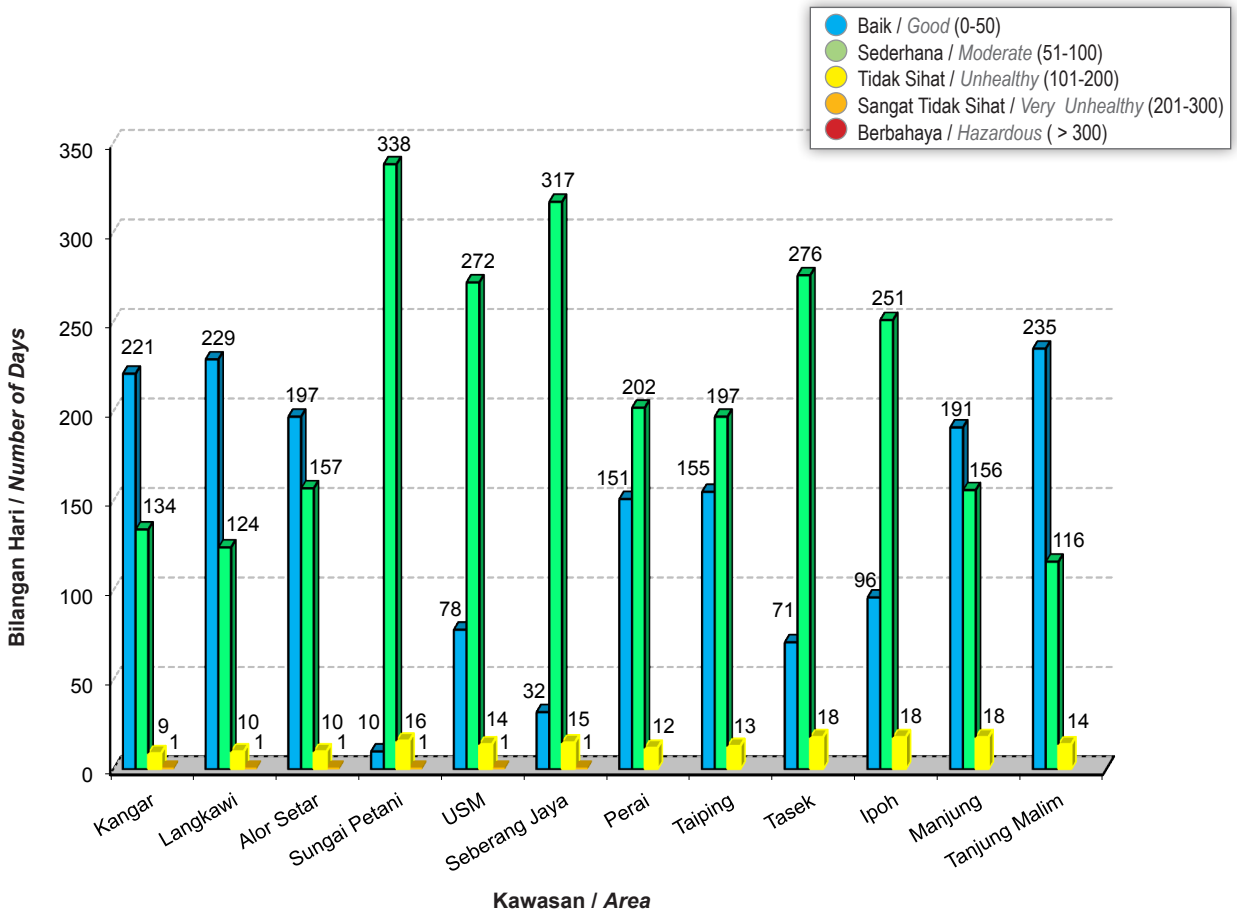
***Figure 1.3** shows the overall air quality status for the northern region of the West Coast of Peninsular Malaysia.*

Wilayah Selatan

Kualiti udara di wilayah selatan Pantai Barat Semenanjung Malaysia (Negeri Sembilan, Negeri Melaka dan Negeri Johor) adalah baik dan sederhana pada kebanyakan masa, kecuali terdapat beberapa hari yang mencatatkan status kualiti udara sangat tidak sihat selama satu (1) hari iaitu Nilai, Seremban dan Pasir Gudang yang disebabkan pencemaran jerebu merentas sempadan. Stesen-stesen lain yang mencatatkan kualiti udara yang tidak sihat adalah Port Dickson (29), Bukit Rambai dan Bandaraya Melaka (34), Muar (18), Larkin (23) dan Kota Tinggi (11). Status kualiti udara tidak sihat di kawasan-kawasan berkenaan adalah disebabkan oleh PM_{10}. **Rajah 1.4** menunjukkan status kualiti udara secara keseluruhan bagi wilayah selatan di Pantai Barat Semenanjung Malaysia.

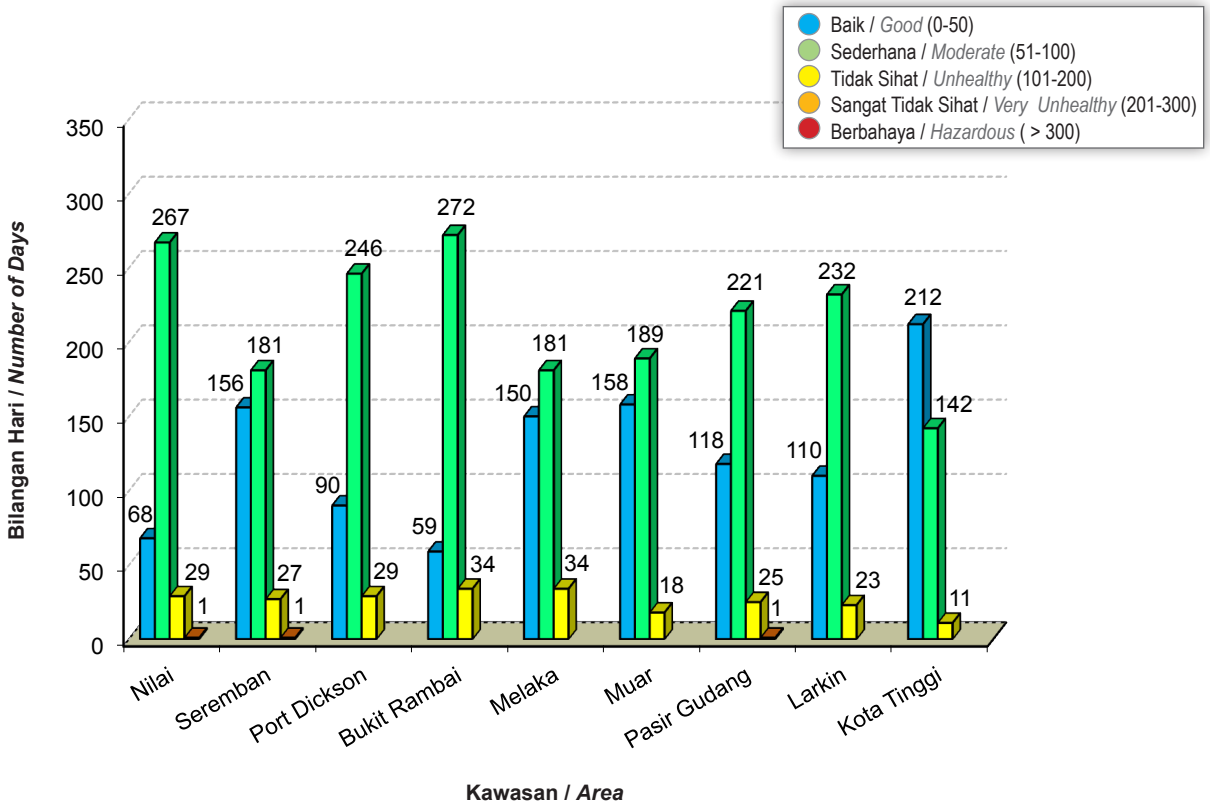
Southern Region

*In the southern region of the West Coast of Peninsular Malaysia (Negeri Sembilan, Melaka and Johor) the air quality was also between good to moderate most of the time, with the exception of one (1) very unhealthy day in Nilai and Pasir Gudang respectively due to the transboundary haze. Other stations that recorded unhealthy days were Port Dickson (29), Bukit Rambai and Bandaraya Melaka (34), Muar (18), Larkin (23) and Kota Tinggi (11). Unhealthy days recorded in these areas were mainly due to PM_{10} pollutants. **Figure 1.4** shows the overall air quality status for southern region of the West Coast of Peninsular Malaysia.*



Rajah 1.3 Malaysia : Status Kualiti Udara, Wilayah Utara Pantai Barat Semenanjung Malaysia, 2015
Figure 1.3 Malaysia : Air Quality Status, Northern Region of The West Coast Peninsular Malaysia, 2015

