

COVID19, Service, and Promotion Balik Scientist Program Exit Presentation

Christian Mark G. Salvador, Ph.D.

Atmospheric Chemistry and Air Pollution Caraga State University (CSU) DOST – Philippine Nuclear Research Institute (PNRI) August 2021 – February 2022 (180 days)



Outline

- Biography
- COVID19
- Service
- Promotion
- 5Ps Summary



Industry, Energy and Emerging Technology Sector

Specialization Earth System (Atmospheric Science)

Host Institutions

Caraga State University

Philippine Nuclear Research Institute

Short-term Engagement

l. Reviewed the Science and Technology Clean Air Roadmap 2019 - 2023

2. Drafted policy on the Reduction of Surface Ozone as an Atmospheric Oxidant in Butuan

3. Contributes to the analysis of long-term trends of atmospheric pollutants of Butuan, Metro Manila, and Boracay

4. Continuous sharing of knowledge and skills to students and researchers on comprehending the local air quality using sophisticated techiques, such as remote satellite data and mass spectrometric techniques

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Biography: Timeline of Scientific Milestones









Biography: Education

Doctor of Philosophy (Earth System Science – Atmospheric Sciences)

Taiwan International Graduate Program National Central University Advisor: Dr. Charles Chou (RCEC - Academia Sinica) **Thesis:** Perturbation of Urban Air Pollution on the Composition of Organic Aerosols in a Subtropical Forestry Area

Bachelor of Science in Chemistry

University of the Philippines – Diliman Advisor: Dr. Lilibeth Coo **Thesis:** The Comparative Air Analysis of the Institute of Chemistry, UP Diliman using Passive Sampler with Activated Charcoal and Commercially Available Adsorbent

Biography: Work

Postdoctoral Research Fellow University Researcher University of Gothenburg in Sweden

Aerosol formation and transformation Rapid and Online Mass Spectrometer for Chemical Characterization of Organic Aerosols Supervised MS and Ph.D. Students Indoor Air Analysis Forest-Urban Interaction International research collaborations





Research Directions: Aerosol Formation





Pierce et al., 2011, Ehn et al., 2014

Research Directions: Indoor Air Science







Major Research Projects

Biomass Burning in China (Formation of NACs)



Influence of Human emissions Indoor Environment



Urban-Forest Interaction



Emissions from Vehicles/Ship



BSP Overall Goal of the Engagements

To determine the composition and trend of the atmospheric pollutants using advanced mass spectrometric techniques which will provide important insights to be used for new environmental policies

- Aerosol composition will dictate the major sources of pollution
- Long term trends of atmospheric pollutants, particularly ozone and particulate matter



COVID19 New Cases in the Philippines



Instruments and Filters were ready but...





Service during BSP Engagement



BSP Lecture Series



Balik- Scientist

_ECTURE SERIES



DR. CHRISTIAN MARK SALVADOR

AUG SPECIATION OF ORGANIC AEROSOLS: THE

- 10 DEVELOPMENTS OF ONLINE MASS SPECTROMETERS AND THEIR APPLICATION IN THE PHILIPPINES
- AUG INDOOR AIR SCIENCE: STEALTH POLLUTANTS AND 17 TRANSMISSION OF COVID PARTICLES
- AUG TUTORIAL/WORKSHOP OF SOFTWARE FOR
- 24 ATMOSPHERIC CHEMISTRY

DR. MIKE PRIESTLEY

AUG EMISSION FROM COMBUSTION PROCESSES AND 31 NON-NEGATIVE FACTORIZATION (NMF)

22 🚳 🔁 🔁 🐇 😂

- Joint effort of DOST-PNRI and CSU in promoting and organizing the event
- More than **2,000 faculty members, researchers and, students** from different higher academic institutions all around the Philippines registered for the event
- At least 300 participants per lecture, with some events reaching more than 600 attendees

1st Lecture: Organic Aerosols and Mass Spectrometer

- Understanding the molecular composition of aerosols is a crucial information
- New advances in Mass Spectrometry • reveal new information regarding the formation and trends of aerosols
- The mixed sources of pollution were uncovered with the combination of MS techniques and Satellite Data.



