



NATIONAL AWARENESS WORKSHOP

**Understanding Air Pollution and Its Sources, Weather, Climate,
and Topography in Indonesia**

Jakarta, September 4th 2026

ACID DEPOSITION MONITORING IN INDONESIA

**Center for Environmental Management Facility (Pusarpedal)
Ministry of Environment**

Acid Deposition is a Transboundary Global Pollution Threat

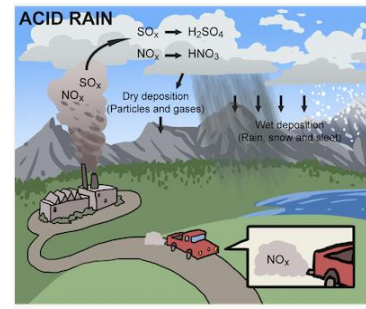
The Air Pollution Phenomenon

- Major environmental issue resulting from increased emissions of SO_x (sulfur oxides) and NO_x (nitrogen oxides).
- Primarily driven by high-intensity combustion in the industrial and transportation sectors.
- Governed by atmospheric conditions such as wind patterns, weather variability, dispersion processes, and climate factors.
- Can be transported across national boundaries, creating local, regional, and global ecological impacts.

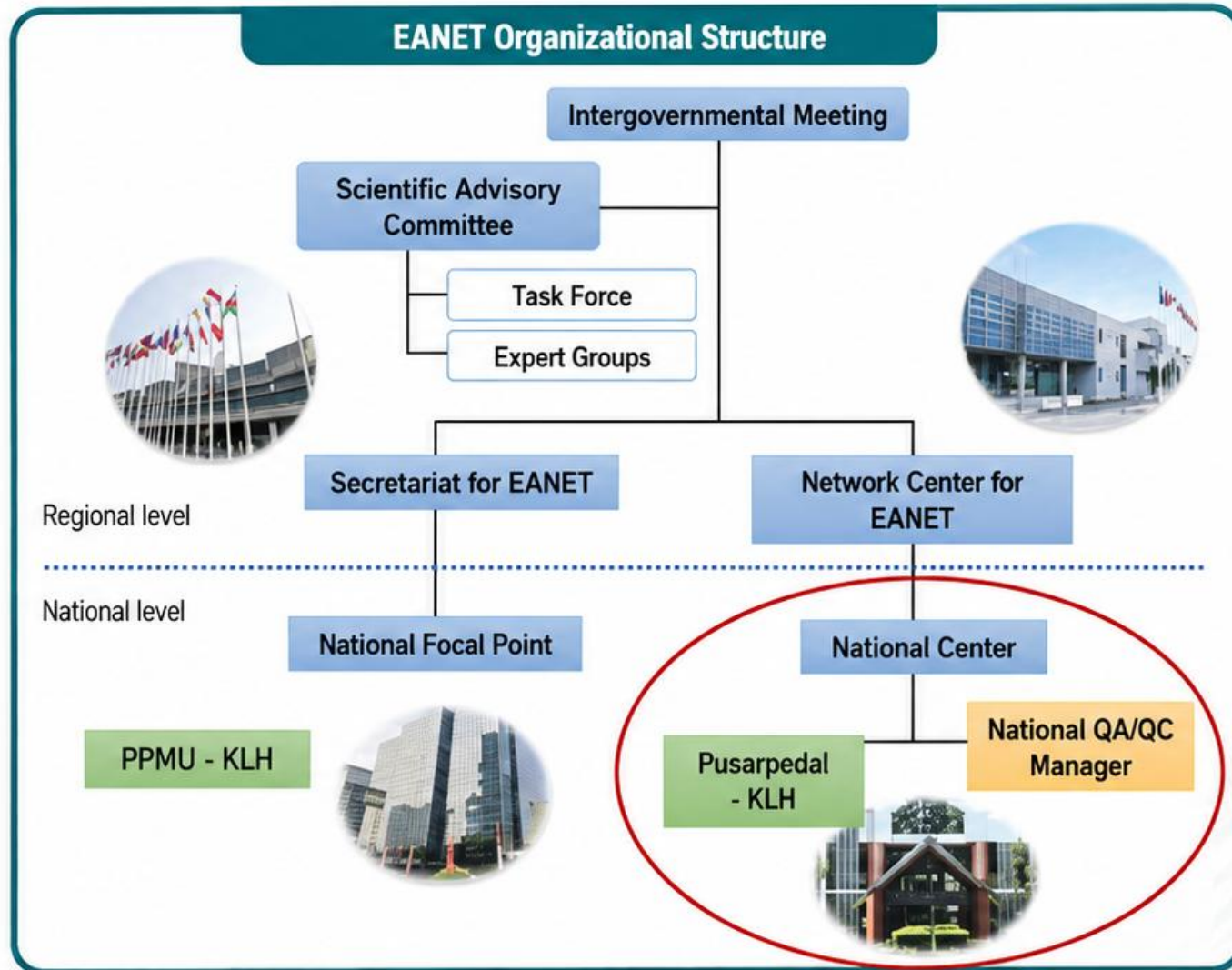


Global Policy Response

- Europe: Established the Convention on Long-Range Transboundary Air Pollution (LRTAP) to monitor and mitigate acid deposition across borders.
- United States: Achieved massive success through emission reduction initiatives utilizing both regulatory caps and advanced technical approaches.
- East Asia: Adopted this vital monitoring framework by establishing the Acid Deposition Monitoring Network in East Asia (EANET).



The Acid Deposition Monitoring Network in East Asia (EANET)



Pusarpedal as the Appointed National Center



Pusarpedal –KLH (CEMF-MoE)

As the designated EANET National Center (NC) for Indonesia, Pusarpedal holds ultimate operational accountability.

Its primary objective is ensuring absolute Data Quality Assurance (QA/QC) across all monitoring sites

