BAB 1
Chapter 1

Kualiti Udara
Air Quality

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

PENGAWASAN KUALITI UDARA

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-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.

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".

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**.

AIR QUALITY MONITORING

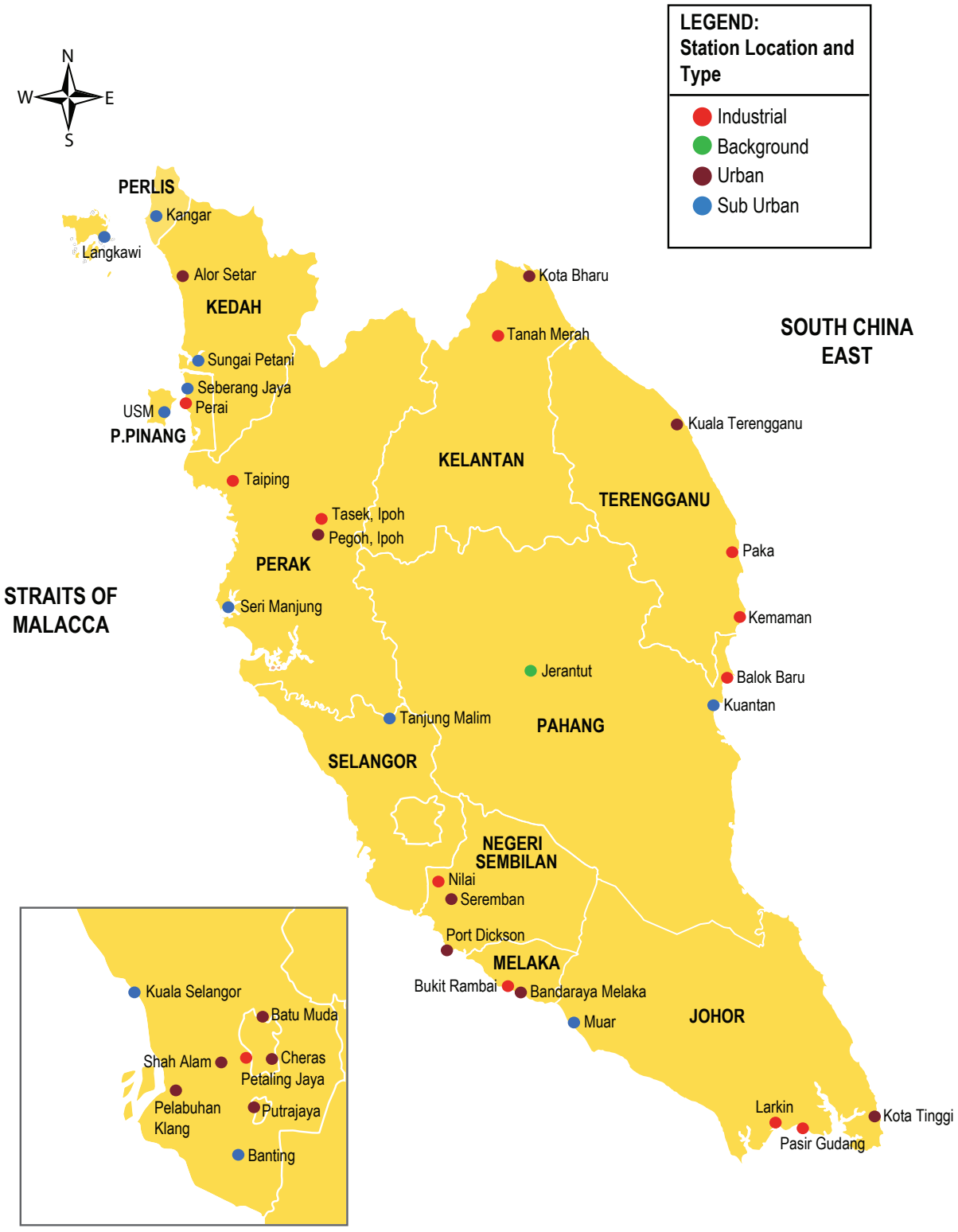
The Department of Environment (DOE) monitors ambient air quality throughout the country at 52 continuous monitoring stations. These monitoring stations are strategically located in urban, sub urban and industrial areas **(Map 1.1 and Map 1.2)** to detect any significant change in the air quality which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

The National Air Quality Monitoring Network is also complemented by manual air quality monitoring stations located at 14 different sites. At these sites, total suspended particulates, particulate matter of less than 10 microns in diameter size (PM_{10}) and heavy metals such as lead are measured at interval of six days using High Volume Sampler.

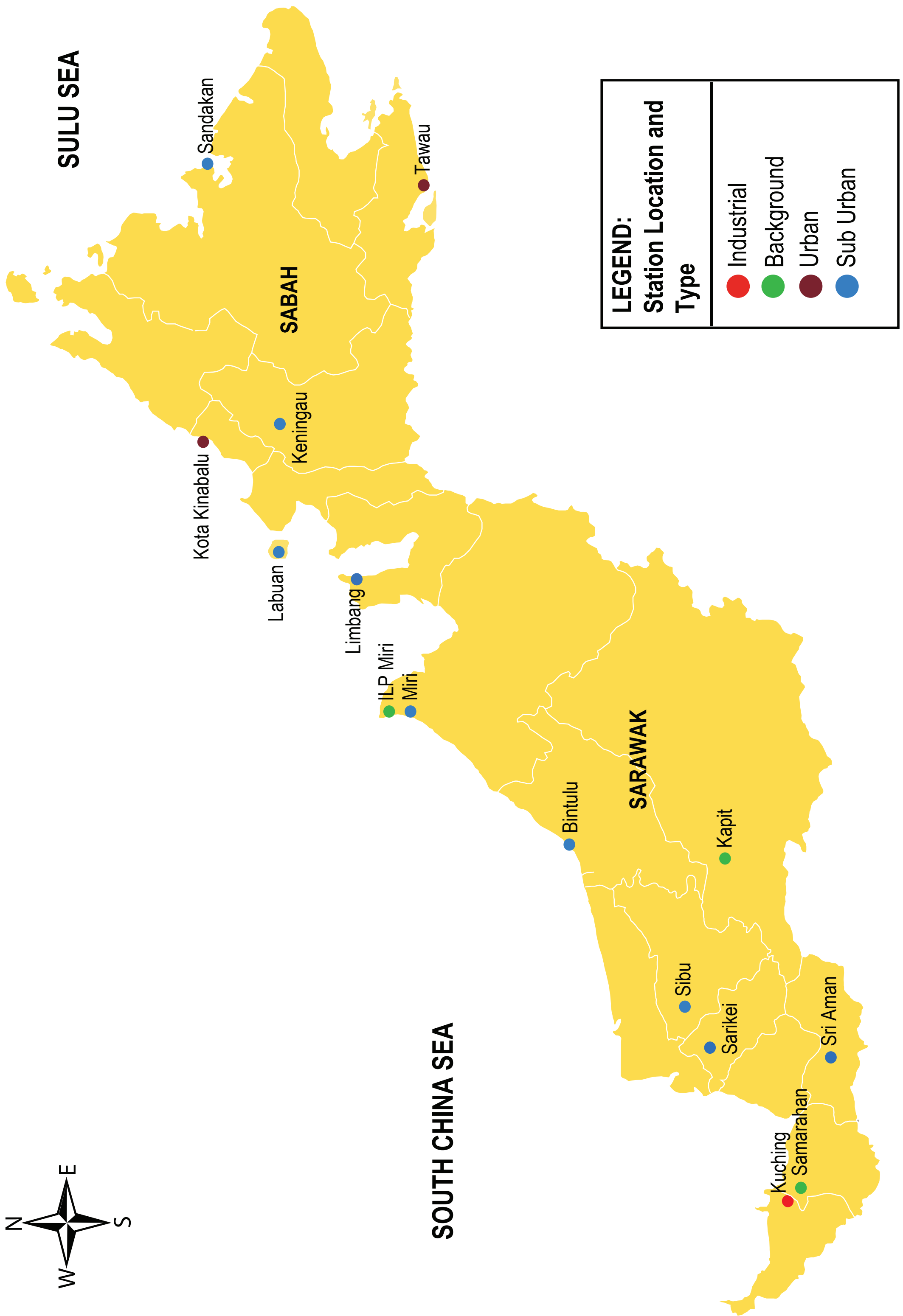
The air quality status is reported in terms of Air Pollution Index (API). The API is calculated based on concentration of five major pollutants which are ground level ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter of less than 10 microns in size (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 Kualti Udara Automatik, 2016 di Semenanjung Malaysia
Map 1.1 Malaysia: Location of Continuous Air Quality Monitoring Stations in Peninsular Malaysia, 2016



Peta 1.2 Malaysia: Lokasi Stesen Pengawasan Kualti Udara Automatik di Sabah & Sarawak, 2016
Map 1.2 Malaysia: Location of Continuous Air Quality Monitoring Stations in Sabah and Sarawak, 2016

STATUS KUALITI UDARA

Berdasarkan Indeks Pencemar Udara (IPU), kualiti udara keseluruhan bagi Malaysia pada tahun 2016 adalah berstatus baik dan sederhana pada kebanyakan masa dan terdapat pengurangan bilangan hari yang tidak sihat dicatatkan pada tahun 2016 dibandingkan tahun 2015.

Malaysia telah mengalami episod jerebu yang sederhana pada tahun 2016 yang berpunca daripada jerebu setempat dan jerebu merentas sempadan. Antara Februari hingga April 2016, beberapa kejadian jerebu setempat telah berlaku iaitu di Klang, Selangor, Miri, Sarawak dan Beaufort, Sabah berikutan kebakaran tanah gambut semasa cuaca panas dan kering serta berlakunya fenomena El-Nino.

Selain itu, beberapa kawasan di Pantai Barat Semenanjung Malaysia telah dilanda episod jerebu merentas sempadan akibat daripada asap kebakaran hutan dan tanah gambut di Sumatera, Indonesia yang telah dibawa oleh angin Monsun Barat Daya pada Ogos 2016.

Terdapat peningkatan tren kualiti udara di kawasan Lembah Klang pada tahun 2016 disebabkan tiada episod jerebu yang serius berbanding yang berlaku pada tahun 2015 seperti ditunjukkan di dalam **Rajah 1.1(a)**. Walau bagaimanapun, habuk halus bersaiz kurang dari 10 mikron, PM_{10} masih merupakan pencemar utama apabila berlakunya kebakaran hutan dan tanah gambut. **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.

AIR QUALITY STATUS

Based on the Air Pollutant Index (API), the overall air quality for Malaysia in 2016 was between good to moderate levels most of the time and there was a reduction in term of number of unhealthy days recorded in 2016 compared to 2015.

