OBJECTIVE

This Policy Brief aims to provide technical guidance, innovative approaches, case studies, and policy recommendations to national and local governments in improving air quality monitoring, especially in the context of the pandemic and protection of public health.

BACKGROUND

The COVID-19 pandemic further emphasized the importance of addressing air pollution, with several studies linking increased COVID mortality to long term exposure to air pollution (Wu et al., Cole et al., 2020).

The Philippines is one, if not the hardest hit by the pandemic in the region, with more than 439,000 positive cases as of December 7, 2020 (Venzon; DOH, 2020). At the same time, the community lockdown implemented since March has led to noticeable improvements in air quality in Metro Manila, with reported reductions of more than 50% in some areas (Sabillo, 2020). Blue skies without haze have been seen in the metro after many years, giving residents a glimpse of what is possible should controls on emission sources such as motor vehicles, which contribute 81% of the capital’s emissions (Environmental Management Bureau [EMB], 2020), are imposed. People have become more conscious of the air they breathe, investing on masks and air filters, to minimize exposure to virus-contaminated air.

As we plan and implement approaches for the ‘New Normal’, strategies to strengthen and employ innovative ways to monitor air quality is a crucial step that must be undertaken by all cities globally. Parallel to this, we should also look into efforts that would quantify and mitigate air pollution that has long affected the environment and the health of the public.
Policies related to Air Quality Monitoring

THE PHILIPPINE CLEAN AIR ACT OF 1999 (REPUBLIC ACT 8749)
Main guiding document outlining mandate of the government and steps to ensure air quality management in the country.

DENR ADMINISTRATIVE ORDER 2000-81 (RA 8749 IRR)
Detailed implementing guidelines of the Philippine Clean Air Act.

DENR ADMINISTRATIVE ORDER 2000-82 (IAQIF-AQCAP)
Detailed implementing guidelines to "serve as the official blueprint with which all government agencies must comply with to attain and maintain clean and healthy air," through the Integrated Air Quality Improvement Framework (IAQIF) – Air Quality Control Action Plan (AQCAP).

DENR ADMINISTRATIVE ORDER 2013-13 & 2020-14 (ESTABLISHING PM$_{2.5}$ STANDARDS)
Establishment of the guideline values for PM$_{2.5}$, and its AQI breakpoints, which were not included in RA 8749 and its IRR. Also includes monitoring requirements of "once every 6 days when using manual method. A minimum of 12 sampling days per quarter of 48 sampling days each year is required."

DENR EMB MEMORANDUM CIRCULAR NO. 2020-003 (CEMS FOR INDUSTRY EMISSIONS)
Streamlining of a uniform Data Acquisition and Handling System (DAHS) as a repository for Continuous Emissions Monitoring Systems (CEMS) and Continuous Opacity Monitoring System (COMS) data for industry emissions.
Most cities face challenges in establishing an up-to-date air quality monitoring system, given the extensive financial and manpower resources required in purchasing, maintaining, and operating it. The limitations in resources result in limited spatial and temporal coverage, and lack of properly maintained and calibrated equipment, often resulting in compromised data.

The Philippines’ Department of Natural Resources and Environment (DENR) - Environmental Management Bureau also face these challenges. Albeit, government initiatives are underway to generate robust and credible air quality data to respond to monitoring needs of the country and contribute to effective decision-making. The National Capital Region has 28 monitoring stations, seven of which are continuous ambient monitoring systems (CAMS) that are connected real-time to the DENR mobile application.

**STATUS, CHALLENGES AND NEEDS IN AIR QUALITY MONITORING**

Air quality monitoring is an integral part of air quality management. Proper characterization of air quality leads to more efficient and effective management strategies, because we cannot manage what we do not measure. Air quality data provides information on the severity of air pollution and its environmental and health impacts, and can also reflect the impacts of pollution control measures, strategies, and policies.
To extend spatial coverage of air quality monitoring in the country to cover more vulnerable populations, there is a need to invest in more monitoring equipment and alternative approaches to monitor air quality. One key strategy is through partnerships with the academia and private sector to address gaps in resources and technical expertise. The role of local government units is also very crucial in providing resources not only to collect, but to interpret monitored data that can support science-based management of emission sources. This multi-sectoral approach is supported by Section 8 of RA 8749 (Philippine Clean Air Act), which states that the Air Quality Control Action Plan (supposedly developed by the DENR), “shall be characterized by a participatory approach to the pollution problem.”
OPPORTUNITIES FOR AIR QUALITY MONITORING IMPROVEMENT UNDER THE NEW NORMAL

