Oral Presentation (IS-20)

Atmospheric Science within a One Health Perspective

Jun Noda[1]*, Sota Tomizawa[1], Kozo Morimoto[2], Satoshi Mitarai[3]

[1]School of veterinary medicine, Rakuno Gakuen University, Ebetsu, Hokkaido, Japan.
[2]Division of Clinical Research, Fukujuji Hospital, Japan Anti-Tuberculosis Association, Tokyo, Japan
[3]Department of Mycobacterium Reference and Research, Research Institute of Tuberculosis Japan Anti-Tuberculosis Association, Tokyo, Japan
*Corresponding author's email: jnoda@rakuno.ac.jp

Keywords: Bioaerosols, Infection control, Non tuberculosis mycobacterium, Particulate matters.

INTRODUCTION

In the atmosphere, particulate matters exist as aerosols which may have essential functions for the earth system to health quality of the individuals. A field of atmospheric sciences associated with aerosols has been focusing mainly on their chemical and physical properties to characterize their role and effect for the climate system, ocean-atmosphere interaction, health-related issue, and more.

It is well recognized that biological aerosols defined as "bioaerosols" to be present ubiquitously in the atmosphere, yet the scientific knowledge of their roles and functions are somewhat limited [1]. Since the bioaerosols may have a significant effect on climate, health quality of human and livestock animals, and ecological system, it is of great importance to acquire further knowledge in many aspects. The bioaerosols such as bacteria, virus fungi, and their fragments are not well in-cooperated with the atmospheric science researches mainly due to the difficulty associated with detection of bioaerosols. Often the concentration of bioaerosols in the air is very low, which requires sampling of a large air mass. Furthermore, the current scientific communities still lack the multidisciplinary approaches to tackle airborne infection, allergen dispersion, the stability of the biological material and more in the atmosphere.

Traditionally in both human and veterinary medical sciences, the bioaerosol investigations focused on understanding the infectivity of potential airborne infectious materials. For example, influenza, tuberculosis, mycoplasma, and other pathogenic ones to be examined. For example, the main focus points are finding strains which are more easily spread and the probability of infection to occur. Also, for the prevention of infectious diseases, understanding host susceptibility and immune response are also important focal points.

However, in the real atmospheric condition, there are many substances in the air both gas and particulate phases. Thus understanding the mechanism of airborne infection requires not only the pathogen by itself, but it also needs to include some other co-existing airborne materials such as dust and air pollutants. Therefore, investigating the viability of bacteria with the effects of the particulate matters commonly found in the atmosphere as the co-existing material is important. Our research activities primarily focus on interactions between the bioaerosols and some other particulate matters such as dust and air pollutant in the atmosphere. This approach tries to evaluate the factors attributing the prolongation or reduction of the viability of bioaerosols. More specifically, understanding the critical factors to determine the viability of airborne pathogen, it may be easier to find solutions to control the airborne infection. Our work also focuses on emerging diseases such as Non-tuberculosis mycobacterium (NTM) clinical case in Japan [2].
In order to achieve global health, the one health approach can bridge the medical and environmental sciences as the multidisciplinary effort to safeguard human, animal, and environmental health.

MATERIALS AND METHODS

For this study, a reaction chamber was deployed to elucidate the interaction and role of the environmental particulate matters as shown in Figure 1. For the examination of the survival of bacterial bioaerosols. Figure 1 indicates a 128 L Teflon chamber system, which has an internal separator to divide two equal size compartments for the preparation of two different aerosolized materials before mixing them. For the generation

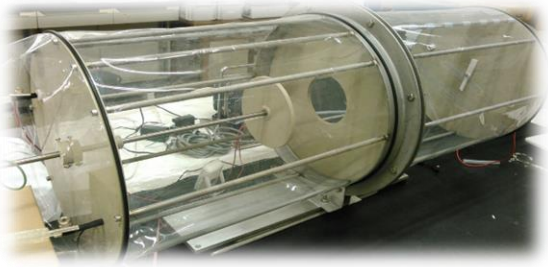

Figure 1. The Teflon chamber system with 128L (64 L ×2 compartments).

of dust aerosols, the dust aerosol generator was prepared with of conventional impinger and silicon tube. The particle free air was introduced through silicon tube to blow off and emitted out the dust particles. For the generation of bacterial bioaerosols, a compressor type nebulizer was employed. This type was rather gentle to aerosolize bacteria. For the measurements of the particle concentration and size distribution, an optical particle counter was used.

As the experimental procedure; one compartment was filled with dust, and another compartment was filled with bioaerosols. After the filling process, the aerosols were stabilized for ca. 5 min. Then particle numbers were measured to confirm equivalent concentrations of the bioaerosol and dust. Then, the middle separator was open to let two components to interact for ca. 60 min. These dust samples were further examined for the viability of DH5α bioaerosols by using a Biosampler to capture the airborne bacteria inside the chamber. The reduction rate of viability was calculated by comparing DH5α bacterial CFUs on the nebulizer liquid and the Biosampler liquid. Different dust samples were compared with the phosphate buffer solution (PBS) driven particle as the control dust. Comparisons were made with Gobi and sludge dust samples. The viability reduction rate of the DH5α bacterial CFU was measured with the culture method. Also, for the NTM related experiment with the presence of soot as air pollutants, *Mycobacterium smegmatis (M. smeg)* was used as a model bacteria for measurement of viability.

