The Life In Dirt: Air Pollution Over The Korean Peninsula

Seoul, the capital city of South Korea, has been breaking record levels of air pollution, continuously reaching a higher density of particulate matter. In the winter of 2018, Seoul picked 101 micrograms per cubic meter of fine dust (PM2.5) (Hong, 2018). It is now usual for Korean people to put on a KF80 or KF94 mask whenever going outside, where KF stands for Korean Filter and is an official approval mark as reliable prevention of fine dust authorized by the Ministry of Food and Drug Safety (Ahn, 2018). The recent severe air pollution of particulate matter emerges as a 'social disaster' since the pollution is getting worse and people's criticisms and concerns are mounted (McCurry, 2019). To address this environmental hazard, this paper will discuss what a particulate matter is, how it affects human health, why Korean Peninsula is suffering from the worst air pollution in recent years, and how the Korean government and other foreign governments may retrieve the pollution.

Figure 1. Visible air pollution during nighttime at Songdo International Business District, South Korea. March 11, 2018. Copyright 2018 by Kangmin Cho.

The major cause of the air pollution of the Korean Peninsula is particulate matter, which refers to invisible nano-particles, specifically, "a mixture of solid particles and liquid droplets found in the air," according to the Environmental Protection Agency (EPA) (n.d.). Most particles are generated from chemical reactions such as sulfur dioxide and nitrogen oxides, and it is usually the result of pollutant emissions from automobiles, factories, and power plants (EPA, n.d.). Among all types of particles, the problematic size of particulate matter is 2.5 micrometers and smaller, which is simply called PM2.5. Since PM2.5 is extremely small that can only be observed by the electron microscope so that it easily passes into the internal organs of humans, it has great threats to human health especially in terms of the respiratory system including throat, lung, and heart. Specifically, an increase in coughing or difficulties in breathing, irregular heartbeat, and even premature death with heart or lung disease can be provoked (EPA, n.d.). One recent research, Lelieveld et al. (2019) from the European Heart Journal, estimated that around 790,000 people face premature death each year in Europe due to polluted air (see Figure 2), which is killing a greater number of people than that of tobacco smoking (Carrington, 2019). Moreover, the U.S. Centers for Disease Control and Prevention pointed out that PM2.5 is associated with adverse birth outcomes and lung cancer (2018). It also becomes one of the major causes of asthma, a chronic disease that inflames and narrows the airways of lungs (National Heart, Lung, and Blood Institute, n.d.).

Figure 2. Estimated excess deaths attributed to air pollution in Europe by disease categories. Jos Lelieveld, Klaus Klingmüller, Andrea Pozzer, Ulrich Pöschl, Mohammed Fnais, Andreas Daiber, Thomas Münzel. (2019). Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions, European Heart Journal, Volume 40, Issue 20, 21 May 2019, Pages 1590–1596, https://doi.org/10.1093/eurheartj/ehz135

Generally, air pollution by particulate matter is caused by internal sources such as industries, automobiles, and power plants. However, external sources due to its geographical location considerably contribute to the air pollution of the Korean Peninsula (Figure 3). The neighboring countries of the west, China and Mongolia, affect the air quality of South Korea frequently

especially when the winter monsoon and westerlies become predominant during winter and spring respectively. The Winter monsoon of Northeast Asia, which is a northwest wind from inner Asia to the Pacific Ocean due to colder continent and warmer ocean, and prevailing westerlies from the west to the east, transports the dust from Mongolia's Gobi Desert (called yellow dust) and pollutants from Chinese power plants and industries. According to the report of the environment ministry of South Korea, it counts for roughly 30 to 50 percent of the PM2.5 on normal days and 60 to 80 percent on the worst days (Fifield & Seo, 2017).

Figure 3. The map of Northeast Asia, focusing on Seoul, South Korea, and its neighboring countries to the west. Bicker, Laura. (2019, June 6). South Korea pollution: Is China the cause of 'fine dust'? BBC News. Retrieved from https://www.bbc.com/news/world-asia-48346344

To investigate the internal and external sources of pollution in more detail, the Korea-United States Air Quality Study (KORUS-AQ) provides meaningful insights as it directly assesses the current air pollution blanketed the Korean Peninsula. KORUS-AQ Study was jointly conducted by the United States National Aeronautics and Space Administration (NASA) and the National Institute of Environmental Research (NIER) of South Korea in May 2017. Using a research aircraft, ships, and ground sites, NASA and NIER studied the air pollution of Seoul and its neighboring rural areas for the six weeks of summer of 2016. Since the research was conducted during May and June, when the influence of external factors is the weakest due to the summer monsoon of southeast wind, it clarifies which internal sources worsen the air quality. From the observation of the study, it shows that the level of PM2.5 generally approached the standard (50 μg/m3) and significantly exceeded it for the last week of May (Figure 4, Figure 5), when the west wind influenced the air quality of South Korea (Figure 6). It indicates that the external sources combined with internal sources are creating poor air quality of South Korea.

