National Assessment on the Atmospheric Environment in Thailand

Pichaid Atipakya

Air Quality and Noise Management Division

Pollution Control Department, Bangkok, Thailand

1. Basic Information on National Monitoring Activities

1.1. Outline of the activities on acid deposition and air pollution in the National Monitoring Plan

The acid deposition monitoring network encompasses a range of activities, including the monitoring of both wet and dry deposition, as well as the assessment of ecological impacts on soil, vegetation, and inland aquatic environments. The Air Quality and Noise Management Division of the Pollution Control Department has been designated by the Royal Thai Government as the National Focal Point and National Center for the Acid Deposition Monitoring Network in East Asia (EANET). Thailand participated in the preparatory phase of EANET from 1998 to 2000, and since 2001, EANET activities have been regularly implemented among participating countries.

Since acid deposition monitoring encompasses a broad range of activities and requires coordination among multiple agencies in Thailand, the Pollution Control Board established the Sub-committee on the Acid Deposition Monitoring Network in Thailand to oversee and coordinate the nationwide implementation of these activities. The Sub-committee is chaired by the Deputy Director-General of the Pollution Control Department, Ministry of Natural Resources and Environment, and consists of representatives from relevant agencies, namely the Department of Treaties and Legal Affairs, Department of Climate Change and Environment, Thai Meteorological Department, the Royal Irrigation Department, Department of Agriculture, Royal Forest Department, the Electricity Generating Authority of Thailand, Pollution Control Department and Experts from university. The Pollution Control Department serves as the secretariat to the Sub-committee.

Between 2020 and 2024, Thailand operated four acid deposition monitoring sites under the EANET network: two urban sites in Bangkok (Bangkok and Samut Prakan), one rural site in Pathum Thani, and one remote site in Kanchanaburi. Acid deposition monitoring in Thailand has been conducted since 2000. In general, all stations monitor both wet and dry deposition. Wet deposition samples are collected daily using an automatic wet-only sampler. Dry deposition is monitored either through automatic ambient air monitoring stations or by using a four-stage filter pack, with samples collected every ten days each month. The assessment of acid deposition status in Thailand presented in this report is based on data collected from nine monitoring sites during the period 2000–2024.

1.2 Monitoring program from 2020 to 2024

Thailand's National Monitoring Plan for EANET for the period 2020–2024 was developed by the Air Quality and Noise Management Division of the Pollution Control Department. The plan specifies the monitoring sites, monitoring activities and parameters, responsible agencies, and the monitoring schedule. The monitoring program covers three major environmental components: wet deposition, dry deposition, and inland aquatic environments, and is implemented in accordance with the EANET monitoring guidelines.

1.3 Monitoring stations

Between 2000 and 2024, there were six (6) designated EANET monitoring sites and three (3) national monitoring sites, as summarized in Table 1.

(1) Kanchanaburi (EANET site) – Located at Vajiralongkorn Dam, Kanchanaburi Province (remote site). Monitoring activities include wet deposition and dry deposition, the latter measured using an automatic analyzer and a filter pack. In addition, ecological monitoring of inland aquatic environments, soil, and vegetation is conducted at this site.
(2) Bangkok (EANET site) – Located within the premises of the Pollution Control Department (PCD) and the Government Public Relations Department (PRD), Bangkok (urban site). The PRD site monitors dry deposition using an automatic analyzer and a filter pack, while the PCD site monitors wet deposition. Both sites are situated in the same area.
(3) Samut Prakan (EANET site) – Located at the Thai Meteorological Department (TMD), Bangkok (urban site). Monitoring activities include wet deposition and dry deposition measured by an automatic analyzer.
(4) Pathum Thani (EANET site) – Located at the Climate Change and Environmental Research Center (CERC), formerly the Environmental Research and Training Center (ERTC), in Pathum Thani Province (rural site). Monitoring activities at this site are limited to wet deposition.
(5) Chiang Mai (EANET site) – Located at Chiang Mai University (CMU), Mae Hia Campus, Chiang Mai Province (rural site). Monitoring includes wet deposition and dry deposition measured using a filter pack.
(6) Nakhon Ratchasima (EANET site) – Located at Sakaerat Silvicultural Research Station (SKR), Nakhon Ratchasima Province (rural site). Monitoring includes wet deposition and dry deposition measured using a filter pack.
(7) Songkhla (National site) – Located at Koh Hong Meteorological Station, Songkhla Province (urban site). Monitoring includes wet deposition and dry deposition measured using a filter pack.
(8) Chon Buri (National site) – Located at Kasetsart University, Si Racha Campus, Chon Buri Province (urban site). Monitoring includes wet deposition and dry deposition measured using an automatic analyzer and a filter pack.
(9) Rayong (National site) – Located at Rayong Health Promotion Hospital, Map Ta Phut, Rayong Province (urban site). Monitoring includes wet deposition and dry deposition measured using an automatic analyzer.

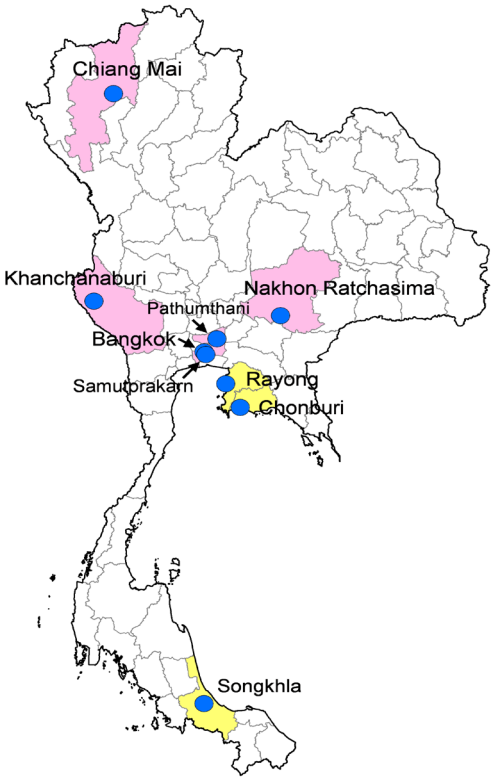


Figure 1. Acid Deposition Monitoring Sites in Thailand

Table 1. EANET Monitoring Sites in Thailand: Locations and Data Availability

City	Site	Classification	Latitude	Longitude	Altitude (m)	Available data (year)
Bangkok	Bangkok	Urban	13°47′04″N	100°32′22″E	5	pH : 2000-2020 2022-2024 Ion : 2000-2020 2022-2023
	Samutprakarn	Urban	13°39′58″N	100°36′21″E	4	pH : 2000 2004-2020 2022-2024 Ion : 2000 2004-2020 2022-2023
Pathumthani	Pathumthani	Rural	14°02′46″N	100°42′43″E	6	pH : 2000-2024 Ion : 2000-2024
Khanchanaburi	Khanchanaburi (Vajiralongkorn Dam)	Remote	14°47′05″N	98°36′05″E	130	pH : 2000-2019 Ion : 2000-2019
Chiang Mai	Chiang Mai (Mae Hia)	Rural	18°45′54″N	98°55′42″E	349	pH : 2001-2019 Ion : 2001-2019
Nakhon Ratchasima	Nakhon Ratchasima	Rural	14°28′04″N	101°54′05″E	409	
Songkhla	Songkhla	Urban	7°01′23″N	100°29′56″E	12	pH/Ion : 2001 2003-2018
Chonburi	Chonburi	Urban	13°07′15″N	100°55′10″E	36	pH : 2003-2018 Ion : 2003-2018
Rayong	Rayong	Urban	12°42′31″N	101°09′58″E	23	pH : 2010-2018 Ion : 2010-2018

1.4 Sampling and Measurements

The measurement parameters and monitoring intervals are summarized in Table 2.

(1) Wet Deposition Monitoring

Wet deposition is monitored using a wet-only sampler to determine precipitation chemistry concentration. A rain gauge is used to measure precipitation amount. Twenty-four-hour composite samples are collected in polyethylene bottles. The collected rainwater samples are weighed and analyzed for chemical composition, including electrical conductivity (EC), pH, and ionic species.

If samples cannot be analyzed within one day or need to be transported from the sampling site to the laboratory, they must be stored at 4 °C or kept in insulated containers with ice packs and delivered to the laboratory on a daily basis.

(2) Dry Deposition Monitoring

Atmospheric gas concentrations, including SO_2, NO_X, and O_3, are measured on-site using automatic analyzers at Bangkok, Samut Prakan, Chonburi, Rayong, and Kanchanaburi. At the Kanchanaburi site, SO_2, NO_X, and O_3 are monitored for two weeks, three times per year (March, July, and November). At the Bangkok and Samut Prakan sites, these gases are monitored continuously throughout the year.

