Citizen Sensing for Environmental Risk Communication

Action Research on $PM_{2.5}$ Air Quality Monitoring in East Asia

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***Abstract*— Air pollution is becoming a serious global health issue. We propose a risk communication method called 3D (detection, data sharing and discussion) to ensure risk awareness for environmental hazards for individual citizens. This paper presents a prototype system of a sensor connected to smartphone which detects $PM_{2.5}$ (Particle Matter with aerodynamic diameters ≤ 2.5 *u*m). Preliminary field tests showed that $PM_{2.5}$ concentration levels differed in the regions we tested in the East-Asian countries. As a next step, we plan to a conduct risk communication experiment through social media discussion involving local residents, experts and public sector, to ensure risk awareness and education of individuals.**

Keywords - participatory sensing; AQI (Air Quality Index).

I. INTRODUCTION

WHO (World Health Organization) estimated that 6.5 million people are dying annually from air pollution [1]. Nearly 90% of the deaths occur in low- and middle-income countries in the South-East Asia and Western Pacific regions, as shown in Figure 1. Also, in 28 countries in Europe, around 400 thousand premature deaths still occur each year due to long-term exposure to PM2.5 [3]. The transboundary health impacts of PM2.5 pollution associated with global trade are greater than those associated with long-distance atmospheric pollutant transport [4].

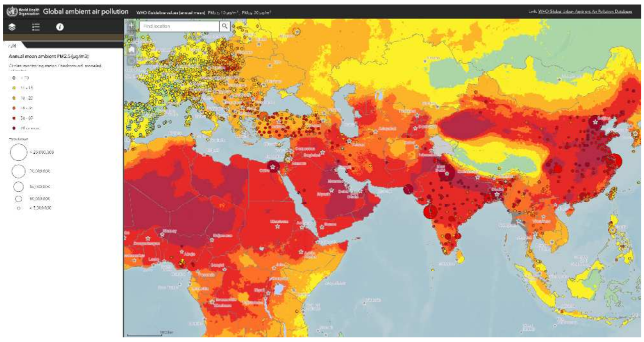

Figure 1. Air Pollution Mapping [2]

Simultaneously, coal use is expanding rapidly, especially in Asia, for cheaper power generation. Koplitz et al. estimated that 15 thousand deaths will occur annually if all of the projected plants become operational in Indonesia by 2030 [5].

II. APPROACH

Town-scale pollution mapping is vital for risk awareness in individuals from the local community, since $PM_{2.5}$ concentration levels differ, even in small areas, depending on the terrain, building structures or vegetation. Further, scientific communication is essential to educate citizens to take appropriate risk avoiding actions, involving public sectors and experts such as meteorologists, environmentalists or medical doctors. To ensure such citizen-centered and autonomous risk communication, we propose the '3D' method as shown in Figure 2 (left).

- *Detection* of environmental pollution by smartphone connected sensors for citizens under open source technology, which is mobile and cost-effective.
- *Data sharing* for swift risk awareness using IoT (Internet of Things) and free cloud system to show clear evidence based on Web-based visualization.
- *Discussion* on healthcare risk, hazard protection or reduction plan including citizens, public sector and experts through democratic social media.

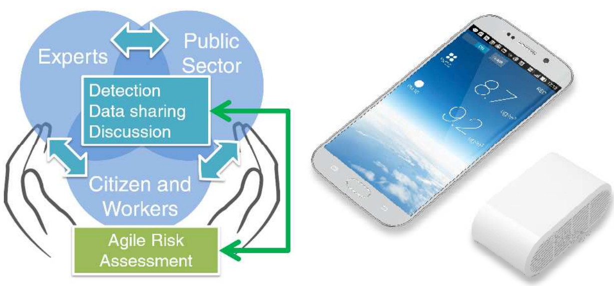

Figure 2. 3D method (left) and Poket $PM_{2.5}$ Sensor (Right)

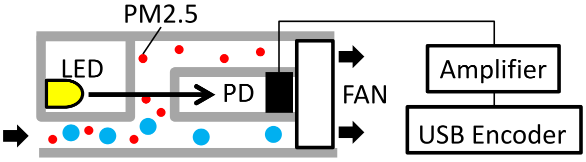

Figure 3. Principle of Pocket $PM_{2.5}$ Sensor Module

We developed 'Pocket $PM_{2.5}$ Sensor' as shown in Figure 2 (right) to demonstrate the 3D in real situation. A free App is capable to generate log data in CSV (Comma-Separated Values) or Google KML (Keyhole Markup Language) format, including GPS (Global Positioning System) information. The sensor has a laser LED (Light Emitting Diode), a PD (photodiode) sensor, a fan, amplifier and USB (Universal Serial Bus) encoder, as shown in Figure 3.

