

# Citizen Sensing for Environmental Risk Communication

## Action Research on PM<sub>2.5</sub> Air Quality Monitoring in East Asia

Yang Ishigaki and Kenji Tanaka  
Graduate School of Informatics and Engineering  
University of Electro-Communications  
Tokyo, Japan  
Email: pokega@tanaka.is.uec.ac.jp

Yoshinori Matsumoto  
Faculty of Science and Technology  
Keio University  
Kanagawa, Japan  
Email: matsumoto@appi.keio.ac.jp

Harrizki Arie Pradana  
STMIK Atma Luhur Pangkalpinang  
Bangka Island, Indonesia  
Email: harrizkiariep@atmaluhur.ac.id

Yasuko Yamada Maruo  
Department of Environment and Energy  
Tohoku Institute of Technology  
Miyagi, Japan  
Email: y-y-maruo@tohtech.ac.jp

**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<sub>2.5</sub> (Particle Matter with aerodynamic diameters  $\leq 2.5 \mu\text{m}$ ). Preliminary field tests showed that PM<sub>2.5</sub> 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 PM<sub>2.5</sub> [3]. The transboundary health impacts of PM<sub>2.5</sub> pollution associated with global trade are greater than those associated with long-distance atmospheric pollutant transport [4].

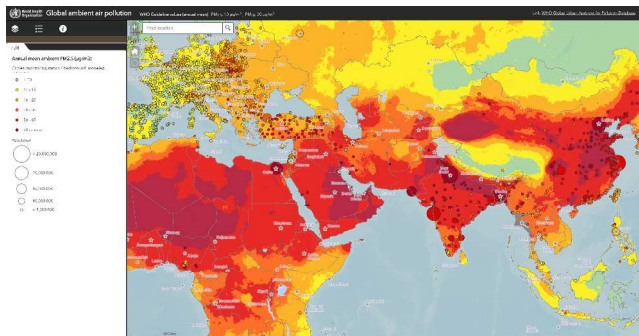


Figure 1. Air Pollution Mapping [2]

Simultaneously, coal use is expanding rapidly, especially in Asia, for cheaper power generation. Koplitz1 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<sub>2.5</sub> 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.

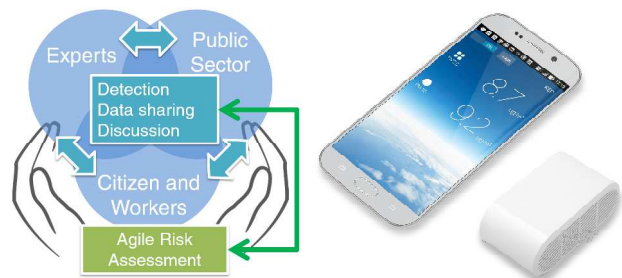


Figure 2. 3D method (left) and Poket PM<sub>2.5</sub> Sensor (Right)

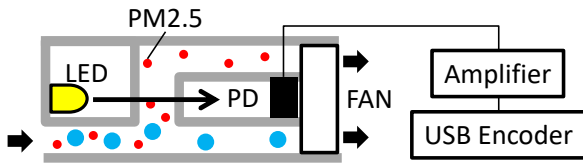


Figure 3. Principle of Pocket PM<sub>2.5</sub> Sensor Module

We developed ‘Pocket PM<sub>2.5</sub> 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<sub>2.5</sub> Sensor. In Tokyo, Japan, the Pocket PM<sub>2.5</sub> Sensor showed a reading of 22.5-25  $\mu\text{g}/\text{m}^3$  in an area close to a public pollution measurement instrument installed by the local government, which reported 21  $\mu\text{g}/\text{m}^3$ . The two readings are considered as almost same. We found a high concentration level (60-83  $\mu\text{g}/\text{m}^3$ ) in smoking and grill restaurants zones, which we call ‘hotspots’. In Weihai, China, the PM<sub>2.5</sub> concentration was around 28-36  $\mu\text{g}/\text{m}^3$  at the seaside and, in contrast, it was 44-57  $\mu\text{g}/\text{m}^3$  in downtown. Also, we found a hotspot (94  $\mu\text{g}/\text{m}^3$ ) close to an exhaust connected to underground restaurants. In Seoul, Korea, PM<sub>2.5</sub> concentration was 47-47  $\mu\text{g}/\text{m}^3$  in downtown, and 30-35  $\mu\text{g}/\text{m}^3$  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<sub>2.5</sub> 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.