Nota : Bacaan adalah berdasarkan IPU Maksimum Harian
Note : Reading based on daily Maximum API



Rajah 1.4 Malaysia : Status Kualiti Udara, Wilayah Selatan Pantai Barat Semenanjung Malaysia, 2015
Figure 1.4 Malaysia : Air Quality Status, Southern Region of The West Coast Peninsular Malaysia, 2015

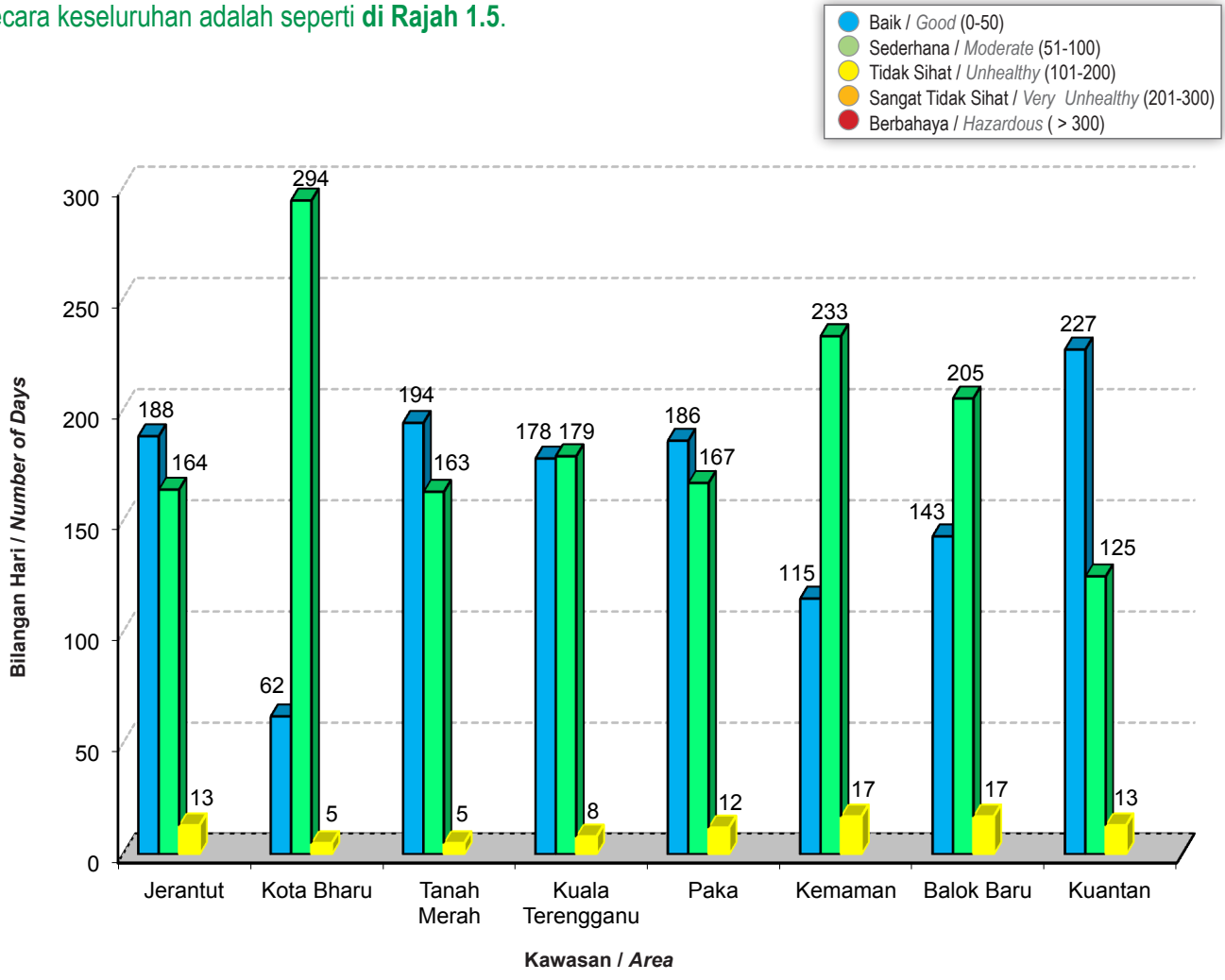
Nota : Bacaan adalah berdasarkan IPU Maksimum Harian
Note : Reading based on daily Maximum API

Status Kualiti Udara di Pantai Timur

Kualiti udara di Pantai Timur Semenanjung Malaysia (Negeri Pahang, Negeri Terengganu, Negeri Kelantan dan timur Negeri Johor) kekal berstatus baik dan sederhana pada kebanyakan masa, kecuali terdapat beberapa hari yang mencatatkan status kualiti udara tidak sihat semasa musim kering iaitu pada bulan Jun hingga September iaitu di Jerantut (13), Kota Bahru dan Tanah Merah (5), Kuala Terengganu (8), Paka (12), Kemaman dan Balok Baru (17) dan Kuantan (13). Status kualiti udara tidak sihat di kawasan-kawasan berkenaan adalah disebabkan oleh pencemar PM_{10} semasa episod jerebu merentas sempadan. Status kualiti udara di Pantai Timur Semenanjung Malaysia secara keseluruhan adalah seperti **di Rajah 1.5**.

Air Quality Status in the East Coast

*In the East Coast of Peninsular Malaysia (Pahang, Terengganu, Kelantan and East Johor) the air quality remained between good to moderate levels most of the time, with the exception of a few unhealthy days during the dry period of June to September which were in Jerantut (13), Kota Bahru and Tanah Merah (5), Kuala Terengganu (8), Paka (12), Kemaman and Balok Baru (17) dan Kuantan (13). Unhealthy days recorded in these areas were due to PM_{10} pollutant during transboundary haze episode. The overall air quality status in the East Coast of Peninsular Malaysia is shown in **Figure 1.5**.*



Rajah 1.5 Malaysia : Status Kualiti Udara, Pantai Timur Semenanjung Malaysia, 2015
Figure 1.5 Malaysia : Air Quality Status, East Coast Peninsular Malaysia, 2015

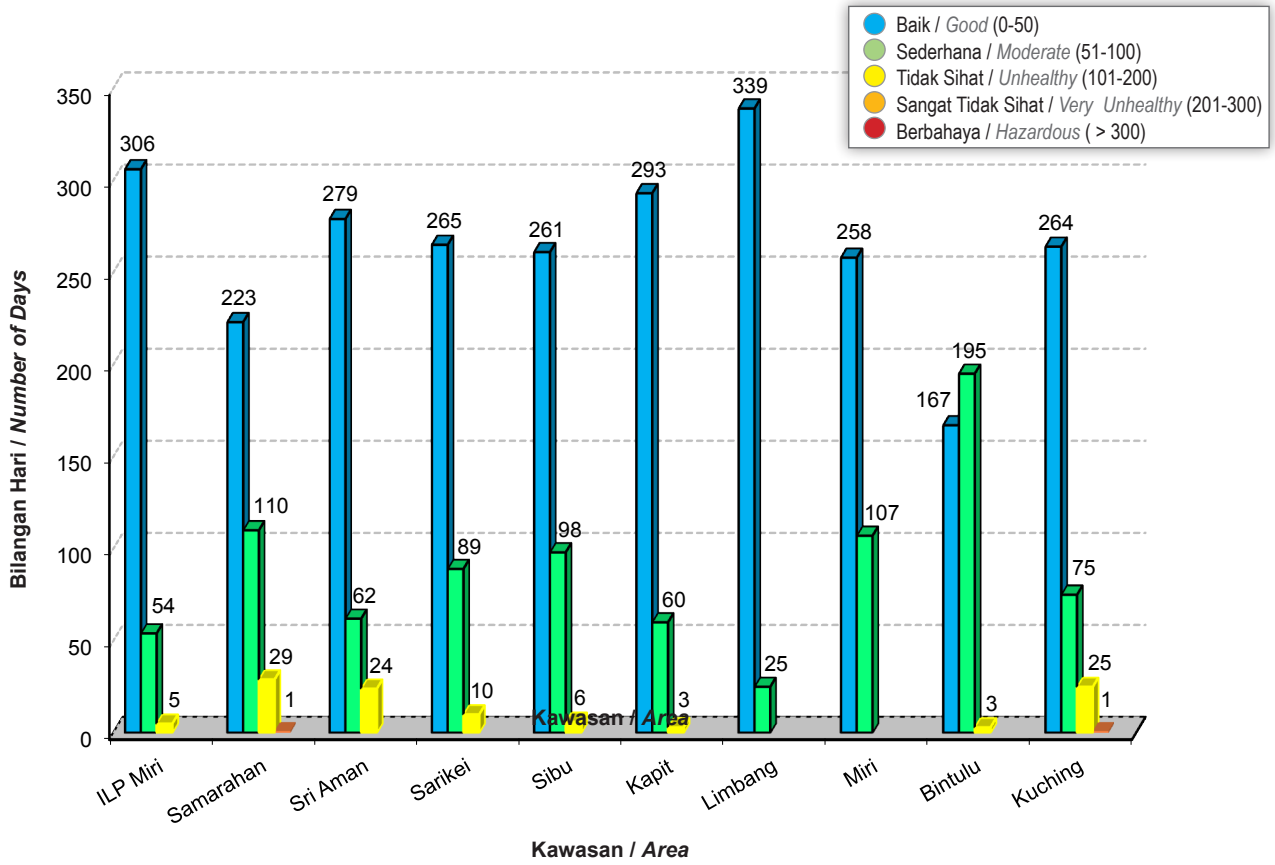
Nota : Bacaan adalah berdasarkan IPU Maksimum Harian
Note : Reading based on daily Maximum API

