Online Workshop
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Physico-chemical and toxicological properties of particles from ironing

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MOTIVATION

- Particulate matter with aerodynamic diameter lower than 10 µm (PM_{10}) in ambient air is responsible for adverse health effects
- Relatively little is known about the concentrations, sources and health effects of PM_{10} in indoor air, although people spend approximately 90% of their time indoors
- One of the domestic activities that most contributes to the increase of PM_{10} levels is ironing

This study aimed at assessing the impact of using different types of irons on indoor PM_{10} levels, and the associated physico-chemical and toxicological characteristics

SAMPLING – Particulate matter on filters

Steam iron

Condition 1

Doors and windows kept closed

Steam iron with boiler

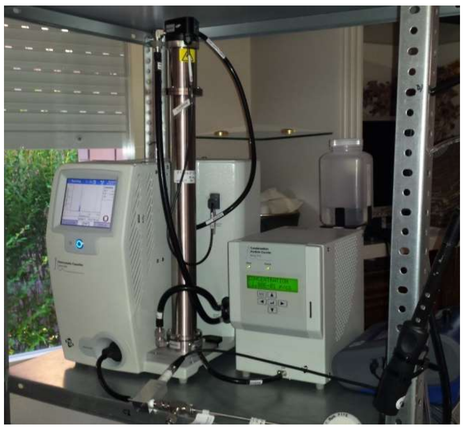
Condition 2

Room doors opened and windows kept closed

High-volume sampling onto quartz filters

Gravimetric determination

SAMPLING – Real time monitoring



Scanning Mobility Particle Sizer (SMPS)
Real time particle size distributions and number concentrations in the range from 7.64 to 310.6 nm

Laser photometric instrument
Real-time particulate matter concentration
(PM_1, $PM_{2.5}$, PM_4, PM_{10}, TSP)

Real time monitor of CO_2, CO, TVOC, T and RH
(WolfSense)