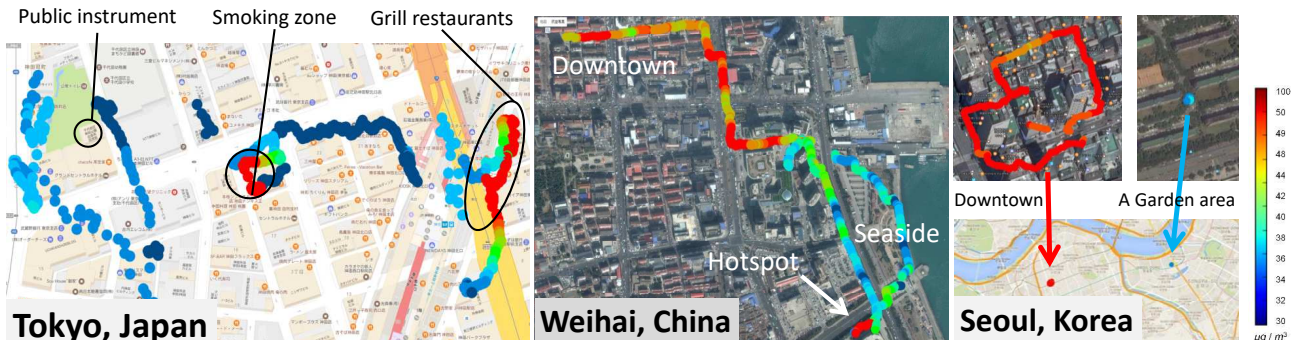


Figure 4. Pollution mapping results in Tokyo, Japan (left), Weihai, China (mid) and Seoul, Korea (right).

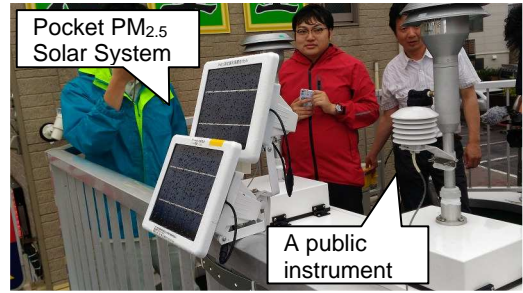


Figure 5. Installation of Pocket PM<sub>2.5</sub> Solar Monitoring system

### IV. CONCLUSION

Pocket PM<sub>2.5</sub> 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

This research is funded by Grants-in-Aid for Scientific Research (KAKENHI) of Japan Society for the Promotion of Science (JSPS) under Grant Number 15H01788.

### REFERENCES

- [1] United Nations Report, “Vast majority of world – 6.76 billion people – living with excessive air pollution”, 7 Sept, 2016. [Online]. Available from: <http://www.un.org/apps/news/story.asp?NewsID=55138#.WXWnFYjyhaQ> (2017.7.24).
- [2] <http://maps.who.int/airpollution/> (Accessed on 2017.7.24).
- [3] European Environment Agency, “Air quality in Europe — 2016 report”, EEA Report No 28/2016, ISSN 1977-8449, 23 Nov 2016. [Online]. Available from: [https://www.envir.ee/sites/default/files/air\\_quality\\_in\\_europe\\_2016\\_report\\_thal16027enn.pdf](https://www.envir.ee/sites/default/files/air_quality_in_europe_2016_report_thal16027enn.pdf) (2017.7.24)
- [4] Q. Zhang, et al., “Transboundary health impacts of transported global air pollution and international trade”, 30 Mar, Vol. 543, pp.705-709, Nature, 2017
- [5] S. Koplitz, et al.: Burden of disease from rising coal emissions in Asia, presentation on *GEOS-Chem Meeting (IGC7)*, Harvard University, May 4-7, 2015.