Malaysia had experienced moderate haze episodes in 2016 that caused by localized and transboundary haze pollution. Between February to April 2016, Malaysia had experienced localized haze episodes due to peatland fires in Klang, Selangor, Miri, Sarawak and Beaufort, Sabah that occurred during hot and dry season and El-Nino phenomenon.

Beside localized haze, few areas in the west coast of Peninsular Malaysia were hit by transboundary haze pollution resulting from land and forest fires in Sumatera, Indonesia during the south westerly monsoon in August 2016.

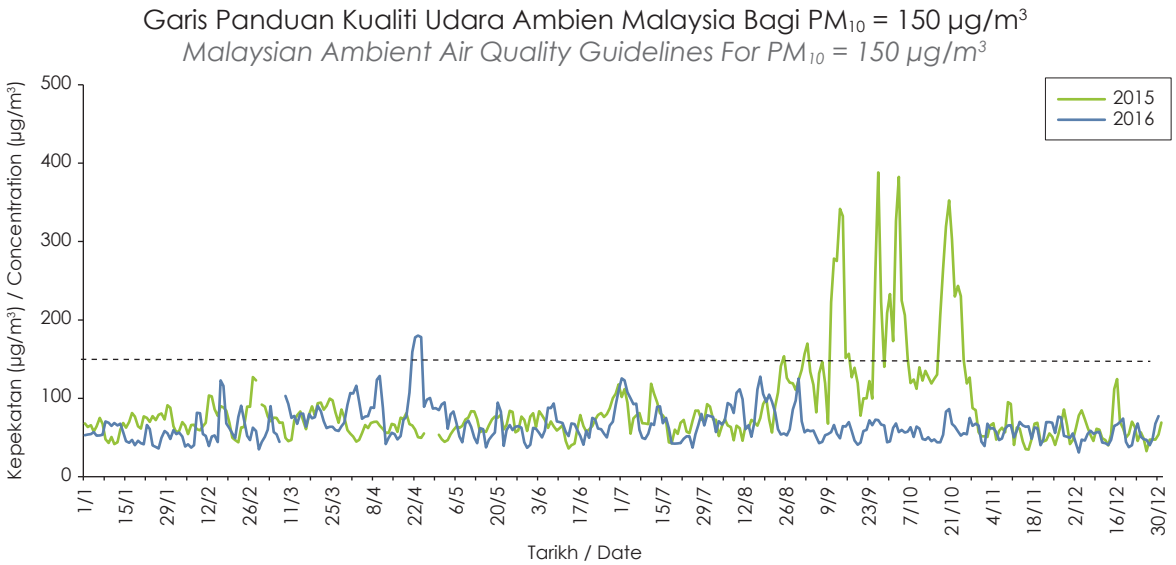
There had been a significant improvement in the overall trend of air quality in Klang Valley in 2016 as shown in **Figure 1.1(a)** as a result of no major haze incidence in 2015. However, particulate matter, PM_{10} remained the predominant pollutant that had caused unhealthy conditions due to forest and peatland fires. **Figure 1.1(b)** shows the daily concentrations of PM_{10} for Klang (urban area) were higher in comparison with some selected stations in sub-urban and rural areas in the country which normally recorded lower levels of PM_{10}.

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.

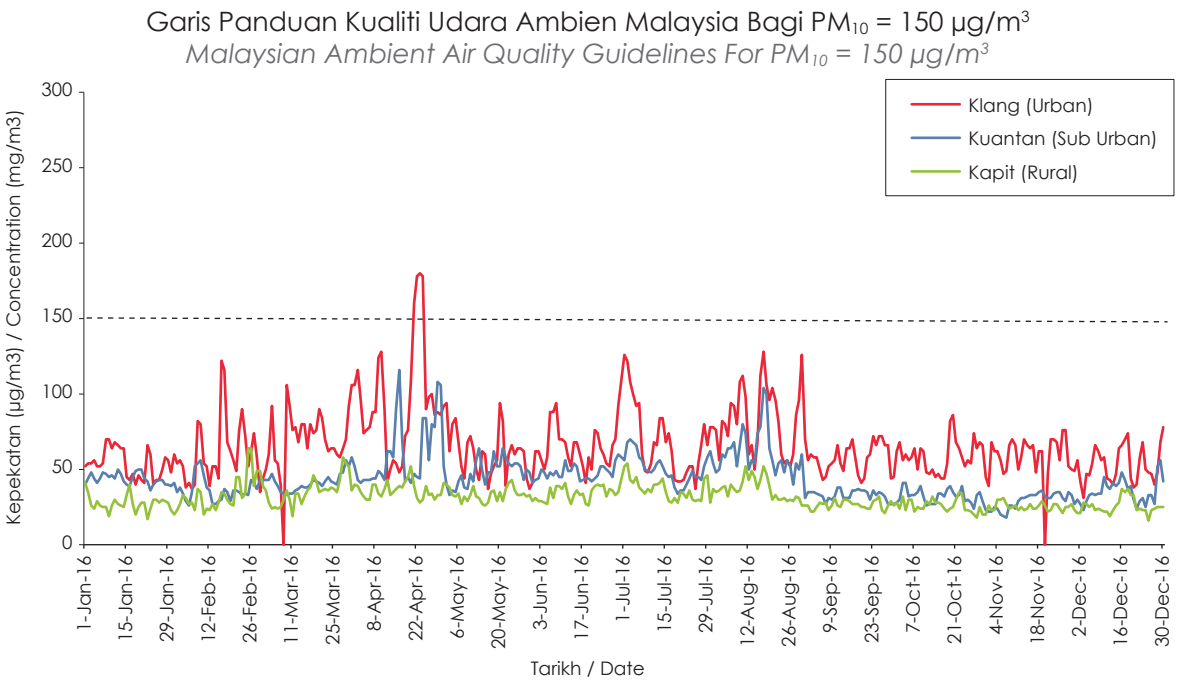
Besides PM_{10}, ground level ozone (O_3) remained the pollutant of concern. O_3 pollutant was formed as a result of chemical reaction between Volatile Organic Compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight. Formation of O_3 enhanced during hot and sunny day. Major sources of VOCs and NO_x emissions were from industries and motor vehicles particularly in urban areas. These resulted in several unhealthy days recorded at various locations in the Klang Valley and in the States of 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 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.

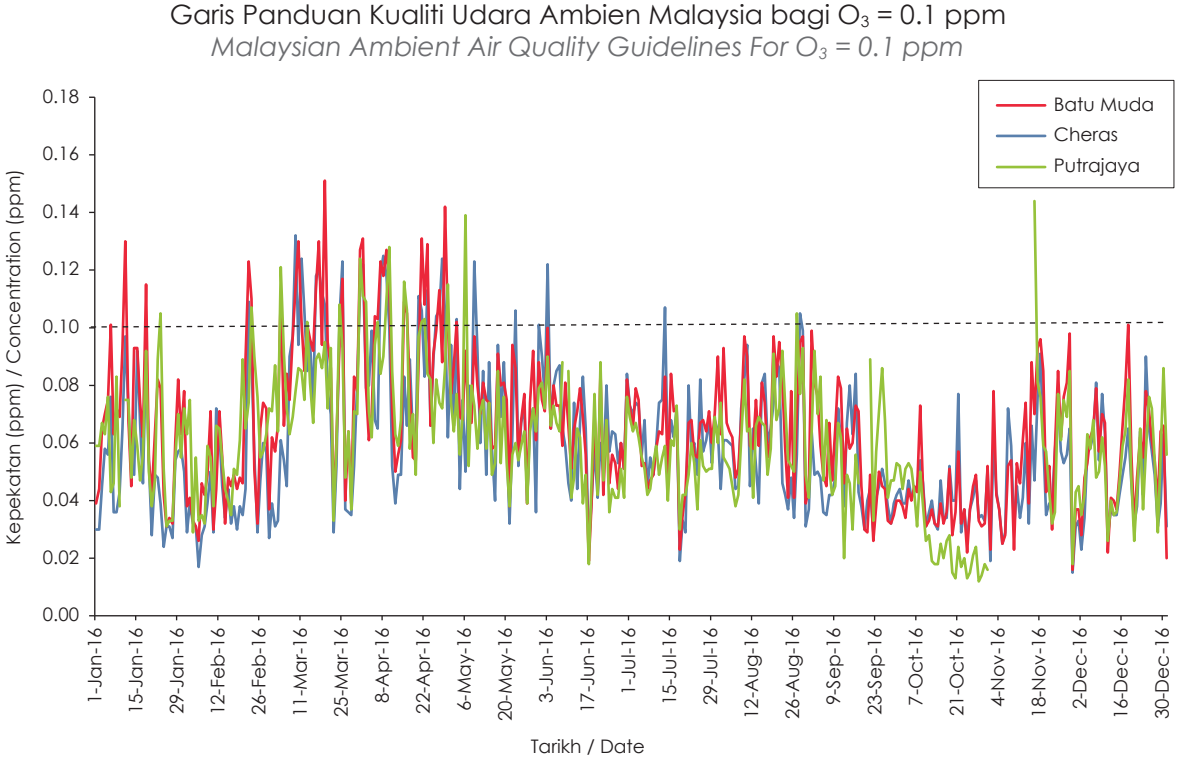


Rajah 1.1(a) : Tren Kepekatan 24 jam bagi Pepejal Terampai (PM_{10}), Klang, 2015 dan 2016
Figure 1.1(a) : Trend of 24-hour Concentration of Particulate Matter (PM_{10}), Klang, 2015 and 2016