Atmospheric gases and aerosol concentrations are also measured using the filter pack method at Chiang Mai, Bangkok, Nakhon Ratchasima, Pathum Thani, Chonburi, Songkhla, and Kanchanaburi.

At all sites except Kanchanaburi, sampling is conducted continuously with a duration of 10 days per sample. At Kanchanaburi, sampling is performed three times per year (14 days per sample), corresponding to the same monitoring periods as the automatic analyzer measurements. The collected samples are analyzed for SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Mg^{2+}, and Ca^{2+} in the particulate (aerosol) phase, and for SO_2, HNO_3, NH_3, and HCl in the gas phase.

(3) Inland Aquatic Environments Monitoring

Inland aquatic environments are monitored at Kanchanaburi. Samples are collected from two locations in the Vajiralongkorn Reservoir, namely Ban Pong Chang (BPC) and Ban Pang Pueng (BPP). Sampling is conducted quarterly, four times per year (March, June, September, and December).

Table 2. Measurement parameters and monitoring interval

Items	Measurement parameters	Monitoring interval
Wet deposition	pH, EC, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-, precipitation amount, CH_3COO^-, $HCOO^-$, PO_4^{3-}	daily
Dry deposition - Automatic analyzer	SO_2, NO_2, NO, O_3, Particulate Matter (PM-10)	- hourly
- Filter pack	HNO_3 , SO_2, NH_3, HCl, Aerosol	- 10 days
Soil	pH (H_2O), pH (KCl), exchangeable (Na^+, K^+, Ca^{2+}, Mg^{2+}), Exchangeable acidity, ECEC, Moisture content	every 3-5 years
Vegetation	observation of tree decline, description of trees	every 3 years
Inland aquatic environment	water temperature, pH, EC, alkalinity, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-, transparency	4 times/year

2 State of Acid Deposition in Thailand

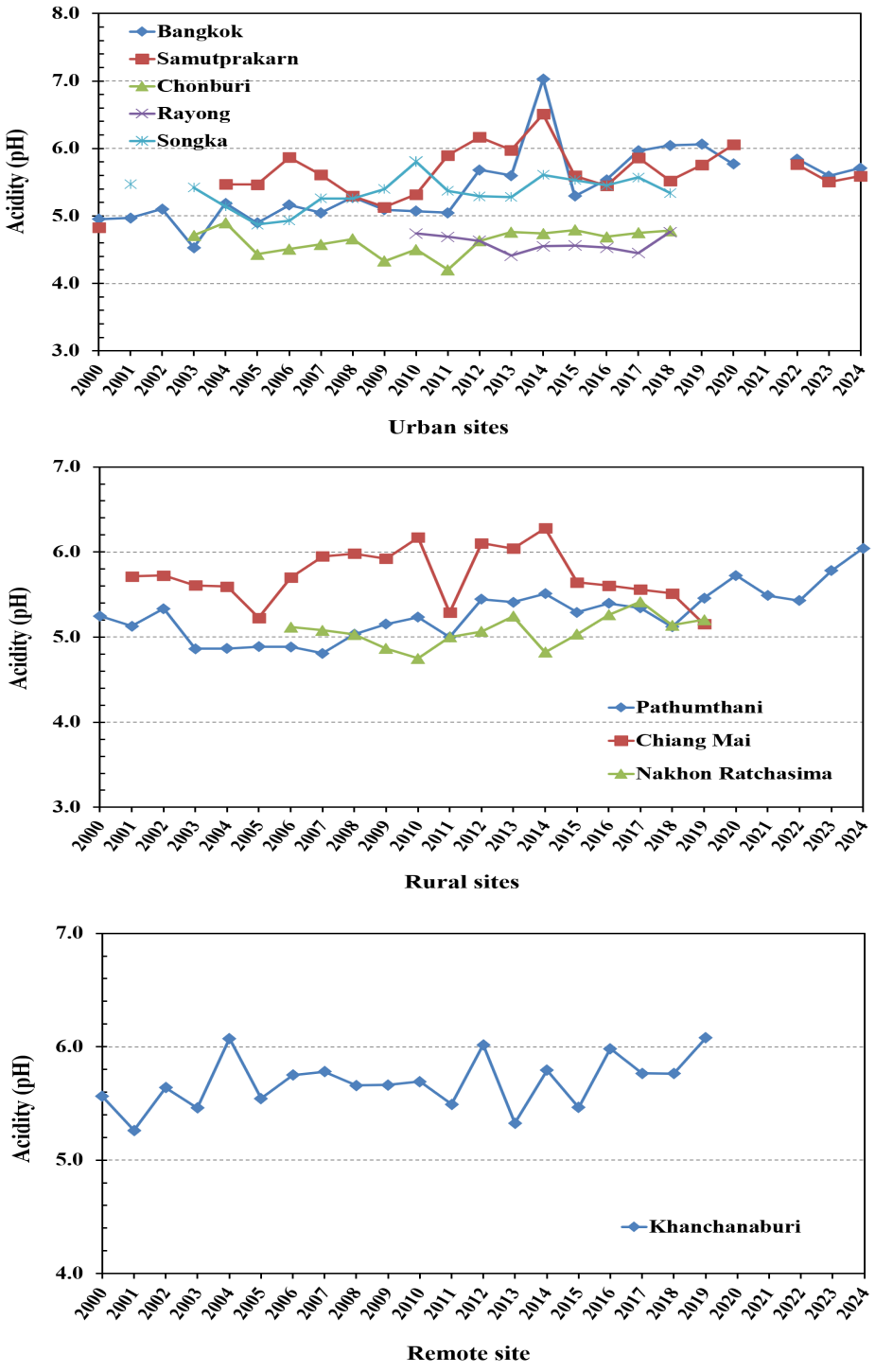
2.1 State of wet deposition

The status of wet deposition in Thailand presented in this report was analyzed based on the EANET data of twenty-year period from 2000 to 2024. In addition to 6 EANET sites in Thailand, Thailand has been attempted to set up the other national sites. Three national sites have also been used to examine the status of wet deposition in Thailand including Songkhla, Chonburi and Rayong.

The acidity or pH of rainwater depends on the concentration of cationic and anionic species. Acidic pH reveals the presence of strong acids, such as SO_4^{2-} and NO_3^-, while neutral or alkaline pH values indicate neutralization of acids by NH_4^+ and soil dust. The naturally existing CO_2, NO_x and SO_2 will dissolve into the clouds and rain droplets then result in pH values of the rain in the clean atmosphere to be between 5.0 and 5.6

Figure 2 shows the annual mean pH of all monitoring sites in Thailand from 2000-2024. It was found that the tendency of the annual mean pH was shown slightly increasing trend for most of the sites except for Rayong (urban), Chonburi (urban) and Chiang Mai (rural), which have not appeared considerable changed. Annual mean pH was ranged from 4.20-7.03 which the lowest pH was observed at Chonburi in 2011 and the highest pH was at Bangkok in 2014. Twenty-years weighted average pH were ranged from 4.56-5.64 which the lowest pH was observed at Chonburi and the highest pH was at Khanchanaburi (remote) as shown in Figure 3.

Figure 4 shows the percentage of samples with pH lower than 5.6 during 2000-2024. It was found that the percentage of samples with pH lower than 5.6 ranged from 18.3 to 85.0, with the lowest value observed at Chiang Mai and the highest value at Rayong. It was also observed that the monitoring sites located in the vicinity of the industrial areas including Chonburi and Rayong were shown pH lower than 5.6 at most of the samples. In contrast, the other six monitoring sites located in urban, rural, and remote areas showed that less than 50 percent of samples had a pH lower than 5.6.