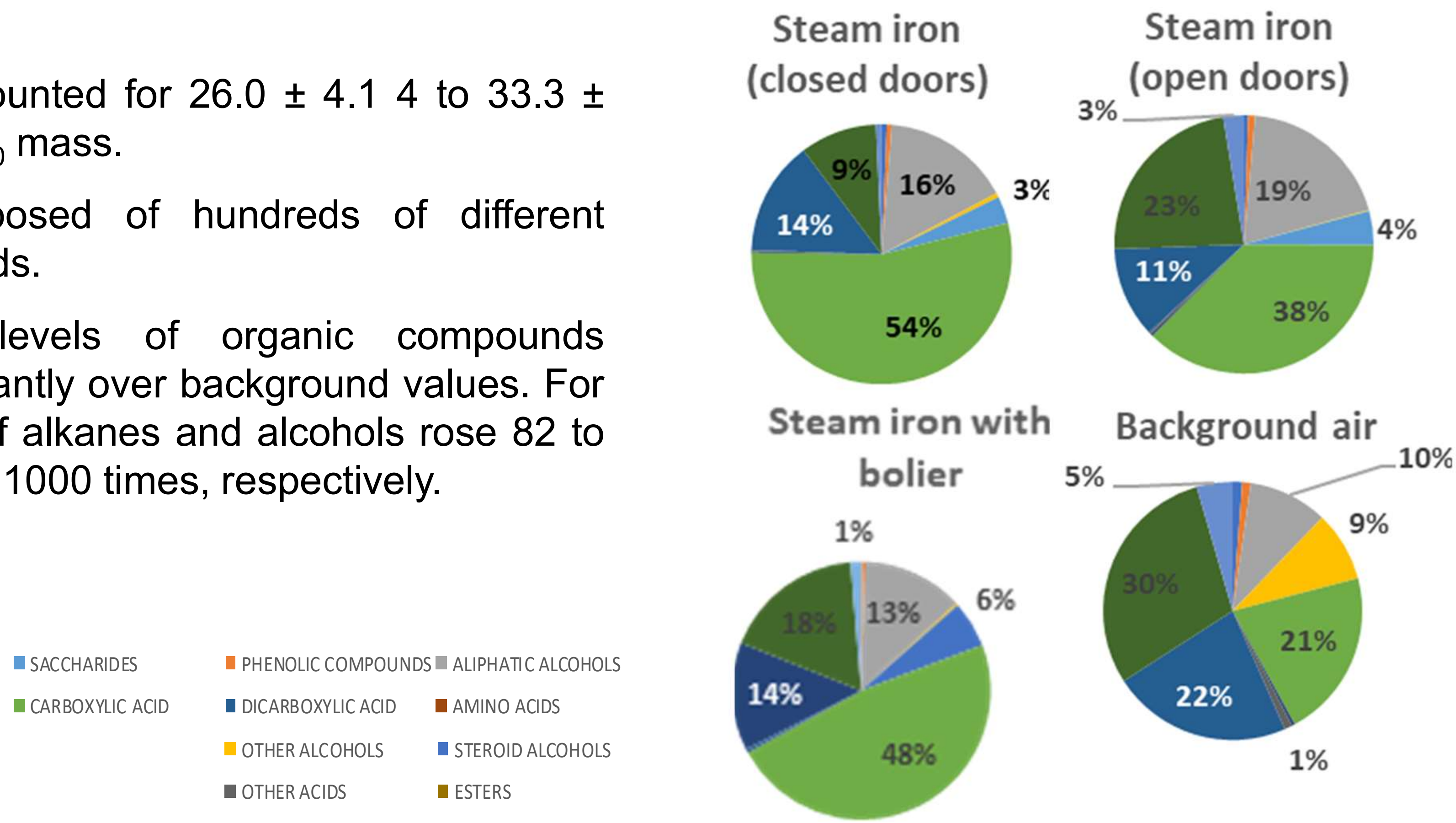
CHEMICAL CHARACTERISATION

Thermo-optical determination of OC/EC

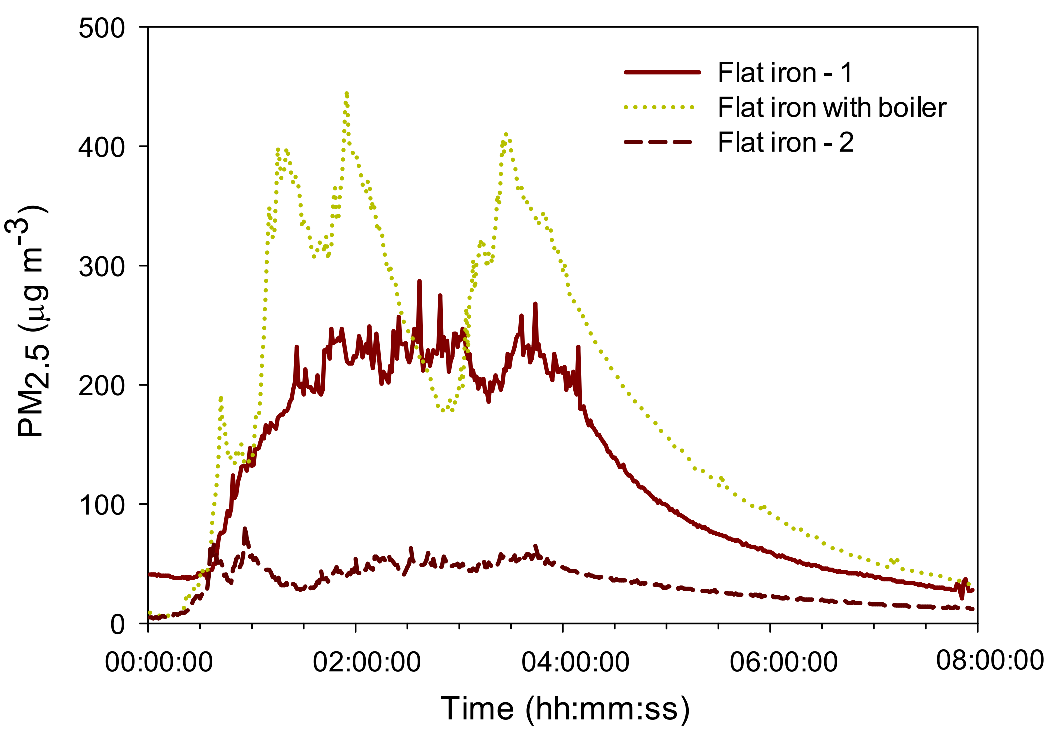
Organic speciation by GC-MS after solvent extraction