40

Euro V

0.6 0.6

0.4



2nd Lecture: Indoor Air and COVID19





- Indoor air studies are vital as humans spend more than 90% indoors
- Ambient atmospheric techniques should be implemented indoors
- Humans are indoor polluters
- **#COVIDisAirborne.** Transmission of COVID19 can be reduced with proper ventilation and filtration

Use CO₂ level as an indicator of the **degree of transmission risk indoors**

#COVIDisAirborne: PNRI's Indoor Air Infographic





3rd Lecture: Tutorial/Workshop on Free Atmospheric Chemistry Software

- GIOVANNI Online tool for visualization, exploration, analysis of NASA Earth Science Data
- MCM-ATCHEM Simulation of gasphase chemical processes involved in the tropospheric degradation of VOCs
- **HYSPLIT** Model calculation of longrange transport pollutants
- Training data sets were provided to DOST-PCIEERD





TUTORIAL/ WORKSHOP OF Software for Atmospheric Chemistry



ZOOM 曲 AUGUST 24 览 2:00 РМ

DR. CHRISTIAN MARK SALVADOR

University Researcher Department of Chemistry and Molecular Biology University of Gothenburg – Sweden

BALIK-SCIENTIST

ecture Series

72 🕑 🕺 72 😤 🤰 😂

4th Lecture: Combustion Processes and NMF





- Pellets over Wood in Boilers
- Reducing pellet fuel loading increases Brown Carbon emissions
- Increasing pellets boiler usage will decrease National PM_{2.5} and BC
- **NMF** to simplify complex datasets, dimensional reduction
- Two-factor solution clustered into 4 groups shows an increase in emissions from trucks.







Particulate Matter (PM) and Ozone (O_3)

- Atmospheric aerosols vary in size and chemical composition
- PM has a significant impact on health and climate
- Ozone is beneficial in stratosphere but not in troposphere (ground level)
- Ozone and OH radicals serve as oxidant to generate PM and other harmful gases
- Elevated O₃ also lead to several respiratory problems

Long term Pollution Trends and Southern Philippines (Butuan)

- In-depth analysis of atmospheric pollutants in the **Southern Philippines is limited**
- CSU, together with DENR-EMB 13, monitored meteorology and pollutants (PM, O3, SO₂) since 2014
- Long-term air quality data sets are essential to evaluate the trends and changes in the emission of atmospheric pollutants









Integration of Satellite Data: GIOVANNI and MERRAero

- **GIOVANNI and MERRAero** were utilized to support and validate ground measurements
- MERRAero is a surface data based on assimilation model and remote sensing
- **Speciated data:** Sulfate, Organic Matter, Sulfate, Black Carbon, dust and Sea Salt

 $PM_{2.5} = 1.375 \times (SO_4) + 1.4 \times [OC] + [BC] + [DS_{2.5}] + [SS_{2.5}]$

Influence of Meteorology and Vehicular Emissions



- Moderate anticorrelation was calculated for both relative humidity and precipitation amount
- Wet deposition contributed to the sink of PM
- The general yearly trend of PM responded well to **traffic volume**

Speciation of Aerosols: Impact of Sea Salt and OM

- Sea salt dominated the mass concentration of PM_{2.5} in Butuan, contributing 58% on average (max 80%)
- OM contributed 20%, especially during spikes in 2015 and 2019.
- Source of OM: Transboundary transport of biomass burning



Threat of Increasing Ozone Level in Butuan



- Trend analysis indicated that O₃ and NO₂ increased by 0.409 ppb year⁻¹ and 0.683 ppb year⁻¹.
- The upward trend of ozone and NO₂ in the southern Philippines was attributed to the growing emissions of automobiles

Contribution of VOCs from Vehicles

- Benzene, Toluene, Xylene increased by 0.238, 1.63, and 0.662 ppb year⁻¹
- The three AVOCs contributed 8.13 (benzene), 133.04 (toluene), and 94.22 (xylene) μg m⁻³ in ozone formation
- More focus should be given to the reduction of Ozone instead of PM



 $OFP_i = [VOC]i \times MIR_i$

COVID-19 Improves Air Quality in Just Three Months

Weekly average concentration of NO₂ in the air in selected cities (Feb-Apr 2020)*



Central locations

 \star 95 percent of NO_2 in the air is caused by fossil fuel combustion Source: World Air Quality Index (WAQI)





Response of PM and O_3 to COVID19 in Butuan

- In 2020, several across the world reported a significant reduction in ambient aerosol mass due to widespread government-enforced lockdown measures
- No noticeable changes in the trend of PM_{2.5} were observed in Butuan
- Ozone reported an increase of 104% in 2020 (37.36 ppb) compared to the data collected in April and May of 2019 (18.31 ppb).