SHORT-TERM

Exploration of validation and use of non-reference instruments to increase spatial coverage of pollution monitoring

There must be investments in higher spatial resolution real-time monitoring, which will be linked to the existing DENR mobile apps and mirrored directly in social media accounts. Increased monitoring coverage can be achieved through the use of locally-calibrated non-US EPA certified reference/equivalent instruments that are less expensive than reference instruments but are portable and has good agreement with data collected from reference systems. While there is no global certification institution for non-reference (lower cost) instruments yet, the US EPA (2018) provides guidance on the calibration process of these instruments through collocation with reference instruments.

This approach may be adopted as supported by Part II, Rule VII, Section of DAO 2000-81 (Philippine Clean Air Act IRR), which states that “other equivalent methods approved by the Bureau may be adopted;” and Section 4 of RA 8749 (Philippine Clean Air Act), which states that it should be the policy of the state to “encourage cooperation and self-regulation among citizens and industries though the application of market-based instruments.”

Case studies in Asia:

- By November 2020, the Maharashtra Pollution Control Board (MPCB) of India and the Indian Institute of Technology-Kanpur (IIT-K) are going to deploy and use low-cost sensors in the Mumbai Metropolitan Region. The monitors will be assessed for accuracy and stability, through inter-comparison with the MPCB’s real-time monitoring stations. Recognizing that reference monitors are more expensive, the outcome of the assessment would hopefully lead to increasing the spatial coverage of air quality monitoring in the country, through low-cost sensors (Chatterjee, 2020).

- An air pollution monitoring network using low-cost sensors are deployed in Hanoi, Vietnam to extend coverage of monitoring in the city and increase public awareness through air quality alerts. The sensors which measure PM$_{10}$, PM$_{2.5}$, CO, NO, SO$_x$, O$_3$, temperature, and humidity, were locally developed by the Vietnam National University Hanoi. To ensure data quality, calibration was performed using data from monitoring stations of the Hanoi Department of Natural Resources and the Environment (DONRE) (VNU, MONTUS, and Nguyen et al, 2019).

- Low-cost monitors were used in Seoul, Korea to measure urban street-level PM$_{2.5}$ concentrations. Fixed-site regulatory monitors managed by the government were used to correct for temporal trends and to normalize measured values from sensors, which were used as input to models to achieve high-resolution urban street-level air quality. Similar to numerous studies outside Asia, the research demonstrates how the use of sensors that are collocated with reference monitors can be instrumental in bridging data gaps, and can be suited for community-based data collection especially in developing countries without extensive air monitoring networks (Lim, et al., 2019).
To determine air quality impacts due to COVID-19 lockdown in Southeast Asia, air pollution data in the form of aerosol optical depth (AOD or aerosols in the air) and NO\textsubscript{2} were obtained through Japan’s Himawari-8 satellite and NASA’s Aura-OMI (Ozone Monitoring Instrument), respectively. Reductions in AOD values during the lockdown were observed for Kuala Lumpur, Brunei, Singapore, and Manila, while higher values were detected in Laos due to biomass-burning activities and meteorological conditions. For most parts of the SEA region, reductions in NO\textsubscript{2} were observed in comparison to average value from 2015-2019, especially in Manila, Bangkok, Kuala Lumpur, and Singapore, likely due to shutdown of businesses, industries, and traffic restrictions (Kanniah et al., 2020).

The University of the Philippines (UP) Diliman mapped satellite-based data of NO\textsubscript{2} before and during the enhanced community quarantine (ECQ) lockdown in NCR. Similar to Kanniah et al.’s (2020) study, data has shown a significant abrupt drop in NO\textsubscript{2} most likely due to decreased vehicle activity during the lockdown.

The use of satellite data to complement ground-based monitoring is an innovative and alternative approach to air quality monitoring, providing information that would otherwise be expensive to collect through sampling instruments. The extensive coverage of remote sensing techniques provides the largest spatial coverage and offers historical information that can help track pollution changes through time.