Core Mandates of the National Center:



- **Technical Coordination:**

Liaises actively with the EANET Regional Network Center & local network members on technical sampling parameters.



- **Laboratory Management & QA/QC:**

Oversees chemical analytical standards, data verification, & calibration protocol enforcement.



- **Proficiency Testing Supervision:**

Coordinates the national participation in international laboratory round-robin testing.



- **Human Capacity Building:**

Conducts continuous training, workshops, & technical knowledge-transfers for local analysts.

Inter-Agency Network Operates Nine Key Monitoring Stations

Coordinated by Pusarpedal

1998-2026 : BMKG (Jakarta, Kototabang, Maros, Jembrana, Lombok Barat), Pusarpedal (Serpong), BRIN (Bandung), BRMP (Bogor)

 Matrix	 Institution	 Period	 Parameter
Rain water	Pusarpedal, BRIN, BMKG (Jakarta, Kototabang, Maros, Jembrana, dan Lombok Barat)	Event, weekly	pH, DHL, Cl^- , NO_3^- , SO_4^{2-} , NH_4^+ , Na^+ , K^+ , Ca^{2+} , Mg^{2+}
Dry deposition by Filter Pack (1999-2024)	Pusarpedal, BRIN, BMKG Jakarta	biweekly	SO_2 , HNO_3 , HCl , NH_3 , Cl^- , NO_3^- , SO_4^{2-} , NH_4^+ , Na^+ , K^+ , Ca^{2+} , Mg^{2+}
Dry deposition by Passive Sampler (1999-2024)	BRIN, BMKG Jakarta	monthly	SO_2 , NO_2
Inland aquatic	Pusarpedal	4x a year	pH, DHL, alkalinity, Cl^- , NO_3^- , SO_4^{2-} , NH_4^+ , Na^+ , K^+ , Ca^{2+} , Mg^{2+}

- ✓ To collect long-term acid deposition trend data from multiple monitoring sites.
- ✓ Network members are eligible to participate in international proficiency testing (round-robin tests) at no cost. Participation in these programs may be used to satisfy one of the requirements for testing laboratory accreditation.