III. Preliminary Results From Field Experiments

A. *Mobile Sensing*

Figure 4 shows pollution mapping results in Japan, China and Korea using a prototype of Pocket $PM_{2.5}$ Sensor. In Tokyo, Japan, the Pocket $PM_{2.5}$ Sensor showed a reading of 22.5-25 ug/m^3 in an area close to a public pollution measurement instrument installed by the local government, which reported 21 ug/m^3. The two readings are considered as almost same. We found a high concentration level (60-83 ug/m^3) in smoking and grill restaurants zones, which we call 'hotspots'. In Weihai, China, the $PM_{2.5}$ concentration was around 28-36 ug/m^3 at the seaside and, in contrast, it was 44-57 ug/m^3 in downtown. Also, we found a hotspot (94 ug/m^3) close to an exhaust connected to underground restaurants. In Seoul, Korea, $PM_{2.5}$ concentration was 47-47 ug/m^3 in downtown, and 30-35 ug/m^3 in a garden area. The difference seems to be related to vegetation.

B. *Fixed Monitoring*

We conducted 24/7 continuous monitoring using the Pocket $PM_{2.5}$ sensors combined with solar cells and 3G/4G network. The monitors have been installed in the vicinity of public pollution measurement instruments, as shown in Figure 5, in cooperation with the local government. The comparative experiments will provide accuracy and reliability assurance continuously.

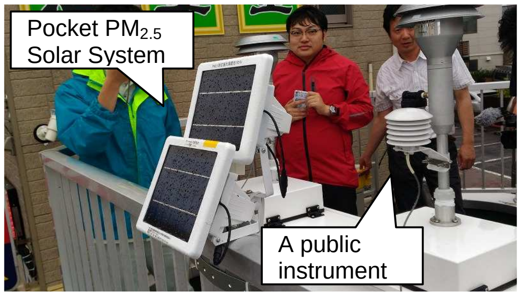

Figure 5. Installation of Pocket $PM_{2.5}$ Solar Monitoring system

IV. Conclusion

Pocket $PM_{2.5}$ Sensor has a great potential for mobile citizen sensing and visualization. Its accuracy seems sufficient, but more assurance is needed by performing regular cross-checking with public monitoring instruments. We plan to conduct a data sharing and risk communication experiment through social media discussion involving local residents, experts and public sector, to ensure monitoring, risk awareness and education of individuals based on the 3D method.

Acknowledgment

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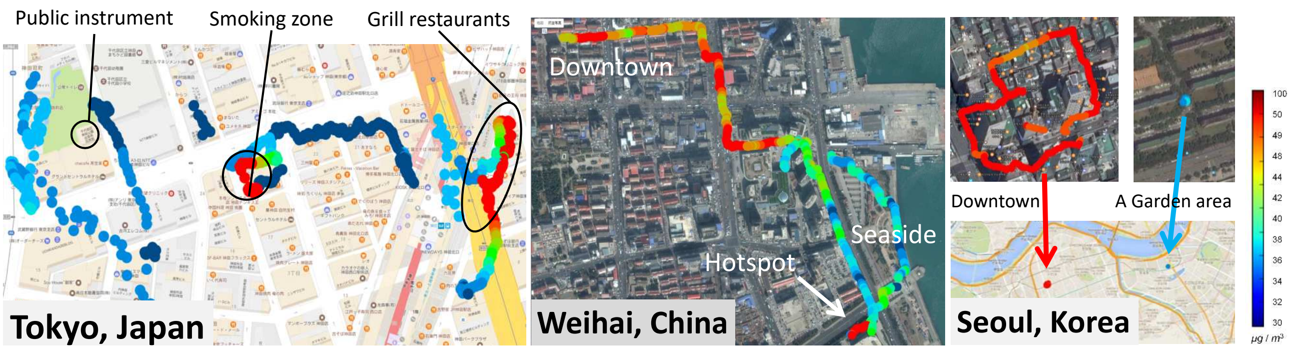

Figure 4. Pollution mapping results in Tokyo, Japan (left), Weihai, China (mid) and Seoul, Korea (right).