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Work Package X
Exposome monitoring and metabolomics profiling

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Project Deliverable

D5.1: Improved wearable PEMs

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Executive Summary

The Deliverable 5.1 provides a summary of the improved wearable Personal Exposome Monitor (PEM). The improved PEM has twice the flow rate compared with the device used in previous publication ¹, which allows for a great number of particles to be collected. Additionally, the improved PEM has a longer battery life, lighter weight, and is equipped with Global Positioning System (GPS) recording to help associate exposures with locations. This improved PEM will be used for longitudinal monitoring of pregnant women from the Finnish Maternity Cohort (FMC), which collects data and samples from all pregnant women in Finland.

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1 Introduction

Exposome refers to the totality of exposures through one's lifetime ², which has a significant impact on personal health. Our published work ¹ suggests that we are exposed to a dazzling array of abiotic and biotic environmental contaminants in our daily lives, far beyond what was previously quantified and understood. We identified significant locational and seasonal patterns on both biological and chemical profiles, reflecting dynamic changes in samples collected from the same person. Perhaps more importantly, we discovered that human exposomes differed substantially between individuals even located in the same general area (e.g Bay Area), demonstrating that traditional monitoring data on broad areas cannot reflect the complexity and dynamics of individual environmental exposures in practice.

The monitoring devices used in the published work were costly (~ USD 2700) and contained battery-drain functionalities that are not suitable for daily monitoring. We adapted another device with improved features. Briefly, the improved PEM has a cartridge with hydrophilic (polyethersulfone) filter to capture the biological components of particulate matter (PM) and a cartridge for sorbents which collect aerosol chemicals (both hydrophilic and hydrophobic). The improved PEM has twice the flow rate as before, which allows a larger amount of particles to be collected. Other features of the device include measuring temperature, humidity, and GPS coordinates. We performed a proof-of-concept study to evaluate the performance of the device. The new device collects more biological and chemical particles compared with the old device. Thus, this new PEM fulfils our aim for the study and will be sent to consented FMC study participants to monitor their personal exposure over the course of the study.

The produced data and results will be integrated to the HEAP platform in collaboration with WP2 (Ethics and regulations) WP7 (data standardisation and integration), WP6 (data management and analysis).

2 Improved PEM

2.1 Technical Specifications

Compared with the older PEM (MicroPEM), the new PEM, called Ultrasonic Personal Aerosol Sampler (UPAS) has twice the flow rate and a longer battery life. In addition, the device is only half the price of the MicroPEM and has a lighter weight (Table 1). The UPAS is also equipped with GPS recordings.

Table 1 Technical Specification comparison



Brand name	RTI -- MicroPEM	AST -- Ultrasonic Personal Air Sampler (UPAS)
Price (USD)	2700	1300
Weight (g)	301	230
Flow Rate	0.5 L/min	1 L/min (potential to reach 2 L/min)
Battery Life	~24h	~30 h
GPS	X	Yes
App Control	X	Yes

Video showing the real size and modularity of the new PEM:

https://drive.google.com/file/d/1E9bk_lj-5xW6yQWJz5Ulyyaa9i5u5dJ6/view?usp=sharing

2.2 Exposome profiling

We performed a pilot test to evaluate the performance of the new device. A participant carried both devices for two weeks. DNA was extracted from the filter and subjected to sequencing. Chemicals were extracted from absorbents and subjected to mass spectrometry analysis, following published methods ^{1,3}.

Sample 729 and 731 were collected from the old MicroPEM, and A1 and A2 were collected from the new UPAS. Total concentrations of all chemicals were 1.55 times higher compared to old devices (Figure 1).

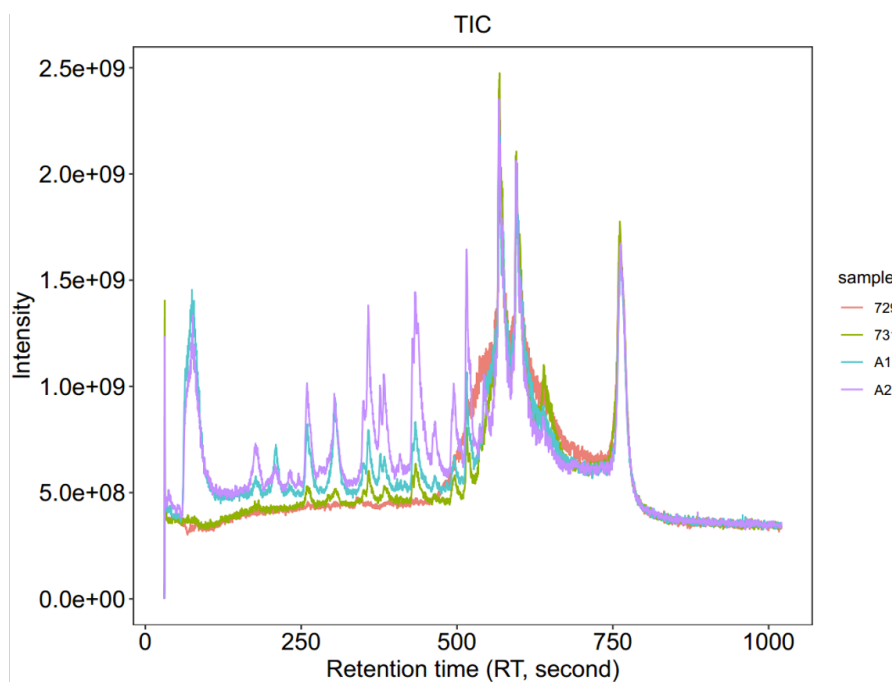


Figure 1 Comparison of chemical concentrations

New PEM collected more DNA compared with old devices (Figure 2).