Monitoring Sites

Kototabang



Jakarta



Maros



Serpong



Bandung



Jembrana



Lombok Barat

1998-1999 : Initial Inception



Stations Added:

**Serpong (Pusarpedal), Jakarta (BMKG)
Kototabang (BMKG), Bandung (BRIN)**

Established the foundational network with four urban and background sites in Java and Sumatra.



2008 : Expansion

Stations Added:

Maros (BMKG - Sulawesi)

Expanded spatial monitoring to represent East Indonesia with an equatorial station.



2019 : Tourism & Conservation Area

Stations Added:

Jembrana (BMKG - Bali), Lombok Barat (BMKG - NTB)

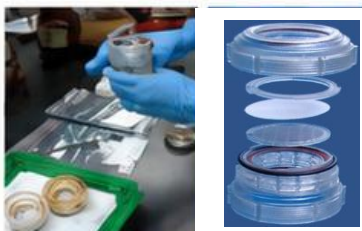
Completed national coverage to capture volcanic and background coastal patterns in Bali and West Nusa Tenggara.

Five Standard Steps Govern the Acid Deposition Monitoring Workflow

01

Sampling Preparation

Preparing sampling devices, checking passive samplers, and sterilizing wet/dry deposition collection containers in local laboratories.



02

Sampling Operation

Deploying collectors at BMKG/Pusarpedal/BRIN sites. Collecting rainwater (weekly/event) and dry filters (bi-weekly/monthly).



Wet Deposition(rain water)



Dry deposition (filter pack)

03

Analysis Preparation

Safe transport of environmental matrices to laboratories. Standardizing chemical reagents, calibration curves, and ion chromatograph.



04

Laboratory Analysis

High-precision analysis of pH, electrical conductivity (DHL), and standard ion composition (cations/anions) via IC systems.



05

Data Processing

Verifying ion balances, compiling data reports, and uploading standardized datasets to the EANET regional network center.



Situ Patengan, Bandung and Situ Gunung, Sukabumi



Monitored regularly to assess the downstream ecological impacts of acid deposition.



Data collection occurs 4 times a year (quarterly) to capture seasonal variations between wet and dry seasons.

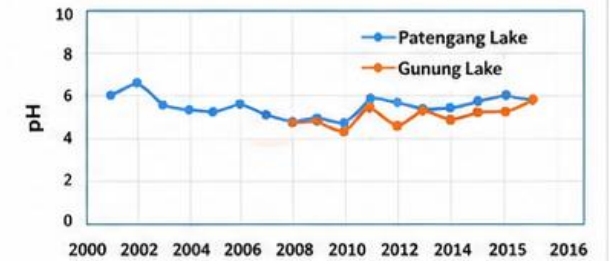
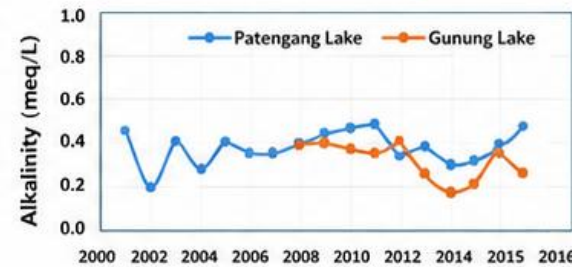


Acts as a key background site located in a mountainous/conserved volcanic area of West Java

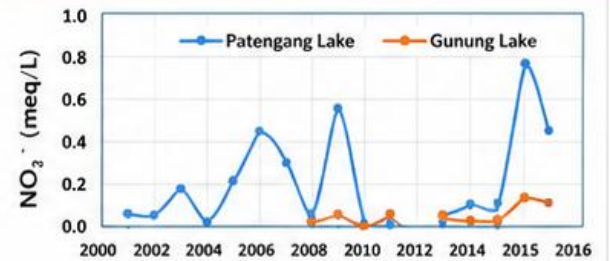
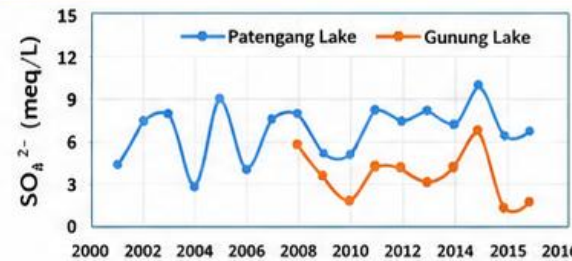