Status Kualiti Udara di Sabah, Labuan dan Sarawak

Kualiti udara di Sabah, Labuan dan Sarawak adalah baik dan sederhana di kebanyakan masa kecuali dua tempat yang mencatatkan satu (1) hari bacaan yang sangat tidak sihat iaitu di Samarahan dan Kuching. Beberapa tempat di Sarawak mencatatkan status kualiti udara tidak sihat adalah di ILP Miri (5), Sri Aman (24), Sarikei (10), Sibu (6) dan Kapit dan Bintulu (3). Status kualiti udara sangat tidak sihat dan tidak sihat di kawasan-kawasan berkenaan adalah disebabkan oleh pencemar PM_{10} semasa episod jerebu merentas sempadan dari Kalimantan, Indonesia. Status kualiti udara di Sarawak secara keseluruhan ditunjukkan dalam **Rajah 1.6** dan di Sabah dan Labuan ditunjukkan dalam **Rajah 1.7**.

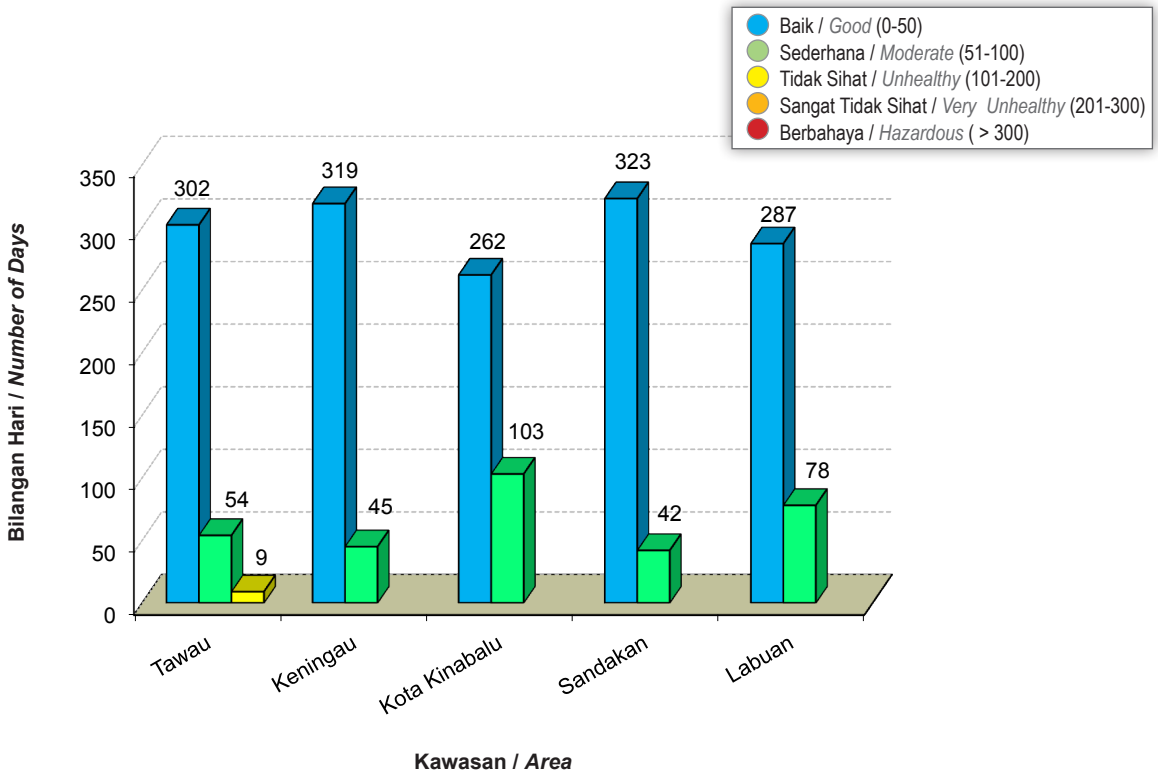
Air Quality Status in Sabah, Labuan and Sarawak

*The air quality in Sabah, Labuan and Sarawak remained between good to moderate levels most of the time with the exception of one (1) very unhealthy day in Samarahan and Kuching respectively. Several places in Sarawak recorded unhealthy days ILP Miri (5), Sri Aman (24), Sarikei (10), Sibu (6) and Kapit and Bintulu (3). Unhealthy days recorded in these areas were due to PM_{10} pollutant during transboundary haze episode from Kalimantan, Indonesia. The overall air quality status in Sarawak is shown in **Figure 1.6** and **Figure 1.7** shows the overall air quality in Sabah and Labuan.*



Rajah 1.6 Malaysia : Status Kualiti Udara, Sarawak, 2015
Figure 1.6 Malaysia : Air Quality Status, Sarawak, 2015

Nota : Bacaan adalah berdasarkan IPU Maksimum Harian
Note : Reading based on daily Maximum API



Rajah 1.7 Malaysia : Status Kualiti Udara, Sabah dan Labuan, 2015
Figure 1.7 Malaysia : Air Quality Status, Sabah and Labuan, 2015

Nota : Bacaan adalah berdasarkan IPU Maksimum Harian
Note : Reading based on daily Maximum API

TREN KUALITI UDARA
AIR QUALITY TREND

Lima (5) pencemar udara iaitu kumin pepejal (PM_{10}), ozon permukaan bumi (O_3), sulfur dioksida (SO_2), nitrogen dioksida (NO_2) dan karbon monoksida (CO) dipantau secara berterusan di 52 buah lokasi. Tren kualiti udara dari tahun 2000 hingga 2015 ditentukan dengan mengambilkira purata data kualiti udara tahunan daripada stesen-stesen pengawasan dan merujuk kepada Garis Panduan Kualiti Udara Ambien Malaysia seperti yang ditunjukkan dalam **Jadual 1.2**.

*Five (5) air pollutants, namely Particulate Matter (PM_{10}), Ground Level Ozone (O_3), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO) were monitored continuously at 52 locations. The air quality trend for the period of 2000 to 2015 was computed by averaging annual air quality data received from the monitoring sites and cross-reference with Malaysia Ambient Air Quality Guidelines as shown in **Table 1.2**.*

Jadual 1.2 Malaysia : Garis Panduan Kualiti Udara Ambien Malaysia
Table 1.2 Malaysia : Ambient Air Quality Guidelines

BAHAN PENCEMAR *POLLUTANT*	MASA PURATA *AVERAGING TIME*	GARIS PANDUAN MALAYSIA *MALAYSIA GUIDELINES*	
		ppm	($\mu g/m^3$)
OZON *OZONE*	1 HOUR *8 HOURS*	0.10 0.06	200 120
KARBON MONOKSIDA *CARBON MONOXIDE*	1 HOUR *8 HOURS*	30.0 9.0	35** 10**
NITROGEN DIOKSIDA *NITROGEN DIOXIDE*	1 HOUR *24 HOURS*	0.17 0.04	320
SULFUR DIOKSIDA SULPHUR DIOXIDE	1 HOUR *24 HOURS*	0.13 0.04	350 105
PEPEJAL TERAMPAI (PM_{10}) *PARTICULATE MATTER (PM_{10})*	24 HOURS *12 MONTHS*		150 50
TOTAL SUSPENDED PARTICULATE (TSP)	24 HOURS *12 MONTHS*		260 90
BESI *LEAD*	*3 MONTHS*		1.5

Nota / *Note* : ** mg/m^3

Kumin Pepejal (PM_{10})