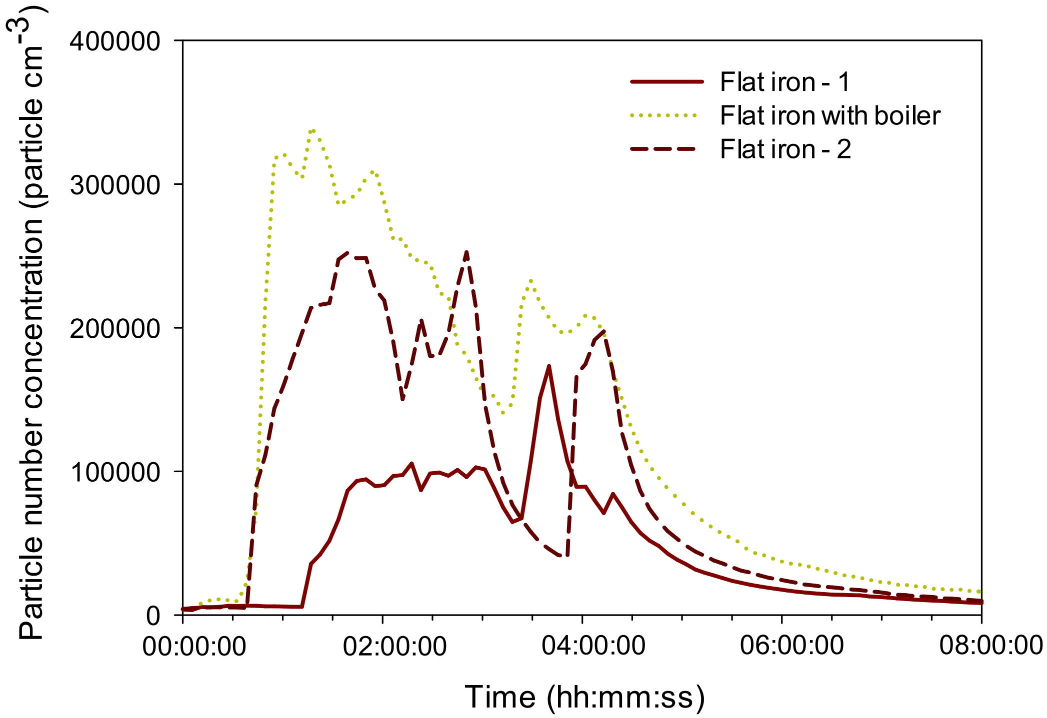
Organic composition of PM_{10}

- Total carbon accounted for 26.0 ± 4.1 4 to 33.3 ± 3.17% of the PM_{10} mass.
- PM_{10} was composed of hundreds of different organic compounds.
- While ironing, levels of organic compounds increased significantly over background values. For example, levels of alkanes and alcohols rose 82 to 143 and 8 to over 1000 times, respectively.