Lake water exhibits a stable neutral pH with very low dissolved mineral contents. Low alkalinity is noted, indicating a moderate buffering capacity against potential future acidic inputs.

Inland Water



pH in lake water is neutral with low alkalinity



Situ Patengan



Situ Gunung

Decade-Long Rainwater pH Trends Reveal Persistent Regional Acidity



Technical Note: A rainwater pH value of less than 5.6 is a direct chemical indicator of acid deposition. Bold values indicate heavy acidic rain.

Monitoring Site	2010	2011	2012	2013	2014	2015	2016	2017	2018
 Kototabang (Remote)	4.8	5.0	5.0	5.0	4.8	4.9	5.3	5.2	5.3
 Jakarta (Urban)	4.7	4.6	4.8	4.8	4.7	4.8	4.9	4.9	4.7
 Maros (Equatorial)	5.2	5.4	5.6	5.5	5.2	5.2	5.3	5.4	5.2
 Bandung (Urban-Industrial)	5.1	5.4	5.5	5.4	5.2	5.4	5.1	5.3	5.7
 Serpong (Suburban)	4.8	4.7	4.9	5.1	5.1	4.9	5.2	5.2	5.2

Gas and Particulate Chemistry Delineates Dry Deposition Profiles

Dry Deposition



Jakarta (Urban)

Gaseous Phase:

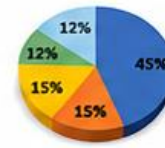
Predominated by highly elevated concentrations of ammonia (NH₃) and sulfur dioxide (SO₂) from heavy transportation and port emissions.

Particulate Phase:

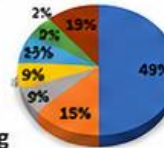
Dominated by sulfate (SO₄²⁻), ammonium (NH₄⁺), and sodium (Na⁺) ions reflecting sea spray mix.



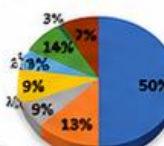
Jakarta



Bandung



Serpong



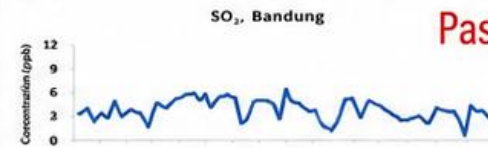
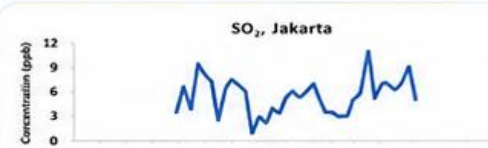
Bandung (Urban-Industrial)

Gaseous Phase:

Marked by elevated nitrogen dioxide (NO₂) and ammonia (NH₃) concentrations driven by dense urban infrastructure and localized industrial combustion.

Particulate Phase:

Characterized by high sulfate (SO₄²⁻) and nitrate (NO₃⁻) load in the PM₁₀ and PM_{2.5} fractions.