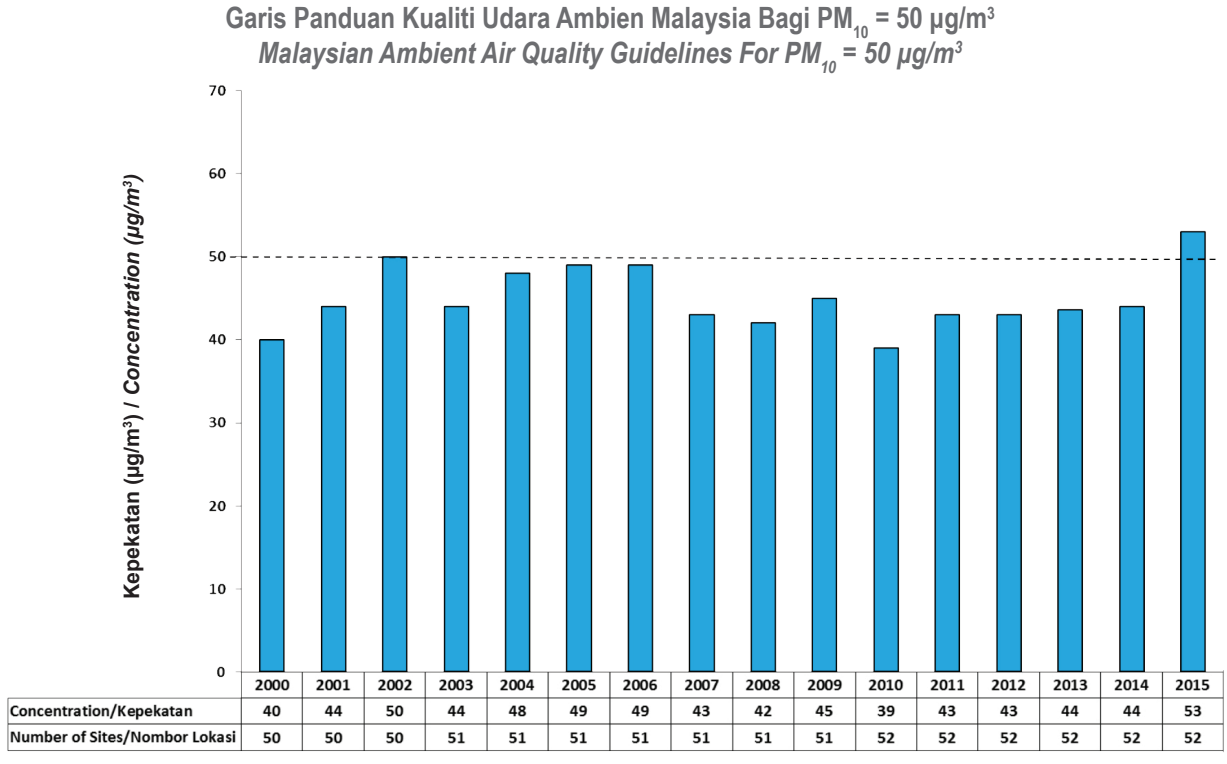
Pada tahun 2015, nilai purata tahunan PM_{10} dalam udara ambien adalah 53 µg/m^3 iaitu telah melebihi had yang ditetapkan dalam Garis Panduan Kualiti Udara Ambien Malaysia iaitu sebanyak 50 µg/m^3. Ini merupakan peningkatan ketara bagi PM_{10} berbanding tahun 2014. Kejadian jerebu merentas sempadan dari Sumatera dan Kalimantan, Indonesia dalam tempoh yang lama telah menyumbang kepada bacaan PM_{10} yang tinggi dicatatkan di kebanyakan kawasan dalam negara.

Tren purata tahunan kepekatan PM_{10} dalam udara ambien antara tahun 2000 hingga 2014 didapati mematuhi Garis Panduan Kualiti Udara Ambien Malaysia **kecuali bagi tahun 2015** seperti yang ditunjukkan dalam **Rajah 1.8**. Berdasarkan kategori guna tanah, nilai kepekatan PM_{10} adalah mematuhi Garis Panduan Kualiti Udara Ambien Malaysia **kecuali kategori guna tanah industri dan bandar pada tahun 2015** seperti yang ditunjukkan dalam **Rajah 1.8 (a)**.

Particulate Matter (PM_{10})

In 2015, the annual average value of PM_{10} in the ambient air was 53 µg/m^3 which exceeded the Malaysian Ambient Air Quality Guidelines value of 50 µg/m^3. There was a significant increase of PM_{10} concentration compared to the 2014. Prolonged transboundary haze pollution from Sumatra and Kalimantan, Indonesia had contributed to the higher PM_{10} readings recorded in most of the areas in the country.

*The trend of the annual average levels of PM_{10} concentration in the ambient air between 2000 and 2014 complied to the Malaysian Ambient Air Quality Guidelines **except for year 2015** as shown in **Figure 1.8**. Based on land use categories, PM_{10} concentration was in compliance with Malaysian Ambient Air Quality Guidelines **except for industrial and urban categories in year 2015** as shown in **Figure 1.8(a)**.*

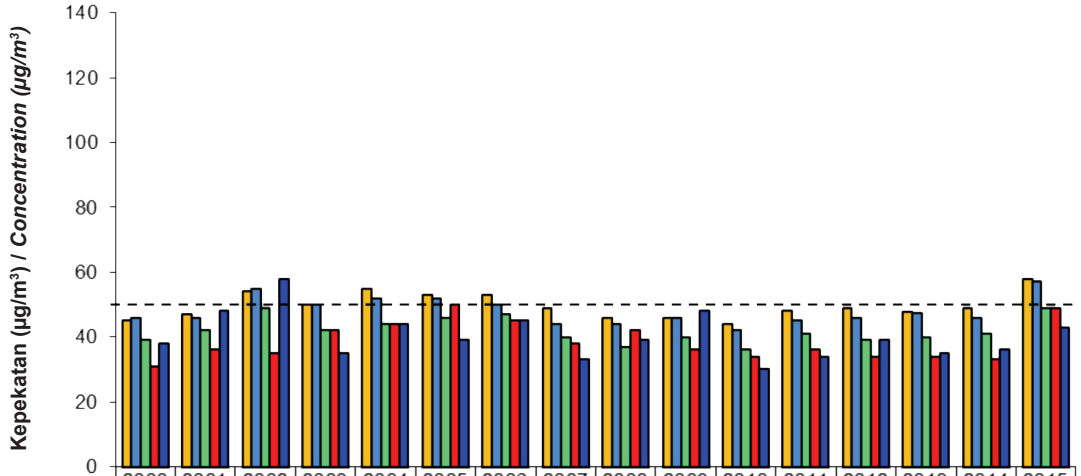


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Concentration/Kepekatan	40	44	50	44	48	49	49	43	42	45	39	43	43	44	44	53
Number of Sites/Nombor Lokasi	50	50	50	51	51	51	51	51	51	51	52	52	52	52	52	52

Rajah 1.8 Malaysia : Purata Kepekatan Tahunan Kumin Pepejal (PM_{10}), 2000 - 2015

Figure 1.8 Malaysia : Annual Average Concentration of Particulate Matter (PM_{10}), 2000 - 2015

Garis Panduan Kualiti Udara Ambien Malaysia Bagi PM_{10} = 50 µg/m³
Malaysian Ambient Air Quality Guidelines For PM_{10} = 50 µg/m³



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Industrial/Industri	45	47	54	50	55	53	53	49	46	46	44	48	49	48	49	58
Urban/Bandar	46	46	55	50	52	52	50	44	44	46	42	45	46	48	46	57
Sub Urban/Luar Bandar	39	42	49	42	44	46	47	40	37	40	36	41	39	40	41	49
Background	31	36	35	42	44	50	45	38	42	36	34	36	34	34	33	49
Rural	38	48	58	35	44	39	45	33	39	48	30	34	39	35	36	43

Rajah 1.8 (a) Malaysia : Purata Kepekatan Tahunan Kumin Pepejal (PM_{10}) Mengikut Guna Tanah, 2000 - 2015
Figure 1.8 (a) Malaysia : Annual Average Concentration of Particulate Matter (PM_{10}) by Land Use, 2000 - 2015

Ozon Permukaan Bumi (O_3)

