CATÓLICA
ESCOLA SUPERIOR DE BIOTECNOLOGIA
PORTO

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Development of a microfluidic paper-based device for aluminium quantification in urine: potential implications for Alzheimer's disease monitoring

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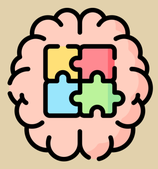
Long-term exposure to high Al(III) concentrations

- **Aluminium intake**
  (air, drinking water, food and drugs)
- **Cosmetic and personal care products**
  (antiperspirants, sun creams and toothpast)
- **Materials containing aluminium**
  (food packaging, aluminium foils and cooking utensils)

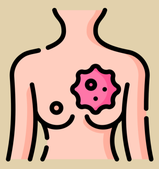
Health risks linked to Al(III) exposure


Autism


Multiple sclerosis


Alzheimer's disease


Kidney and liver damage


Breast cancer

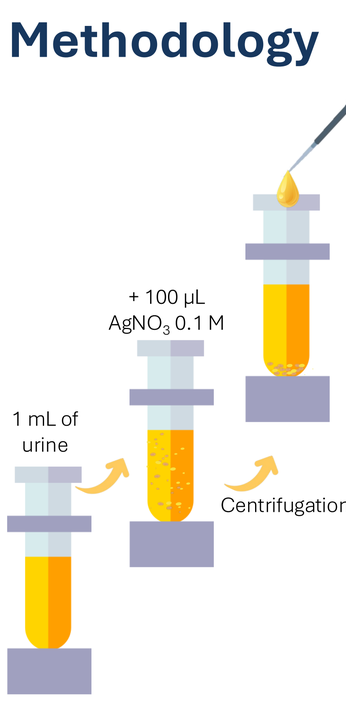

Parkinson's disease

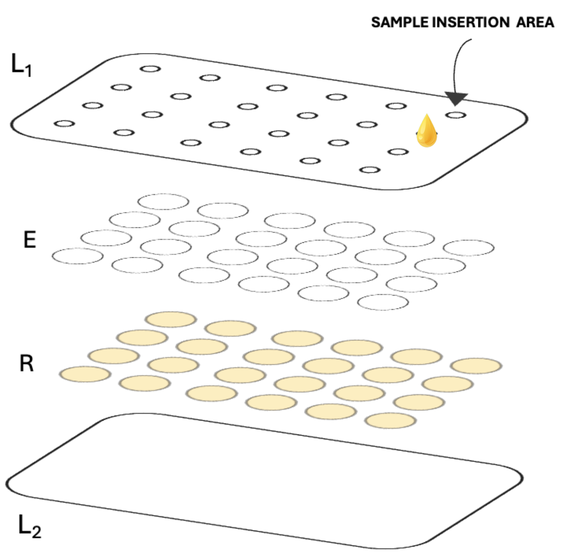
Alzheimer's disease (AD) monitoring using urine samples

- Urine: non-invasive and easy-to-collect sample
- Reflects systemic Al(III) accumulation
- Allows early screening and exposure assessment
- Enables point-of-care testing

Risk of AD with Al(III) concentration > 0.1 mg/l

Methodology





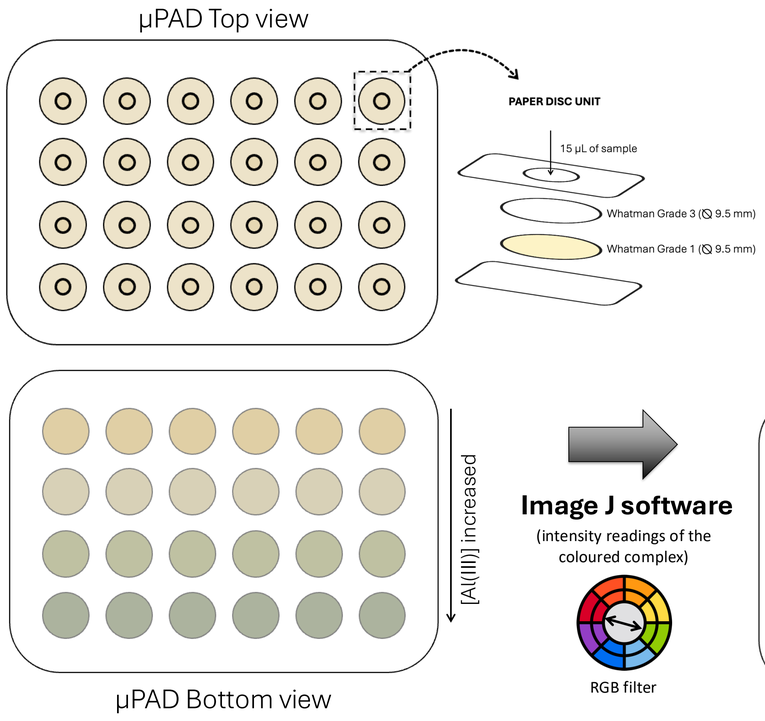
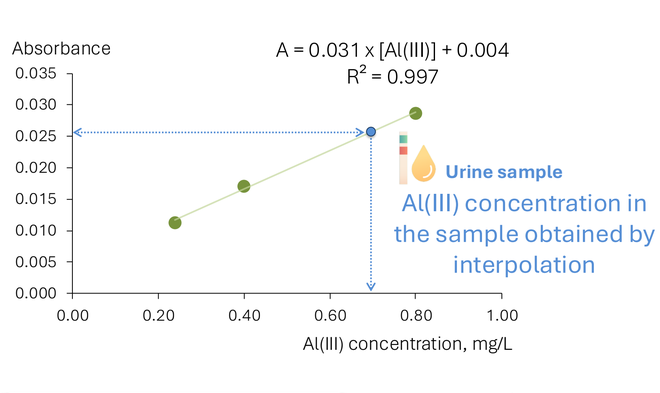
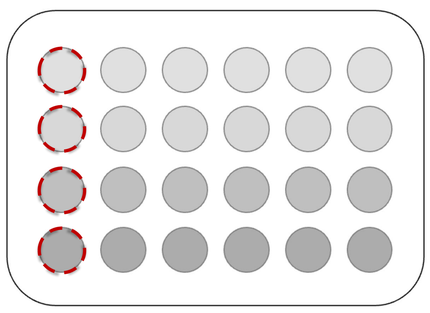