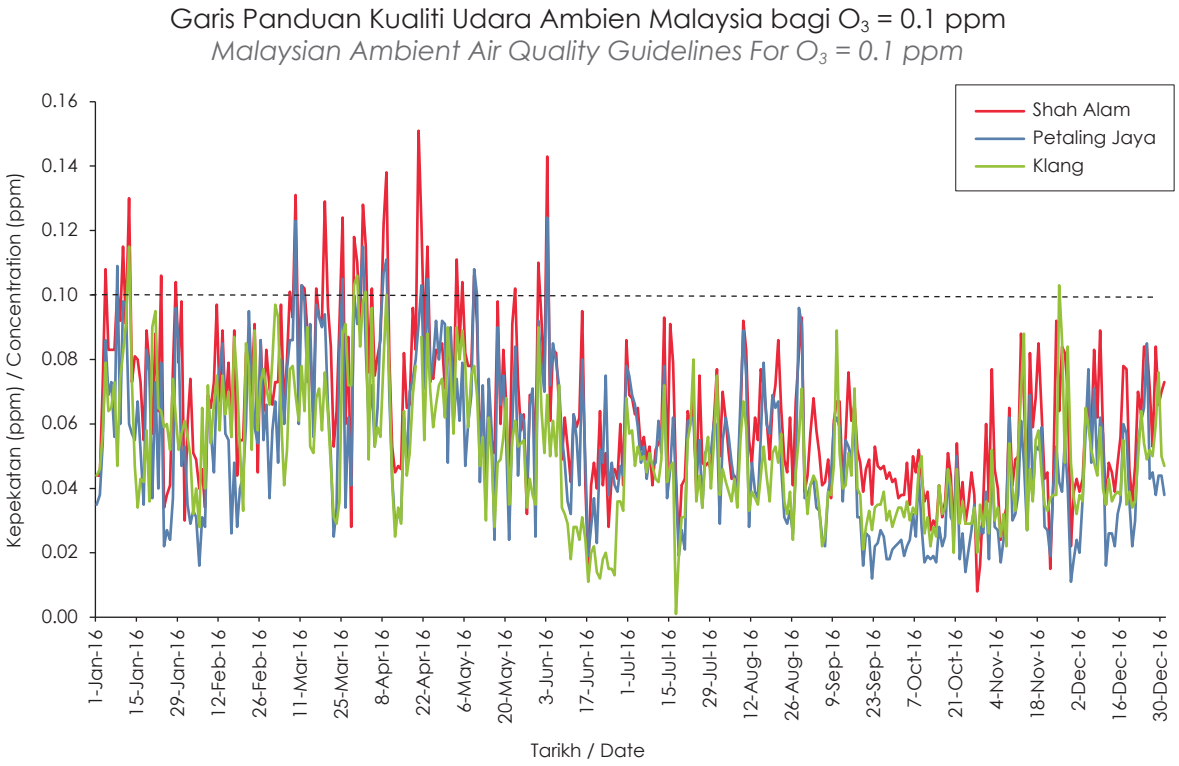
Rajah 1.1(b) : Tren Kepekatan 24 Jam Pepejal Terampai (PM_{10}), Malaysia, 2016

Figure 1.1(b) Malaysia : Trend of 24 Hours Concentration of Particulate Matter (PM_{10}), Malaysia, 2016

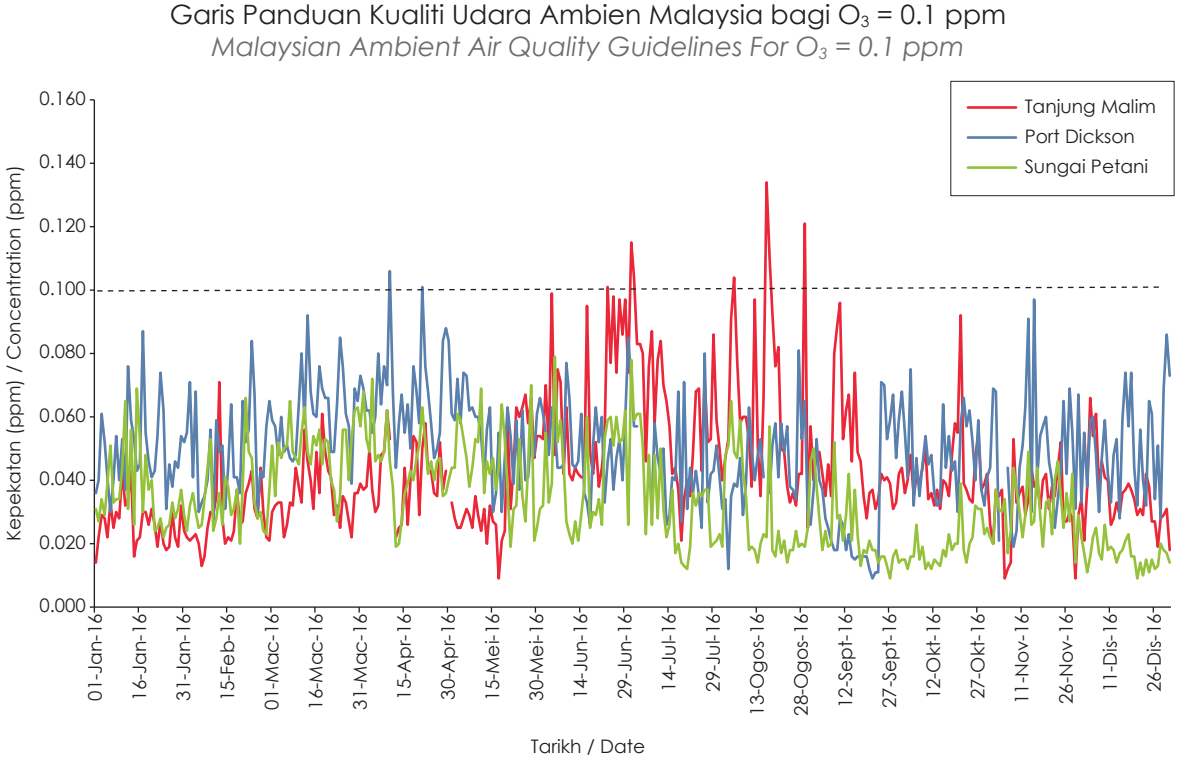


Rajah 1.1(c) Malaysia: Tren Kepekatan Maksimum Harian Ozon (O_3) 1 Jam, Lembah Klang, 2016

Figure 1.1(c) Malaysia: Trend of Daily Maximum 1 hour Concentration of Ozone (O_3), Klang Valley, 2016



Rajah 1.1(d) Malaysia: Tren Kepekatan Maksimum Harian Ozon (O_3) 1 Jam, Lembah Klang, 2016
Figure 1.1(d) Malaysia: Trend of Daily Maximum 1 hour Concentration of Ozone (O_3), Klang Valley, 2016



Rajah 1.1(e) Malaysia : Tren Kepekatan Maksimum Harian Ozon (O_3) 1 Jam, Malaysia 2016
Figure 1.1(e) Malaysia : Trend of Daily Maximum 1 hour Concentration of Ozone (O_3), Malaysia 2016

STATUS KUALITI UDARA DI PANTAI BARAT

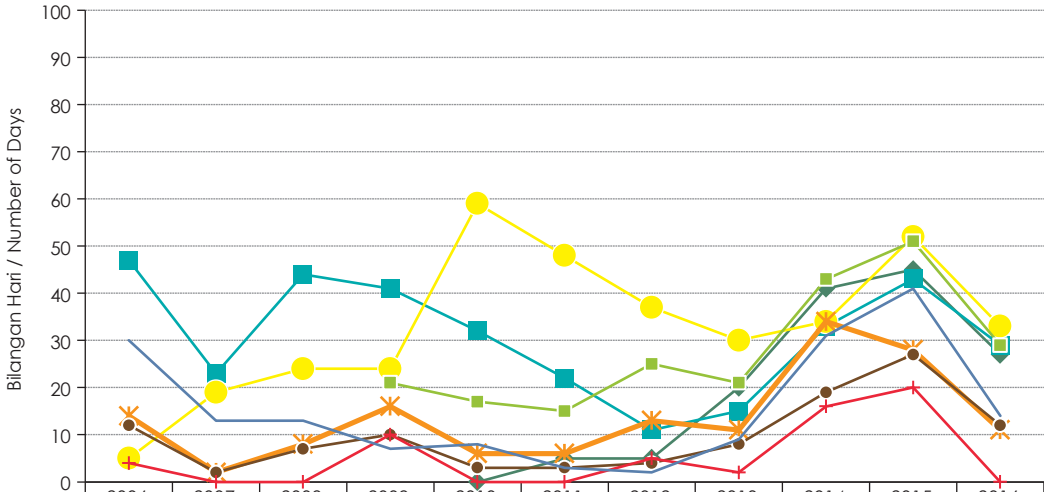
Lembah Klang

Pada tahun 2016, status kualiti udara di Lembah Klang mencatatkan 34 peratus baik, 61 peratus sederhana dan 5 peratus tidak sihat. Bilangan hari di mana status kualiti udara mencatatkan paras tidak sihat yang tertinggi adalah di Cheras, Kuala Lumpur (33 hari) **(Rajah 1.1)**. Status kualiti udara tidak sihat yang dicatatkan adalah kebanyakannya disebabkan oleh pencemar PM_{10} daripada kebakaran hutan dan tanah gambut 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 2016, the air quality in the Klang Valley was good 34 percent of the time, moderate 61 percent and five (5) percent at an unhealthy level. The highest number of unhealthy days was recorded in Cheras, Kuala Lumpur (33 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.**



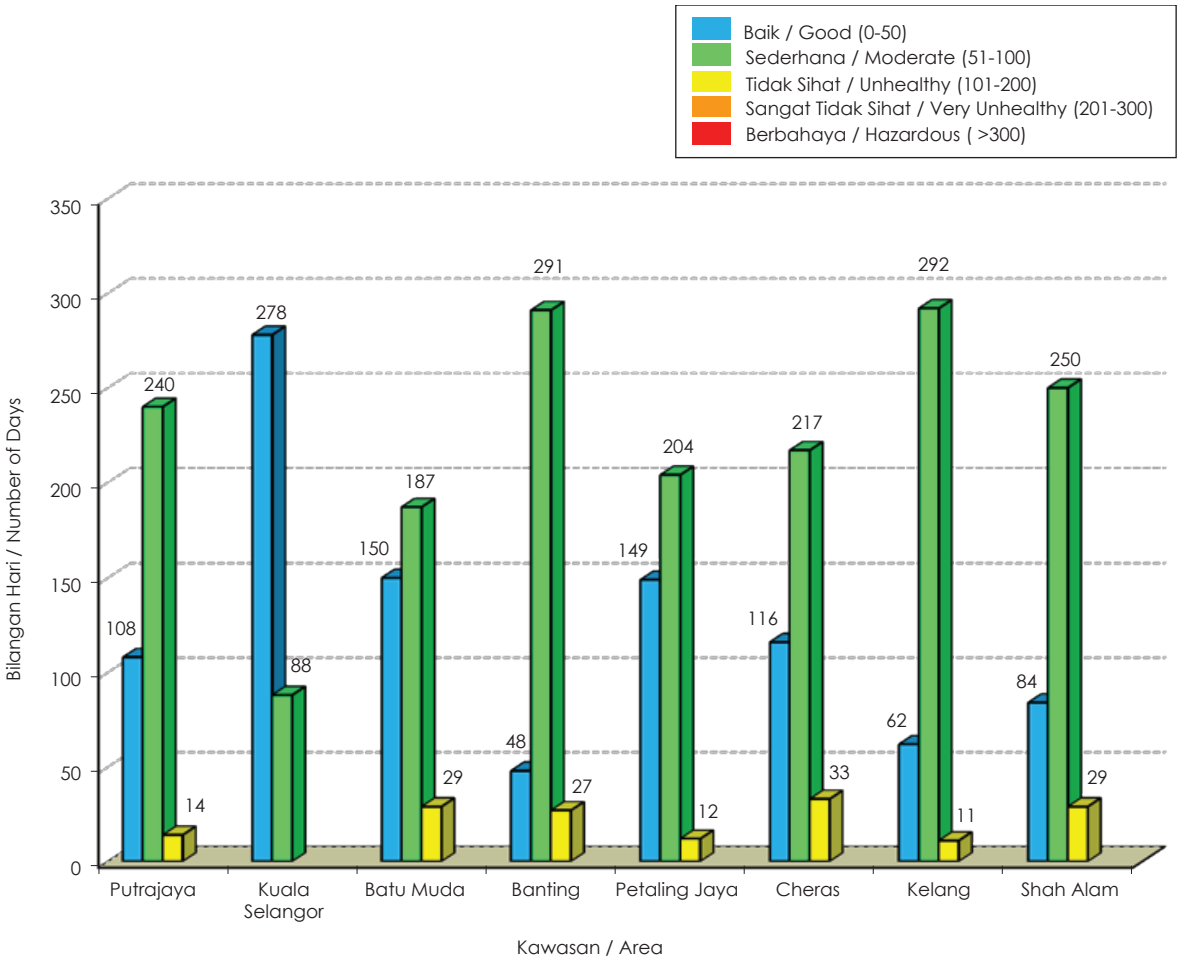
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Banting					0	5	5	20	41	45	27
Shah Alam	47	23	44	41	32	22	11	15	33	43	29
Cheras	5	19	24	24	59	48	37	30	34	52	33
Klang	14	2	8	16	6	6	13	11	34	28	11
Petaling Jaya	12	2	7	10	3	3	4	8	19	27	12
Kuala Selangor	4	0	0	10	0	0	5	2	16	20	0
Putrajaya	30	13	13	7	8	3	2	9	31	41	14
Batu Muda				21	17	15	25	21	43	51	29