Submission and Publication in International Journal (AAQR)



Assessment of Impact of Meteorology and Precursor in Long-Term Trends of PM and Ozone in a Tropical City

Manuscript IDAAQR-21-10-OA-0269Manuscript Type:Original ArticleDate Submitted by the Author:05-Oct-2021Complete List of Authors:Salvador, Christian Mark; Department of Science and Technology, Philippine Council for Industry, Energy and Emerging Technology Research and Development; Alindajao, Angeles; Integrated Laboratories Division, Department of Agriculture - Regional Field Office XIII, Taguibo, Butuan City, Philippines; Department of Mathematics, Caraga State University, Ampayon, Butuan City, Philippines; Department of Mathematics, Caraga State University, Ampayon, Butuan City, Philippines; Department of Mathematics, Caraga State University, Ampayon, Butuan City, Philippines Hanagement Research and Training Center, Caraga State University, Ampayon, Butuan City, Philippines, Management Research and Training Center, Caraga State University, Ampayon, Butuan City, Philippines, Mineral Resources Management Research and Training Center, Caraga State University, Ampayon, Butuan City, Philippines, Mineral Resources Management Research Institute, Commonwealth Avenue, Diliman, Quezon City, Philippines Bautista VII, Angel; Department of Science and Technology (Philippines) - Philippine Nuclear Research Institute, Commonwealth Avenue, Diliman, Quezon City, Philippines Pabroa, Preciosa Corazon; Philippine Nuclear Research Institute, Commonwealth Avenue, Diliman, Quezon City, Philippines Pabroa, Preciosa Corazon; Philippine Nuclear Research Institute, CAPANGPANGAN, REY; Mindanao State University-Naawan Campus, Department of Physical Sciences and MathematicsKeywords:MERRAero, Ozone forming potential, Tropical city, Long-term trends	Journal:	Aerosol and Air Quality Research
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	Keywords:	MERRAero, Ozone forming potential, Tropical city, Long-term trends



Research

Assessment of Impact of Meteorology and Precursor in Long-term Trends of PM and Ozone in a Tropical City

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ABSTRACT

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ORIGINAL RESEARCH

https://doi.org/10.4209/aaqr.210269

Reduction of Surface Ozone as an Atmospheric Oxidant in Butuan

Christian Mark Garcia Salvador, Ph.D.

Balik Scientist Department of Science and Technology-Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD) Hosted by: Caraga State University and DOST Philippine Nuclear Research Institute August 2021-January 2022

Executive Summary/Purpose Statement

Ozone (stratospheric) has been regarded as beneficial in the atmosphere as it protects against harmful radiation. However, ground (tropospheric) ozone poses a threat to health as it can induce acute respiratory problems. More importantly, it serves as an oxidant that initiates atmospheric reactions that produce oxygenated pollutants and particulate matter (PM). In the last seven years, the atmospheric oxidation capacity of Butuan was steadily increasing, which was accounted for by the enhancement of precursor volatile organic compounds (VOCs, Benzene, Toluene, Xylene) emitted from vehicles. More stringent regulations on vehicle exhaust emissions should be implemented. It is also recommended to include after-treatment exhaust systems to curb the emissions of both VOCs and, NO_x which are the main precursors of ozone formation.

Background

Elevated concentration ozone in the atmosphere is widely known as a good indicator of atmospheric protection against harmful ultraviolet rays coming from the Sun. The ozone layer reduces the exposure of humans to UVB radiation, which can cause premature aging and skin cancer. However, this is only true if the ozone is situated 10 to 15 kilometers above the surface of the earth. At ground level, tropospheric ozone is harmful to the people and environment due to its oxidation capacity. Ozone is delirious to human health; exposure to it resulted in over eight million premature deaths per year. Elevated concentration of ozone can also lead to reduced lung function, chest pain, throat infection, asthma, and bronchitis. Also, few sensitive crops and vegetation such as ponderosa pine can hamper photosynthesis and plant growth, which can change ecosystem habitat quality and nutrient cycles. More importantly, higher tropospheric ozone elevates the atmospheric oxidation potential which accelerates processes that leads to poor air quality.

Unlike primary pollutants like particulate matter and carbon monoxide, ozone is not directly emitted to the atmosphere, instead, chemical reactions of nitrogen oxides (NO_x) and VOCs generate ozone in the troposphere. In urban areas like Butuan, the main sources of NO_x and VOCs are automobile exhausts. Reduction of the emissions of benzene, toluene, xylene, and NO₂ from vehicles would result in to decrease in ozone at ground level.

Analysis

Since 2014, the DENR-Environmental Management Bureau of Region XII has been measuring atmospheric pollutants such as PM, O_3 , SO_2 , CO, and VOCs. The measurement station is situated in the Caraga State University, which provides a good representative of the atmospheric conditions of an urban environment with a busy transport sector. The mean concentration of ozone during the seven-year measurement was 22.3±9.5 ppb. No hourly data was available for

Policy Paper on Ozone Reduction in Butuan

- Based on the results of long-term trends of pollutants in Butuan, a policy recommendation was conveyed to DENR-EMB Region 13.
- Monitoring and reduction of Ozone should be prioritized to limit respiratory problems and secondary production of pollutants

