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論文題目	Air pollution study in Northwest Africa; case of the urban city of Bamako in Mali		
(論文内容の要旨)			
<p>This thesis was initiated to provide information on the air quality in the urban city of Bamako in Mali where information is very lax. It contains four chapters.</p> <p>The first chapter gives an overview on the air pollution issues in West Africa in general and in Bamako particular. Anthropogenic activities emit chemicals such as particulate matter (PM), nitrogen oxides (NO_x), and sulfur dioxide (SO₂). This affects the entire ecosystem including human health. This is accentuated in the developing regions where clean energy source is not widely available. Bamako the capital city Mali is not an exception. The population growth and the attendant requisites result in high pollutants emission into the atmosphere.</p> <p>The second chapter describes the sampling sites and the methodology. Bamako city is located in Northwest Africa, it had a population of about 3 million in 2021 and an area of 267 Km². Different sampling types were conducted. The personal exposure to particulate matter 2.5 microns or less in diameter (PM_{2.5}) was investigated using palm-sized optical PM_{2.5}-sensors. Four groups of local inhabitants; the group of office workers (OW), the group of students (ST), the group of cooks (COOK) and the group of drivers (DRI) carried PM_{2.5}-sensors around their neck from September 2020 to February 2021. PM was collected on quartz and polytetrafluoroethylene (PTFE) filters to characterize the chemical composition and provide further information on the health risks. The samples were collected in household microenvironments (during insecticide (IST), incense (ICS) use and cooking) and in outdoor microenvironment (traffic sector) during April 2021. Additionally, ICS and IST samples were collected in the laboratory of the Asia Center for Air Pollution research (ACAP) to confirm the results from the samples collected in Bamako and compared different IST and ICS products from Mali and Japan. The collected samples were subject to laboratory analysis to measure PM components. This included the ionic compounds using ion chromatography system (ICS), the organic and elemental carbon (OC, EC) using a thermal optical carbon analyzer (DRI 2001) and the metallic composition using an Inductively coupled plasma Couple Mass spectrometry (ICP-MS).</p> <p>The third chapter presents the results. It contained five sections. The first section on the personal exposure to PM_{2.5} indicated that exposure concentrations exceeded the World Health Organization (WHO) daily and yearly limit (25 and 10 µg/m³ respectively). The 3-days average exposure was 49, 20, 38 and 76 µg/m³ for the group of OW, ST, DRI and COOK respectively. Similar patterns were observed in the participants with higher PM_{2.5} concentration during the IST/ ICS combustion (207 ± 115 µg/m³), the cooking activity (42 ± 1) and in the traffic sector (35 ± 6 µg/m³). DRI and COOK groups presented the highest exposure concentration during their working hours. Furthermore, gender segregation exposure was observed between OW males and OW females. OW females were exposed to supplementary PM from cooking. The second and third section indicated that the PM composition chemical from different emission sources varied. Furthermore, the same IST and ICS samples collected in Bamako city and in the laboratory presented different components' distribution. Suggesting that the difference in combustion conditions including oxygen availability and heat source resulted to the difference in the constituents' distribution. The IST/ICS from Mali and Japan presented different PM composition. The health risk assessment was conducted for adults and children using the US EPA (United States Environmental Protection Agency) model. The non-carcinogenic risk; Hazard Index (HI) and Hazard Quotient (HQ) and, the carcinogenic risk (CR) was estimated. HI was ≤ 6.04 and</p>			

(続紙 2)

I CR > 1E-6. Indicating unsafe exposures for adults and children. In general, indoor microenvironments presented greater health risks than outdoor microenvironments. The source apportionment using the Chemical Mass Balance (CMB) and the Principal Component Analysis (PCA) showed that soil dust resuspension and biomass combustion highly contributed to the PM pollution. The fourth section provided information on the daily and monthly concentration of criteria air pollutants. The last section presented the findings from the survey. The respondents reported health issues varying from minor (such irritations and asthma) to sever issues (such as chronic pulmonary diseases and lung cancers). The majority did not know the cause of their diseases. However, these diseases were previously associated to air pollution exposure. Suggesting that air quality could be a factor contributing to the reported heath issues. The respondents were willing to contribute to the efforts to reducing air pollution. This could be an asset for the local government and organizations in implementing air pollution mitigation strategies.

The fourth chapter encompasses this work with a general conclusion. It gives an overview of the findings and provides recommendations. The air pollution in Bamako city was strongly related to the daily habits and the local conditions. Resulting to a high exposure to air pollutants and elevated associated health risks. This research demonstrated the complexity of air pollution in Bamako city and the urge to control emission sources likewise protect the population's health.

(論文審査の結果の要旨)

本論文はアフリカ北西部のマリ共和国の首都であるバマコ市での大気質について報告したものである。アフリカは驚異的なスピードで経済発展が進行しているにもかかわらず、環境に対する配慮の欠乏は深刻である。特に経済的に貧しいマリ共和国では都市の大気に加えて室内における汚染も深刻である。小型のポータブルPMセンサーを現地に送り被験者に常時携帯してもらい、種々の業態での人暴露量を調べた。その結果、業態により大きなPM2.5の暴露量の差異が認められた。タクシー運転手や料理作成に従事する労働者の曝露量が多いことが明らかとなった。また室内においては業態の種類にかかわらず夜間の曝露が飛躍的に大きいことも明らかとなった。これは蚊取り線香とお香による曝露であることが明らかとなった。室内でのPM曝露による人体への健康影響を評価するために、現地でエアロゾルサンプラーを持ち込み大気の捕集を行い、フィルターを日本に持ち帰り化学分析を行った。また、現地で使用されている蚊取り線香とお香も持ち帰り燃焼により発生するエアロゾルの分析も進めた。これらの結果をEPAが提案している健康リスク指標に従い評価した。これらの研究成果はマリにおいて初めての成果であり、今後さらに発展する北西アフリカにおける大気汚染緩和に向けた科学的な基礎を提案することから、地球環境学の発展に大きく貢献した。

よって本論文は博士(地球環境学)の学位論文として価値あるものと認める。また、令和4年6月8日、論文内容とそれに関連した事項について試問を行った結果、合格と認めた。

要旨公開可能日： 年 月 日以降