ASSESSMENT OF RAINFALL ACIDITY AND ALKALINITY BEFORE AND DURING THE COVID-19 COMMUNITY LOCKDOWN IN METRO MANILA

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ABSTRACT

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The implication of community quarantine in Metro Manila, which lasted for a few months as a counter-measure to control the escalating COVID-19 pandemic, has dramatically restricted anthropogenic activities that may lead to rainfall acidity. This study aims to assess the effect of the COVID-19 lockdown on the rainwater composition of Metro Manila. The assessment was based on the data collected from Acid Deposition Monitoring Network in East Asia (EANET) for the study period from 2000 to 2021. The study employed statistical techniques such as Pearson correlation to see the relationship of rainfall pH concentration to meteorological parameters (rainfall amount, temperature, relative humidity, wind speed, wind direction) and; the Mann-Kendall test to determine the direction and significance of the detected rainfall acidity trends, while Sen's slope determined the magnitude of its increase or decrease; Two-sample t-test for identifying if the pre- and during lockdown has a significant difference. The accumulated results showed that among all the meteorological parameters used in this study, only the wind speed was found to have no significant correlation to the rainfall pH. However, the difference between the two periods using the t-test shows that the lockdown period has a lesser pH value, not necessarily crossing the regular rain threshold line but remaining mostly alkaline than pre-lockdown.

Keywords: acid rain, alkaline rain, quarantine, trend analysis, COVID-19, Metro Manila

(2020). Long-range aerosol transport and impacts on size-resolved aerosol composition in Metro Manila, Philippines. *Atmospheric Chemistry and Physics*, *20*(4), 2387–2405. https://doi.org/10.5194/acp-20-2387-2020

Data Report – EANET Acid Deposition Monitoring Network in East Asia. (n.d.). Retrieved June 9, 2023, from https://www.eanet.asia/about/site-information/

Davies, T. D., Kelly, P. M., Brimblecombe, P., Farmer, G., & Barthelmie, R. J. (1986). Acidity of Scottish rainfall influenced by climatic change. *Nature*, *322*(6077), Article 6077. https://doi.org/10.1038/322359a0

Diaz-Caneja, N., Bonet, A., Gutierrez, I., Martinez, A., & Villar, E. (1989). The chemical composition of rainfall in a city of Northern Spain. *Water, Air, and Soil Pollution*, *43*(3), 277–291. https://doi.org/10.1007/BF00279197

Edrada, E. M., Lopez, E. B., Villarama, J. B., Salva Villarama, E. P., Dagoc, B. F., Smith, C., Sayo, A. R., Verona, J. A., Trifalgar-Arches, J., Lazaro, J., Balinas, E. G. M., Telan, E. F. O., Roy, L., Galon, M., Florida, C. H. N., Ukawa, T., Villanueva, A. M. G., Saito, N., Nepomuceno, J. R., … Solante, R. M. (2020). First COVID-19 infections in the Philippines: A case report. *Tropical Medicine and Health*, *48*(1), 21. https://doi.org/10.1186/s41182-020-00203-0

Enano, J. O. (2021, August 12). *Taal still blowing off steam; safety warnings stay*. INQUIRER.Net. https://newsinfo.inquirer.net/1472506/taal-still-blowing-off-steam-safety-warnings-stay

Gautam, S. (2020). COVID-19: Air pollution remains low as people stay at home. *Air Quality, Atmosphere & Health*, *13*(7), 853–857. https://doi.org/10.1007/s11869-020-00842-6

Ge, B., Wang, Z., Gbaguidi, A. E., & Zhang, Q. (2016). Source Identification of Acid Rain Arising over Northeast China: Observed Evidence and Model Simulation. *Aerosol and Air Quality Research*, *16*(6), 1366–1377. https://doi.org/10.4209/aaqr.2015.05.0294

IQAir. (2022). *Manila Air Quality Index (AQI) and Philippines Air Pollution | IQAir*. https://www.iqair.com/philippines/ncr/manila

Kalisa, E., Fadlallah, S., Amani, M., Nahayo, L., & Habiyaremye, G. (2018). Temperature and air pollution relationship during heatwaves in Birmingham, UK. *Sustainable Cities and Society*, *43*, 111–120. https://doi.org/10.1016/j.scs.2018.08.033

Khare, P., Goel, A., Patel, D., & Behari, J. (2004). Chemical characterization of rainwater at a developing urban habitat of Northern India. *Atmospheric Research*, *69*(3), 135–145. https://doi.org/10.1016/j.atmosres.2003.10.002