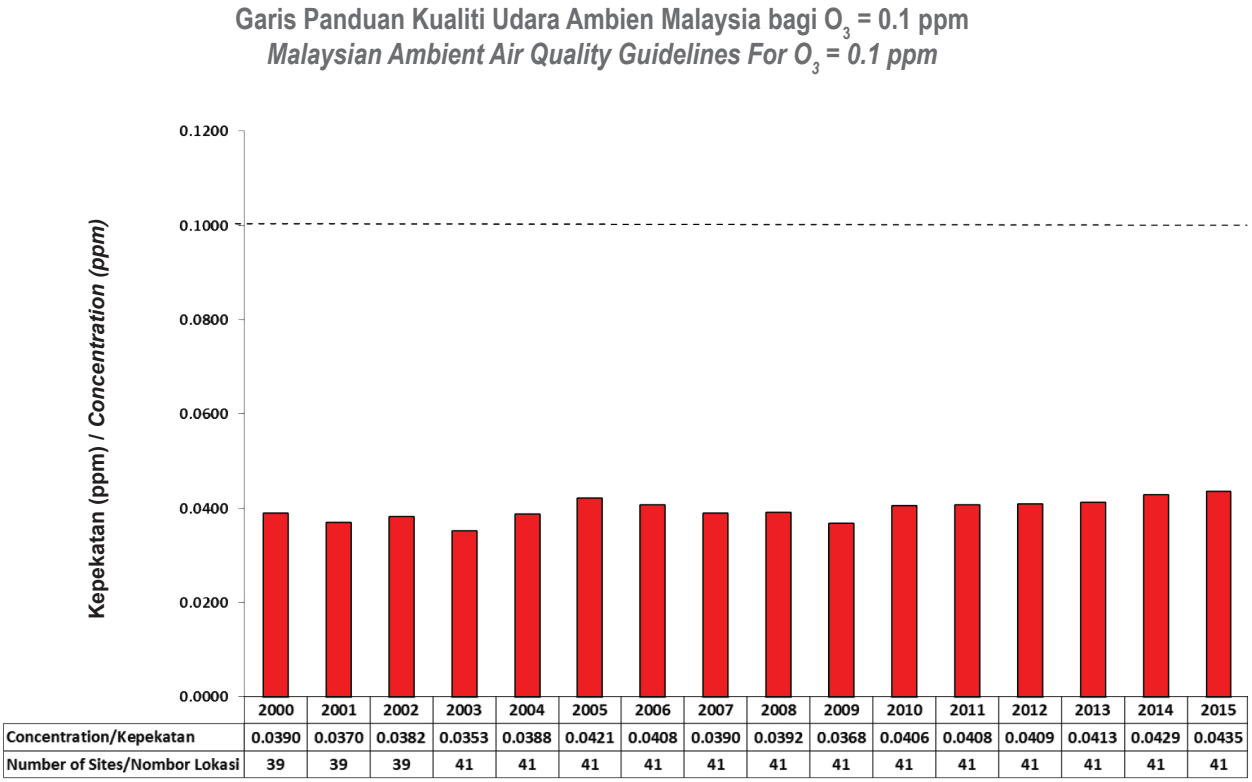
Pada tahun 2015, purata tahunan kepekatan maksimum harian ozon didapati meningkat sedikit berbanding tahun 2014. Secara keseluruhannya, tren purata tahunan kepekatan maksimum ozon dalam udara ambien dari tahun 2000 hingga 2015 adalah mematuhi had sebanyak 0.1 ppm seperti yang ditetapkan dalam Garis Panduan Kualiti Udara Ambien Malaysia dan tren tersebut adalah seperti yang ditunjukkan dalam **Rajah 1.9.**

Rajah 1.9(a) menunjukkan kepekatan ozon untuk pelbagai kategori guna tanah dari tahun 2000 hingga 2015. Kawasan bandar mencatatkan bacaan ozon lebih tinggi disebabkan oleh jumlah trafik yang lebih tinggi dan keadaan atmosfera yang kondusif menyebabkan pembentukan ozon. Pencemaran ozon juga ketara di beberapa kawasan sub-bandar dan pedalaman disebabkan oleh pergerakan angin yang membawa pencemar ozon yang terhasil daripada tindakbalas oksid-oksid nitrogen (NO_x) dan sebatian organik meruap (VOC) daripada kenderaan bermotor dan industri.

Ground Level Ozone (O_3)

*In 2015, there was a slight increase in annual average daily maximum one-hour ozone concentrations compared to 2014. The overall trend on the annual average daily maximum one-hour ozone concentrations in ambient air from 2000 to 2015 were well below the limit of 0.1 ppm as stipulated in the Malaysian Ambient Quality Guidelines and the trend is as shown in **Figure 1.9**.*

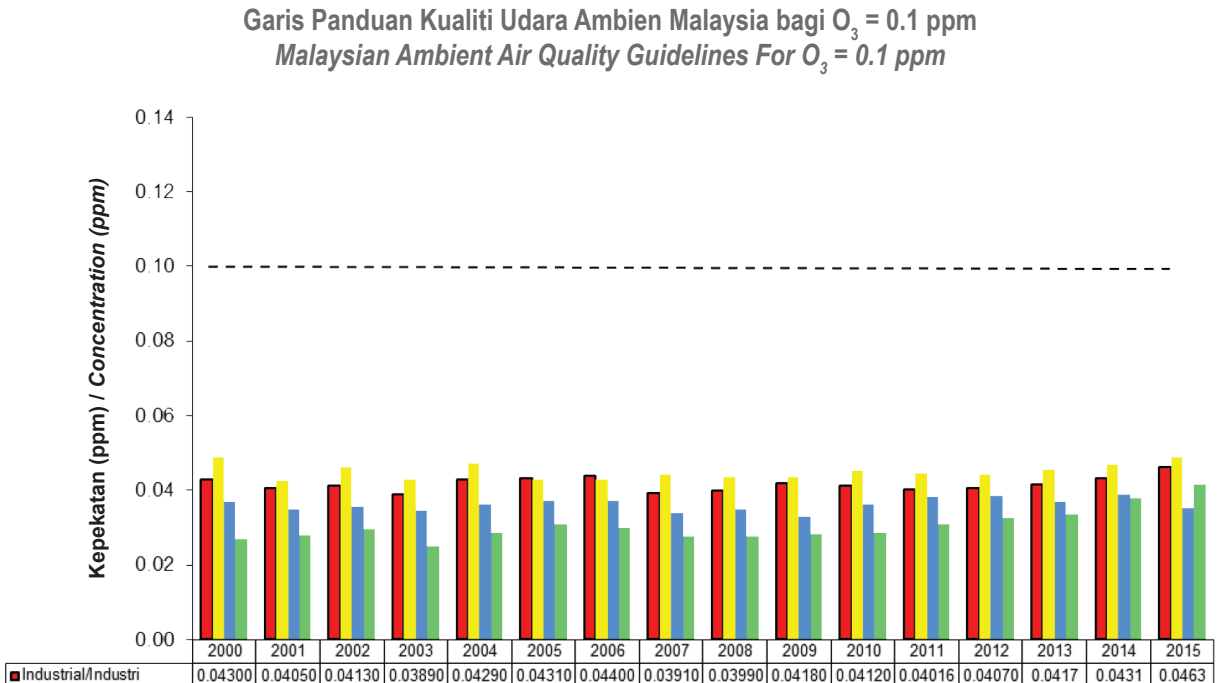
***Figure 1.9(a)** shows the ozone concentration for various land use categories between 2000 and 2015. Urban areas recorded higher levels of ozone due to higher traffic volume and a conducive atmospheric condition resulting in its formation. Ozone pollution was also dominant in some sub urban and rural areas due to downwind effect transporting ozone pollution from the sources of ozone precursors namely nitrogen oxides (NO_x) and volatile organic compound (VOC) emitted from motor vehicles and industries.*



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Concentration/Kepekatan	0.0390	0.0370	0.0382	0.0353	0.0388	0.0421	0.0408	0.0390	0.0392	0.0368	0.0406	0.0408	0.0409	0.0413	0.0429	0.0435
Number of Sites/Nombor Lokasi	39	39	39	41	41	41	41	41	41	41	41	41	41	41	41	41

Rajah 1.9 Malaysia : Purata Kepekatan Tahunan Ozon (O_3), 2000 - 2015

Figure 1.9 Malaysia : Annual Average Concentration of Ozone (O_3), 2000 - 2015



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Industrial/Industri	0.04300	0.04050	0.04130	0.03890	0.04290	0.04310	0.04400	0.03910	0.03990	0.04180	0.04120	0.04016	0.04070	0.0417	0.0431	0.0463
Urban/Bandar	0.04900	0.04260	0.04610	0.04280	0.04710	0.04280	0.04285	0.04410	0.04350	0.04370	0.04530	0.04472	0.04410	0.0457	0.0469	0.0489
Sub Urban/Luar Bandar	0.03700	0.03480	0.03550	0.03450	0.03630	0.03730	0.03714	0.03410	0.03510	0.03310	0.03640	0.03833	0.03860	0.0370	0.0388	0.0354
Background	0.02700	0.02790	0.02980	0.02500	0.02870	0.03110	0.03000	0.02770	0.02780	0.02840	0.02870	0.03085	0.03270	0.0335	0.0378	0.0416

Rajah 1.9 (a) Malaysia : Purata Kepekatan Tahunan Ozon (O_3) Mengikut Guna Tanah, 2000 - 2015