Note : Rain sample of Bangkok (PCD) for all year round in 2014 carried out on daily basis by bulk method

Figure 2. Annual mean pH for the monitoring sites in Thailand during 2000-2024

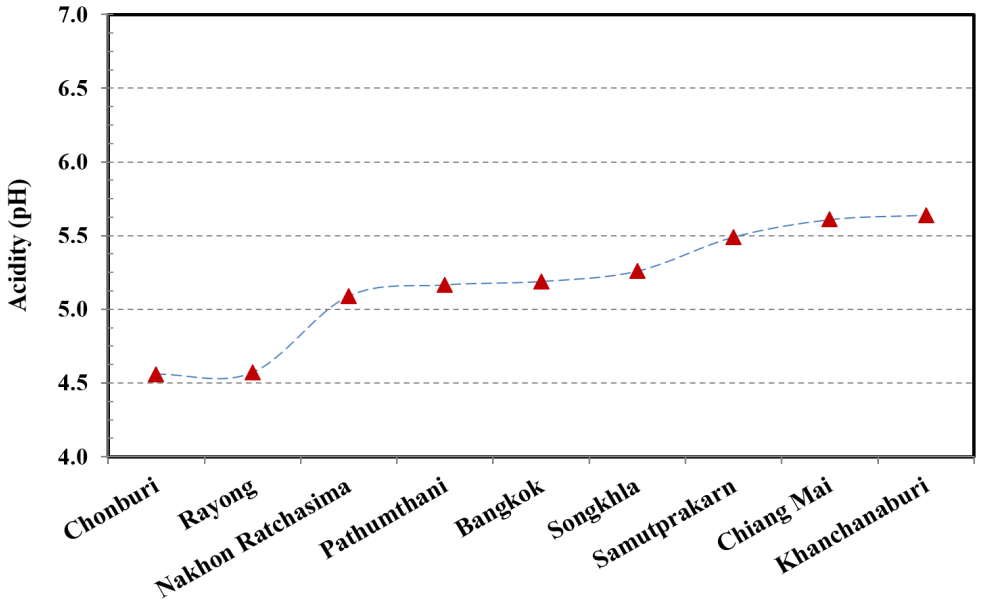


Figure 3. Twenty-year weighted average pH (2000-2024)

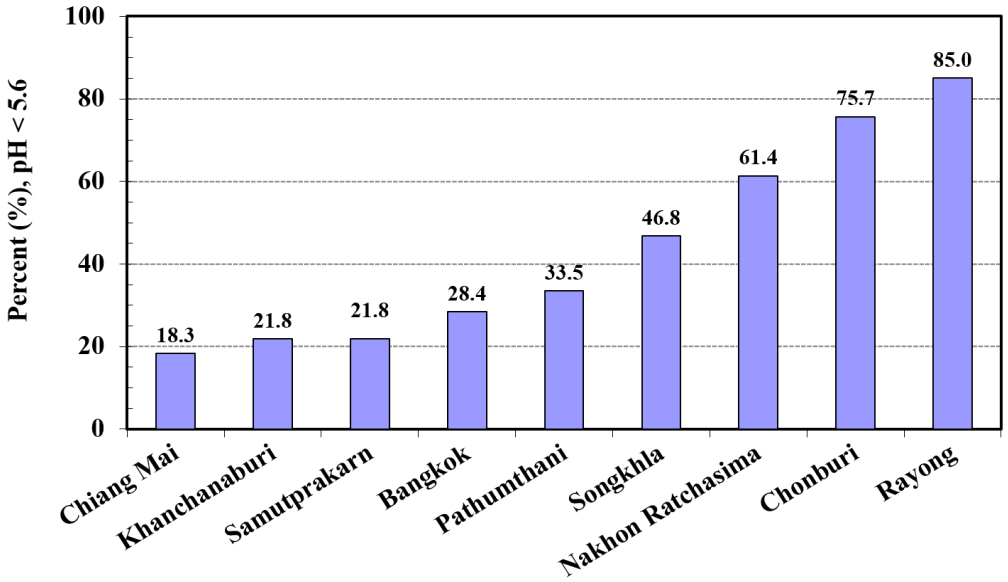


Figure 4. Percentage of samples with pH lower than 5.6 during 2000-2024

The frequency distribution of pH during 2000-2019 is shown in Figure 5. In this study, the pH range of urban areas (industrial areas) was mostly found in the range lower than 4.5 to 5.0, i.e., Chonburi at pH lower than 4.5 to 5.0 with n = 1,395 and Rayong at pH range of 4.5-5.0 with n = 561. Urban area (city area), pH level was found normally at pH range of 5.5-7.0, i.e., Bangkok (PCD) at pH range of 6.0-6.5 with n = 1,378, Samutprakarn (TMD) at pH range of 6.0-6.5 with n = 1,383 and Songkhla at pH range of 5.5-6.0 with n = 1,987. For rural areas, pH level was found normally at pH range of 5.5-6.5, i.e., Nakhon Ratchasima at pH range of 5.5-6.0 with n = 1,713, Pathumthani at pH range of 6.0-6.5 with n = 2,104, and Chiang Mai at pH range of 6.0-6.5 with n = 1,784. For remote area at Khanchanaburi, the pH level was found normally at pH range of 5.5-6.0 with n = 1,451.

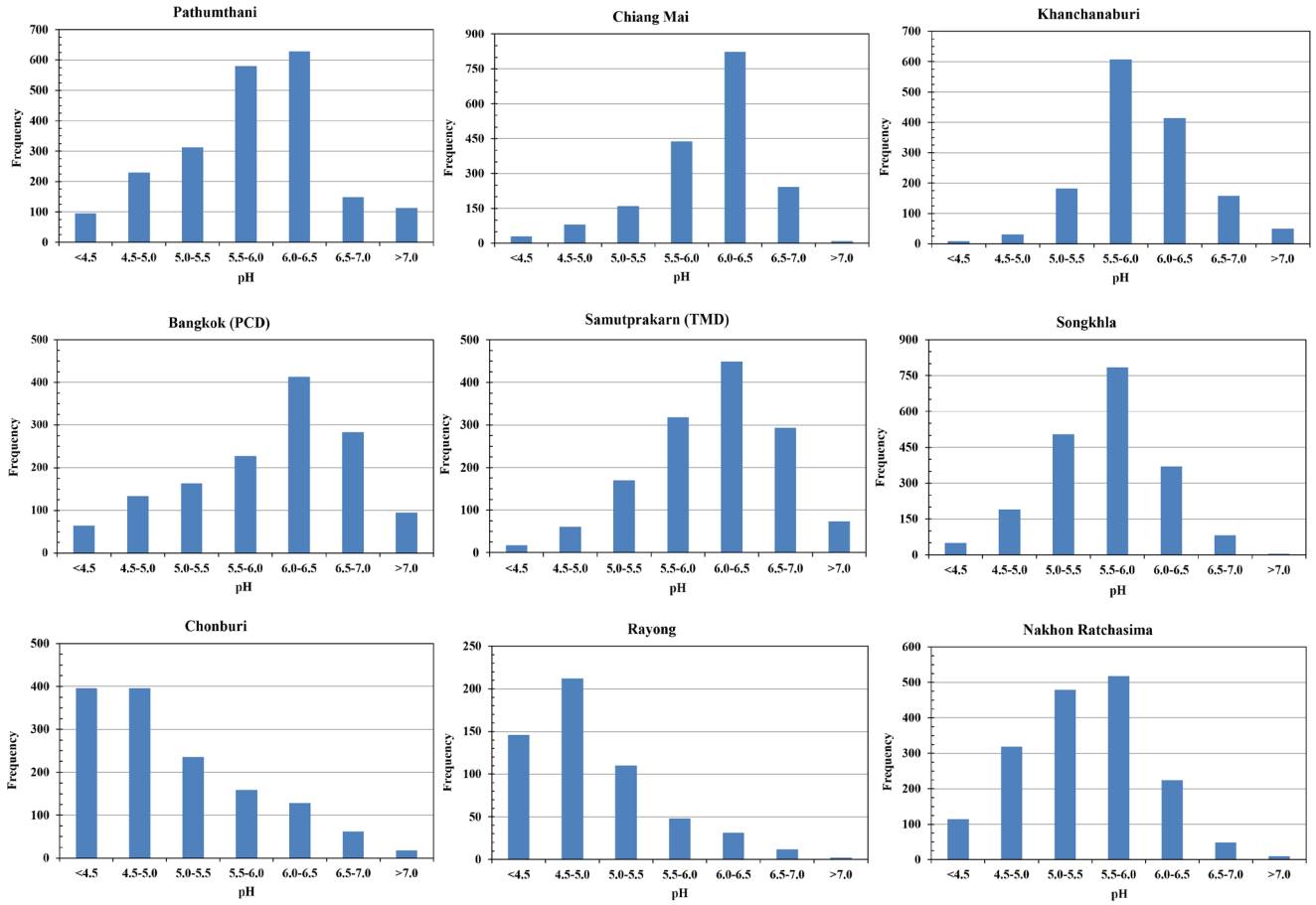


Figure 5. pH frequency distribution for the monitoring sites in Thailand during 2000-2024

SO_4^{2-} and NO_3^- ions are released from the strong acids, H_2SO_4 and HNO_3, and they are not involved in the neutralization reaction once dissociated. Because the concentrations of SO_4^{2-} and NO_3^- ions remain unchanged throughout the neutralization, the SO_4^{2-} and NO_3^- concentrations are numerically identical to those of H_2SO_4 and HNO_3, respectively. The initial concentration of the H^+ ion is equal to the concentration sum of SO_4^{2-} and NO_3^-, which is termed *input acidity*, denoted as A_i in the following formula:

$$A_i = [nss\text{-}\ SO_4^{2-}] + [NO_3^-]$$

where concentrations are in the unit of eq mole L^{-1}. The parameter pA_i is defined in a similar manner to pH, as follows, and corresponds to the pH if no neutralization takes place after the initial formation of sulfuric and nitric acids.

$$pA_i = -log_{10}([nss\text{-}\ SO_4^{2-}] + [\ NO_3^-])$$

The pH and pAi are the indices providing information on acid and base balance in precipitation. During the neutralization process, the pH increased with additional bases, while the pAi remained constant throughout the process.