Regional PM Mass of Metro Manila and Boracay



- Metro Manila and Boracay are two of the most crucial urban regions in the Philippines
- The total area of NCR is 619.57 sq. kilometers with a dense population of 13,484,462 in 2020:
- In 2015, the number of tourists increased to 1.5 million, contributing to unprecedented anthropogenic activities in this area

Profile and Sources of Regional PM_{2.5}

- Metro Manila and Boracay PM Mass:
 12.3 ± 2.4 and 12.9 ± 3.6 μg m⁻³
- Major Component: Sea Salt followed by OM (Boracay) and Sulfate (Metro Manila)
- Regional PM underestimated the groundbased measurement by at least 50% due to missing NO₃



Black Carbon and OM: Long Range Transport



- Metro Manila recorded 0.30 ± 0.16 μg m⁻³ average concentration of BC, twice the mean values observed in Boracay (0.17 ± 0.16 μg m⁻³)
- Two periods (September 2015 and 2019) with prominent spikes of OM were observed in MM and Boracay, (OM > 7μg m⁻³)
- The suspected source of high OM, as well as BC, was biomass burning, rampant in equatorial
 Southeast Asia between August to October and intensified by southwest monsoon

Formation of Sulfate and its Contribution to PM

- Sulfate had a significant mass burden in PM mass of Metro Manila
- In the megacity, **photochemistry** was one of the drivers of the formation of sulfate aerosols.
- High aerosol liquid water content during the 2nd half of the year induced multiphase oxidation of SO₂ in aerosol particles



Submission to International Journal (AAQR)

Variability and Source Characterization of Regional PM of Two Urban Areas Dominated by Biomass Burning and Anthropogenic Emission

Special Issue on Air Pollution and its Impact in South and Southeast Asia

🖿 List of Issues Articles In Press 🏥 12 April 2022 💿 Reach: 180

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Urban Air Quality South East Asia

Christian Mark G. Salvador ⁽[®] ■ ¹, Jhon Robin dR. Yee², lara Chantrelle V. Coronel², Angel T. Bautista VII², Raymond J. Sugcang², Mark Anthony M. Lavapiez³, Rey Y. Capangpangan ^{(®} ⁴, Preciosa Corazon B. Pabroa ^{(®} ■ ²

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Call for Papers

Aerosol and Air Quality Research



Call for Papers for the special issue on "Air Pollution and its Impact in South and Southeast Asia"

Submitted: January 16, 2021 Accepted: April 12, 2022

Ultrafine Particles (UFP) and their effect on Health





- Death due to exposure to PM is increasing even with decreasing trends of PM₁₀ and PM_{2.5} in the Philippine
- Ultrafine particles are aerosols with an aerodynamic diameter of 0.1 μm or less.
- UFPs constitute the largest fraction of aerosol in terms of particle number, particularly in urban areas
- Currently, UFPs are not monitored due to lack of environmental limits and policies

Policy Paper on UFPs

Assessment of Exposure of Filipinos to Atmospheric Ultrafine Particles: Missing Cause of Mortality from PM

Christian Mark Garcia Salvador, Ph.D.

Balik Scientist Department of Science and Technology-Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD) Hosted by: Caraga State University and DOST Philippine Nuclear Research Institute August 2021-January 2022

Executive Summary/Purpose Statement

In the last few years, the reported annual $PM_{2.5}$ and PM_{10} (particles with diameter less than 2.5 and 10 µm) of the Philippines rarely exceeded the yearly mass concentration limits set by the Department of Environment and Natural Resources (DENR). However, the estimated death due to exposure to ambient particulate matter is still increasing (690 deaths per year) with 32,018 deaths in 2019, which was almost 6500 more compared to 2010 (fig S1). The disconnect between the typical air quality parameter and mortality count indicates there must be another parameter contributing to the increasing death of the Filipinos due to poor air quality. Here, ultrafine particles (UFPs) are recommended to be considered as an air quality indicator, in addition to $PM_{2.5}$ and PM_{10} . UFPs, or particles with a diameter less than 100 nm, can easily penetrate the deepest lung areas. With high surface area available, harmful compounds can partition into these particles and cause health problems such as pulmonary infection, diabetes, and cancer. Thus, it is highly recommended that besides the particle mass concentration, particle number concentration should be monitored particularly in urban areas with significant vehicle emissions.

Background

Particulate matter is typically described based on its size (i.e. diameter), which is directly linked to its potential to inflict health problems. Particles with a diameter of less than 10 µm can be inhaled and pass through the nose and throat with varying resistance/hindrance depending on the size of the particles. Inhaled particles between 5 to 10 µm are removed by alveolar macrophages and lung lymphatics while significant accumulation of 1 to 2.5 µm particles is observed at terminal bronchiole. Smaller particles, particularly UFPs, can easily infiltrate the alveoli of the lungs. Technically, UPFs are still a component of PM₁₀ and PM_{2.5}, however, these two air quality parameters are usually described in terms of mass concentration, in which the UFP contributes insignificantly. UFPs dominate the particle number concentration (PNC) of the ambient aerosols, while larger particles report low PNC due to coagulation and condensation (see fig S2).