Rajah 1.1 Malaysia : Bilangan Hari Tidak Sihat, Lembah Klang, 2006 - 2016
Figure 1.1 Malaysia : Number of Unhealthy Days, Klang Valley, 2006 - 2016

Nota: Bacaan adalah berdasarkan IPU Maksimum Harian
Note: Reading 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 their started operation since 2003, 2009 & 2010, respectively

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



Rajah 1.2 Malaysia : Lembah Klang, Status Kualiti Udara, 2016
Figure 1.2 Malaysia : Klang Valley Air Quality Status, 2016

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. Tiada kawasan yang mencatatkan bacaan status kualiti udara sangat tidak sihat manakala stesen yang mencatatkan status kualiti udara tidak sihat adalah Sungai Petani (1 hari), USM (3 hari), Tasek, Ipoh (1 hari), dan Tanjung Malim, (7 hari). Status kualiti udara tidak sihat di kawasan-kawasan berkenaan adalah disebabkan oleh pencemar PM_{10} dan O_3.

Northern Region

The overall air quality status of the northern region of the West Coast of Peninsular Malaysia covering Perlis, Kedah, Pulau Pinang and Perak, was between good to moderate most of the time. No area recorded very unhealthy day while unhealthy days were recorded in Sungai Petani (1 day), USM (3 days), Tasek, Ipoh (1 day), and Tanjung Malim (7 days). Unhealthy days recorded at those areas were mainly due to PM_{10} pollutants and O_3.

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

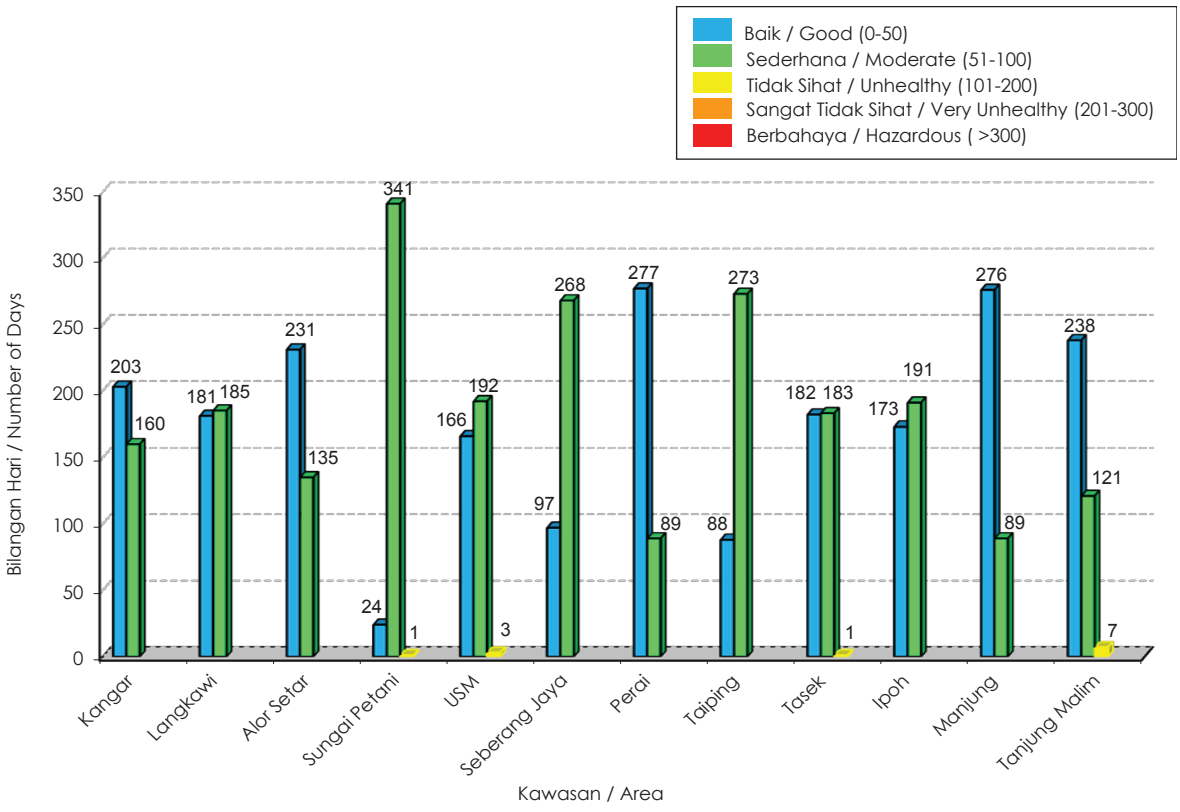
Wilayah Selatan

Kualiti udara di wilayah selatan Pantai Barat Semenanjung Malaysia (Negeri Sembilan, Negeri Melaka dan Negeri Johor) adalah baik dan sederhana pada kebanyakan masa, dan tiada kawasan yang mencatatkan status kualiti udara sangat tidak sihat. Stesen-stesen lain yang mencatatkan kualiti udara yang tidak sihat adalah Nilai (14), Kota Tinggi (4), Seremban (3), Port Dickson, Bukit Rambai dan Larkin (2) dan Pasir Gudang (1). 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.

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

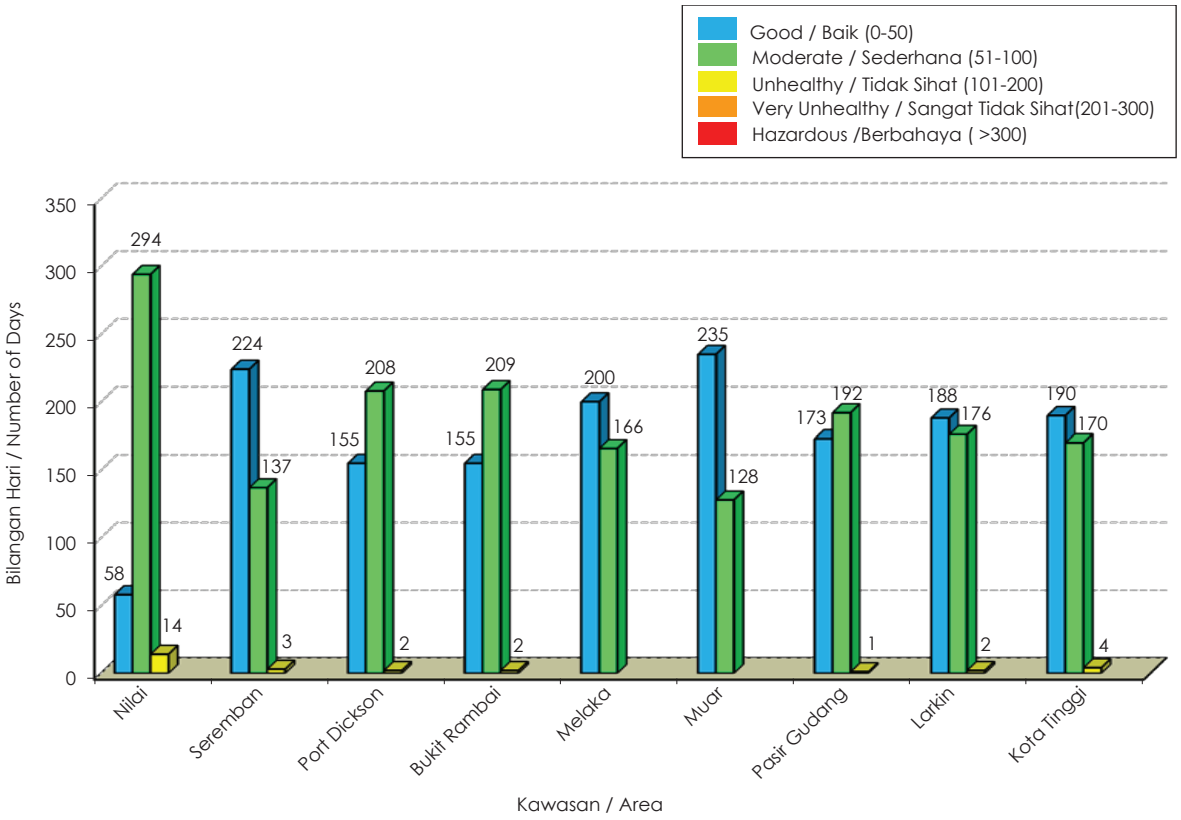
Southern Region

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, and no area recorded very unhealthy day. Other stations recorded unhealthy days were Nilai (14), Kota Tinggi (4), Seremban (3), Port Dickson, Bukit Rambai dan Larkin (2) and Pasir Gudang (1). Unhealthy days recorded at those 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, 2016
Figure 1.3 Malaysia : Air Quality Status, Northern Region of The West Coast Peninsular Malaysia, 2016

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, 2016
Figure 1.4 Malaysia : Air Quality Status, Southern Region of The West Coast Peninsular Malaysia, 2016