Kulshrestha, U. C., Kulshrestha, M. J., Sekar, R., Vairamani, M., Sarkar, A. K., & Parashar, D. C. (2001). Investigation of Alkaline Nature of Rain Water in India. *Water, Air, and Soil Pollution*, *130*(1), 1685–1690. https://doi.org/10.1023/A:1013937906261

Kumar, P., Masago, Y., Mishra, B. K., & Fukushi, K. (2018). Evaluating future stress due to combined effect of climate change and rapid urbanization for Pasig-Marikina River, Manila. *Groundwater for Sustainable Development*, *6*, 227–234. https://doi.org/10.1016/j.gsd.2018.01.004

L. Atienza, M. E. (2021). The Philippines a Year under Lockdown. *Verfassungsblog: On Matters Constitutional*. https://doi.org/10.17176/20210426-173702-0

Lalu, G. P. (2021, July 3). *Taal Volcano remains restive, minor eruptions recorded—Phivolcs*. INQUIRER.Net. https://newsinfo.inquirer.net/1454872/taal-volcanos-main-crater-still-upwelling-small-eruptions-recorded

Lenntech. (n.d.). *Effects of acids and alkalis on aquatic life*. Retrieved June 12, 2023, from https://www.lenntech.com/aquatic/acids-alkalis.htm?fbclid=IwAR17n-g5hDdmLUqhgW_o4aVUyePq8-tcsPHCHiPlPcz1A1xgNJrRqJaY2_0

Likens, G., Wright, R., Galloway, J., & Butler, T. (1979). Acid Rain. *Scientific American, a Division of Nature America, Inc.*, *241, No. 4*, 43–51.

Liu, Y., Zhou, Y., & Lu, J. (2020). Exploring the relationship between air pollution and meteorological conditions in China under environmental governance. *Scientific Reports*, *10*(1), Article 1. https://doi.org/10.1038/s41598-020-71338-7

Losno, R., Bergametti, G., Carlier, P., & Mouvier, G. (1991). Major ions in marine rainwater with attention to sources of alkaline and acidic species. *Atmospheric Environment. Part A. General Topics*, *25*(3), 763–770. https://doi.org/10.1016/0960-1686(91)90074-H

Ma, L., Dadashazar, H., Hilario, M. R. A., Cambaliza, M. O., Lorenzo, G. R., Simpas, J. B., Nguyen, P., & Sorooshian, A. (2021). Contrasting wet deposition composition between three diverse islands and coastal North American sites. *Atmospheric Environment (Oxford, England : 1994)*, *244*, 117919. https://doi.org/10.1016/j.atmosenv.2020.117919

Mohajan, H. (2018, October 17). *Acid Rain is a Local Environment Pollution but Global Concern* [MPRA Paper]. https://mpra.ub.uni-muenchen.de/91622/

Nicomedes, C. J. C., & Avila, R. M. A. (2020). An analysis on the panic during COVID-19 pandemic through an online form. *Journal of Affective Disorders*, *276*, 14–22. https://doi.org/10.1016/j.jad.2020.06.046

Otmani, A., Benchrif, A., Tahri, M., Bounakhla, M., Chakir, E. M., El Bouch, M., & Krombi, M. (2020). Impact of Covid-19 lockdown on PM10, SO2 and NO2 concentrations in Salé City (Morocco). *Science of The Total Environment*, *735*, 139541. https://doi.org/10.1016/j.scitotenv.2020.139541

Pasia, J. S., EnP Torrentira Jr. PhD, M. C., Navarra, H. C., & Makilan, M. (2020). *Air Quality Trends amid Covid-19 Lockdown in Metro Manila, Philippines: A Preliminary Case Review | Journal of Humanities and Social Sciences Studies*. *2*(6). https://doi.org/10.32996/jhsss.2020.2.6.16

Pathak, R. K., Yao, X., Lau, A. K. H., & Chan, C. K. (2003). Acidity and concentrations of ionic species of PM2.5 in Hong Kong. *Atmospheric Environment*, *37*(8), 1113–1124. https://doi.org/10.1016/S1352-2310(02)00958-5

Payus, C. M., Jikilim, C., & Sentian, J. (2020). Rainwater chemistry of acid precipitation occurrences due to long-range transboundary haze pollution and prolonged drought events during southwest monsoon season: Climate change driven. *Heliyon*, *6*(9), e04997. https://doi.org/10.1016/j.heliyon.2020.e04997

Pervaiz, S., Javid, K., Khan, F. Z., Zahid, Y., & Akram, M. A. N. (2020). Preliminary Assessment of Air During COVID-19 Lockdown: An Unintended Benefit to Environment: DOI: 10.32526/ennrj.18.4.2020.35. *Environment and Natural Resources Journal*, *18*(4), Article 4.