The physical dimensions of UFP induce more health problems compared to larger particles, particularly for people who usually spend so much time in the street and roadside. UFPs have a larger surface area where toxic compounds can be adsorbed on the surface and can inflict a myriad of health dilemmas such as lung inflammation. Exposure to UFPs cause DNA exidative

- A policy paper was drafted regarding the importance of monitoring and analyzing UFPs in different regions of the Philippines.
- UFPs may be the missing link between the increasing mortality and decreasing levels of PM
- The ultimate goals are to identify locally available standardized methods that can measure UFPs and to set an atmospheric limit of concentration of UFP
- The policy paper was sent to Environment Sector, Industrial Technology Development Division (ITDD), PCIEERD - DOST



(1) PROJECT PROFILE Program Title: Project Title: Atmospheric Ultrafine particles: A New Metric for Health and Air Quality Project Leader/Sex: Christian Mark Salvador, Ph.D. (Balik Scientist) with Mark Anthony Lavapiez Project Duration (number of months): Project Start Date: Project End Date: Implementing Agency Caraga State University -Department of Chemistry Address/Telephone/Fax/Email KM 7 NH1, Butuan City, Agusan del Norte, Caraga Region/09985359620/ mmlavapiez@carsu.edu.ph

(2) COOPERATING AGENCY/IES (Name/s and Address/es)

Dr. Preciosa Pabroa and Dr. Angel Bautista VII- Philippine Nuclear Research Institute (DOST-PNRI) - Commonwealth Avenue, Diliman, Quezon City

Dr. Rey Capangpangan - Mindanao State University Naawan Campus - Pedro Pagalan St., Poblacion, Naawan, Misamis Oriental

Prof. Judelyn Patero - Surigao Del Sur State University (SDSSU) - Cantilan, 8317 Surigao del Sur

(3) SITE(S) OF	IMPLEMENTA	TION				
IMPLEMEN TATION SITES NO.	COUNTRY	REGION	PROVINCE	DISTRICT	MUNICIPA LITY	BARANGAY
1.	Philippines	13	Agusan Del Norte (Butuan)			
2.	Philippines	NCR	Quezon City			
3.	Philippines	10	Misamis Oriental (Naawan)			
4.	Philippines	13	Surigao Del Sur			
(4) TYPE OF RESEARCH (5) R&D PRIORITY AREA & PROGRAM (based of HNRDA 2017-2022) ✓ Applied Agriculture, Aquatic and Natural Resource ✓ Applied Agriculture, Aquatic and Natural Resource ✓ Industry, Energy and Emerging Technolo Sector: Atmosphere/Air Quality ✓ Disaster Risk Reduction and Climate Change Adaptation ✓ Basic Research Basic Research				(based on Resources - echnology mate		
Sustainable Development Goal (SDG) Addressed			Goal 3: Good he Goal 13: Climate	ealth and well-t e action	peing	

Research Proposal on UFPs

- A multi-institution/university proposal was drafted with the overall aim of establishing local limits on UFP levels
- UFPs in several regions in the Philippines with different atmospheric conditions will be accessed to ambient concentration of UFPs
- Understanding the variability of ambient UFPs will also improve our knowledge of extreme atmospheric pollution events

#COVIDisAirbone: Research Proposal in limiting Indoor Transmission

- COVID19 has caused several mortalities across the globe and COVID19 is here to stay.
- Airborne transmission is more prevalent compared to other modes of infection
- One of the most promising approaches in limiting indoor transmission of COVID19 is the utilization of air purifiers that can be easily integrated into closed space areas
- Air purifiers are expensive, especially those with "gimmicks" (e.g. ionizers) that do not necessarily reduce SARS-COV-2 air concentration.



DOST Form 2 (for Basic/Applied Research) DETAILED RESEARCH & DEVELOPMENT PROJECT PROPOSAL

(1) PROJECT PROFILE Program Title:

Project Title: Modified Corsi-Rosenthal Box: Development and analysis of an inexpensive and locally available air-purifier for the reduction of COVID-19 transmission Project Leader/Sex: Dr. Preciosa Corazon B. Pabroa (Female) with Balik Scientist Dr. Christian Mark Salvador Project Duration (number of months): 12 months Project Start Date: January 1, 2023 Project End Date: December 31, 2023 Implementing Agency (Name of University-College-Institute, Department/Organization or Company): Department of Science and Technology (Philippines) - Philippine Nuclear Research Institute

Address/Telephone/Fax/Email (Barangay, Municipality, District, Province, Region): Commonwealth Avenue, Diliman, Quezon City, 1101, National Capital Region pcbpabroa@pnri.dost.gov.ph

(2) COOPERATING AGENCY/IES (Name/s and Address/es)

(3) SITE(S) OF	IMPLEMENTA	TION				
IMPLEMEN	COUNTRY	REGION	PROVINCE	DISTRICT	MUNICIPALITY	BARANGAY
TATION						
SITES NO.						
1.						
2.						
3.						
4.						
5.						