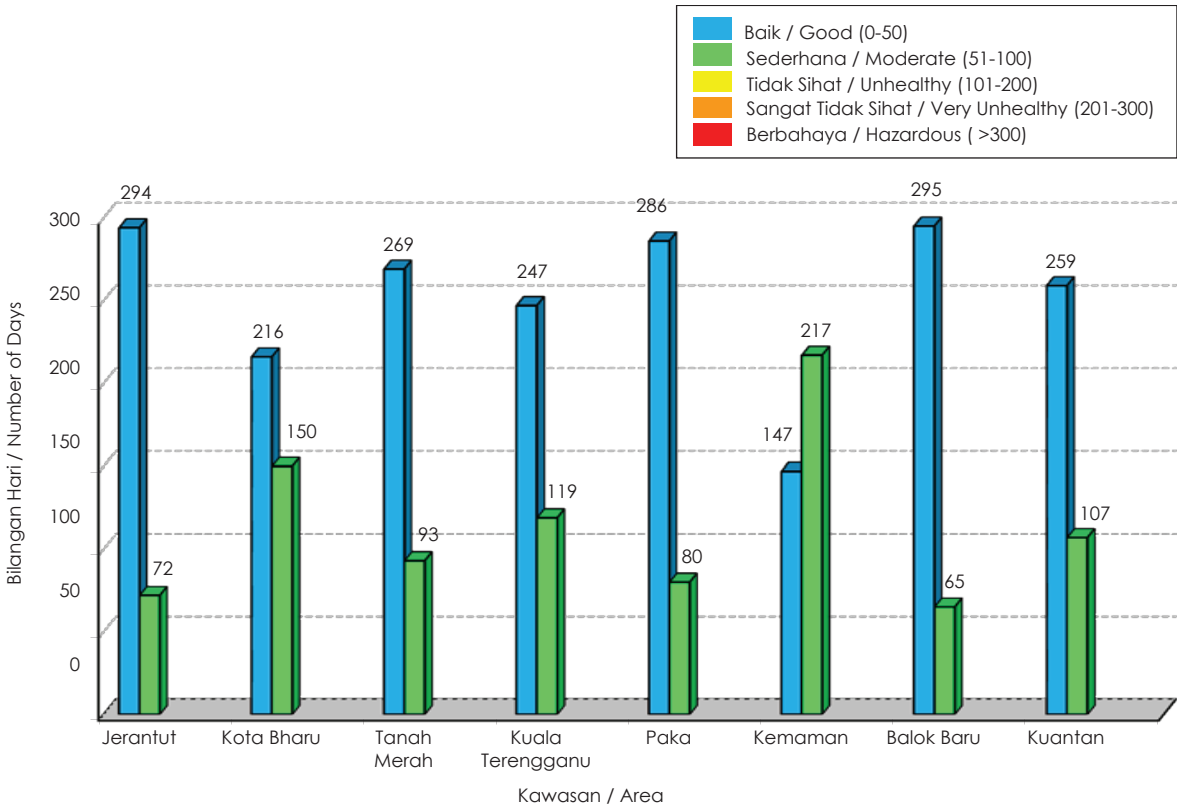
Nota: Bacaan adalah berdasarkan IPU Maksimum Harian
Note: Reading based on daily Maximum API

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, dan tiada kawasan yang mencatatkan status kualiti udara tidak sihat sepanjang tahun 2016. 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, and no area recorded unhealthy days in year 2016. 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, 2016
Figure 1.5 Malaysia : Air Quality Status, East Coast Peninsular Malaysia, 2016

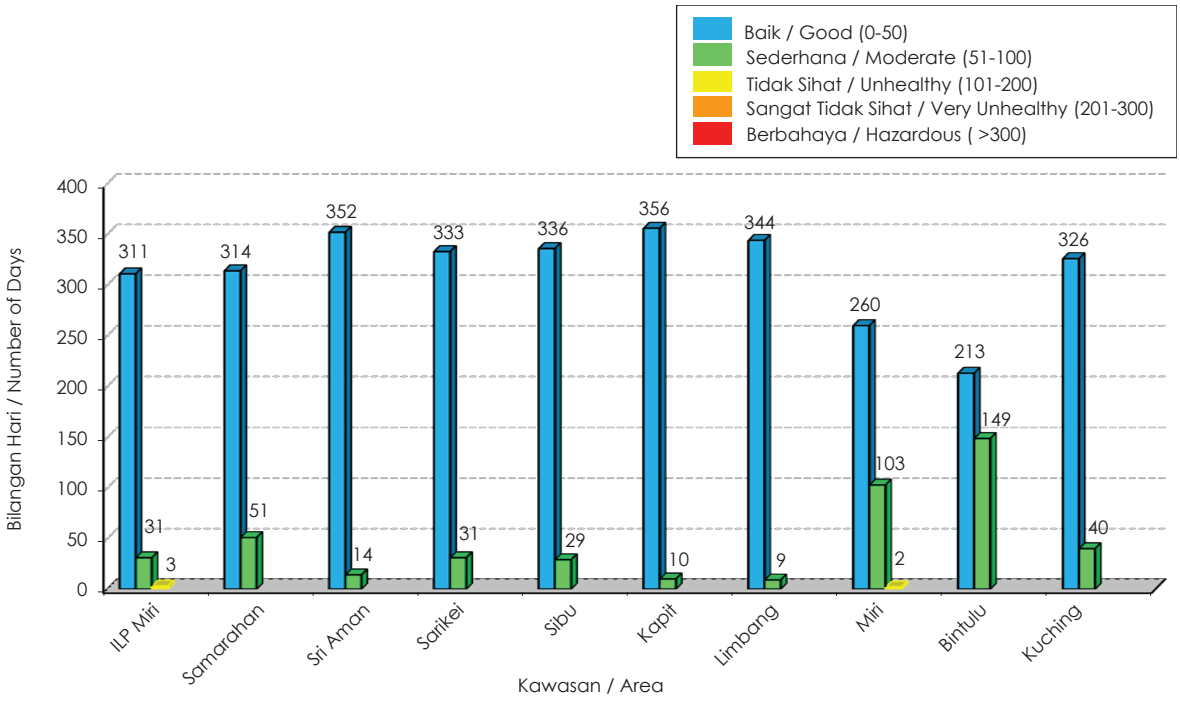
Nota: Bacaan adalah berdasarkan IPU Maksimum Harian
Note: Reading based on daily Maximum API

STATUS KUALITI UDARA DI SABAH, LABUAN DAN SARAWAK

Kualiti udara di Sabah, Labuan dan Sarawak adalah baik dan sederhana di kebanyakan masa dan tiada kawasan yang mencatatkan bacaan hari yang sangat tidak sihat. Hanya dua stesen mencatatkan status kualiti udara tidak sihat iaitu ILP Miri (3) dan Miri (2). Status kualiti udara tidak sihat di kawasan berkenaan adalah disebabkan oleh pencemar PM_{10} semasa jerebu yang berlaku akibat kebakaran hutan tanah gambut pada Mac 2016. Status kualiti udara di Sarawak secara keseluruhan ditunjukkan dalam **Rajah 1.6** dan di Sabah dan Labuan ditunjukkan dalam **Rajah 1.7**.

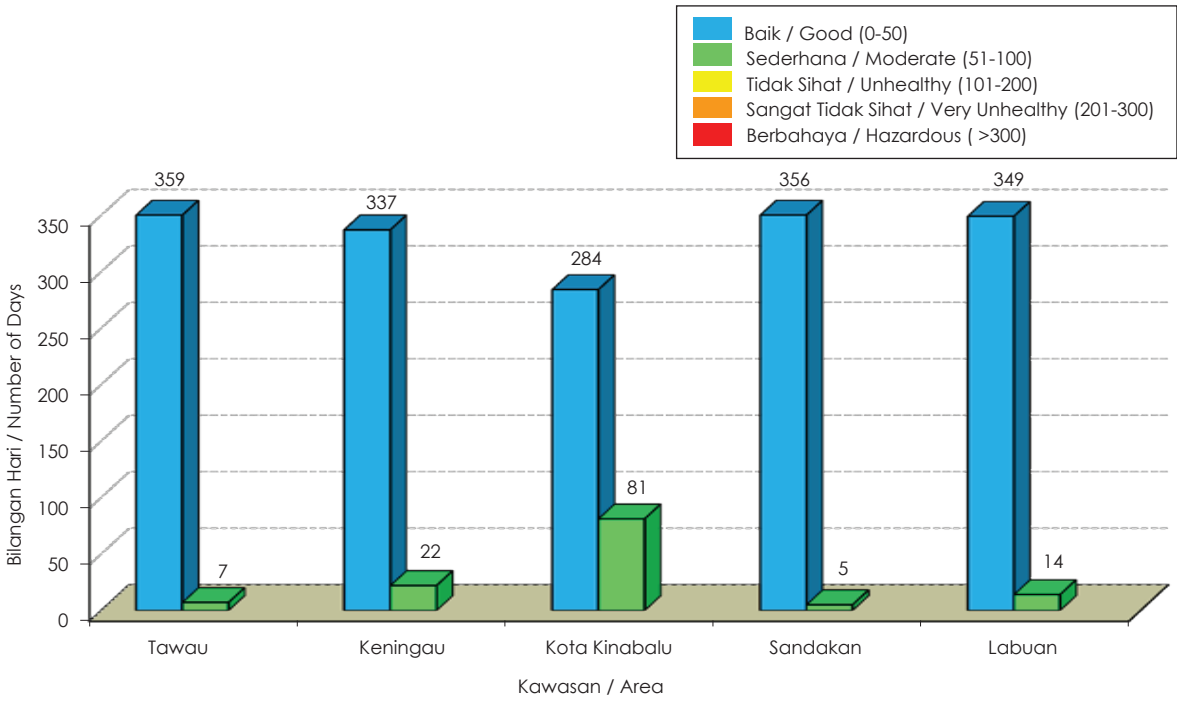
AIR QUALITY STATUS IN SABAH, LABUAN AND SARAWAK

The air quality in Sabah, Labuan and Sarawak remained between good to moderate levels most of the time and no area recorded very unhealthy day. Only two stations recorded unhealthy days namely ILP Miri (3) and Miri (2). Unhealthy days recorded at those areas were due to PM_{10} pollutant during localized haze episode resulted from peat forest fire in March 2016. 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, 2016
Figure 1.6 Malaysia : Air Quality Status, Sarawak, 2016

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



Rajah 1.7 Malaysia : Status Kualiti Udara, Sabah dan Labuan, 2016
Figure 1.7 Malaysia : Air Quality Status, Sabah and Labuan, 2016

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

TREN KUALITI UDARA

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 2016 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**.