Prakash, J., Agrawal, S. B., & Agrawal, M. (2023). Global Trends of Acidity in Rainfall and Its Impact on Plants and Soil. *Journal of Soil Science and Plant Nutrition*, *23*(1), 398–419. https://doi.org/10.1007/s42729-022-01051-z

Proclamation No. 922 s. 2020 | GOVPH. (n.d.). Official Gazette of the Republic of the Philippines. Retrieved March 29, 2022, from https://mirror.officialgazette.gov.ph/2020/03/08/proclamation-no-922-s-2020/

PSA. (2021, August 23). *Highlights of the National Capital Region (NCR) Population 2020 Census of Population and Housing (2020 CPH) | Philippine Statistics Authority*. https://psa.gov.ph/content/highlights-national-capital-region-ncr-population-2020-census-population-and-housing-2020

Queensland Government. (2016, September 27). *Nitrogen oxides | Air pollutants*. corporateName=The State of Queensland; jurisdiction=Queensland.

https://www.qld.gov.au/environment/pollution/monitoring/air/air-pollution/pollutants/nitrogen-oxides

Ravelo, C. (2022, September 16). *Stepwise Regression: What is it and should you use it?* Statistics Solutions. https://www.statisticssolutions.com/stepwise-regression-what-is-it-and-should-you-use-it/

Regmi, R. (2018). Urbanization and Related Environmental Issues of Metro Manila. *Journal of Advanced College of Engineering and Management*, *3*, 79. https://doi.org/10.3126/jacem.v3i0.18906

Saxena, A., Sharma, S., Kulshrestha, U. C., & Srivastava, S. S. (1991). Factors affecting alkaline nature of rain water in Agra (India). *Environmental Pollution*, *74*(2), 129–138. https://doi.org/10.1016/0269-7491(91)90109-A

Sheng, L., Gao, H., Zhang, Y., Pang, H., & Lei, H. (2002). [Observational characteristics of the concentrations of NOx, O3, SO2 and CO over Bohai Sea in summer]. *Huan jing ke xue= Huanjing kexue*, *23*(6), 31–35.

Singh, A., & Agrawal, M. (2008). *Acid rain and its ecological consequences*. 10.

Singh, B., Nobert, M., & Zwack, P. (1987). Rainfall acidity as related to meteorological parameters in Northern Quebec. *Atmospheric Environment (1967)*, *21*(4), 825–842. https://doi.org/10.1016/0004-6981(87)90079-5

Tanner, P. A., & Law, P.-T. (2002). Effects of Synoptic Weather Systems Upon the Air Quality in an Asian Megacity. *Water, Air, and Soil Pollution*, *136*(1), 105–124. https://doi.org/10.1023/A:1015275404592

UCAR. (2022). *How Weather Affects Air Quality | Center for Science Education | University Corporation for Atmospheric Research*. https://scied.ucar.edu/learning-zone/air-quality/how-weather-affects-air-quality

US EPA. (n.d.). *Acid Rain Students Site: PH Scale*. Retrieved June 12, 2023, from https://www3.epa.gov/acidrain/education/site_students/phscale.html

US EPA. (2016a, February 9). *What is Acid Rain?* https://www.epa.gov/acidrain/what-acid-rain

US EPA. (2022). *Nitrogen Oxides Control Regulations | Ground-level Ozone | New England | United States Environmental Protection Agency* [Overviews & Factsheets,]. https://www3.epa.gov/region1/airquality/nox.html

US EPA, O. (2016b, June 2). *Sulfur Dioxide Basics* [Overviews and Factsheets]. https://www.epa.gov/so2-pollution/sulfur-dioxide-basics

Vlasov, D., Kasimov, N., Eremina, I., Shinkareva, G., & Chubarova, N. (2023). Major ions and potentially toxic elements in atmospheric precipitation during the COVID-19 lockdown in Moscow megacity. *Urban Climate*, *48*, 101422. https://doi.org/10.1016/j.uclim.2023.101422

Waikato Regional Council. (2022). *Weather and air quality*. Waikato Regional Council. https://www.waikatoregion.govt.nz/environment/air/weather-and-air/

Wei, H., Liu, W., Zhang, J., & Qin, Z. (2017). Effects of simulated acid rain on soil fauna community composition and their ecological niches. *Environmental Pollution*, *220*, 460–468. https://doi.org/10.1016/j.envpol.2016.09.088

Zhang, X., Jiang, H., Jin, J., Xu, X., & Zhang, Q. (2012). Analysis of acid rain patterns in northeastern China using a decision tree method. *Atmospheric Environment*, *46*, 590–596. https://doi.org/10.1016/j.atmosenv.2011.03.004