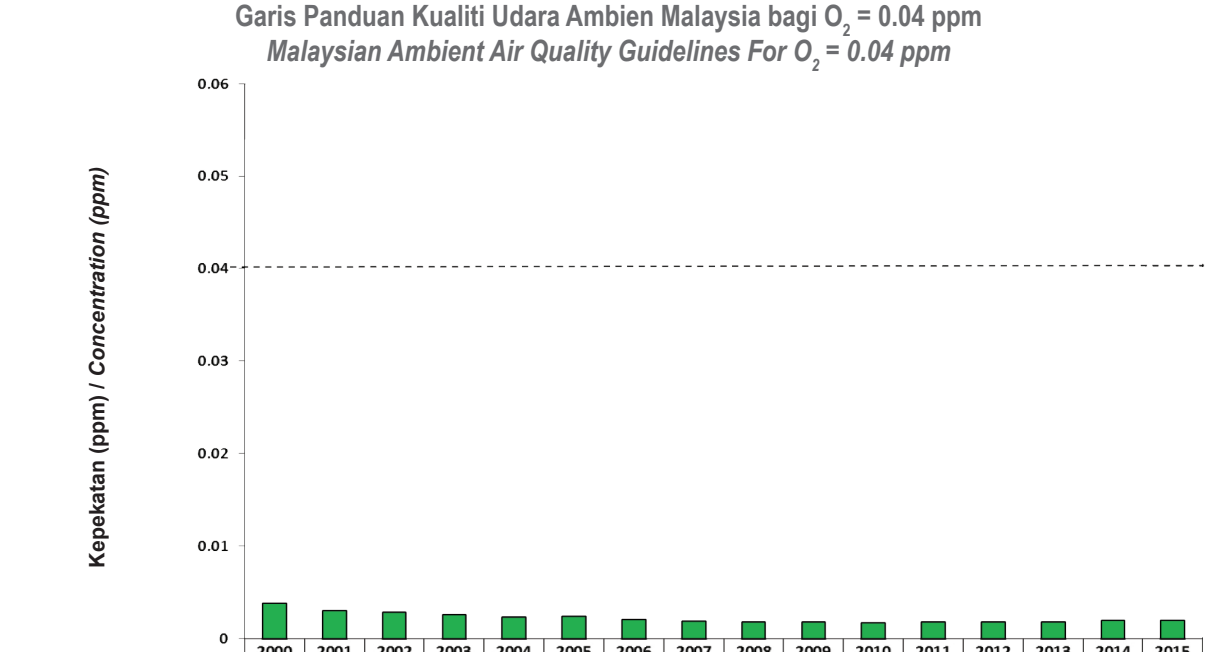
Figure 1.9 (a) Malaysia : Annual Average Concentration of Ozone (O_3) by Land Use, 2000 - 2015

Sulfur Dioksida (SO_2)

Secara umumnya, purata kepekatan tahunan SO_2 menunjukkan tren penurunan dari tahun 2000 hingga 2015 **(Rajah 1.10)** dan ia adalah jauh di bawah had sebanyak 0.04 ppm seperti yang ditetapkan dalam Garis Panduan Kualiti Udara Ambien Malaysia. Ini adalah disebabkan oleh penggunaan bahan api berkualiti EURO-2M yang lebih baik di negara ini bermula dari bulan September 2009 dan penguatkuasaan yang lebih ketat oleh JAS serta penggunaan gas asli secara meluas dalam proses industri dan kegunaan kenderaan. Mulai 1 September 2015, EURO-4M RON97 telah dilaksanakan dan pada November 2015 EURO-5 Diesel yang mengandungi kandungan sulfur kurang dari 10 mg/l pula telah diperkenalkan di pasaran. Walaupun jumlah kenderaan yang menggunakan bahan api tersebut adalah kurang dari penggunaan EURO-2M, sedikit sebanyak ia mempengaruhi tren pelepasan SO_2 di kawasan industri dan bandar yang menunjukkan semakin berkurangan pelepasan SO_2. **Rajah 1.10 (a)** menunjukkan kepekatan purata tahunan bagi sulfur dioksida mengikut kategori guna tanah.

Sulphur Dioxide (SO_2)

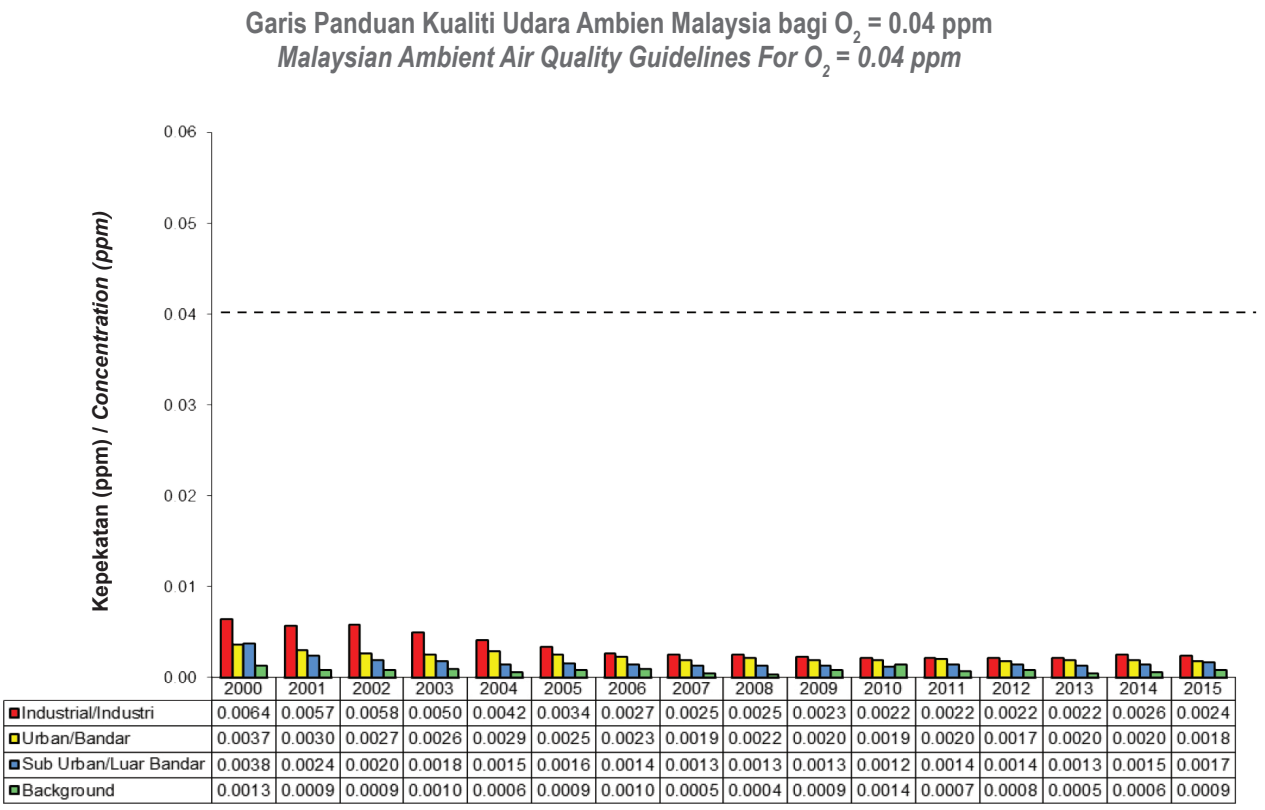
Generally, the annual average SO_2 concentration shows a declining trend between 2000 and 2015 ***(Figure 1.10)*** *and it is well below the limit of 0.04 ppm as stipulated in the Malaysian Ambient Air Quality Guidelines. This was attributed by the use of better fuel quality EURO-2M in this country starting from September 2009 and also stricter enforcement by the DOE as well as widely use of natural gas for industrial combustion process and vehicles. Starting from 1st September 2015, petrol EURO-4M RON 97 had been implemented and EURO-5 Diesel with the sulfur content less than 10 mg/l had been introduced in the market in November 2015. Though the numbers of vehicles using both types of fuels were low but still they affected the trend of SO_2 in urban and industrial areas which was lower by using these fuels.* ***Figure 1.10(a)*** *shows the annual average concentrations of sulphur dioxide from different categories of land use.*



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Concentration/Kepekatan	0.0038	0.003	0.0029	0.0026	0.0023	0.0024	0.0021	0.0019	0.0018	0.0018	0.0017	0.0018	0.0018	0.0018	0.0020	0.002
Number of Sites/Nombor Lokasi	43	43	43	44	44	44	44	44	44	44	44	44	44	44	44	42

Rajah 1.10 Malaysia : Purata Kepekatan Tahunan Sulfur Dioksida (SO_2), 2000 - 2015