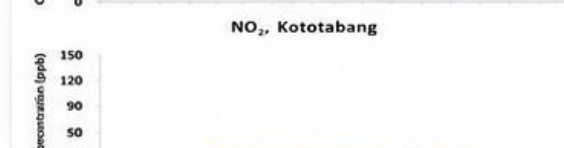
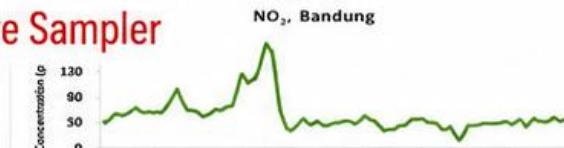
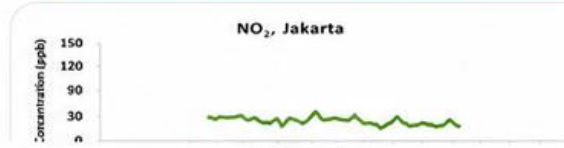
Serpong (Suburban)

Gaseous Phase:

Exhibits intermediate sulfur dioxide (SO₂) levels but substantial ammonia (NH₃) trends, correlated with suburban agricultural and waste footprints.

Particulate Phase:

Exhibits robust ammonium (NH₄⁺) and sulfate (SO₄²⁻) association, indicating neutralized secondary aerosols.



Passive Sampler

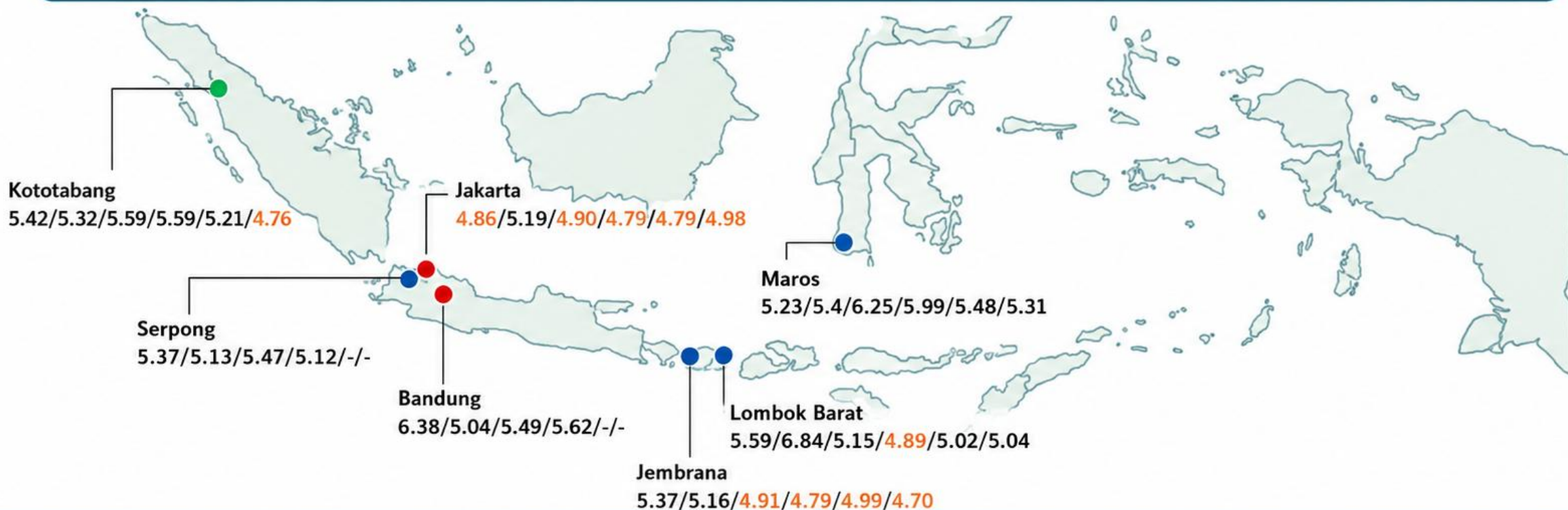
Recent Monitoring (2019 - 2024) Highlights Acid Rain in New Sites



