A bi-parametric paper-based sensor for Al(III) and Fe(III) monitoring in well waters

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➢ Introduction

WELL WATER MONITORING

Limitations of conventional methods (ICP or AAS)

Expensive equipment

Specialized technicians

Complex sample transport

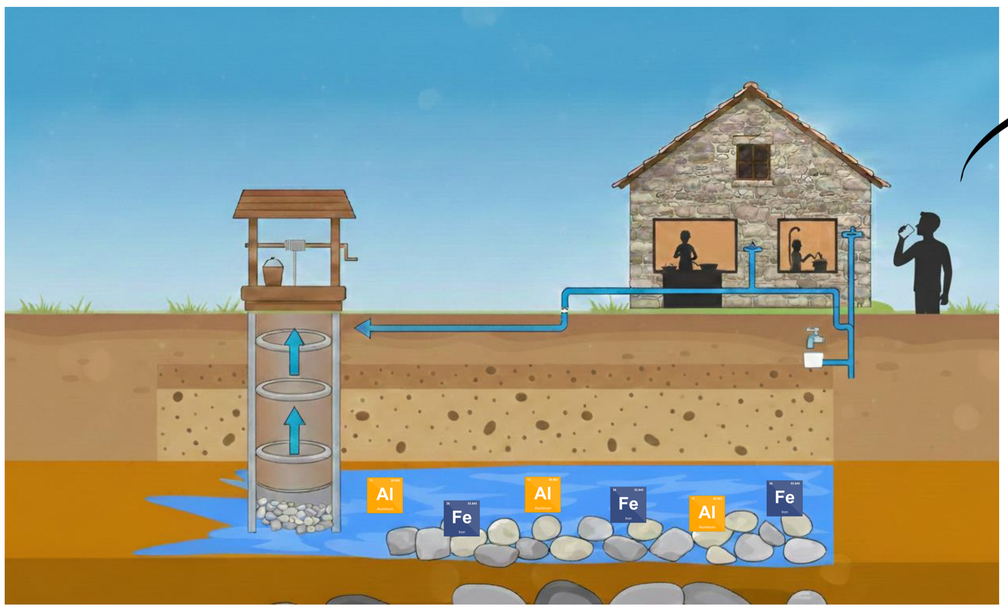
Microfluidic Paper-based Analytical Device (µPAD)

Low cost analysis

Simple fabrication

Portability (on-site monitoring of domestic wells)

Bi-parametric determination in a single device



HEALTH IMPACTS & RISKS

Al — Aluminum

Linked to neurodegenerative disorders

(Alzheimer and Parkinson's disease)