Temporal evolution of particle number and concentration





- When using the iron with boiler, $PM_{2.5}$ levels increased from 5 µg m^{-3} to over 400 µg m^{-3}
- Particle number concentrations increased over the background levels by 16 - 97 times during ironing
- Particle number increased from < 100 to more than 300,000/cm^3

Estimation of PM emission rates

$$\frac{dC_{in}}{dt} = P\alpha C_{out} + \frac{Q_s}{V} - (\alpha + \kappa)C_{in}$$

$$\overline{Q_s} = V \times \left[\frac{C_{in} - C_{in0}}{\Delta t} + \overline{(\alpha + \kappa)}\,\bar{C}_{in} - \alpha C_{in0}\right]$$

$$\frac{dC_{in}}{dt} = -(\alpha + \kappa)C_{in}$$

$$\ln\left(\frac{C_{in_t}}{C_{in_0}}\right) = -(\alpha + \kappa)t$$

	Steam iron I	Steam iron II	Steam iron with boiler
Air exchange rate (α, h^{-1})	0.25 ± 0.13	1.8 ± 0.39	0.38 ± 0.06
PM_{10} initial mass concentration (µg m^{-3})	51.0 ± 2.83	16.0 ± 1.41	21.0 ± 2.83
PM_{10} peak mass concentration (µg m^{-3})	340 ± 62.2	98.0 ± 15.6	444 ± 15.6
$PM_{2.5}/PM_{10}$ (%)	94 ± 0.2	87 ± 5.7	94 ± 2.3
PM_1/PM_{10} (%)	93 ± 0.4	85 ± 6.3	93 ± 2.6
Particle number initial concentration (particles × 10^3 cm^3)	3.59 ± 1.27	5.95 ± 1.55	7.18 ± 3.41
Particle peak number concentration (particles × 10^5 cm^3)	4.38 ± 1.18	2.55 ± 0.0315	3.61 ± 0.303
Emission rate PM_{10} (µg s^{-1})	6.62 ± 1.35	1.92 ± 1.64	8.34 ± 3.07
Emission rate particle number (particles × 10^{11} min^{-1})	11.6 ± 2.28	8.12 ± 0.0873	15.3 ± 3.45

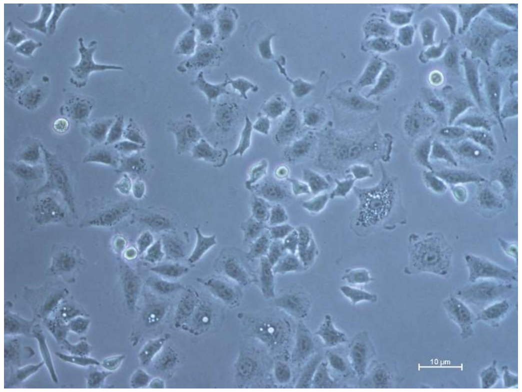
CITOTOXICITY ASSESSMENT

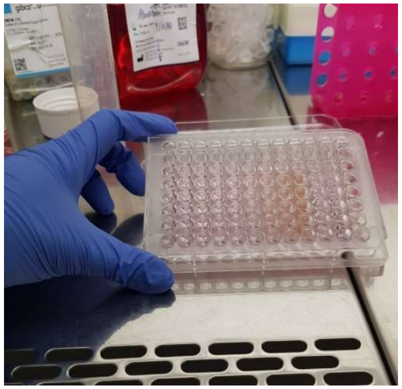
In vitro testing is a common first step in assessing particle-related health hazards. Viability assays are frequently used to compare the toxicity of different particle types and to generate dose−response data.

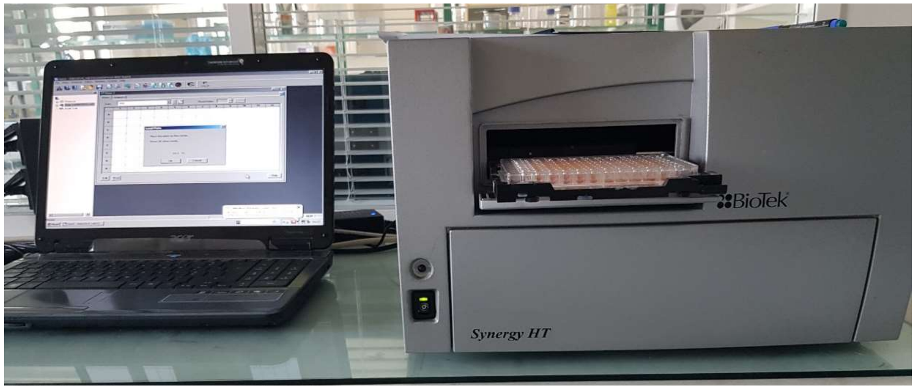
WST-8 enzyme-based method: rely on a reductive coloring reagent and dehydrogenase in a viable cell to determine **cell viability** with a colorimetric method.