Figure 1.10 Malaysia : Annual Average Concentration of Sulphur Dioxide (SO_2), 2000 - 2015



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Industrial/Industri	0.0064	0.0057	0.0058	0.0050	0.0042	0.0034	0.0027	0.0025	0.0025	0.0023	0.0022	0.0022	0.0022	0.0022	0.0026	0.0024
Urban/Bandar	0.0037	0.0030	0.0027	0.0026	0.0029	0.0025	0.0023	0.0019	0.0022	0.0020	0.0019	0.0020	0.0017	0.0020	0.0020	0.0018
Sub Urban/Luar Bandar	0.0038	0.0024	0.0020	0.0018	0.0015	0.0016	0.0014	0.0013	0.0013	0.0013	0.0012	0.0014	0.0014	0.0013	0.0015	0.0017
Background	0.0013	0.0009	0.0009	0.0010	0.0006	0.0009	0.0010	0.0005	0.0004	0.0009	0.0014	0.0007	0.0008	0.0005	0.0006	0.0009

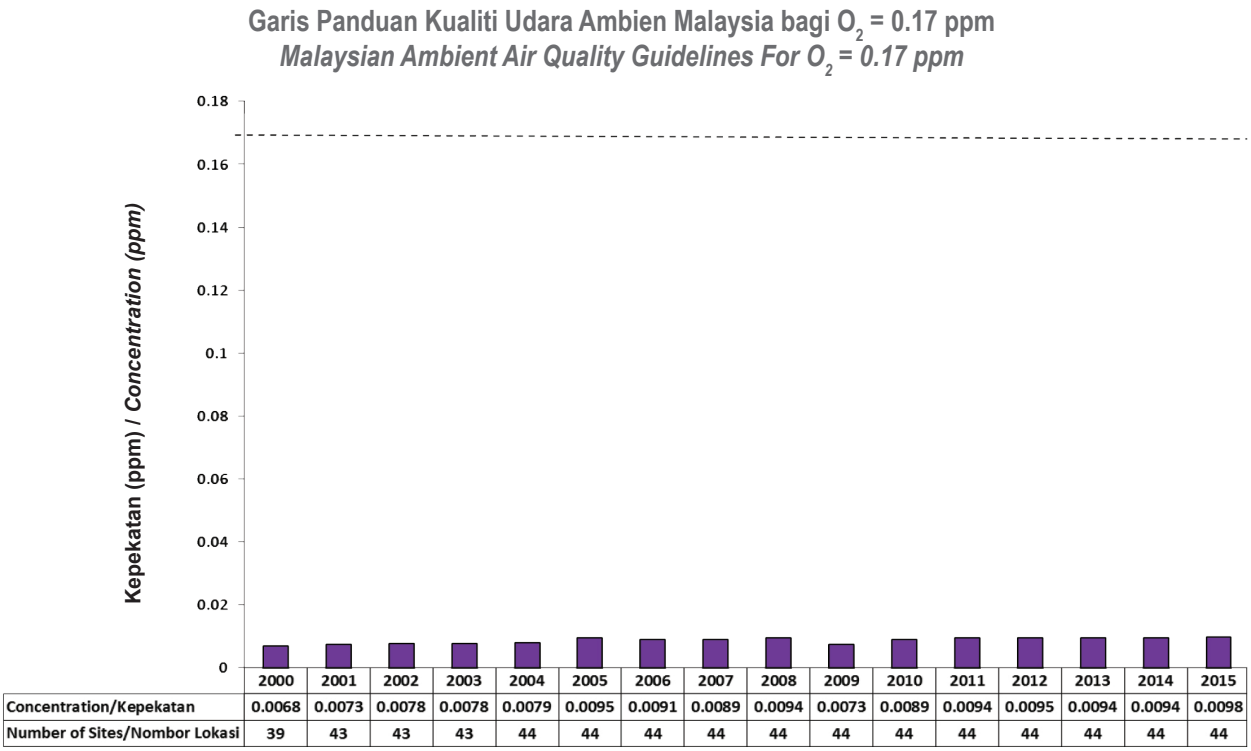
Rajah 1.10 (a) Malaysia : Purata Kepekatan Tahunan Sulfur Dioksida (SO_2) Mengikut Guna Tanah, 2000 - 2015
Figure 1.10 (a) Malaysia : Annual Average Concentration of Sulphur Dioxide (SO_2) by Land Use, 2000 - 2015

Nitrogen Dioksida (NO_2)

Pada tahun 2015, tiada sebarang perubahan yang ketara bagi NO_2 berbanding tahun 2014. Kepekatan NO_2 kekal tinggi di kawasan bandar dan perindustrian disebabkan oleh peningkatan yang ketara dalam bilangan kenderaan bermotor dan proses pembakaran. Anggaran beban pelepasan NO_2 menunjukkan sebanyak 65 peratus adalah daripada industri, 27 peratus daripada pelepasan kenderaan bermotor, 6 peratus daripada loji janakuasa dan 2 peratus daripada lain-lain sumber. Kepekatan purata tahunan NO_2 dalam udara ambien dari tahun 2000 hingga 2015 adalah stabil dan jauh berada di bawah had yang ditetapkan dalam Garis Panduan Kualiti Udara Ambien Malaysia. **Rajah 1.11 dan Rajah 1.11 (a)**

Nitrogen Dioxide (NO_2)

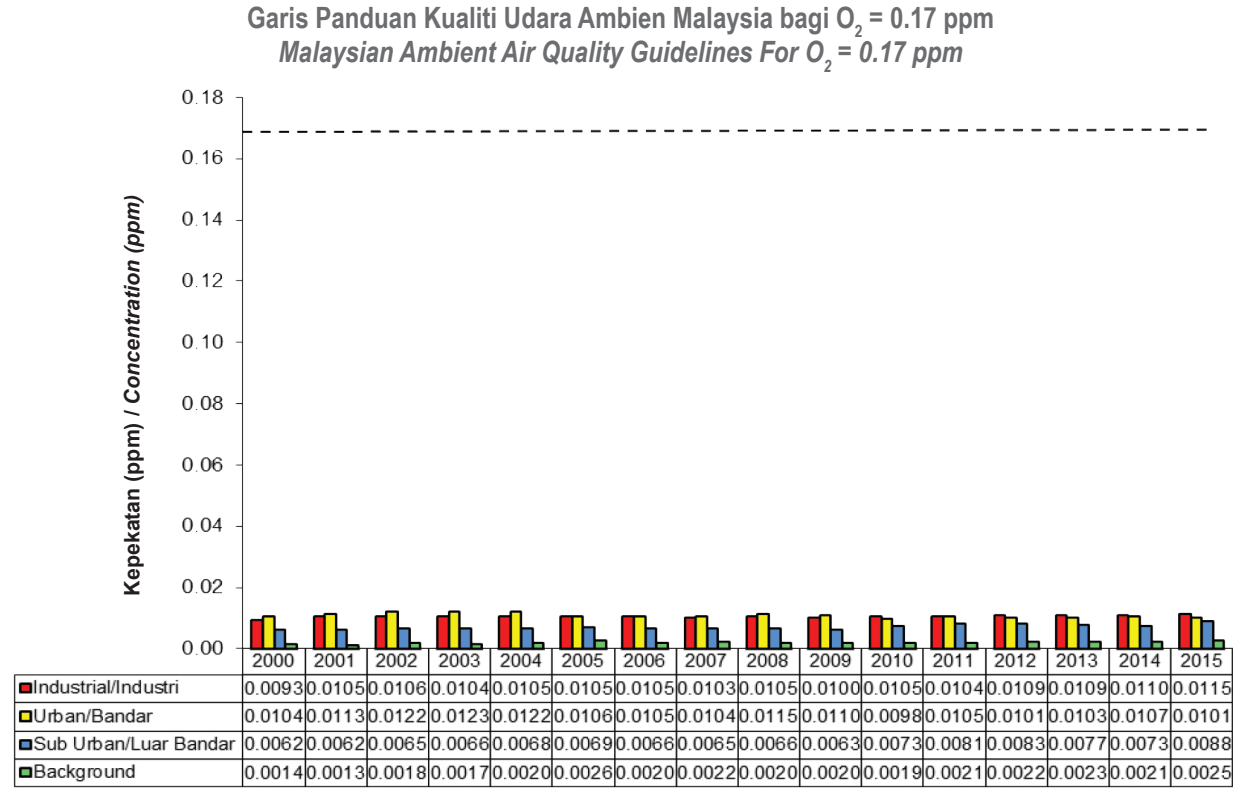
In 2015, there was no significant change of NO_2 concentration compared to the 2014 level. The NO_2 concentrations remain high in urban and industrial areas mainly due to a significant increase in the number of motor vehicles and combustion processes. Estimation on NO_2 emission load indicated that 65 percent was from industries while 27 percent from motor vehicles, 6 percent from power plants and 2 percent from other sources. The annual average concentration of NO_2 in the ambient air from 2000 to 2015 remains almost constant and well below the Malaysia Ambient Air Quality Guidelines. ***Figure 1.11 and Figure 1.11(a)***