Use of satellite data to complement ground-based monitoring

Case studies in Asia
OPPORTUNITIES FOR AIR QUALITY MONITORING IMPROVEMENT UNDER THE NEW NORMAL

Air quality dispersion modeling to guide air quality monitoring and map impacts of emission sources

Air quality dispersion models offer an alternative approach to estimate the contribution of emission sources to the quality of air. Models can fill in pollution concentration in areas with limited or no available ground-based monitoring equipment, increasing spatial resolution of available data. Air quality models also guide policy development as it can estimate, calculate, and forecast air pollutant concentrations under various scenarios, from changes in emission sources and atmospheric conditions, to impact assessments of air quality management policies and programs.

This approach is widely applied for ECC applications for industry emissions, with guidelines provided through MC 2008-003 (Guidelines for Air Dispersion Modelling) which can be updated to reflect more sophisticated models and to cover other sources of pollution.

- In Bataan, emission inventory and CALPUFF air quality dispersion modeling were performed to determine the impact of more strict industry emission standards. The study has shown that there will be a significant decrease in the contribution of coal-fired power-plants to the ambient air pollution (PM<sub>2.5</sub>) especially if international best practice of most stringent standards would be implemented.

Visualization of the estimated change in ambient PM<sub>2.5</sub> in Bataan under stringent to more stringent industry emission standards (Clean Air Asia, 2020).

Mobilize citizen science to systematically report areas with poor air quality and sources with high emissions (for vehicle and industry emissions)

Citizen science can also be utilized through public participation in research efforts. Collected information from the general public can help in monitoring air pollution and emission sources (e.g., perception of air quality, vehicle congestion, stack emissions, etc.). In the longer-term, deployment of locally-calibrated sensors can also be facilitated by the public with guidance from national and local government units and academia.

- In 2018, families and 967 schools in Antwerp, Belgium, participated in the largest citizen science project in the world, using passive samplers that volunteers installed in their houses or schools facing roadsides, to measure nitrogen dioxide (NO<sub>2</sub>). The project was called project CurieuseNeuzen Vlaanderen (Curious Noses Flanders), and the samplers used were calibrated with government reference monitoring stations.

- The call for volunteers was announced through a local newspaper and attracted 53,000 interested people. When the involved citizens found the increase in NO<sub>2</sub> with more vehicle emissions, behavioral studies showed that they used their cars less (European Environment Agency, 2019).

The participants of the CurieuseNeuzen Vlaanderen citizen science project put up the NO<sub>2</sub> samplers in windows facing roads, together with a v-shaped window sign shown in the photo (Flanders Environment Agency).

This approach can be performed in line with Section 15 of the RA 8749 (Philippine Clean Air Act), which states that the DENR and “the Department of Science and Technology (DOST), other agencies, the private sector, the academe, NGOs and People’s Organizations, shall establish a National Research and Development Program for the prevention and control of air pollution. The Department shall give special emphasis to research on and the development of improved methods having industry-wide application for the prevention and control of air pollution.”
Continued capacity building for improvement of air quality monitoring systems, including training, use of a combination of the above approaches, partnerships, and other approaches

Air quality monitoring systems must keep up with rapid changes in air pollution monitoring technologies, and this can be done through continuous capacity building of the individuals and institutions responsible for it. Rule XLV of DAO 2000-81 (Philippine Clean Air Act IRR) states that “shall provide the LGUs with technical assistance, training and a continuing capability-building program to prepare them to undertake full administration of the air quality management and regulations within their territorial jurisdiction,” but capacity building can be further strengthened through engagement and partnerships with other sectors described in this policy brief, in exploring and using various approaches in air quality monitoring and overall air quality management.
POLICY AND RESEARCH RECOMMENDATIONS

Operationalize the Air Pollution Research and Development Program (RA 8749 Section 15), which states that “The Department (DENR), in coordination with the Department of Science and Technology (DOST), other agencies, the private sector, the academe, NGOs and POs, shall establish a National Research and Development Program for the prevention and control of air pollution. The Department shall give special emphasis to research on and the development of improved methods having industry-wide application for the prevention and control of air pollution. Such a research and development program shall develop air quality guideline values and standards in addition to internationally-accepted standards. It shall also consider the socio-cultural, political and economic implications of air quality management and pollution control,” which will streamline all research and air quality management needs of the EMB and guide policy development. As explained by the DOST, a formal agreement (i.e. MOA) must be led by the DENR to facilitate this.