AIR QUALITY TREND

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 2016 was computed by averaging annual air quality data received from the monitoring sites and with reference to 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	(µg/m3)
Ozon / Ozone	1 Hour 8 Hours	0.10 0.06	200 120
Karbon Dioksida / Carbon Monoxide	1 Hour 8 Hours	30.0 9.0	35** 10**
Nitrogen Dioxide / Nitrogen Dioksida	1 Hour 24 hours	0.17 0.04	320
Sulphur Dioxide / Sulfur Dioksida	1 hour 24 Hours	0.13 0.04	350 105
Pepejal Terampai (PM_{10}) / Particulate Matter (PM_{10})	24 Hours 12 Months		150 50
Jumlah Pepejal Terampai / Total Suspended Particulate (TSP)	24 Hours 12 Months		260 90
Besi / Lead	3 Months		1.5

Nota / Note: ** mg/m3

Kumin Pepejal (PM_{10})

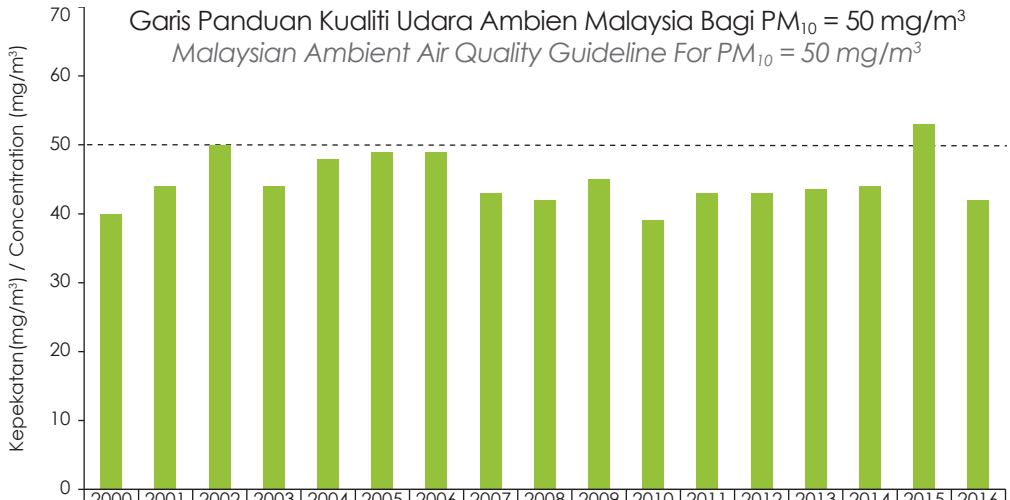
Pada tahun 2016, nilai purata tahunan PM_{10} dalam udara ambien adalah 42 µg/m³ iaitu masih belum melebihi had yang ditetapkan dalam Garis Panduan Kualiti Udara Ambien Malaysia iaitu sebanyak 50 µg/m³. Ini merupakan pengurangan ketara bagi PM_{10} berbanding tahun 2015. Kejadian jerebu tempatan dan merentas sempadan dari Sumatera dan Kalimantan, Indonesia memberi kesan kepada bacaan PM_{10} yang dicatatkan di kebanyakan kawasan dalam negara.

Tren purata tahunan kepekatan PM_{10} dalam udara ambien bagi tahun 2016 didapati mematuhi Garis Panduan Kualiti Udara Ambien Malaysia seperti ditunjukkan dalam **Rajah 1.8**. Berdasarkan kategori guna tanah, nilai kepekatan PM_{10} adalah mematuhi Garis Panduan Kualiti Udara Ambien Malaysia seperti yang ditunjukkan dalam **Rajah 1.8(a)**.

Particulate Matter (PM_{10})

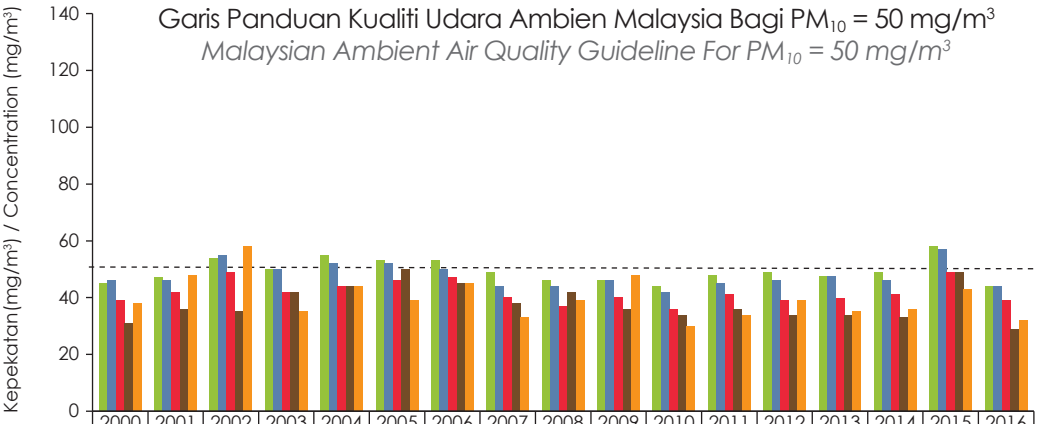
In 2016, the annual average value of PM_{10} in the ambient air was 42 µg/m³ which is lower than the Malaysian Ambient Air Quality Guidelines value of 50 µg/m³. There was a significant decrease of PM_{10} concentration compared to the 2015. Localised and transboundary haze pollution from Sumatra and 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 for 2016 complied with the Malaysian Ambient Air Quality Guidelines as shown in **Figure 1.8**. Based on land use categories, PM_{10} concentration was in compliance with Malaysian Ambient Air Quality Guidelines as shown in **Figure 1.8(a)**.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Concentration / Kepekatan	40	44	50	44	48	49	49	43	42	45	39	43	43	44	44	53	42
Number of Sites / Nombor Lokasi	50	50	50	51	51	51	51	51	51	51	52	52	52	52	52	52	52

Rajah 1.8 Malaysia : Purata Kepekatan Tahunan Kumin Pepejal (PM_{10}), 2000 - 2016
Figure 1.8 Malaysia : Annual Average Concentration of Particulate Matter (PM_{10}), 2000 - 2016



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Industrial/Industri	45	47	54	50	55	53	53	49	46	46	44	48	49	48	49	58	44
Urban/Bandar	46	46	55	50	52	52	50	44	44	46	42	45	46	48	46	57	44
Sub Urban/Luar Bandar	39	42	49	42	44	46	47	40	37	40	36	41	39	40	41	49	39
Background	31	36	35	42	44	50	45	38	42	36	34	36	34	34	33	49	29
Rural	38	48	58	35	44	39	45	33	39	48	30	34	39	35	36	43	32

Rajah 1.8(a) Malaysia : Purata Kepekatan Tahunan Kumin Pepejal (PM_{10}) Mengikut Guna Tanah, 2000 - 2016
Figure 1.8(a) Malaysia : Annual Average Concentration of Particulate Matter (PM_{10}) by Land Use, 2000 - 2016

Ozon Permukaan Bumi (O_3)

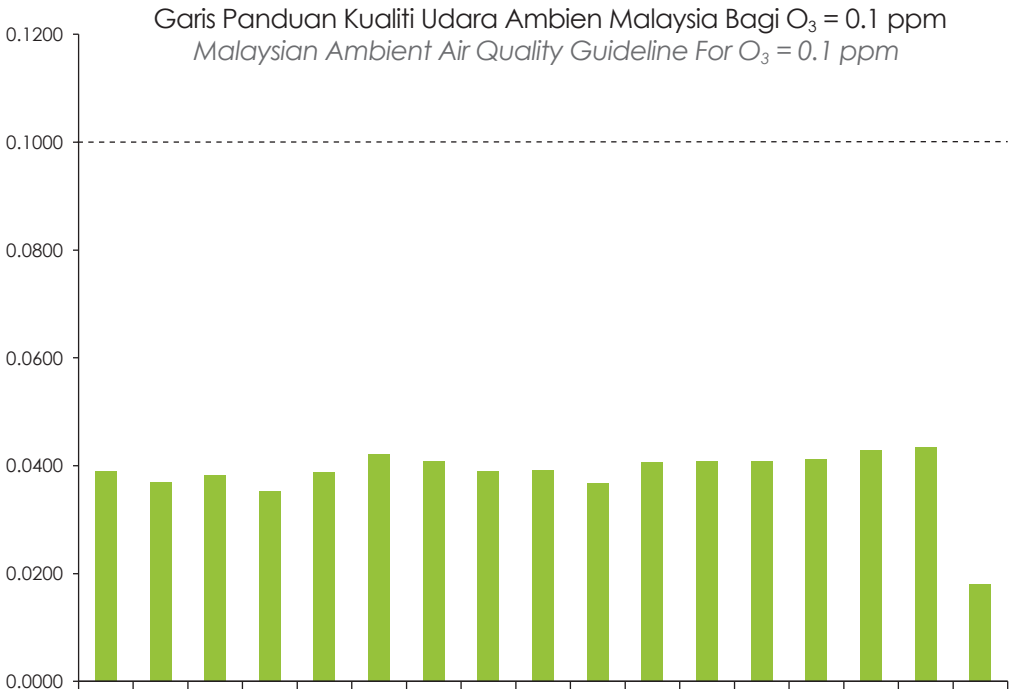
Pada tahun 2016, purata tahunan kepekatan maksimum harian ozon didapati paling rendah berbanding dengan tahun-tahun sebelumnya. Secara keseluruhannya, tren purata tahunan kepekatan maksimum ozon dalam udara ambien dari tahun 2000 hingga 2016 adalah mematuhi had sebanyak 0.1 ppm seperti yang ditetapkan 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 2016. 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)

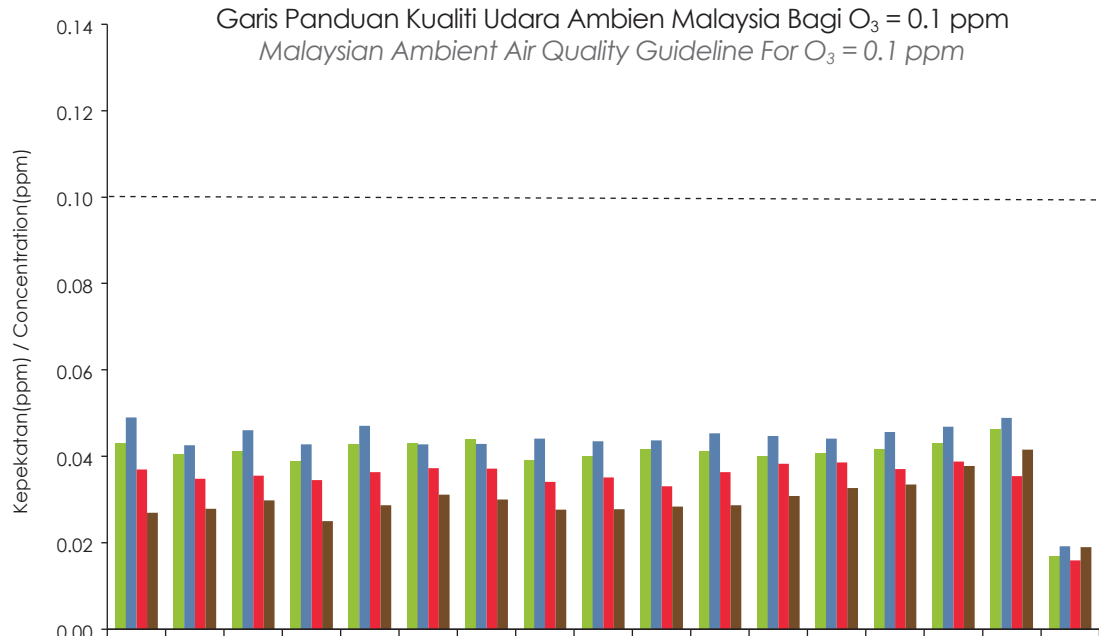
In 2016, there was a lowest concentration in annual average daily maximum one-hour ozone concentrations compared to the previous years. The overall trend on the annual average daily maximum one-hour ozone concentrations in ambient air from 2000 to 2016 were well below the limit of 0.1 ppm as stipulated in the Malaysian Ambient Quality Guidelines and the trends are as shown in **Figure 1.9**.