A549 cell line

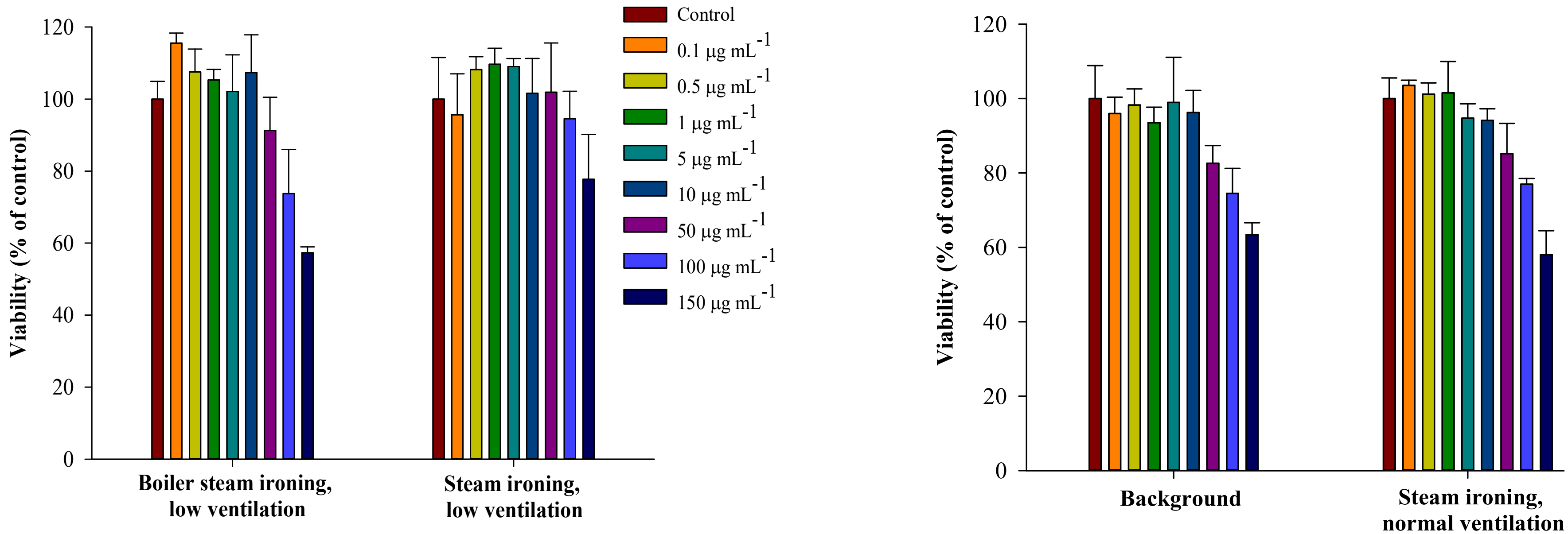
- **Organism: human (*Homo sapiens*)**
- **Cell type: epithelial**
- **Tissue: lung**