(4) TYPE OF RESEARCH Basic ✓_ Applied	(5) R&D PRIORITY AREA & PROGRAM (based on HNRDA 2017-2022) Agriculture, Aquatic and Natural Resources Commodity: Health Priority Topic: Industry, Energy and Emerging Technology Sector: Disaster Risk Reduction and Climate Change Adaptation Basic Research Sector:
Sustainable Development Goal (SDG) Addressed	Goal 3: Good health and well-being

Promotion of Balik Scientist Program



Invited Talks as Balik Scientist: ASIANALYSIS 2021



Invited Speech

I-18

Identification of Chemical Markers in Submicron Organic Aerosols: Implications for Source Attribution

Christian Mark Salvador¹ and Charles C.-K. Chou²

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 Research Centre for Environmental Changes, Academia Sinica, Taipei 11529, Taiwan

Scientific studies have indicated that atmospheric aerosols could have significant impacts on the climate system and also the public health. Organic matter is one of the major components of the atmospheric aerosols; however, due to the complexity in its composition and some technical reasons, the content of organic matter in aerosols is usually reported in terms of "organic carbon" (OC) and the knowledge of the molecular composition is rather limited. In this study, we developed a TD-PTR-ToF-MS for characterization of organic matters contained in atmospheric aerosols [1]. This instrument has been deployed to investigate molecular composition of submicron aerosols in a forested area in western Taiwan [2]. The results show that the major ions detected by the TD-PTR-ToF-MS account for $\sim 80\%$ of the mass of organics loaded on filter samples. We retrieved molecular information of tog 30 compounds in this study and, furthermore, identified 3 groups of markers, representing impacts of urban pollution, biomass burning, and biogenic aerosols, respectively. Fig. 1 illustrates the time series and molecular composition of the markers, which account for 16%, 9%, and 6% of the total organic mass. The results of this study evidence the intrusion of urban air pollution into downwind forested areas in the western Taiwan.

DOST-BALIK SCIENTIST PROGRAM (BSP) Balik Puso, Balik Pilipinas, Balik Scientist

BSP is the brain gain initiative of the government which aims to tap into the ingenuity and expertise of Filipinos abroad to strengthen the S&T capabilities of local researchers in the academe, public and private sectors, and industry.

The program was established in 1975 and was later reinstated in the Department of Science and Technology (DOST) in 1993. The Republic Act 11035 also known as an"Act Institutionalizing the Balik Scientist Program" was signed by President Rodrigo Roa Duterte on June 15, 2018.

Who can apply?



Invited Talks as Balik Scientist: Air Quality FGD DOST-PCIEERD





High Resolution Mass Spectrometers for Air Quality Improvement

Christian Mark Salvador, Ph.D. University Researcher Department of Chemistry and Molecular Biology University of Gothenburg, Sweden **High Resolution Aerosol Mass Spectrometers**

Provides real-time chemical composition of aerosols such as chloride, nitrates, organic, and sulfates

Aerosol Mass Spectrometer (AMS) and ACSM measures mass loading and chemical composition of non-refractory aerosol particles in real-time

Chemical Ionization Time-of-Flight Mass Spectrometer (ToF-CIMS) provides real-time identification and quantification of gas-phase compounds in sampled air.





Invited Talks as Balik Scientist: Clean Air Virtual Forum







Influence of New Vehicle Exhaust **Emission Standards on Air Quality**

	Liyuan Zhou, Åsa M. Hallquist, Mattias Hallquist,
25	Michael Priestley, Samuel M. Gaita, Ake Sjödin, Martin Jerksjö, Håkan Salberg, Ingvar Wängberg,
	Johan Mellqvist, Qianyun Liu, Berto P. Lee, and Chak K. Chan



EURO Emission Standards and Philippines

∧ ∨ 5 of 16 @

○ To curb the air pollutants, **vehicle** emission standards were developed for new vehicles sold

- Most Recent: EURO 6
- ◎ In the Philippines, Cars should be integrated with EURO IV and V fuels





Invited Events: Balik Scientist Annual Convention

DOST

The Balik Scientist Program Annual Convention 2021

Meet our Modern Hero



DR. CHRISTIAN MARK G. SALVADOR

2021 Balik Scientist Awardee

Philippine Council for Industry, Energy, and Emerging Technology Research and Development