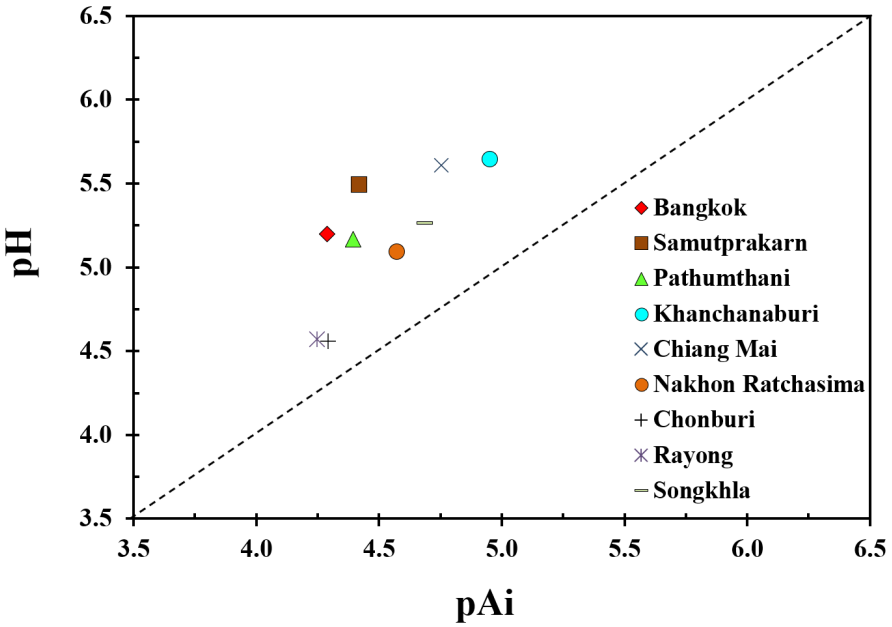


Figure 6. The pH-pAi diagram for the annual mean of monitoring sites in Thailand during 2000-2024

Figure 6 shows a relationship between the 2000-2024 annual mean pH and pAi for the monitoring sites in Thailand from 2000-2024. It was found that all sites' plots are successfully located above the diagonal line of the pH-pAi diagram, in which pH is equal to pAi. The pH and pAi respectively ranged from 4.56-5.64 and 4.25-4.95. This overshooting of pH values was caused by the existence of an appreciable amount of bases such as $CaCO_3$ and NH_3.

In acid deposition chemistry, Nitric acid and Sulphuric acid are the two important acids. The relative contribution of these two acids is evaluated in terms of corresponding anions, NO_3^- and nss-SO_4^{2-}. Knowing the ratio of the two acids is useful in identifying major acidifying substances. Nitric and sulphuric acids play an exclusively important role in acidification of the atmosphere and ecology, although some significant roles are played by some other acids. The NO_3^- and nss-SO_4^{2-} are so stable that they are free from further acid-base interactions. The relative contribution for the entire concentration range for the two anions can be determined in the form of the NO_3^- fraction for the sum of the ion pair, NO_3^- and nss-SO_4^{2-}: $[NO_3^-]/([NO_3^-] + [\text{nss-}SO_4^{2-}])$, which is denoted as fraction #1or F1 for simplicity.

$$F1 = [NO_3^-]/([\text{ nss-}SO_4^{2-}]+[\ NO_3^-])$$

The F1 was calculated as a weighted average from 2000-2024 for all sites in Thailand, as shown in Figure 7. It was found that at all sites, the F1 values were lower than 0.5, which means H_2SO_4 was more significant than HNO_3 in the acidification of rain. The maximum, 0.51, occurred at Pathumthani and was followed by 0.49, 0.48, 0.47, 0.44, 0.43, 0.41, 0.28 and 0.25 for Bangkok, Chiang Mai, Nakhon Ratchasima, Songkhla, Kanchanaburi, Samutprakarn, Chonburi and Rayong, respectively. The lowest ratio was found at 0.25 for Rayong, where H_2SO_4 was two times more dominant acid than HNO_3 on an equivalent basis.

Whereas F1 could focus on the two acids, a similar discussion would be applicable to a pair of two basic compounds, NH_3 and $CaCO_3$. In precipitation samples, these compounds would be represented by NH_4^+ and nss-Ca^{2+}, which suggests defining a fraction, F2, to assess the importance of atmospheric NH_3 relative to $CaCO_3$ as:

$$F2 = [NH_4^+]/([\text{ nss-}Ca^{2+}] + [NH_4^+])$$

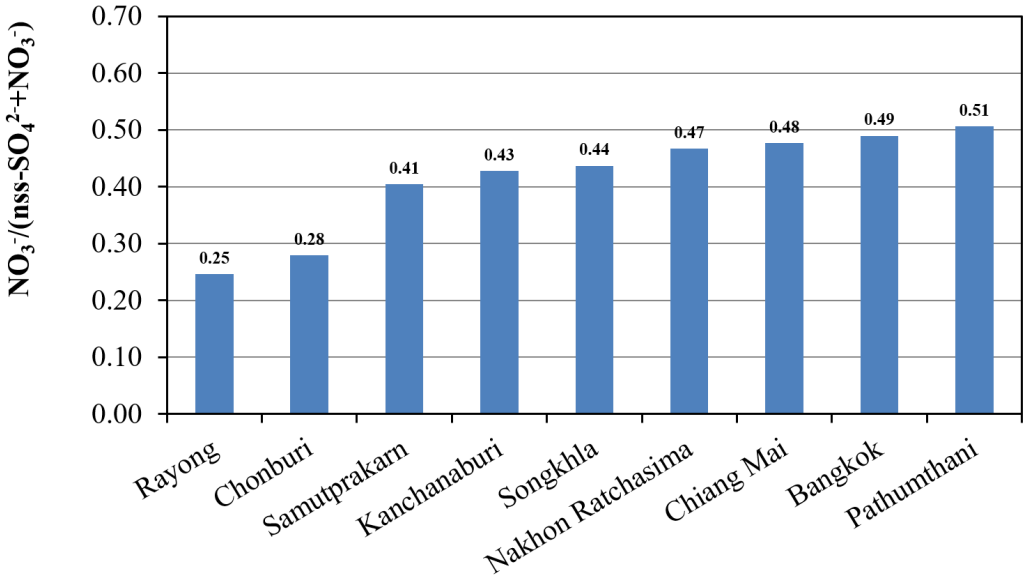


Figure 7. Equivalent fraction of Nitrate ; $[NO_3^-]/([\ nss\text{-}SO_4^{2-}]+[\ NO_3^-])$

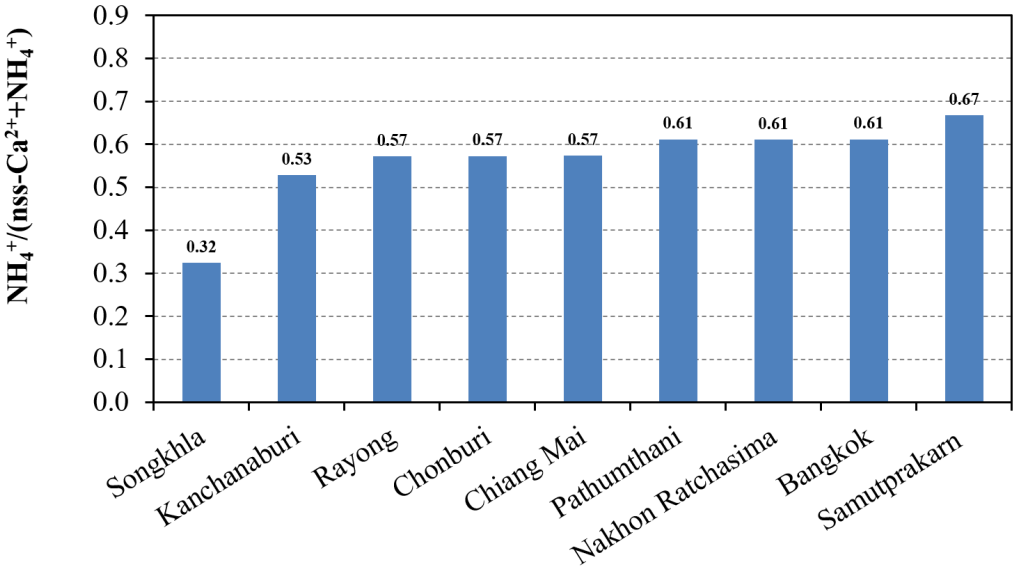


Figure 8. Equivalent fraction of Ammonium ; $[NH_4^+]/([\ nss\text{-}Ca^{2+}] + [NH_4^+])$

Figure 8 displays the F2 ratio for the weighted average from 2000-2024 in order of increasing ratio. The values for F2 are in a wide range from 0.32 to 0.67. Most of the ratios are greater than 0.50, where the two compounds work equally as bases in the interaction. It was found that eight out of nine sites showed F2 greater than 0.50, which are Samutprakarn, 0.67; Bangkok, 0.61; Nakhon Ratchasima, 0.61; Pathumthani, 0.61; Chiang Mai, 0.57; Chonburi, 0.57; Rayong, 0.57; and Khanchanaburi, 0.53. For these sites, ammonia is the dominant base in comparison with $CaCO_3$. Another site in Songkhla showed F2 less than 0.5, indicating that $CaCO_3$ is the dominant base.