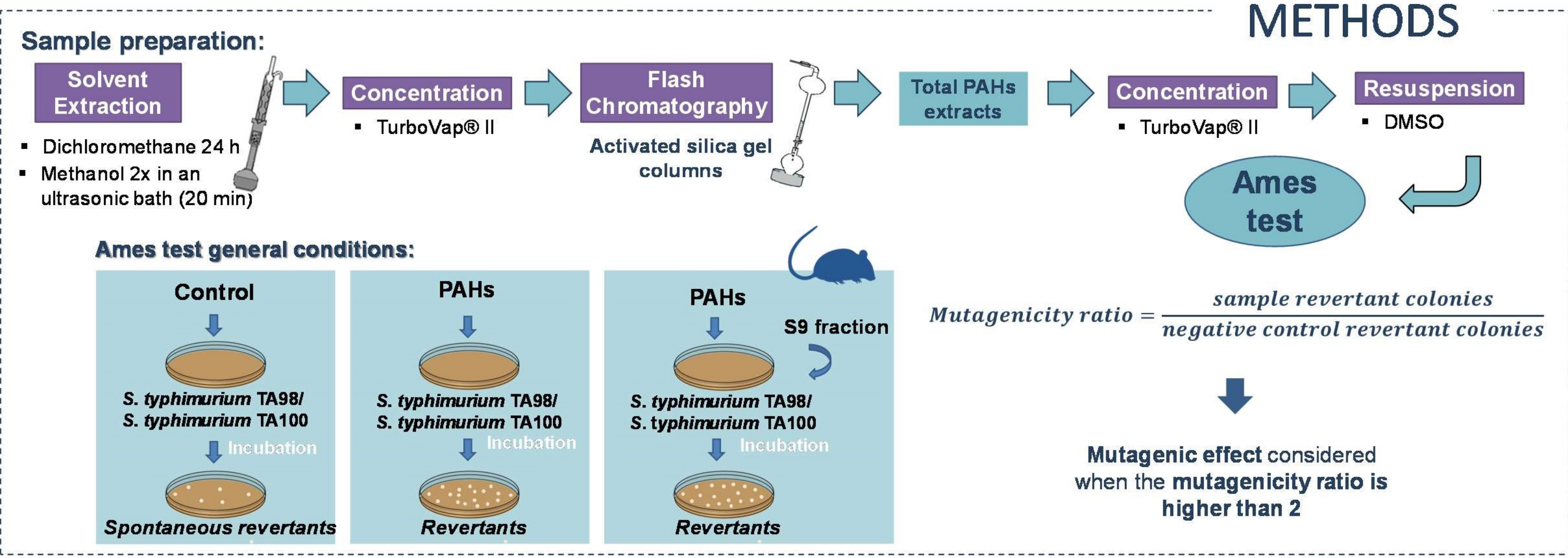


CITOTOXICITY ASSESSMENT – Cell viability



- A decrease in cell viability for all samples at the three highest concentrations (50, 100 and 150 µg mL^{-1}) was observed.
- At the highest concentration (150 µg mL^{-1}), samples from steam ironing, under normal and low ventilation conditions, and from boiler steam ironing, presented a decrease of 42±6, 22±12 and 43±2% in cell viability, respectively.
- The background air sample also induced a considerable decrease in cell viability (37±3%) at the highest concentration.

MUTAGENICITY ASSESSMENT



MUTAGENICITY ASSESSMENT

	Ratio		
	TA98	TA98/S9	TA100
Boiler, low ventilation	1.23 ± 0.05	1.02 ± 0.06	1.02 ± 0.16
Steam iron, low ventilation	1.11 ± 0.34	0.63 ± 0.09	1.00 ± 0.02
Steam iron, normal ventilation	1.23 ± 0.05	0.63 ± 0.33	0.97 ± 0.23
Background air	1.34 ± 0.62	0.83 ± 0.39	0.96 ± 0.15

Ames test for TA100 with S9 metabolic activation in progress.

All the samples presented ratios below 2, which suggest that **there is no mutagenic effect**

CONCLUSIONS

- Ironing clothes contributes to the emission of PM_{10} with a very complex organic composition, significantly increasing the indoor levels.
- The organic extracts from these particles were found to have cytotoxic effects, but not mutagenic.
- Given the organic compounds detected, it is necessary to assess the quantities and quality of detergents and fabric softeners used in washing clothes. In the course of the activity, measures must be taken to promote efficient ventilation.
- Further research is needed, covering other irons and categories of clothing.

Acknowlegments

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OBRIGADA!