

Investigation into Characteristics and Emission Sources of Ambient Nano-particles (PM0.1)

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学 位 論 文 概 要

Dissertation Summary

学位請求論文 (Dissertation)

題名 (Title) Investigation into Characteristics and Emission Sources of Ambient Nano-particles (PM_{0.1})
(大気中ナノ粒子 (PM_{0.1})の特性と発生源に関する考察)

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学位論文概要 (Dissertation Summary)

1. Introduction

Ambient aerosol nanoparticles have been getting an increasing attention from their health risk point of view because of high deposition possibility in the alveoli region. Less information on the status and characteristics of ambient aerosol nanoparticles as well as their emission sources than fine particles yet. Because of high cost of the devices capable of monitoring and sampling nanoparticle, status and characteristics of the ambient aerosol nanoparticles have not been compared between different locations in different countries so far. In this study, characteristics of PM_{0.1}, particles smaller than 0.1 μm, were discussed on its ability as a tool to describe influences of emission sources and transboundary transportation of emitted particles. For this purpose, three different categories of area each of which has a different environmental background, were selected to discuss the contribution of different type of emission sources and meteorological conditions, or, Hokuriku area in Japan, an inland city in Nigeria and cities in Southeast Asia. The air sampling has been conducted at each sampling site for selected periods then chemical components of size segregated ambient particles including PM_{0.1} were analyzed to discuss emission sources along with the analysis of air mass movement and hot spots that were used to discuss influences of the transboundary transportation of air pollutants emitted by open biomass burning.

2. Methodology

2.1 Air sampling: A cascade air sampler, termed here as an Ambient Nano Sampler, that can collect PM_{0.1}, PM_{0.5}, PM₁, PM_{2.5}, PM₁₀, TSP at an air flow rate of 40 l/min was used as a common sampler. Quartz fibrous filters of Ø55 mm that had been pre-baked at 350 °C in an oven for 1 hour then conditioned at 21.5 ± 1.5 °C, and 35 ± 5 % RH in a PM_{2.5} weighing chamber for 48 hours before and after sampling were used to collect particles. An inertial filter consisting of webbed stainless steel fibers (average fiber diameter $d_f=9.8\mu\text{m}$, Nippon Seisen Co. Ltd., felt type, SUS-316) plugged in a cartridge nozzle of Ø 5.25 mm was used for the separation of PM_{0.1}.

2.2 Analysis of chemical components: The thermal/optical analyses of carbonaceous components in particles collected on QFF were conducted using a carbon analyzer, following the IMPROVE protocol. Water soluble ions and organic carbon were analyzed by using an ion chromatography and a TOC analyzer, respectively after extracting sample filters in ultra-pure water

2.3 Backward trajectory and hotspots: 72 hour backward trajectories of air parcels arriving at each monitoring site at a distance of 500 meters from the average ground level were calculated using the Hybrid Single-Particle Lagrangian Integrated Trajectory Model version 4. Geographic locations of hotspots or active fires in Japan and other neighboring countries with a resolution of 1 km × 1 km that are available from MODIS satellite remote sensing imagery were used to specify possible areas corresponding to biomass burning.

3 Discussion on each target area

3.1 Hokuriku region in Japan

Procedure: For a better understanding of the contribution of local emissions as traffic and open burning of crop residues as well as influence of the long range transportation, the PM monitoring was conducted at three locations spreading over Hokuriku region. The Kanazawa site was located in the Kakuma campus of Kanazawa University in an outskirts of Kanazawa city that is the prefectural capital of Ishikawa prefecture. The sampling site was on a balcony on the sixth floor of a 7-story building. The Toyama site was located on the rooftop of a 3-story building, National Institute of Technology, Toyama College in Toyama city. The Toyama site was located in a southern periphery of the city area surrounded by areas of mixed land uses by paddy fields, residential areas with local community roads. The Suzu site was located on the rooftop of a 3-story lecture hall building of the Noto School in Suzu city that is the city located most north in Noto Peninsula. The site was in a small local community adjacent to a beach in its eastern side

(~120 m) and surrounded by managed forest area with small agricultural fields. The sampling at the Kanazawa site has been continued since 2010 while it was started in 2014 at the Toyama and the Suzu sites. At all sampling sites, the duration for each sampling was set as continuous 7 days, twice a month. The information on the sampling is summarized in Table 2 where Spring, Summer, Autumn and Winter were here defined as March to May, June to August, September to November and December to February. 2110 available samples in 356 sets from the 3 sampling sites in Hokuriku region were collected as a total.