Figure 1.9(a) shows the ozone concentration for various land use categories between 2000 and 2016. 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 of 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	2016
Kepekatan / Concentration	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	0.0180
Nombor Lokasi / Number of Sites	39	39	39	41	41	41	41	41	41	41	41	41	41	41	41	41	41

Rajah 1.9 Malaysia : Purata Kepekatan Tahunan Ozon (O_3), 2000 - 2016
Figure 1.9 Malaysia : Annual Average Concentration of Ozone (O_3), 2000 - 2016



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Industri / Industrial	0.0430	0.0405	0.0413	0.0389	0.0429	0.0431	0.0440	0.0391	0.0399	0.0418	0.0412	0.0402	0.0407	0.0417	0.0431	0.0463	0.0170
Bandar / Urban	0.0490	0.0426	0.0461	0.0428	0.0471	0.0428	0.0429	0.0441	0.0435	0.0437	0.0453	0.0447	0.0441	0.0457	0.0469	0.0489	0.0192
Luar Bandar / Sub Urban	0.0370	0.0348	0.0355	0.0345	0.0363	0.0373	0.0371	0.0341	0.0351	0.0331	0.0364	0.0383	0.0386	0.0370	0.0388	0.0354	0.0159
Background	0.0270	0.0279	0.0298	0.0250	0.0287	0.0311	0.0300	0.0277	0.0278	0.0284	0.0287	0.0309	0.0327	0.0335	0.0378	0.0416	0.0190

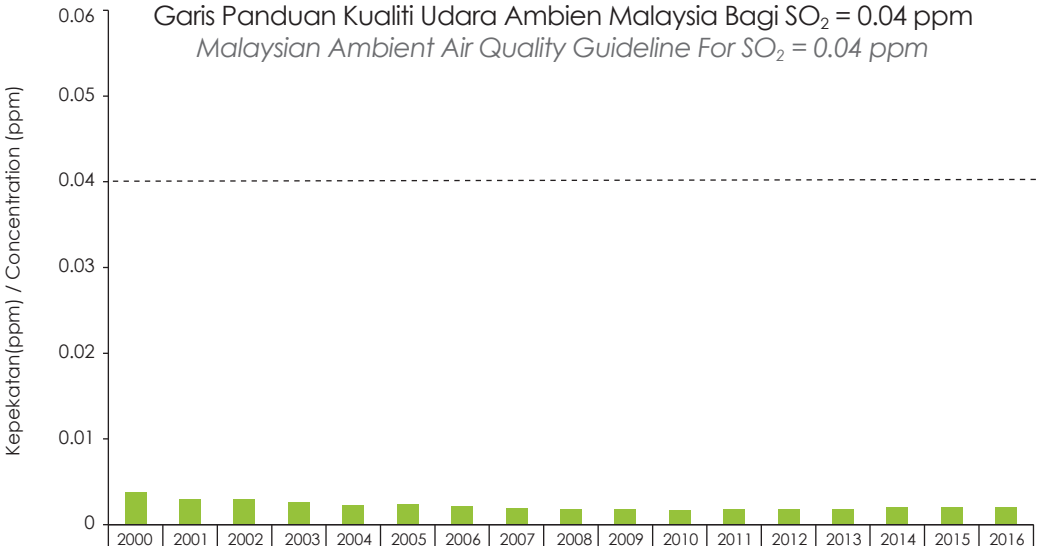
Rajah 1.9(a) Malaysia : Purata Kepekatan Tahunan Ozon (O_3) Mengikut Guna Tanah, 2000 - 2016
Figure 1.9(a) Malaysia : Annual Average Concentration of Ozone (O_3) by Land Use, 2000 - 2016

Sulfur Dioksida (SO_2)

Secara umumnya, purata kepekatan tahunan SO_2 menunjukkan tren penurunan dari tahun 2000 hingga 2016 **(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 disebabkan oleh penggunaan bahan api berkualiti EURO2M 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, EURO4M RON97 telah dilaksanakan dan pada November 2015 EURO5 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 EURO2M, 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.

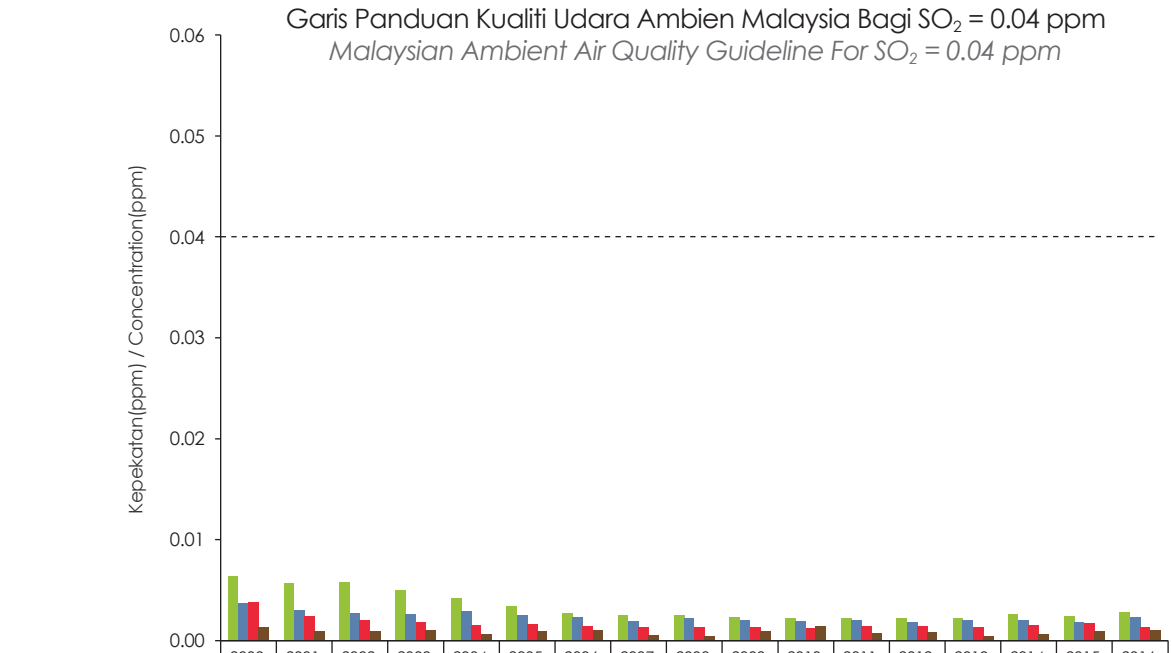
Sulphur Dioxide (SO_2)

Generally, the annual average SO_2 concentration shows a declining trend between 2000 and 2016 **(Figure 1.10)** and it is well below the limit of 0.04 ppm as stipulated in the Malaysian Ambient Air Quality Guidelines. This is due to the use of better fuel quality EURO2M in this country starting from September 2009 and also stringent enforcement by the DOE as well as widely use of natural gas for industrial combustion process and vehicles. Starting from 1st September 2015, petrol EURO4M RON 97 had been implemented and EURO5 Diesel with the sulfur content less than 10 mg/l had been introduced in the market in November 2015. Though lower number of vehicles used both types of fuels compared to EURO2M vehicles but it was shown that the trend of SO_2 has decreased in urban and industrial areas. **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	2016
Kepekatan / Concentration	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	0.002
Nombor Lokasi / Number of Sites	43	43	43	44	44	44	44	44	44	44	44	44	44	44	44	42	44

Rajah 1.10 Malaysia : Purata Kepekatan Tahunan Sulfur Dioksida (SO_2), 2000 - 2016
Figure 1.10 Malaysia : Annual Average Concentration of Sulphur Dioxide (SO_2), 2000 - 2016



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Industri / Industrial	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	0.0028
Bandar / Urban	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	0.0023
Luar Bandar / Sub Urban	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	0.0013
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	0.0010

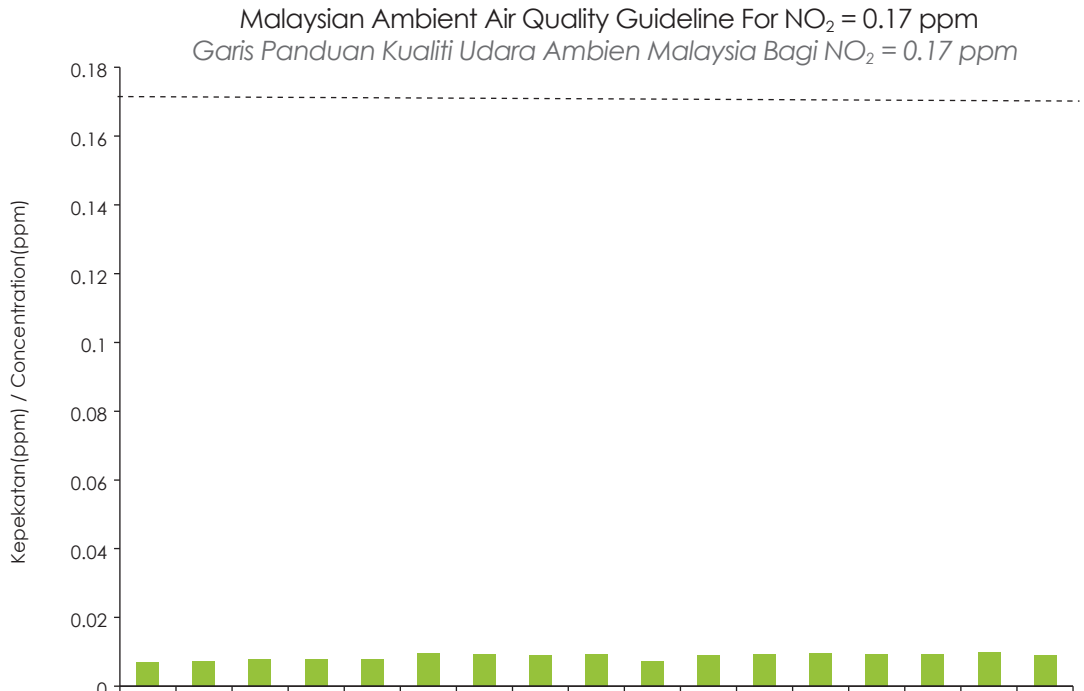
Rajah 1.10(a) Malaysia : Purata Kepekatan Tahunan Sulfur Dioksida Mengikut Guna Tanah (SO_2), 2000 - 2016
Figure 1.10(a) Malaysia : Annual Average Concentration of Sulphur Dioxide (SO_2) by Land Use, 2000 - 2016

