Observational Studies of $PM_{2.5}$ Components and Source Apportionment in EANET Countries (Project Activity 6 in 2022)

I. Introduction and objectives of the studies

1. Fine particulate matter ($PM_{2.5}$) is considered as an important environmental pollutant and has adverse effects on human health, including effects on the heart, nervous, and vascular system. Moreover, $PM_{2.5}$ is proved to be linked to degradation of visual range, with the features of light extinction. To evaluate these effects, components of $PM_{2.5}$ need to be investigated at different temporal and spatial scales because chemical properties in $PM_{2.5}$ are important factors to determine the effects. Niigata City is located in eastern Japan and faces the Northeast Asian continent. Since the northeast Asian continent is upwind with respect to Niigata during the winter monsoon period, $PM_{2.5}$ in Niigata is probably influenced by long-range transport from the continent. A field observation study including seasonal intensive measurement of $PM_{2.5}$ from 2015 to 2021 has conducted, and the source apportionment using observational data and receptor model was conducted.

2. Bangkok Metropolitan Region (BMR) is a region consisting of populated central area of Bangkok and surrounding provinces, sharing industry, infrastructure, and housing. BMR has been suffered serious air pollution issues due to rapid economic growth, urbanization, and motorization. In order to design appropriate air pollution countermeasures, information on major contributing sources of air pollutants such as particulate matter and O_3. The Thai government operates national monitoring network of gaseous and particulate pollutants as well as precipitation. There were several previous studies focusing on the PM pollution in BMR with the detail PM compositions for source apportionment studies. However, there are lack of long term monitoring data of PM and precipitation, which are necessary to analyze source apportionment of PM. The two joint projects between Japan and Thailand have implemented monitoring of chemical components of $PM_{2.5}$, coarse particles (>2.5 µm) and precipitation at the selected sites in BMR. By using these monitoring data and receptor models, vehicle exhaust, biomass burning and secondary formation could be identified as the main sources of $PM_{2.5}$ in BMR.

II. Observation methodologies and major results

3. The Niigata-Maki EANET station is located at 1 km from the seashore, and 25 km southwest of the center of Niigata City, Japan. There are no industrial sources near Niigata-Maki site, but a small community (approximately 1300 population) is located 2 km northwest of the station, and thus it is classified as a rural station. Air masses reaching the station are dependent on seasonal wind patterns, which are affected by the monsoon circulation: in winter the northwest cold currents prevail, while in summer they are replaced by the North Pacific High. 56 chemical components (including EC, OC, Cl^-, NO_3^-, SO_4^{2-}, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, 23 metallic elements and 19 organic components) in $PM_{2.5}$ from 2015 to 2021 were analyzed, and the seasonal variations of chemical characteristics in PM2.5 were elucidated. The detailed description of observation methodology is shown in the literature (Li et al, 2018, Huo et al., 2016). By using the observational data and the Positive Matrix Factorization model, source contribution of each source factor was calculated.

4. Daily mean concentrations of $PM_{2.5}$ at the Niigata-Maki station were lower than Japanese Environmental Quality Standard for $PM_{2.5}$ (35 μg m^{-3} for daily average) for most days. $PM_{2.5}$ concentration variation was highly correlated with meteorological conditions. In all seasons, SO_4^{2-} and OC were main components of $PM_{2.5}$, with a particularly high proportion of SO_4^{2-} in summer and OC in autumn. In winter, the proportion of NO_3^- was higher than in other seasons, while the proportion of EC was generally the same in all seasons. By applying organic component data for PMF analysis, it is feasible to evaluate more detailed source contribution concentrations of $PM_{2.5}$, including the impact of secondary particles generated from plant-derived VOCs. In spring and autumn, the contribution of pinene aerosol (Plant origin) was relatively large. In summer the contribution of SO_4^{2-} aerosol was the largest, and the contribution isoprene aerosol (Biogenic) was also larger compared to the other seasons. In winter, the contribution of inorganic secondary aerosol such as SO_4^{2-} and NO_3^- aerosol was the large.

5. By the Japan Thailand Clean Air Partnership (JTCAP) project, 24 hour sampling of $PM_{2.5}$ was conducted at 3 sites in BMR once a two or three days during December 2018 to April 2019,. The monitoring sites were selected to cover various site characteristics. One is located in the industrial area of Bang Na district, the second one is in the residential area of Phaya Thai district, and third one is at the roadside of Din Daeng district. The collected $PM_{2.5}$ samples were analyzed by sent to Japan for ionic and metallic components by PCD, and for carbon components for analysis by ACAP. The detailed description of observation methodology is also shown in the literature (Sato et al, 2020). The $PM_{2.5}$ concentrations at 3 sites exceeded the national standard of 24 hour average (50 μg/m^3) from late December 2018 to late January 2019. hereafter, the $PM_{2.5}$ concentration was lowered in February and the concentration increased again in April and May. By comparison among the sites, the roadside site was the highest, followed by the industrial site and the residential site. When organic components of $PM_{2.5}$ in Bangkok were measured by Gas Chromatograph/Time-of-Flight Mass Spectrometer (GC/TOFMS), the unique peaks of terephthalic acid and 1-octacosanol were detected for $PM_{2.5}$ in BMR. The organic speciation analysis data suggest that biomass burning source is one of important sources of high PM2.5 episode in Bangkok. It is also notable that the atmospheric concentrations of malonic acid, succinic acid, glutaric acid and phthalic acid in Bangkok were higher than those in Japan. These organic substances are dicarboxylic acids and considered to be tracer of secondary photochemical reactions of aliphatic and aromatic hydrocarbons. Therefore, secondary organic aerosol formation is the other important sources of high PM2.5 episode. Furthermore, the atmospheric concentrations of terephthalic acid, isophthalic acid and 1-octacosanol were also higher in Bangkok, which implies high contribution of plastic waste burning and primary biogenic formation.

6. By the joint project of JICA Research Institute, Asian Institute of Technology (AIT), ACAP and the Pollution Control Department (PCD). long term monitoring of PM and acid deposition was conducted at the two sites which represent urban and suburb area of Bangkok (Narita et al., 2019). One is located at the rooftop of the PCD office building in urban area of Bangkok. The PCD building is mainly surrounded by houses, commercial places, and institutions within a radius of 5 km. It is approximately located of 0.75 km away from the main road, which has heavy traffic congestion during rush hours. The other site is at the rooftop of the ambient laboratory of AIT in Pathumtani, suburb area of Bangkok. This site is surrounded by many canals, rice paddies and other crops fields, as well as some small and medium industries. The monitoring were conducted simultaneously at these two sites during the period from September 2015 to March 2017. The

detailed description of observation methodology is shown in the literature (Sato et al, 2020). The annual Volume Weighted Mean (VWM) shares of OC, EC, and inorganic ions in precipitation were 27.0, 1.0, and 72.0 %, and 27.2, 0.7, and 72.2% at AIT and PCD sites, respectively. Compared with the ratios in aerosols, the contribution of carbonaceous components (OC and EC) to inorganic ions in precipitation was smaller than that in aerosols. In particular, the percentage of EC was much smaller in rainwater than in aerosols. Comprehensive results of chemical characteristics of carbonaceous species and inorganic ions in precipitation and aerosol is published in a research paper (Huo et al., 2020).

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