Summary on Japan: 1) The seasonal behavior of the PM concentration at all sites were basically similar reflecting similar meteorological characteristics. 2) Because of a larger amount of pollutants from local sources such as traffic and residential energy use, the PM at the Toyama site was the largest while that at the Kanazawa site was not as large as the size of a city adjacent to the site because of the rather isolated location and the larger precipitation than at the other sites in the autumn and winter seasons. 3) The concentration and influence of secondary organic carbon for the PM_{0.1} carbon content were the largest at the Toyama site. 4) Evidences may not be sufficient to explain the influence of the transboundary transportation of air pollutants by air mass. 5) For a further understanding, more detailed information concerning the various chemicals in different sizes of particles should also be examined.

3.2 Inland city in Nigeria

Procedure: The sampling site was located in Akure city, which is the largest and capital city of Ondo state in the south west geopolitical zone of Nigeria. The sampling site was located on the roof of a building at the Federal College of Agriculture (FCA). The FCA is located in a suburban residential area surrounded by agricultural fields, 350m south from a highway and approximately 1.3km west from another high running road between the Akure city area and the sampling site. The site was surrounded by trees in the tropical rainforest zone, residential buildings, tarred and untarred roads for low levels of vehicular traffic, farms, and a waste dump site. The air sampling for 24 hours was conducted for a period between Oct. 14, 2017 and Oct.20, 2017.

Summary on Nigeria: 1) Average PM_{0.1} mass concentration (43.1 $\mu\text{g}/\text{m}^3$) was quite large comparing to other countries including developing countries in Southeast Asia., 2) PM_{0.1} fraction was nearly 2 times larger than those in other locations in the world, indicating influences of more local emission sources or secondary formation. 3) OC in PM_{0.1} dominated PM mass and the most of OC was water insoluble (WISOC) that had a weak correlation to soot-EC. or,

fissile fuel burning. 4) WSOC in $PM_{0.1}$ was clearly correlated to SO_4^{2-} and oxalate, indicating WSOC was very much related to particles from the secondary formation from emitted matters from oil burning. 5) Transboundary or long range transportation of smoke particles could be negligible while influences of emission in oil field could be possible. 6) Behaviors of $PM_{0.1}$ in Akure, Nigeria were quite different from those in different countries. $PM_{0.1}$ can be said as a parameter sensitive to local environment.

3.3 Cities in South East Asia

Procedure: In south East Asia 4 campaigns was conducted from 2016- 2018 by the difference purpose. The first trial campaign was established in March to April 2016 under expectation of forest fire period in Chiang Mai or northern of Thailand. The second campaign managed during Indonesia forest fire in 2017 from January to October, mainly for this campaign was focusing of spearing of the smoke to southern of east Asia and the third campaign Chiang Mai forest fire in 2018 during January to April and the last campaign was Asian Game in 2018 during early September which is occurred in Indonesia According to campaign 2016 focusing on Chiang Mai forest fire..

Summary on cities in Southeast Asia: 1) Much larger mass concentration of $PM_{0.1}$ was founded in cities in Southeast Asia. 2) Influences of events as forest fire in Chiang Mai was clear only in Chiang Mai, indicating the transboundary influence to characteristics of $PM_{0.1}$ was not so significant. 3) The Behavior of OC/EC vs. EC in $PM_{0.1}$ was similar between cities in East Asian countries when the event as forest fires are not happened.

4 Conclusion

1) $PM_{0.1}$ was confirmed to well describe primary particles from local sources as well as components by the secondary formation from gaseous pollutants. 2) For the transboundary transportation of primary and secondary particles, behavior of $PM_{0.1}$ was found to be not so sensitive. Hence, when $PM_{0.1}$ is clearly influenced by the transportation, the influence should be regarded as being significant. 3) Behavior of some chemical components as WSOC in Nigeria can be understood only by examining characteristics of $PM_{0.1}$. 4) $PM_{0.1}$ can be a useful and unique platform to understand behaviors of ambient particles particularly emitted from local sources.