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Concentration/Kepekatan	0.0068	0.0073	0.0078	0.0078	0.0079	0.0095	0.0091	0.0089	0.0094	0.0073	0.0089	0.0094	0.0095	0.0094	0.0094	0.0098
Number of Sites/Nombor Lokasi	39	43	43	43	44	44	44	44	44	44	44	44	44	44	44	44

Rajah 1.11 Malaysia : Purata Kepekatan Tahunan Nitrogen Dioksida (NO_2), 2000 - 2015

Figure 1.11 Malaysia : Annual Average Concentration of Nitrogen Dioxide (NO_2), 2000 - 2015



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Industrial/Industri	0.0093	0.0105	0.0106	0.0104	0.0105	0.0105	0.0105	0.0103	0.0105	0.0100	0.0105	0.0104	0.0109	0.0109	0.0110	0.0115
Urban/Bandar	0.0104	0.0113	0.0122	0.0123	0.0122	0.0106	0.0105	0.0104	0.0115	0.0110	0.0098	0.0105	0.0101	0.0103	0.0107	0.0101
Sub Urban/Luar Bandar	0.0062	0.0062	0.0065	0.0066	0.0068	0.0069	0.0066	0.0065	0.0066	0.0063	0.0073	0.0081	0.0083	0.0077	0.0073	0.0088
Background	0.0014	0.0013	0.0018	0.0017	0.0020	0.0026	0.0020	0.0022	0.0020	0.0020	0.0019	0.0021	0.0022	0.0023	0.0021	0.0025

Rajah 1.11 (a) Malaysia : Purata Kepekatan Tahunan Nitrogen Dioksida (NO_2) Mengikut Guna Tanah, 2000 - 2015

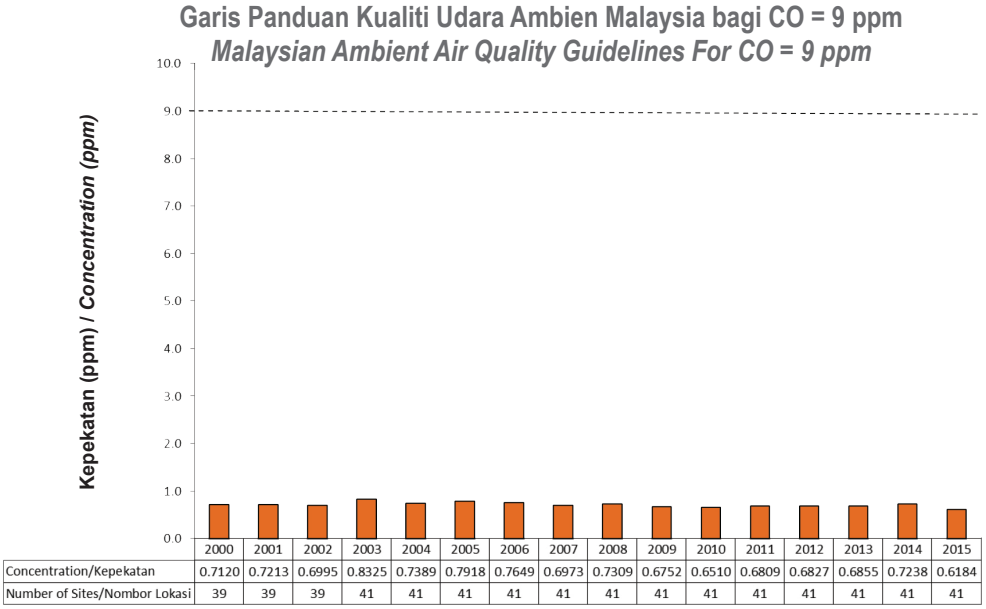
Figure 1.11 (a) Malaysia : Annual Average Concentration of Nitrogen Dioxide (NO_2) by Land Use, 2000 - 2015

Karbon Monoksida (CO)

Terdapat sedikit pengurangan tahap kepekatan CO pada tahun 2015 berbanding dengan tahun 2014 tren kepekatan CO dari tahun 2000 hingga 2015 adalah stabil. Tahap kepekatan yang dicatatkan juga mematuhi Garis Panduan Kualiti Udara Ambien Malaysia **(Rajah 1.12)**. Di kawasan bandar, kepekatan CO adalah lebih tinggi yang berpunca daripada pelepasan kenderaan bermotor dengan menyumbang sebanyak 95 peratus daripada beban pelepasan CO pada tahun 2015. **Rajah 1.12 (a)** menunjukkan kepekatan CO untuk pelbagai kategori guna tanah.

Carbon Monoxide (CO)

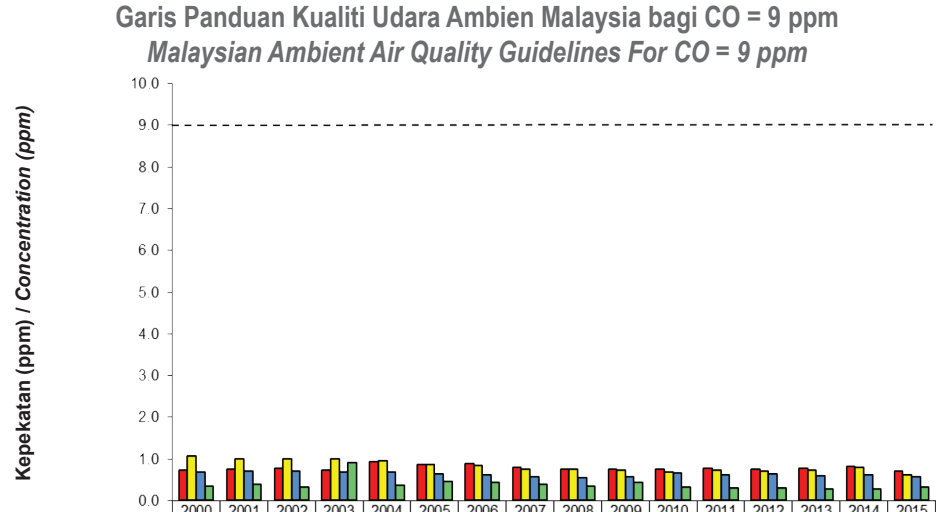
*There was a slight decrease of CO level in 2015 compared to 2014. However the trend of CO concentration from 2000 to 2015 remains almost constant. The levels recorded were well in compliance to the Malaysian Ambient Air Quality Guidelines **(Figure 1.12)**. In urban areas, the concentration of CO was higher where the main source of emission was motor vehicles, which contributed to 95 percent of CO emission load in 2015. **Figure 1.12(a)** shows CO concentrations for various categories of land use.*



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Concentration/Kepekatan	0.7120	0.7213	0.6995	0.8325	0.7389	0.7918	0.7649	0.6973	0.7309	0.6752	0.6510	0.6809	0.6827	0.6855	0.7238	0.6184
Number of Sites/Nombor Lokasi	39	39	39	41	41	41	41	41	41	41	41	41	41	41	41	41

Rajah 1.12 Malaysia : Purata Kepekatan Tahunan Karbon Monoksida (CO), 2000 - 2015

Figure 1.12 Malaysia : Annual Average Concentration of Carbon Monoxide (CO), 2000 - 2015



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Industrial/Industri	0.7390	0.7614	0.7676	0.7405	0.9442	0.8734	0.8830	0.7977	0.7537	0.7501	0.7439	0.7662	0.7576	0.7670	0.8116	0.7050
Urban/Bandar	1.0710	1.0091	0.9934	0.9981	0.9632	0.8636	0.8529	0.7635	0.7511	0.7288	0.6933	0.7221	0.7004	0.7418	0.7923	0.6219
Sub Urban/Luar Bandar	0.6890	0.7169	0.7187	0.6768	0.6784	0.6335	0.6150	0.5766	0.5509	0.5775	0.6541	0.6146	0.6447	0.6012	0.6258	0.5840
Background	0.3470	0.3978	0.3182	0.9145	0.3700	0.4582	0.4500	0.3924	0.3579	0.4379	0.3357	0.3123	0.2932	0.2899	0.2886	0.3357

Rajah 1.12 (a) Malaysia : Purata Kepekatan Tahunan Karbon Monoksida (CO) Mengikut Guna Tanah, 2000 - 2015

Figure 1.12 (a) Malaysia : Annual Average Concentration of Carbon Monoxide (CO) by Land Use, 2000 - 2015