REN	IATE					fV	Search	HDS
	HOME	NEWS	ENTERTAINMENT	SPORTS	LIFESTYLE	TECH & TREND	OPINION	CA
sa Tsina	Dayuhan p	wede na sa	Pinas; mga kondisyo	n, rekisito ala	amin! Pa	gkawala ng mga sa	bungero, wal	a pan

A → NATIONWIDE, TOP STORIES →

Balik Scientists, pinalakas ang R&D sa Pilipinas sa gitna ng pandemya



Invited Events: Next Gen Round Table Discussion and AER49 Virtual Presser



	VIRTUAL PRESSER
PROGR	AMME OF ACTIVITIES mber 6, 2021 2:00 PM
Moderator Depu	r: <mark>Dr. Vallerie Ann I. Samson</mark> Ity Director, DOST-PNRI
Ho: Supervising Scie	st: Framelia V. Anonas ence Research Specialist, DOST-PNRI
PNRI Institutional Video	
Welcome Remarks	Dr. Preciosa Corazon B. Pabroa AEW Executive Committee Chairperson
Acknowledgment of Par	ticipating Media Friends
Message	Dr. Christian Mark G. Salvador Balik Scientist
Message	Dr. Thomas Neil B. Pascual, MHPEd S&T Fellow III
Introduction of the DOST	-PNRI Senior Staff
Atoms At Work in 2021	Dr. Carlo A. Arcilla DOST-PNRI Director
Q&A with Dr. Carlo Arcille and S&T Fellow	a and the Senior Staff with Balik Scientist
Closing Remarks	

Promotion: Courtesy Visits

Dean Esamel Paluga and Dr. Rolando Paluga of CSU



Engr. Andrea Cabonita of DOST-CARAGA





Dr. Intano and Prof. Juancho of SDSSU



Dr. Carlo Arcilla of PNRI

Promotion: Eight Publications as Balik Scientist

nature	Research Article	Status
ARTICLE https://doi.org/10.1038/s41467-022-28383-9 OPEN Dia a ta a diaga a sintia na a fi a su ti su la ta a si tu a ta a su ti su la ta a si tu a ta a su ti su la ta a si tu a ta a s	1) Photodissociation of particulate nitrate as a source of daytime tropospheric Cl_2	Accepted in Nature Communications (IF =14.919)
Photodissociation of particulate nitrate as a source of daytime tropospheric Cl ₂ Xiang Pengo ^{1,2} , Ta Wango ^{1™} , Weihao Wang ^{1,3} , R. Ravishankara o ⁴ , Christian George o ⁵ , Men Xia ¹ , Min Cai ⁶ , Qinyi Lio ⁷ , Christian Mark Salvador ^{8,15} , Ohio Lau ⁹ , Xiaopu Lyu ¹ , Chun Nan Poon ¹ , Abdelwahid Melloukto ⁷ , rujing Wu ²⁰ , Watuas Hallquisto ⁸ , Alfonso Saiz-Lopezo ⁷ , Hai Guo ¹ , Hartmut Herrmann o ^{11,12} , Chuan Yu ^{1,13} , Jianing Dai ^{1,16} , Yanan Wang ¹ , Xinke Wang ⁵ , Alfred Yu ⁹ , Kenneth Leung ⁹ , Shuncheng Lee ¹ & Jianmin Chen o ¹⁴	2) Assessment of Impact of Meteorology and Precursor in Long-term Trends of PM and Ozone in a Tropical City	Accepted in Aerosol and Air Quality Research
 ¹⁵Present address: Balik Scientist Program, Department of Science and Technology - Philippine Council for Industry, Energy and Emerging 	3) Variability and Source Characterization of Regional PM of Two Urban Tropical Cites: Biomass Burning vs Anthropogenic Emission	Accepted in Aerosol and Air Quality Research
Technology Research and Development, Bicutan, Taguig 1630	4) Molecular Composition of Submicron Organic Aerosols: Evidences Extensive Footprint of Urban Air Pollution	Under Review

Promotion: Eight Publications as Balik Scientist



Contents lists available at ScienceDirect

Atmospheric Pollution Research

journal homepage: www.elsevier.com/locate/apr



Characterization, source apportionment and associated health risk assessment of respirable air particulates in Metro Manila, Philippines

Preciosa Corazon B. Pabroa^{a,*}, Joseph Michael D. Racho^a, Arvin M. Jagonoy^a, Jeff Darren G. Valdez^a, Angel T. Bautista VII^a, Jhon Robin Yee^a, Rene Pineda^b, Juliot Manlanaz^b Armand L Atanacio^c, Iara Chantrelle V. Coronel^a,