The average annual deposition of nss-SO_4^{2-} and NO_3^- (2000-2024) in Thailand is illustrated in Figure 9. The deposition of nss-SO_4^{2-} is in the range of 4.0 - 26.6 mmol/m^2/y. The highest amount of nss-SO_4^{2-} was found at Rayong (urban site, industrial area), with an annual flux of about 26.6 mmol/m^2/y, and the lowest amount was found at Khanchanaburi (remote site), with an annual flux of about 4.0 mmol/m^2/y. The deposition of NO_3^- is in the range of 5.9 - 37.9 mmol/m^2/y. The highest amount of NO_3^- was found at Bangkok (urban site, city area), with an annual flux of about 37.9 mmol/m^2/y, and the lowest amount was found at Khanchanaburi, with an annual flux of about 5.9 mmol/m^2/y. It was clearly seen that at monitoring sites located in the industrial areas such as Rayong and Chonburi, the annual deposition of nss-SO_4^{2-} was found to be much higher than NO_3^-. The higher sulfate deposition might have been contributed by high SO_2 emissions from industrial fossil fuel combustion.

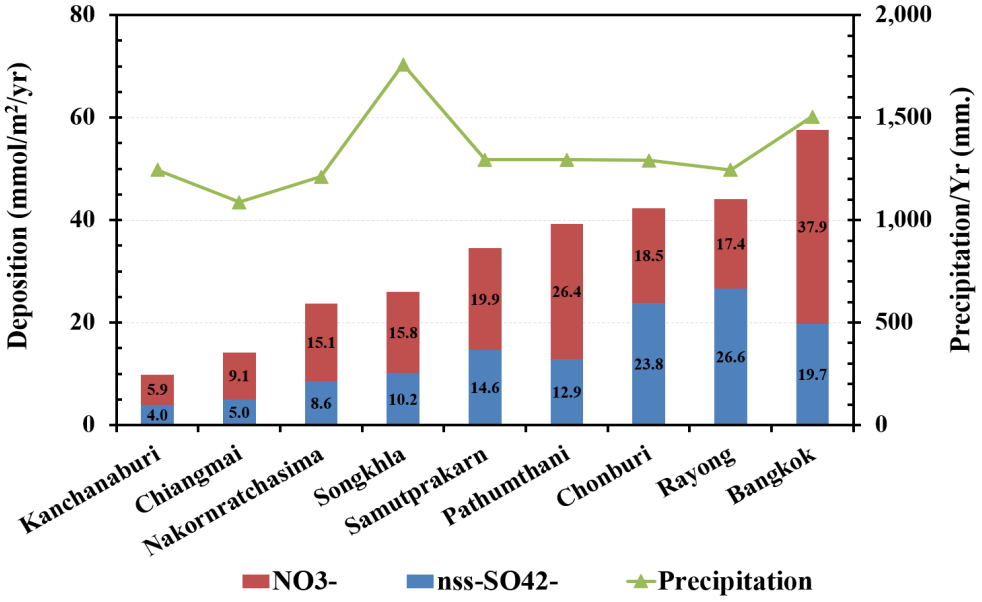


Figure 9. Average annual deposition of nss-SO_4^{2-} and NO_3^- (2000-2024)

2.2 State of dry deposition

Ambient Air Quality Situation

Overall, ambient air quality across Thailand in 2025 showed an improving trend. The concentration of particulate matter with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$) decreased by 13% compared with the previous year, while the concentration of particulate matter with an aerodynamic diameter of 10 micrometers or less (PM_{10}) declined by 9% compared with 2024. These improvements were partly attributable to the implementation of the 2025 Measures for Addressing Forest Fires, Haze, and Particulate Matter Pollution, which focused on reducing emission sources, minimizing the extent of burned areas, and strictly enforcing relevant laws and regulations.

Nevertheless, $PM_{2.5}$, PM_{10}, and ground-level ozone (O_3) concentrations continued to exceed the national ambient air quality standards in several areas. In 2025, the five provinces experiencing the most significant air quality problems were Nan, Saraburi, Samut Sakhon, Nong Khai, and Rayong, with 109, 106, 104, 93, and 90 days of air quality standard exceedances, respectively.

In contrast, six provinces recorded no exceedances of the national ambient air quality standards throughout the year, indicating the best air quality conditions. These provinces were Yala, Nakhon Si Thammarat, Narathiwat, Surat Thani, Phuket, and Songkhla.

Regarding other air pollutants, namely nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO), no exceedances of the national ambient air quality standards were observed. However, their nationwide average concentrations increased compared with the previous year.

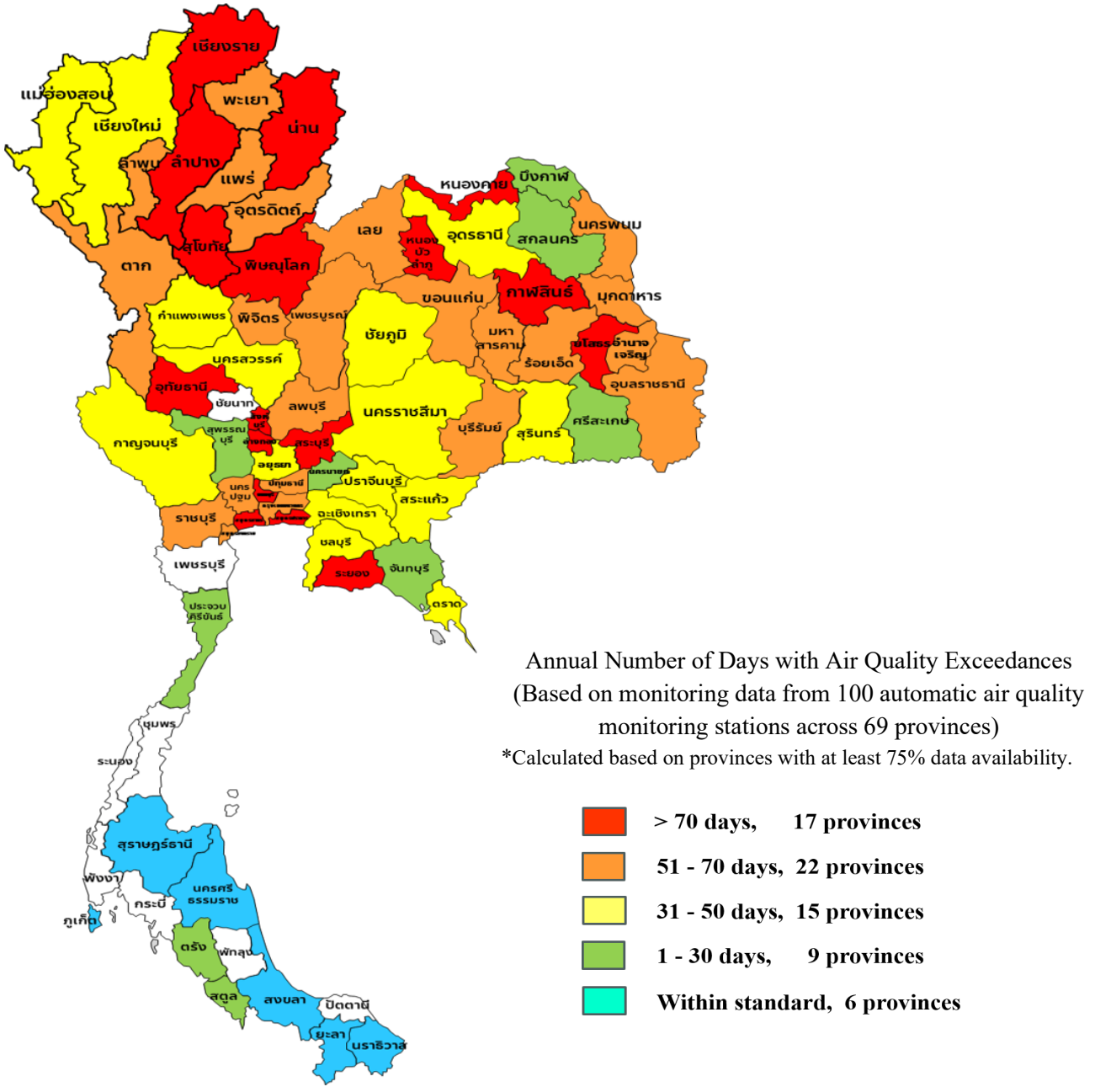


Figure 10. Annual Number of Days with Air Quality Exceedances (2025)

Air Quality Situation Over the Past 10 Years (2016–2025)

Fine Particulate Matter (PM2.5)

The nationwide annual average concentration of $PM_{2.5}$ has shown a declining trend. In 2025, the nationwide annual average concentration was 21 micrograms per cubic meter (µg/m³), representing a 13% decrease compared with 2024, when the annual average was 24 µg/m³.