Annual average of rainwater pH 2019-2024
pH<5.6 → indication of acid deposition

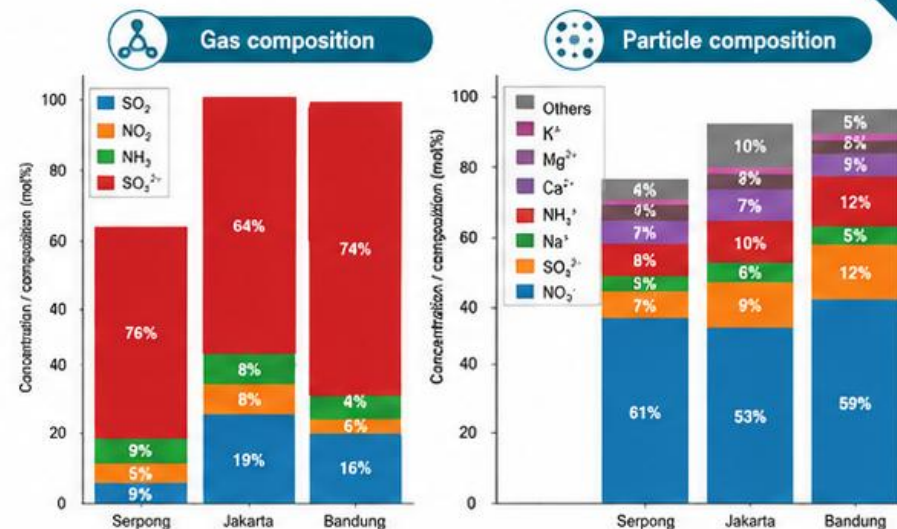
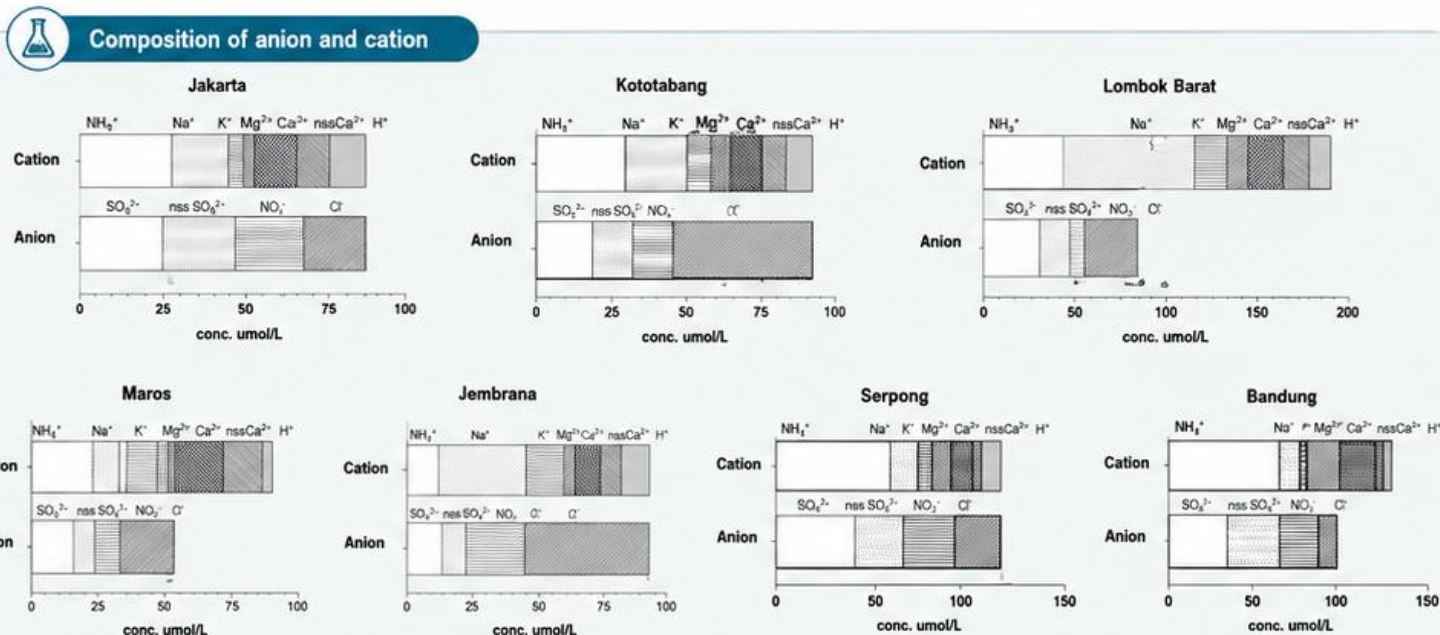
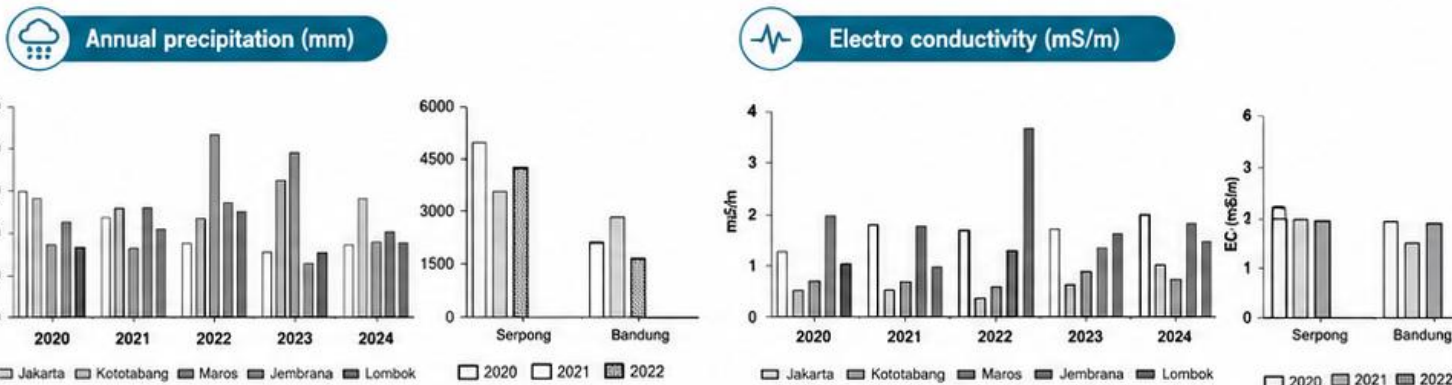