Figure 4. Observations of PM2.5 in Seoul, Busan, and Gwangju (three of the largest cities in South Korea) during the KORUS-AQ Study period. National Institute of Environmental Research, & United States National Aeronautics and Space Administration. (2017). KORUS-AQ Rapid Science Synthesis Report. Retrieved from https://espo.nasa.gov/sites/default/files/documents/KORUS-AQ%20RSSR.pdf

Figure 5. Highlighted Figure 4 plot during the period of May 17 to May 22 and May 25 to 28. National Institute of Environmental Research, & United States National Aeronautics and Space Administration. (2017). KORUS-AQ Rapid Science Synthesis Report. Retrieved from https://espo.nasa.gov/sites/default/files/documents/KORUS-AQ%20RSSR.pdf

Figure 6. Different meteorological conditions during the observation period of the KORUS-AQ Study. It shows that during the last week of May 2016 the external sources due to wind from China added pollutants to the air of the Korean Peninsula. National Institute of Environmental Research, & United States National Aeronautics and Space Administration. (2017). KORUS-AQ Rapid Science Synthesis Report. Retrieved from https://espo.nasa.gov/sites/default/files/documents/KORUS-AQ%20RSSR.pdf

The KORUS-AQ Study also suggests which components of the particulate matter in Seoul is dominant by analyzing the composition of the aerosol. The study grouped the components into two categories, primary emissions, and secondary production. From Figure 7, three observations commonly show that the secondary production takes more than three-quarters of particulate matter pollution while sulfate and nitrate comprise of nearly half of the secondary

production. Thus, it is evident that the reductions in volatile organic compounds (VOCs), nitrogen oxide (NOx), sulfur dioxide (SO2), and ammonium (NH3) emissions will be effective to significantly improve the PM2.5 pollution.

Figure 7. The average composition of particles observed during KORUS-AQ Study. DC-8 is the research aircraft used for the study, SMA stands for Seoul Metropolitan Area, and Olympic Park and KIST are the two ground sites in Seoul. National Institute of Environmental Research, & United States National Aeronautics and Space Administration. (2017). KORUS-AQ Rapid Science Synthesis Report. Retrieved from https://espo.nasa.gov/sites/default/files/documents/KORUS-AQ%20RSSR.pdf

The expected damage from continuing air pollution for South Korea is critical. According to the Organization for Economic Cooperation and Development (OECD), it predicted that 1,069 people per million will face premature death by 2060 directly from air pollution (Figure 8). In terms of economics, air pollution will lead to a GDP loss of 0.69% by 2060 (Figure 8). Thus, assessing the problem and reducing the density of particulate matter is necessary for environment, human heath, and economic prosperity.

Figure 8. Expected number of premature death and change in GDP from extra health costs, lower productivity, and reduced farm output by 2060. Organization for Economic Cooperation and Development. (2016). The Economic Consequences of Air Pollution. Retrieved from

http://www.oecd.org/env/air-pollution-to-cause-6-9-million-premature-deaths-and-cost-1-gdp-by-2060.htm

There have been several attempts to improve the air quality of the Korean Peninsula by the Korean government and often with China. To prevent the internal causes of particulate matter, Seoul metropolitan government enforced a new law that orders vehicles off the roads on certain days based on the tags, although the effect of the regulation is very limited (Fifield & Seo, 2017). In addition to the restrictions on vehicles, Korean government decided to shut down 14 coal-fired power plants during this winter and maximum 27 plants in coming March, which is expected to reduce the amount of local black carbon (McCurry, 2019), while announced a record rise in the budget to deal with the air pollution for the coming year (McBride, 2019). One interesting attempt is, with the Chinese government, South Korea is planning to create artificial rain to reduce air pollution. By spreading sodium chloride or potassium chloride to the clouds to induce precipitation, it purposes to generate the artificial rain over the Yellow sea, the sea between South Korea and China, before the particulate matters from China arrive the Korean Peninsula (“South Korea plans artificial rain,” 2019).

Although it seems to take time to clear the air of the Korean Peninsula, scientists, researchers, and policymakers are coping with the pollution to bring clean air back. However, in case of South Korea’s air pollution, South Korea alone will never be able to purify their polluted air due to the substantial external sources beyond the borderline. The transboundary pollutions around the world similar to South Korea’s issue is widespread and can only be solved when there are joint actions between countries. People will get rid of their lives in the dirt and reclaim their right to breathe only if international agreement and cooperation to take joint actions handles the pollution.

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