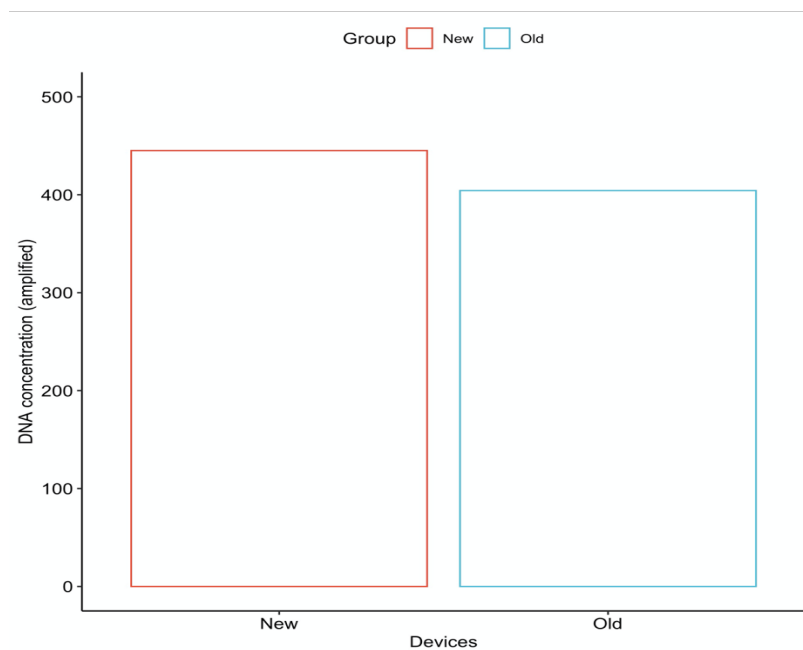


Figure 2 Comparison of DNA concentrations

Example GPS data collected by improved PEM (Figure 3). Size of the dot represents the time spent on the location.

P1 GPS

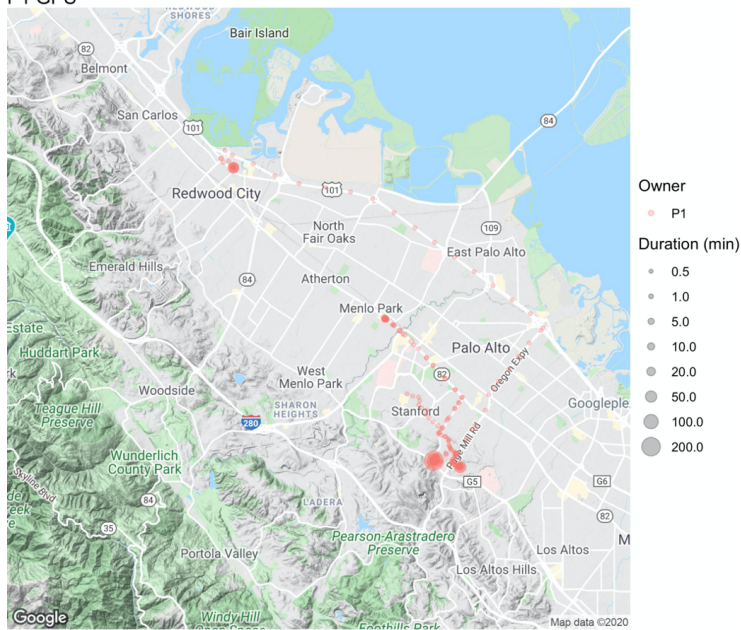


Figure 3 Example GPS data collected

3 Summary and Future Plans

We successfully adopted an improved PEM suitable for daily exposure monitoring. Compared with the older device, the improved PEM has twice the flow rate (with the potential to reach four times the flow rate) and a longer battery life. In addition, the improved PEM costs only half the price of the older one, weighs lighter, and can record GPS coordinates. We demonstrated the improved PEM collects more materials compared with the old device.

The improved PEM meets our expectations for the study. The device will be deployed to consented participants in the study for longitudinal monitoring.

This deliverable is the starting point towards personal exposome and metabolomics profiling. This requires close collaboration with HEAP work packages as WP8 (epigenomics) and WP9 (metagenomics) to produce and integrated analysis of the data for exposome risk assessment. At the moment, WP5 is defining the metadata model to integrate the PEM data into the HEAP platform.

4 References

- [1] Jiang, C. *et al.* Dynamic Human Environmental Exposome Revealed by Longitudinal Personal Monitoring. *Cell* 175, 277–291.e31 (2018).
- [2] Wild, C. P. Complementing the genome with an ‘exposome’: the outstanding challenge of environmental exposure measurement in molecular epidemiology. *Cancer Epidemiol. Biomarkers Prev.* 14, 1847–1850 (2005).
- [3] Jiang, C. *et al.* Decoding Personal Biotic and Chemical Environmental Exposures. *Nature protocols*. Manuscript accepted.