Nitrogen Dioksida (NO_2)

Pada tahun 2016, tiada sebarang perubahan yang ketara bagi NO_2 berbanding tahun 2015. 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 2016 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))**

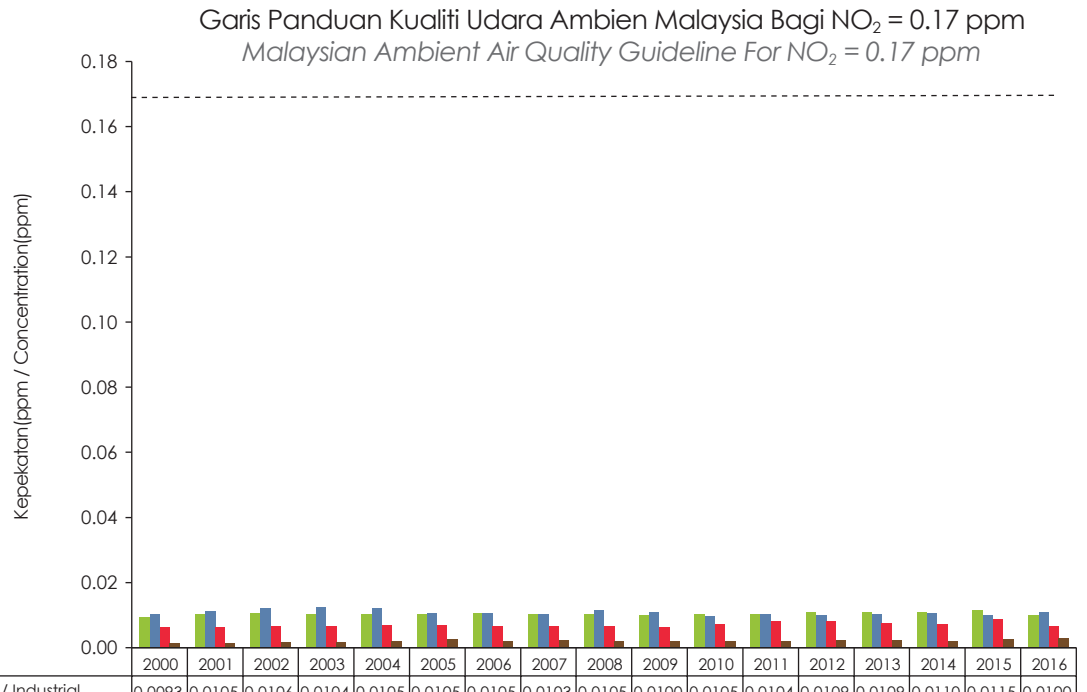
Nitrogen Dioxide (NO_2)

In 2016, there was no significant change of NO_2 concentration compared to the 2015 level. The NO_2 concentrations remained 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 2016 remained 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	2016
Kepekatan / Concentration	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	0.009
Nombor Lokasi / Number of Sites	39	43	43	43	44	44	44	44	44	44	44	44	44	44	44	44	44

Figure 1.11 Malaysia : Annual Average Concentration of Nitrogen Dioxide (NO_2), 2000 - 2016
Rajah 1.11 Malaysia : Purata Kepekatan Tahunan Nitrogen Dioksida (NO_2), 2000- 2016



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Industri / Industrial	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	0.0100
Bandar / Urban	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	0.0110
Luar Bandar / Sub Urban	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	0.0066
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	0.0030

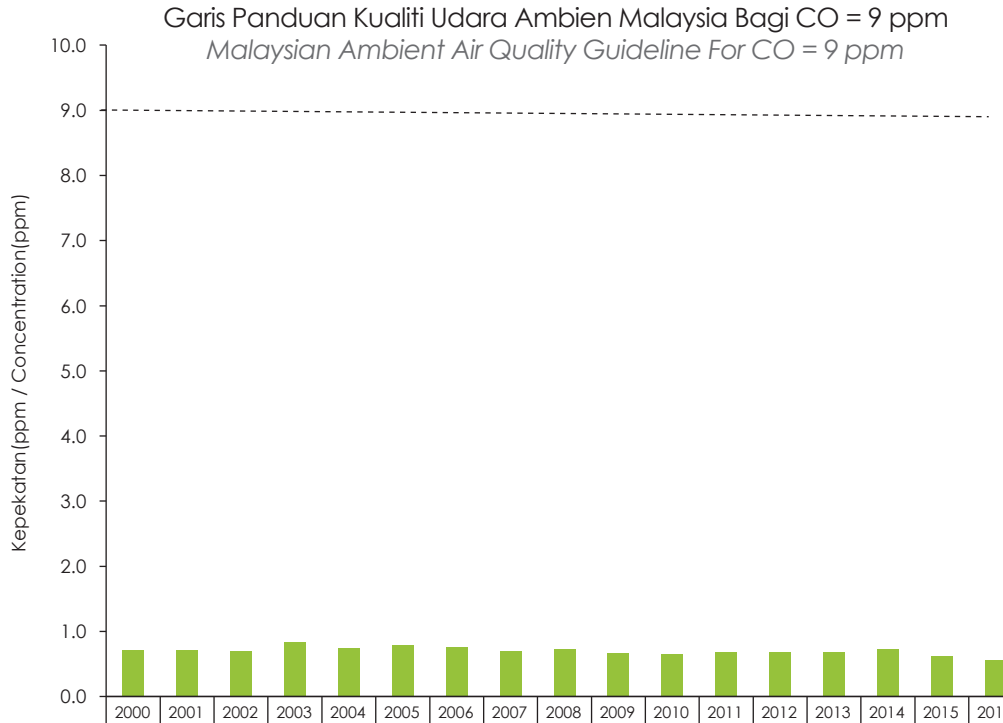
Rajah 1.11(a) Malaysia : Purata Kepekatan Tahunan Nitrogen Dioksida (NO_2) Mengikut Guna Tanah, 2000 - 2016
Figure 1.11(a) Malaysia : Annual Average Concentration of Nitrogen Dioxide (NO_2) by Land Use, 2000 - 2016

Karbon Monoksida (CO)

Terdapat sedikit pengurangan tahap kepekatan CO pada tahun 2016 berbanding dengan tahun 2015. Walau bagaimanapun, tren kepekatan CO dari tahun 2000 hingga 2016 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 2016. **Rajah 1.12(a)** menunjukkan kepekatan CO untuk pelbagai kategori guna tanah.

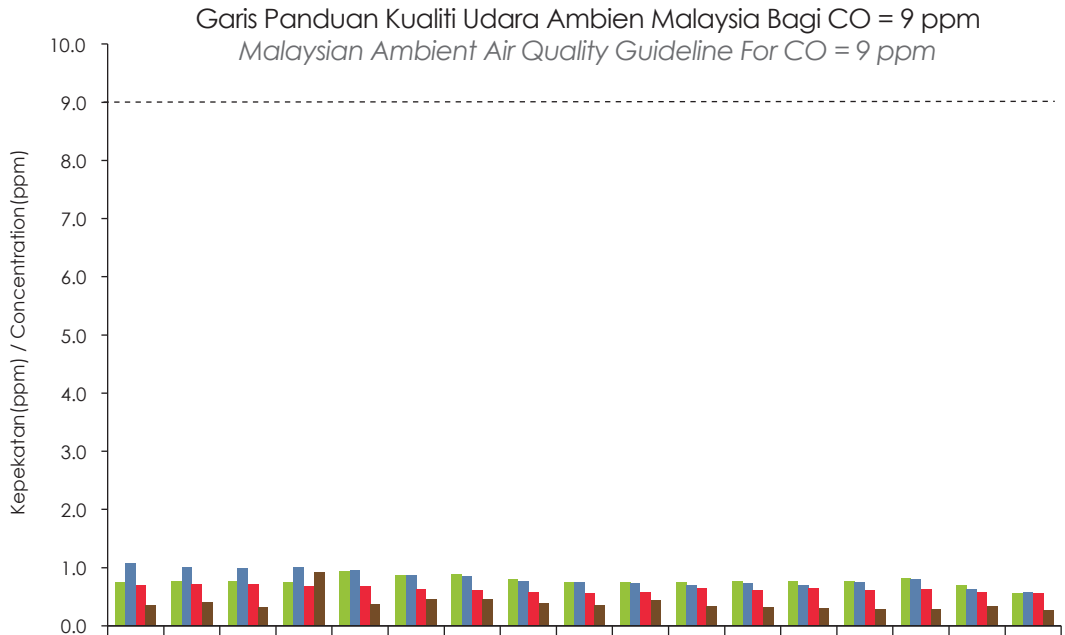
Carbon Monoxide (CO)

There was a slight decrease of CO level in 2016 compared to 2015. However the trend of CO's concentration from 2000 to 2016 remains almost constant. The concentration level also complies with the Malaysian Ambient Air Quality Guidelines **(Figure 1.12)**. In urban areas, the concentration of CO is higher due to motor vehicle emissions that contributed to 95 percent of CO emissions in 2016. **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	2016
Kepekatan / Concentration	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	0.5588
Nombor Lokasi / Number of Sites	39	39	39	41	41	41	41	41	41	41	41	41	41	41	41	41	41

Rajah 1.12 Malaysia : Purata Kepekatan Tahunan Karbon Dioksida (CO), 2000 - 2016
Figure 1.12 Malaysia : Annual Average Concentration of Carbon Monoxide (CO), 2000 - 2016



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Industri / Industrial	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	0.5527
Bandar / Urban	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	0.5784
Luar Bandar / Sub Urban	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	0.5637
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	0.2680

Rajah 1.12(a) Malaysia : Purata Kepekatan Tahunan Karbon Dioksida (CO) Mengikut Guna Tanah, 2000- 2016
Figure 1.12(a) Malaysia : Annual Average Concentration of Carbon Monoxide (CO) by Land Use, 2000 - 2016