Based on data from 100 air quality monitoring stations nationwide, the highest 24-hour average concentrations ranged from 23.6 to 289.8 µg/m³, while annual average concentrations ranged from 9 to 32 µg/m³ (Figure 11).

* The national ambient air quality standard for $PM_{2.5}$ (24-hour average) was set at 50 µg/m³ until 31 May 2023. From 1 June 2023 onward, the standard was revised to 37.5 µg/m³.

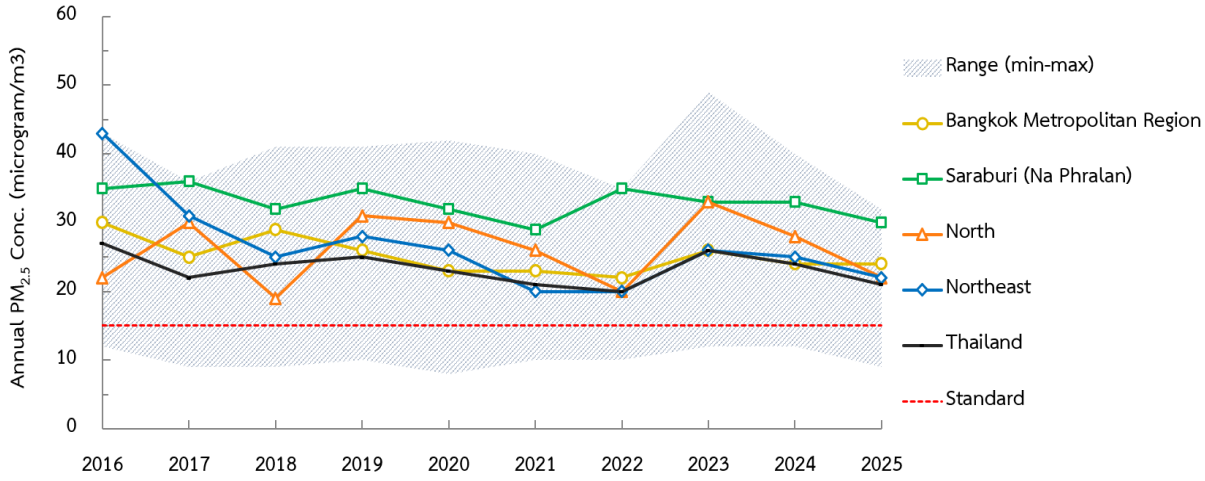


Figure 11. Annual Average $PM_{2.5}$ Concentrations (2016–2025)

Particulate Matter (PM_{10})

The nationwide annual average concentration of PM_{10} showed a declining trend. In 2025, the nationwide annual average concentration was 40 micrograms per cubic meter (µg/m³), representing a 9% decrease compared with 2024, when the nationwide annual average was 44 µg/m³.

Based on air quality monitoring data from 40 monitoring stations (including only stations with at least 75% data availability), the maximum 24-hour average concentrations ranged from 52 to 338 µg/m³, while the annual average concentrations ranged from 19 to 103 µg/m³ (Figure 12).

* The national ambient air quality standards for PM_{10} are 120 µg/m³ for the 24-hour average concentration and 50 µg/m³ for the annual average concentration.

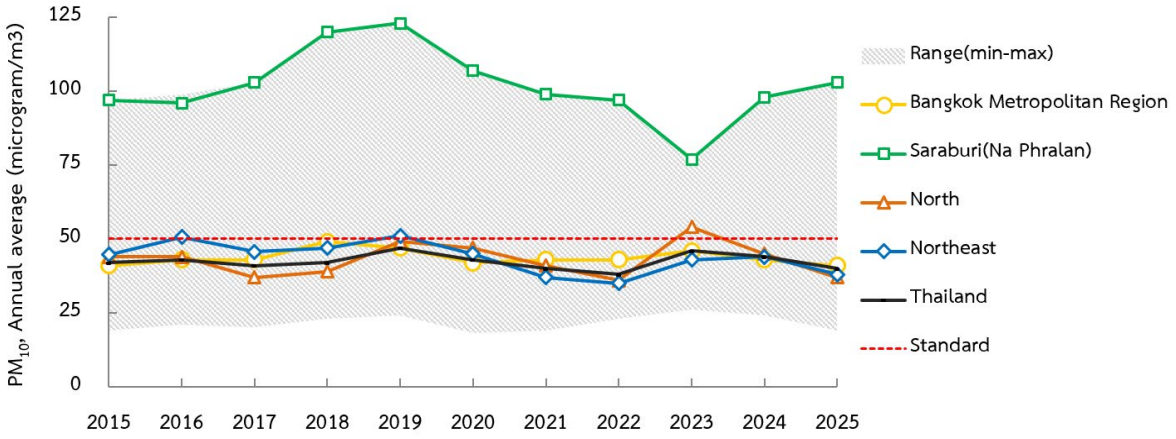


Figure 12. Annual Average PM_{10} Concentrations (2015–2025)

Ground-Level Ozone (O_3)

The nationwide ozone concentration showed an increasing trend. In 2025, the annual average ozone concentration was 112 parts per billion (ppb), representing a 10% increase compared with 2024, when the average concentration was 102 ppb. Ozone concentrations showed an increasing trend across all areas.

Based on data from 26 air quality monitoring stations (including only stations with at least 75% data availability), the maximum 1-hour average concentrations at individual monitoring stations ranged from 86 to 171 ppb, while the maximum 8-hour average concentrations ranged from 76 to 124 ppb* (Figure 13).

This increasing trend in ozone concentrations is attributed to meteorological conditions, together with increased transportation and industrial activities.

* The national ambient air quality standards for ozone are 100 ppb for the 1-hour average and 70 ppb for the 8-hour average.

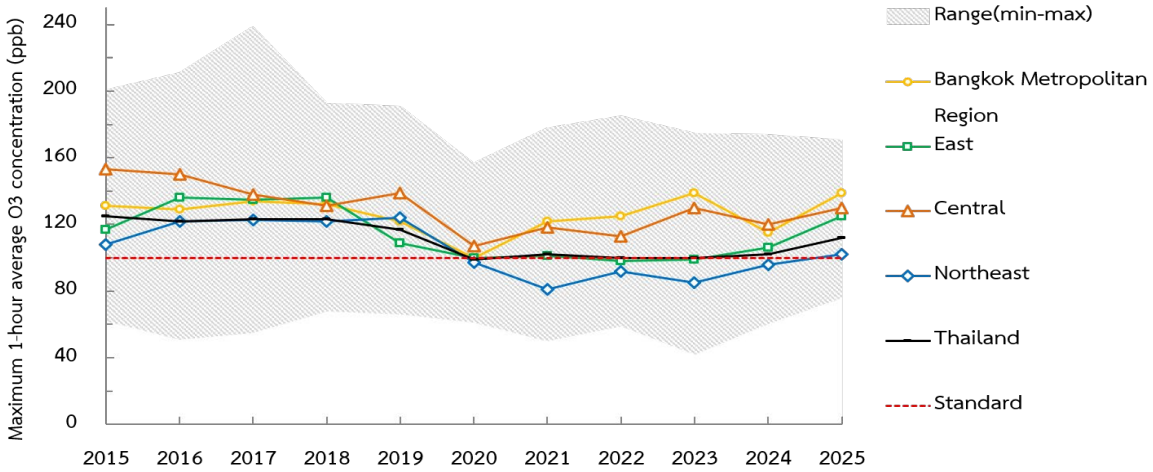


Figure 13. Maximum 1-Hour Average Ozone (O_3) Concentrations (2016–2025)

Nitrogen Dioxide (NO_2)

The maximum 1-hour average concentrations at individual monitoring stations ranged from 1 to 91 parts per billion (ppb), while annual average concentrations ranged from 0 to 14 ppb, with an overall average of 5 ppb. All monitoring stations recorded concentrations within the national ambient air quality standards, and the overall situation remained relatively unchanged compared with 2024 (Figure 14).