RESEARCH TOPICS

- Development and validation of local sensors (ongoing)
- GIS and satellite-based AQ monitoring
- Pollution control devices for emission sources
- Big data analytics for air quality forecasting
- Citizen Science approach on monitoring air pollution and its sources
- Air quality dispersion modeling
POLICY AND RESEARCH RECOMMENDATIONS

1. Review and revision of ambient air quality, vehicle, and industry emission standards
   - The Philippine Clean Air Act mandates the review and revision of standards in specific time frames. Given rapid changes in technology, increase in emission sources, and the new normal, these actions should be performed in a timely manner:
     - On an annual basis, review and revise when necessary, the list of Hazardous Air Pollutants and the National Ambient Air Quality Standards for Source Specific Air Pollutants, with the participation of all stakeholders (Rule XXVI, Section 2)
     - Every two years or as the need arises, review and revise vehicle emission standards together with the Department of Transportation (DOTr) and Land Transportation Office (LTO), to “achieve substantial improvement in air quality for the health, safety and welfare of the general public” (Rule XXXIII, Section 1)
     - Every two (2) years, or as the need arises and subject to public consultations, review and revise the specifications of unleaded gasoline and of automotive and industrial diesel for further improvement in formulation (Part X, Rule XXXVI, Section 4)
     - Every two years since the enactment of the Clean Air Act or as the need arises, revise and publish emission standards, to further improve the emission standards for stationary sources of air pollution (Section 19)

   - It is recommended to study and monitor more types of air and climate pollutants (greenhouse gases (GHGs) and short-lived climate pollutants (SLCPs), given that they have similar sources and can be addressed synergistically through an integrated Clean Air and Climate Change Action Plan approach.

- DENR DAO No. 2000-82 or the IAQIF which serves as the “official blueprint with which all government agencies must comply with to attain and maintain clean and healthy air,” must be revised to show clearer integration of roles and policies between national and local government agencies and other stakeholders in implementing the Clean Air Act and improvement of AQ monitoring. Efforts started in November 2019 by the DENR and Clean Air Asia must be continued, with revisions that would address identified challenges, guide and integrate air quality management planning in all levels, and ensuring sustained actions under the new normal.

3. Clear integration of policies specific to air pollution and health

- Exposure to air pollution claimed an estimated 5 million premature deaths in 2017 alone and has reduced life expectancy by 20 months (HEI, 2019). The COVID-19 pandemic has highlighted the need to further protect (respiratory) health to reduce health risks, thus policies that clearly integrate pollution and health studies must be prioritized.

- The DENR and Department of Health (DOH), together with other agencies and stakeholders must further strengthen partnerships in implementing the Universal Health Care Law.

- Specific policies, guidelines, and programs for environmental health protection must be further developed through the Inter-Agency Committee on Environmental Health (IACEH), and the National Environmental Health Action Plan (NEHAP).

- Under the new normal and more developing research showing how aerosols can increase spread of pathogens such as COVID-19 (Marr, 2020), it is also recommended to develop guidelines for indoor air quality (and ventilation) together with the DOH.
4. Improve communication of air quality to the public
- The National Quality Status Report must be reported to the public annually, pursuant to Section 6 of the Clean Air Act. Several reports have been published in the past, but not in regular annual periods. It is recommended to report air quality data in a more timely manner, to keep the public updated.
- Improve the air quality data website portal and mobile apps to increase dissemination and awareness of the public on air quality, and consider other means of reporting data such as newspapers, board displays in public places, TV, and radio, to reach people which do not have access to internet and gadgets.

5. Streamline data collection process for air quality monitoring data interpretation and emissions inventory through LGUs
- While the DENR is mandated to monitor the quality of air, local government units can also play an important role in providing additional information that can help in the interpretation of pollution data. These include vehicle and foot traffic, records of specific events that can impact air pollution (e.g. fiestas, fires, accidents), and higher-data resolution inventories of emission sources.
- A more integrative approach to air quality management and action planning from local to national levels can help cities develop solutions and address air pollution.

6. Formalization of partnerships with academia and private sector
- The success of a more extensive air quality monitoring network and overall air quality management can be further achieved through partnerships with academic institutions and private sector which can provide technical, financial, manpower, communication, and policy development support.
- In order to foster and implement these partnerships, it must be formalized and institutionalized through clear agreements (e.g. Memorandum of Agreement or Letter of Commitments) that identifies clear roles of parties. This is line with the participatory approach embodied in the Clean Air Act.


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Clean Air Asia is an international non-governmental organization leading the regional mission for better air quality, and healthier, more livable cities throughout Asia. Clean Air Asia’s approach is one of science-based, actionable guidance combined with an ethos of partnerships and collaboration to ensure our work has meaningful and sustainable impact.

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