Image J software
(intensity readings of the coloured complex)

RGB filter

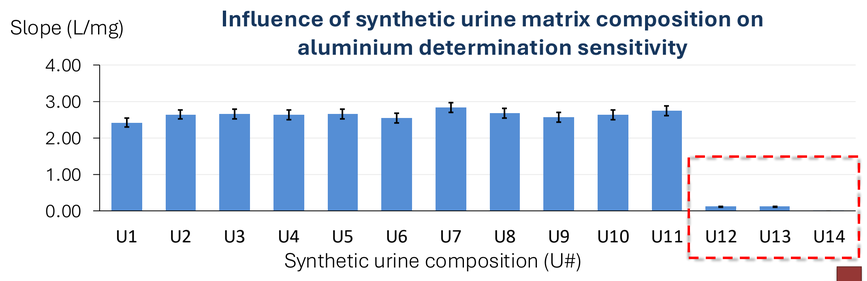




$A = \log_{10}(I_0/I_s)$

A - Absorbance
I_0 - Intensity of the blank
I_S - Intensity of the sample

Results



Matrix ID (U#)	Matrix composition	Matrix ID (U#)	Matrix composition
U1	Sodium chloride	U8	U7 + Glucose
U2	U1 + Sodium sulphate	U9	U8 + Creatinine
U3	U2 + Urea	U10	U9 + Calcium chloride
U4	U3 + Ammonium chloride	U11	U10 + Magnesium sulphate
U5	U4 + Bicarbonate sulphate	U12	U11 + Citric acid
U6	U5 + Lactic acid	U13	U11 + Potassium dihydrogen phosphate
U7	U6 + Uric acid	U14	U11 + Di-potassium hydrogen phosphate

Citric acid interference minimization:

[Al(III)], mg/L	[Citric acid], g/L	Absorbance	RE %
0.80	0.00	0.019	-
	0.10	0.019	1.2%
	0.15	0.017	-9.6%
	0.20	0.007	-62%
	0.40	0.003	-84%

0.40 g/L → Expected concentration of citric acid in urine samples

✓ Dilute the sample 4x to avoid interference

Phosphate interference minimization:

	$AgNO_3$	Intensity values	RE %
U11	no	211.5	-
U14	yes	212.4	0.4%
1.2 mg/L Al(III) in U11	no	197.6	-
1.2 mg/L Al(III) in U14	yes	197.5	-0.1%

✓ $AgNO_3$ as a masking agent, precipitating phosphate and significantly improving the method's selectivity

µPAD optimization studies:

Work on going...

Parameters	Tested conditions	Chosen conditions
Colour reagent	ERC and CAS	CAS
Layers number	1, 2 and 3	2
Layers order (1st/2sd)	R layer/E layer or E layer/R layer	E layer/R layer
Filter paper type (R layer)	Qualitative, ashless quantitative, hardened low ash and hardened ashless	Qualitative
Paper porosity (Both layers)	2.5 - 25 µm	11 µm
Paper thickness (E layer)	180 and 390 µm	390 µm
Paper disc diameter (E layer)	9.5 and 12.7 mm	9.5 mm
CAS concentration	0.2 - 1.5 g/L	1.0 g/L
Sample volume	10 - 40 µL	20 µL

Low cost, rapid analysis and user-friendly operation

Early diagnostic tool for potential health risks associated with Al(III) exposure

Disposable and portable: easily transportable to remote locations

µPAD designed according to the WHO guidelines

Acknowledgements

Juliana I. S. Aguiar thanks FCT – Fundação para a Ciência e a Tecnologia for the grant 2023.00790.BD. This work was also supported by National Funds from FCT through project UIDB/50016.

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