* The national ambient air quality standards for nitrogen dioxide are 170 ppb for the 1-hour average and 30 ppb for the annual average.

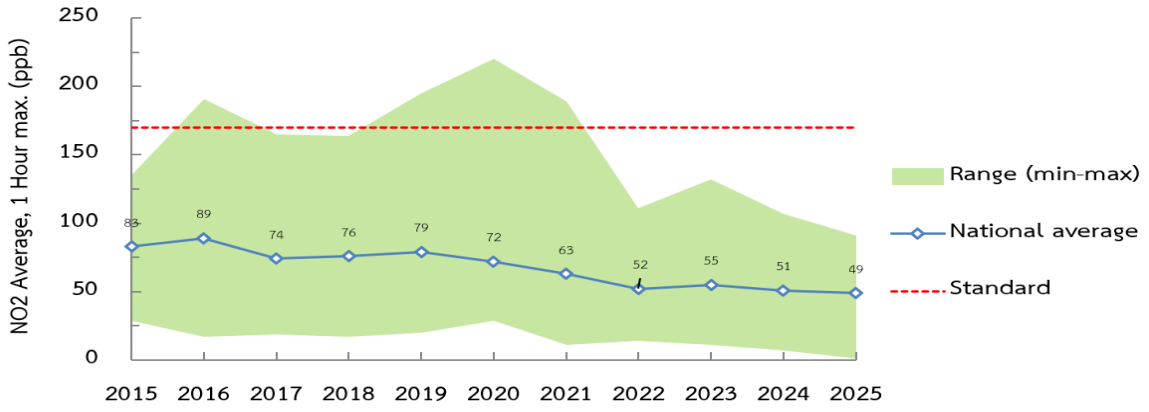


Figure 14. Annual Nitrogen Dioxide (NO_2) Concentrations: Average of Daily Maximum 1-Hour Values (2016–2025)

Sulfur Dioxide (SO_2)

The maximum 1-hour average concentrations at individual monitoring stations ranged from 2 to 54 parts per billion (ppb), while annual average concentrations ranged from 0 to 2 ppb, with an overall average of 1 ppb. All monitoring stations recorded concentrations within the national ambient air quality standards, and the overall situation remained relatively unchanged compared with 2024 (Figure 15).

* The national ambient air quality standards for sulfur dioxide are 300 ppb for the 1-hour average and 40 ppb for the annual average.

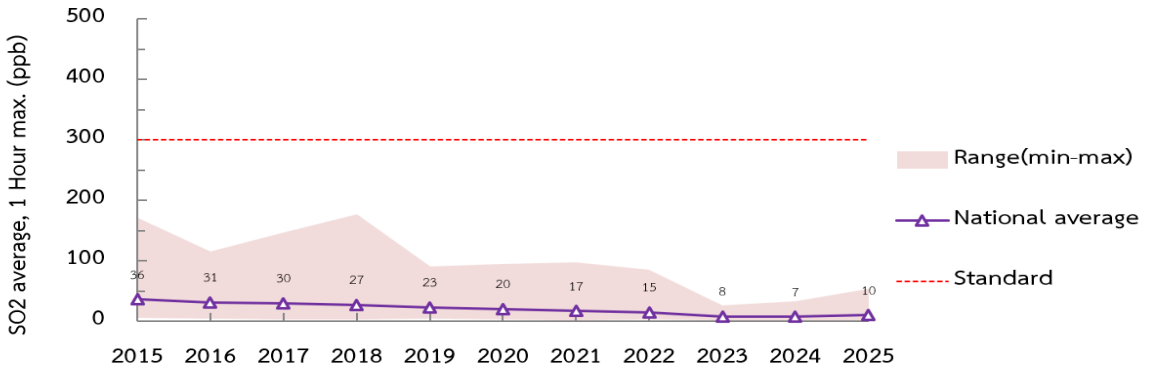


Figure 15. Annual Sulfur Dioxide (SO_2) Concentrations: Average of Daily Maximum 1-Hour Values (2015–2025)

Carbon Monoxide (CO)

The maximum 1-hour average CO concentrations at individual monitoring stations ranged from 0.72 to 3.42 parts per million (ppm), while the maximum 8-hour average concentrations ranged from 0.45 to 2.94 ppm. All measured concentrations were within the national ambient air quality standards. The CO concentrations also showed no significant changes compared with 2024 (Figure 16).

* The national ambient air quality standards for carbon monoxide are 30 ppm for the 1-hour average concentration and 9 ppm for the 8-hour average concentration.

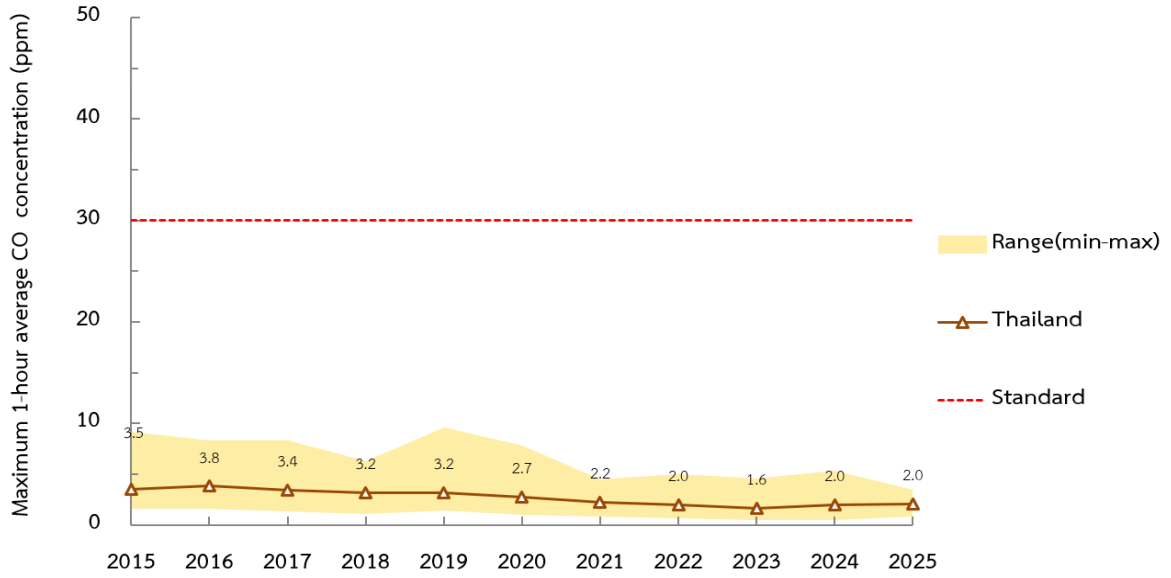


Figure 16. Annual CO Concentrations: Annual Average of Daily Maximum 1-Hour Concentrations (2016–2025)

3. Policy Recommendations for Air Quality Management

3.1 Short-Term Policy Recommendations (1–2 Years)

Agricultural Sector

1) Expand the implementation of projects promoting the incorporation of agricultural residues into the soil and the production of organic fertilizers in areas at high risk of open burning. Hotspot data and vulnerable-area information should be used as a basis for identifying and prioritizing target areas for budget allocation, machinery, and agricultural inputs. Pilot projects should be implemented in areas at high risk of PM2.5 pollution to demonstrate tangible outcomes in terms of reducing open burning and particulate matter emissions. Volunteer soil doctors should serve as key personnel in transferring knowledge and promoting community-level practices for managing agricultural residues without burning.
2) Promote a transition to non-burning sugarcane cultivation by providing incentives and support for the production of fresh-cut sugarcane and increasing deductions or penalties for burnt sugarcane. Provide interest-free loans to farmers for purchasing agricultural machinery to facilitate non-burning harvesting practices. In addition, promote the utilization of sugarcane leaves as fuel in power plants and industrial facilities.

Transportation Sector

1) Strengthen the inspection and supervision of private vehicle inspection centers nationwide to ensure that vehicle inspections are conducted comprehensively, accurately, and in accordance with established procedures, and that inspection certificates are issued based on actual vehicle conditions. This will help ensure that all private vehicle inspection centers operate in accordance with consistent quality standards nationwide.
2) During periods of severe PM2.5 pollution, implement Work From Home policies and encourage the use of electronic meetings to reduce travel demand, thereby helping to reduce PM2.5 emissions.
3) Promote the use of new vehicles, clean-energy vehicles, and public transportation systems.