Overview: Rainwater acidity remains a widespread phenomenon across major islands. Newer stations in Jembrana (Bali) and Lombok Barat (NTB) also register indicators below 5.0

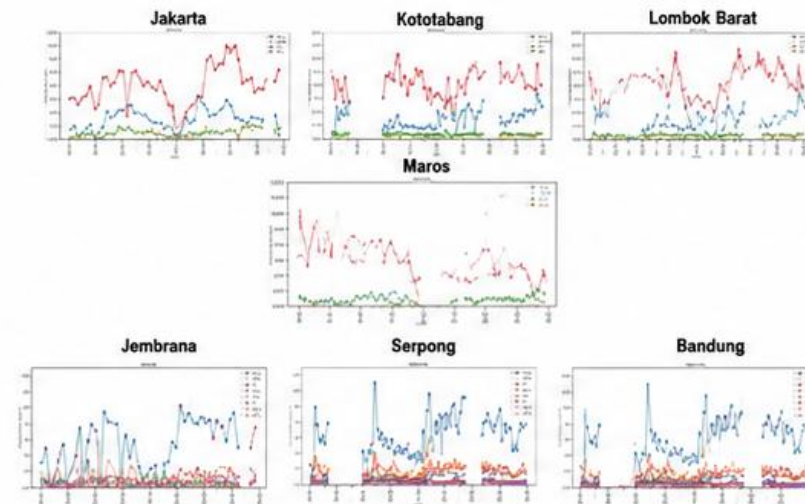


Recent Monitoring (2020 - 2024)