RESULT AND DISCUSSION

For the experiment with *Escherichia coli* (DH5α) viability test by exposing different dust materials. The control dust of PBS indicated the 10^{-5} order of reduction and desert sand from Mongolia showed significantly higher reduction and the tsunami sludge dust indicated significantly lower reduction rates. Possible reasons for these differences might be caused by the physical and chemical properties of dust samples. For the physical property differences, the sludge dust has more spiky surface shape than desert dust. The different surface shape with a large roughness may have acted as a shelter for the aerosolized E. Coli from the drying process. For the chemical properties, ca. 4.7 times higher organic matter and 3 to 4 times higher calcium and iron contents were observed with the sludge dust. The higher concentration of organic matter might have caused a higher affinity with bacterial phospholipids and lipopolysaccharides found on the E. Coli cell membrane. Furthermore, these bacterial cell membrane materials possess substantial negative charge properties to more strongly bind to them. Since this experiment could not determine the sticking force between bacteria and dust, this is only the speculation.

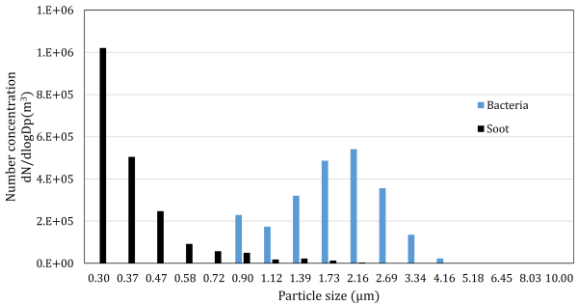

Figure 2. The size distribution pattern of soot (black) and bacteria (blue).

For the higher concentration of organic matter led to conduct another experiment, which tries to expose bacteria to the even higher concentration of organic matter of soot. This experiment focused on how soot can attribute the survival of bacterial as bioaerosols. Another experiment with soot and *M. smeg* particle number and size distributions are indicated on Figure 2. From the size distributions in Figure 2, soot has the higher number of fine size range particles compare to M. *smeg* particles. The soot may coat the bacterial surface. If the soot successfully attaches to the surface to coat bacteria, it may help to prolong the survival of bacteria in the atmosphere by reducing environmental stresses. For viability test with aerosolized bacteria alone and a mixture of bacteria and soot indicated no significant difference; thus soot alone would not affect the viability of bacteria.

The aerosol samples from this experiment were further exposed to UV-C ray for 15-60 sec. as environmental stress. The result indicated that there was a tendency to have a higher survival rate with the mixture of bacteria and soot group. From these experiments, the soot may act as a protective material for the airborne bacteria. Since soot is commonly found in the atmosphere as air

pollutants, it is possible to find it together with bioaerosols in the atmosphere. The presence of soot may bring an effect to change the viability of bacteria. It is important to understand the factor sustaining bacterial viability with the presence of soot and other air pollutants. Since the viability of pathogen directly reflects the infection dynamics, understanding the effect of the air pollutants and other environmental particles for the viability of bioaerosol is an important aspect to be investigated.

CONCLUSION

The aerosol related investigation in this work demonstrated the important and valuable insight of the one health approach. Understanding the infection mechanism and dynamic for some airborne related sickness in the multidisciplinary approach may bring new insight into the controlling infectious diseases. There are many other health issues to be tackled with the one health approach. Thus, medical science, environmental science, and also social science should have more collaboration and share the information. Further investigation of health issues with the one health approach may help to reduce the risk of infection to safeguard our lives. In order to improve health qualities in many levels, the one health approach can bridge the medical, environmental, and other sciences as the multidisciplinary effort to safeguard human, animal, and environmental health.

ACKNOWLEDGMENTS

We would like to thank all the member of environmental health, bacteriology, and zoonosis units at Rakuno Gakuen University. This work was supported by kaken 15K00568.

REFERENCES

[1] Fröhlich-Nowoisky J, Kampf C, Weber B, Huffman A, Pöhlker C, Andreae M, Lang-Yona N, Burrows S, Gunthe S, Elbert W, Su H, Hoor P, Thines E, Hoffmann T, Després V, Pöschl U. Setijanto H, Nisa' C, and Novelina S. 2016. Bioaerosols in the Earth system: Climate, health, and ecosystem interactions. *Atmospheric Research* 182: 346–376.

[2] Morimoto K, Hasegawa N, Izumi K, Namkoong H, Uchimura K, Yoshiyama T, Hoshino Y, Kurashima A, Sokunaga J, Shibuya S, Shimojima M, Ato M, and Mitarai S. 2017. A Laboratory-based Analysis of Nontuberculous Mycobacterial Lung Disease in Japan from 2012 to 2013. *Ann. Am. Thorac. Soc.* 14(1):49-56.