Industrial Sector

1) Strengthen the regulation, monitoring, and inspection of industrial emission sources, and ensure strict and consistent enforcement of relevant environmental laws. Introduce incentives and tax benefits for factories that invest in pollution control equipment, adopt clean technologies, or achieve air pollutant emission levels below the prescribed standards. Furthermore, promote voluntary environmental performance benchmarking programs to encourage industrial facilities to compete in achieving emission levels lower than regulatory limits.
2) Strengthen the supervision and regulation of industrial establishments, particularly during the dry season when the risk of particulate matter resuspension and dispersion is high. The Department of Primary Industries and Mines has established urgent measures to ensure that industrial operators, particularly those located within the Na Phra Lan Subdistrict Pollution Control Area, strictly comply with environmental impact prevention and mitigation measures. Key measures include:

- Ensuring that blasting operations are conducted in accordance with technical and scientific principles to minimize dust emissions from blasting activities.
- Spraying water to suppress dust and improving transportation routes, as well as outdoor mineral stockpiles and overburden storage areas within industrial premises, to reduce dust accumulation and dispersion.
- Maintaining trees surrounding industrial facilities to serve as buffer zones that help prevent dust from spreading beyond facility boundaries.
- Inspecting dust collection and control systems at stone-crushing, grinding, and screening plants, as well as mineral processing facilities, to ensure their effective operation and continuous use throughout operating hours.
- Regularly cleaning industrial premises, mineral stockpile areas, and overburden storage areas to minimize dust accumulation.
- Inspecting truck wheel-washing systems to ensure their effective operation and requiring all trucks to have their wheels washed before leaving industrial premises.
- Ensuring that truckloads are completely covered with tarpaulins before leaving industrial premises.
- Enforcing speed limits for trucks traveling through community areas and along unpaved or non-concrete roads.
- Encouraging industrial operators to regularly clean public roads and transportation routes used for transporting minerals, rocks, and overburden materials.

3.2 Long-Term Policy Recommendations (3–10 Years)

Agricultural Sector

1) Transition agricultural production systems towards non-burning practices by establishing an enabling ecosystem. This includes promoting the incorporation of rice stubble and straw into the soil to facilitate decomposition and conversion into organic fertilizer; encouraging farmers to use straw balers to collect rice straw for alternative uses instead of open burning, such as livestock feed or fuel for biomass power plants; and providing interest-free loans to support the purchase of agricultural machinery.
2) Amend relevant legislation under the Sugarcane and Sugar Act B.E. 2527 (1984), as amended, to reduce sugarcane burning and promote the delivery of high-quality fresh-cut sugarcane to sugar mills.
3) Establish appropriate criteria, procedures, and guidelines for managing agricultural burning based on the specific circumstances of each area.

Transportation Sector

1) Strengthen vehicle emission standards by adopting more stringent requirements and improving vehicle inspection and emission testing methods and procedures to ensure effective enforcement and alignment with the new standards.
2) Study plans and approaches for prohibiting the importation of used vehicle and marine engines.
3) Restructure the transportation system by improving connectivity among public transportation networks and rail systems, while promoting freight transportation by rail and other low-emission transport modes. This includes developing rail transportation systems powered by low-emission engines or electric vehicles (EVs) for public services to reduce air pollution from diesel locomotives.
4) Promote the adoption of electric vehicles and clean energy, while developing adequate, accessible, and systematically integrated energy and electricity infrastructure to support the widespread use of electric and other clean-energy vehicles.
5) Introduce continuous incentive measures to encourage the adoption of electric vehicles, such as reducing vehicle registration and annual renewal fees, providing insurance subsidies, and offering financial incentives for EV purchases.
6) Enforce EURO 6 emission standards for newly manufactured vehicles in accordance with the established implementation roadmap.
7) Accelerate the transition across all sectors towards electric and clean-energy vehicles, while promoting the phase-out of old vehicles from the national vehicle fleet, particularly diesel-powered vehicles.
8) Encourage and support the public in maintaining their vehicle engines through various programs and activities, such as campaigns offering incentives or discounts for vehicle servicing and maintenance during periods of severe PM2.5 pollution.

Industrial Sector

1) Establish and revise air pollutant emission control standards to ensure appropriate coverage of pollutants that pose risks to human health, taking into account the type and scale of industrial operations.
2) Support and promote the adoption of Clean Production practices and the sustainable development of green businesses.

3) Promote the adoption of Cleaner Production principles and the Circular Economy concept in the industrial sector to minimize waste generation and pollutant emissions from the product design stage onwards.
4) Conduct research and promote the adoption of clean technologies, such as advanced dust collection systems and catalytic technologies for reducing nitrogen oxides (NOx) and volatile organic compounds (VOCs).
5) Develop policy proposals and practical guidelines for controlling and reducing ambient concentrations of benzene and 1,3-butadiene to ensure compliance with applicable standards, taking into account local conditions and the country's sustainable economic development objectives.
6) Propose mechanisms for applying the carrying capacity values for benzene and 1,3-butadiene to manage and control emissions of these pollutants from targeted industrial facilities and related activities within industrial estates and industrial port areas in Map Ta Phut.
7) Implement proactive measures by establishing work plans to assess the effectiveness of mining operators' compliance with environmental impact prevention and mitigation measures, as well as to evaluate environmental protection systems at stone-crushing, grinding, and screening facilities. Environmental quality surveillance should be conducted through ambient particulate matter monitoring in communities within Na Phra Lan Subdistrict, Chaloem Phra Kiat District, Saraburi Province. Monitoring should cover total suspended particulates (TSP) and particulate matter with an aerodynamic diameter of 10 micrometers or less (PM10), based on 24-hour average concentrations, twice a year, to monitor environmental conditions in the Na Phra Lan area. Mining operators should be provided with recommendations to improve and enhance the effectiveness of their implementation of the prescribed environmental impact prevention and mitigation measures. Environmental surveillance data and assessment results on compliance with these measures should be submitted to the Primary Industries and Mines Offices and the Provincial Industry Offices concerned. These agencies should oversee industrial establishments within their respective jurisdictions and follow up on the implementation of the required measures. Furthermore, operators should be encouraged and supported in participating in the Green Mining Promotion Program and the Corporate Social Responsibility Department of Primary Industries and Mines (CSR-DPIM) Program. These initiatives aim to promote environmentally friendly operations, corporate social responsibility, and active participation in sustainable community development.

Transboundary Haze Management

1) Establish formal cross-border cooperation through partnerships with neighboring countries and their relevant government authorities, as follows:

1.1) Develop cross-border cooperation frameworks at the sister-city or paired border-town level, ensuring equal consideration of all parties and providing opportunities for stakeholders to participate in jointly formulating proposals. These cooperation frameworks should subsequently be elevated to the policy level for consideration and assignment of responsibilities to relevant agencies. For example, the Department of Disaster Prevention and Mitigation could facilitate cooperation in disaster risk management, disaster mitigation, and early warning systems.

1.2) Promote knowledge transfer and experience sharing with neighboring countries to provide them with information and insights that can support the development of policies and measures to address transboundary haze pollution.

2) Strengthen the capacity of communities in paired border towns to prevent and address transboundary haze pollution by developing subdistrict-level measures to reduce the risks of forest fires and agricultural burning. These measures should include: (1) controlling agricultural burning; (2) prohibiting hunting and the lighting of fires in forest areas; and (3) allocating forest areas for livelihood activities subject to clearly defined no-burning conditions.
3) Strengthen coordination and cooperation between local authorities in Thailand and neighboring countries along the border to monitor, prevent, and address transboundary haze pollution, with relevant authorities assigned to coordinate implementation.
4) Encourage farmers to transition from monoculture farming systems to regenerative or integrated farming practices. This will help prevent contract farming arrangements involving large agribusiness groups and farmers from contributing to agricultural burning and the generation of numerous hotspots in neighboring countries.
5) Implement trade-related measures to regulate imports of animal feed corn produced without burning through commercial mechanisms, in accordance with the Ministry of Commerce Notification dated 30 December B.E. 2568 (2025).

6) Develop and disseminate knowledge and lessons learned, and scale up the implementation of zero-burning highland agriculture practices across the ASEAN region.

7) Strengthen and enhance international cooperation through bilateral, subregional, ASEAN, and multilateral frameworks to jointly address transboundary haze pollution.

Overall Management and Coordination

1) Accelerate efforts to raise public awareness and strengthen public literacy on measures to reduce pollution sources and protect themselves from PM2.5 exposure through various communication channels. This should also include promoting research and innovation to prevent and mitigate adverse health impacts associated with air pollution.
2) Promote and support innovations aimed at protecting public health, particularly among vulnerable groups, including young children, older persons, pregnant women, and individuals with underlying health conditions. Examples include the establishment of dust-free rooms and the promotion of anti-dust mosquito nets.

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