David D. Cohen[°] Christian Mark G. Salvador

Philippine Nuclear Research Institute, Commonwealth Avenue, Diliman, Quezon City, 1101, Philippines ADB Avenue, Ortigas Center, Pasig City, 1605, Phil

Balik Scientist Program, Department of Science and Technology (Philippines) - Philippine Council for Industry, Energy and Emerging Technology Research and velopment, Bicutan, Taguig, 1630, Philippines

Research Article	Status
5) A four carbon organonitrate as a significant product of secondary isoprene chemistry	Under Review
 6) Characterization, Source Apportionment and Associated Health Risk Assessment of Respirable Air Particulates in Metro Manila, Philippines 	Accepted in Atmospheric Pollution Research
7) Particulate Matter Source Characterization: A Comparative Study of Highly Urbanized Areas vs. Prime Tourist Area in South East Asia	In Preparation
8) Health Risk Profiles of Highly Industrial Metropolis and A Prime Tourist Area in South East Asia	In Preparation

5Ps SUMMARY

5Ps Summary – People Trained and Publication

	Name	Duration	Place (if applicable)	
People Trained	Tutorial/Workshop of Software for Atmospheric Chemistry	2 hours with more than 200 participants	Online	
	Title of	Date of Submission		
	Assessment of Imp Precursor in Long- Ozone in a	act of Meteorology and term Trends of PM and a Tropical City	October 2021	
Publications	Variability and Sou Regional PM of Tw Biomass Burnin En	January 2022		

5Ps Summary – Presentation Made

	Title of Presentation	Date	Place
<section-header><section-header></section-header></section-header>	Speciation of Organic Aerosols: The developments of online mass Spectrometers and their application in the Philippines	August 2021	BSP lecture Series
	Indoor Air Science: Stealth pollutants and transmission of COVID particles.	August 2021	BSP lecture Series
	Emission from combustion processes and Non-Negative Matrix Factorization. (Mike Priestley)	August 2021	BSP lecture Series
	High-Resolution Mass Spectrometers for Air Quality Improvement	October 2021	PCIEERD Air Quality focus group discussion (Online)

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	High-Resolution Mass Spectrometers for Air Quality Improvement	October 2021	PCIEERD Air Quality focus group discussion (Online)

5Ps Summary – Presentation Made

	Title of Presentation	Date	Place
	Identification of Chemical Markers in Submicron Organic Aerosols: Implications for Source Attribution	October 2020	Asianalysis XV (Taipei, Taiwan)
Presentation made	High Resolution Mass Spectrometers for Air Quality Improvement	October 2020	PCIEERD Air Quality Focus Group Discussion
	Influence of New Vehicle Exhaust Emission Standards on Air Quality	November 2020	2021 Clean Air Virtual Forum

5Ps Summary - Proposals

	Title of Proposal	Date of submission	Funding Agency
	Atmospheric Ultrafine particles: A New Metric for Health and Air Quality	To be submitted	PCIEERD – Air Quality
Proposal	Modified Corsi-Rosenthal Box: Development and analysis of an inexpensive and locally available air- purifier for the reduction of COVID- 19 transmission	To be submitted	PCIEERD – Air Quality

5Ps Summary – Policy Papers

	Title of Proposal	Submitted to:
Policy Recommendation	Assessment of Exposure of Filipino to Atmospheric Ultrafine Particles: Missing Cause of Mortality from PM	Environment Sector, Industrial Technology Development Division (ITDD), PCIEERD - DOST
	Reduction of Surface Ozone as an Atmospheric Oxidant in Butuan	DENR-EMB Region 13.

5Ps Summary – Other Activities

		Activity	Date
	Other Activities	Project Planning Document	August 2021
		Preparation of filters and instruments for fieldwork measurement in Agusan del Norte and Metro Manila	August 2021
		Video Production for promotional materials for DOST- CARAGA National and Regional S&T week	October 2021
		Resource Speaker for the Balik Scientist Program (BSP) Annual Convention	November 2021

5Ps Summary – Other Activities

	Activity	Date
	Rapporteur for Next Generation Researchers Roundtable Discussion	November 2021
	Writing and Review of Three Research Papers of PNRI	Nov 2021 – Feb 2022
Other Activities	Proposal meeting with Dr. Custer Deocaris of PNRI and Air Quality Researchers from De la Salle University	December 2021
	Participation in Virtual Presser of DOST-PNRI for Atomic Energy Week-49	December 2021

Acknowledgments

- Dr. Preciosa Pabroa, Dr. Angel Bautista VII and Iara Coronel of DOST-PNRI
- Mark Lavapiez of CSU
- Dr. Rey Capangpangan of MSU Naawan
- Judelyn Patero of SDSSU
- Julie Atienza, Edz Rogelia and the rest of the BSP-DOST PCIEERD Team
- Atty Benigno De Guzman of POEA

Thank You!