Acid Deposition



Dominated by NH_3 in gas phase, and SO_4^{2-} in particulate phase



Scientific Publications Ground Indonesia's Research Contributions



Regional Assessment Participation

- Indonesia consistently contributes the national assessment chapter for the regional 'Periodic Report on the State of Acid Deposition in East Asia (Part II)' compiled by EANET.
- Key submission cycles completed successfully: 2006, 2011, 2016, 2021, and 2026
- All official technical guidelines, manuals, and data are published on the regional server at <http://www.eanet.asia/> for transparent scientific acce:



● Periodic Report on the State of Acid Deposition in East Asia (PRSAD)



Peer-Reviewed Papers (Last 10 Years)

- The State of Wet Deposition in Several Monitoring Sites in Indonesia 2008 – 2015 (Lestari et al., Jurnal Ecolab 2018)
- Monitoring of The Acid Deposition Impact on Chemical Parameter Quality in Situ Patenggang – Bandung (Lestari et al., Ecolab 2019)
- Plankton Response to the Potential Acid Deposition in Situ Patengan Bandung (Efadeswarni et al., Environment Asia 2020)
- The trend of Ammonia Deposition in Serpong and Bandung (Asri Indrawati et al, ECOLAB Vol. 14 No.2, November 2020 : 147-156)
- Characteristics of Acid Deposition in Urban and Sub-Urban Area (Asri Indrawati et al, 2021, Springer Proceedings in Physics, vol 275. Springer)
- Air Quality Comparison Based on Dry Deposition Parameters in Jakarta, Bandung, and Serpong (Lestari et al., Ecolab 2021)
- Measurement of Ambient Ozone Concentration using Passive Sampler (Tanti et al., JKPK 2022)
- Preliminary Study of Wet Deposition Sources in Serpong, Jakarta, and Kototabang Using the PMF Model (Mukhtar et al., Ecolab 2022)
- Characteristics of Marine Aerosol Deposition and Its Relation to Wind Condition in Three Locations of West Java (Dyah Aries Tanti, INCREASE 2022. Springer Proceedings in Physics, vol 290. Springer, Singapore)
- Effect of rainfall on the chemical composition of rainwater in monitoring acid deposition in Greater Bandung (Dandy Reivaldo et al, Indonesian Journal of Urban and Environmental Technology (2023): 49-62)
- The influence of rainfall to ion deposition concentrations in West Java (Amalia Nurlatifa et al, 2023, AIP Conf. Proc. 2941, 040015)
- Spatiotemporal Distribution in Chemical Composition of Wet Atmospheric Deposition in Bandung Indonesia (Indrawati et al., Environ Sci Pollut Res 2024)
- Central Tendency Data Real-Time Acid Rain Measurement to Evaluate Tool's Performance Using Statistical Analysis (Ardiansyah et al., Int. J. Adv. Sci. Eng. Inf. Techno 2024)

Six Mitigation Strategies Aim to Reduce Fossil Fuels and Air Pollution



✓ Fossil Fuel Reduction

Actively reducing reliance on heavy coal and crude oil combustion in industrial sectors to restrict baseline SOx & NOx precursors.



✓ Green Transportation

Encouraging public transport, carpooling, implementing Car Free Day, and promoting green mobility (walking, bicycling).



✓ Reforestation

Urban forestry and industrial-zone tree planting initiatives to maximize natural particulate absorption and air filtering capacity.



✓ Recycling Initiatives

Systemic community-level recycling and waste management to minimize open waste burning, a major source of urban particulates.



✓ Reducing Plastics

Enforcing local plastic restrictions and waste management strategies to lower emission-intensive manufacturing footprints.



✓ Energy Efficiency

Promoting energy-efficient household appliances and switching off devices when not in use to reduce power plant demand.

TOP 10 WAYS TO MAKE YOUR HOME ENERGY EFFICIENT



THANK YOU

Our commitment to science, collaboration,
and action continues for a cleaner air
and a sustainable future.



SCIENCE

Reliable data for
informed decisions.



COLLABORATION

Stronger partnerships
for greater impact.



ACTION

Sustainable solutions
for a better tomorrow.



Together, we monitor. Together, we understand.
Together, we protect our environment.