Multiple sclerosis

Autism

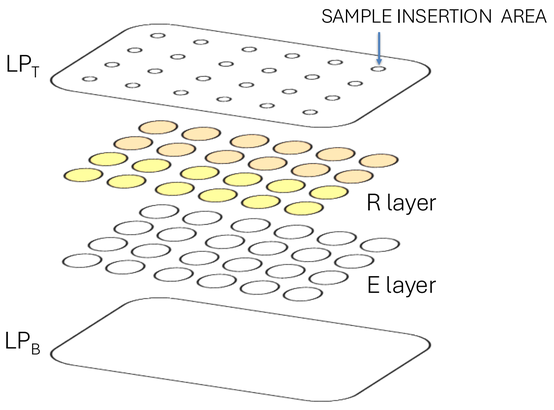
Fe — Iron

Affects aesthetic properties in water

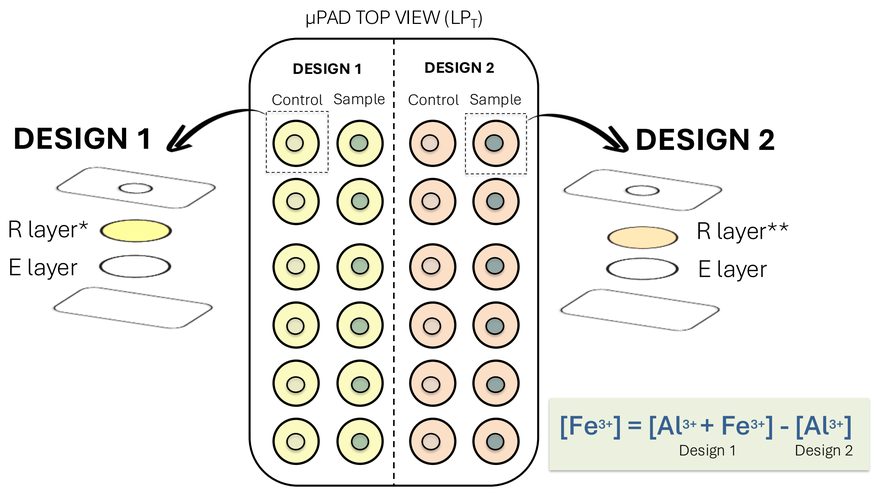
(taste and reddisch colour)

Promotes oxidative stress through free radical forming

➢ Methodology

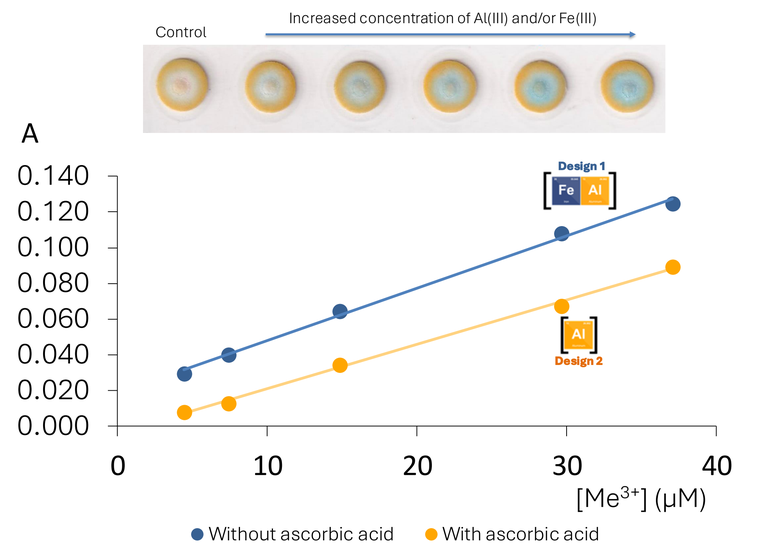


LP_T: Laminating Pouch (top view)
LP_B: Laminating Pouch (bottom view)
R layer: Reagent layer
E layer: Empty layer



$[Fe^{3+}] = [Al^{3+} + Fe^{3+}]_{Design\ 1} - [Al^{3+}]_{Design\ 2}$

*R layer was prepared using **CR1 reagent** (CAS + Acetate buffer)
R layer was prepared using **CR2 reagent (CAS + Acetate buffer + Ascorbic acid)



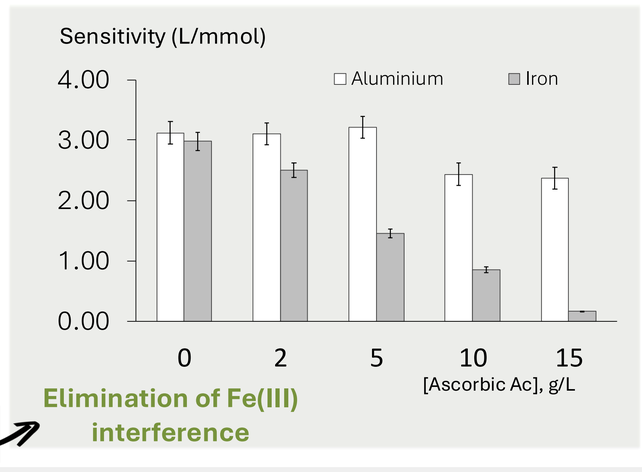
➢ Results

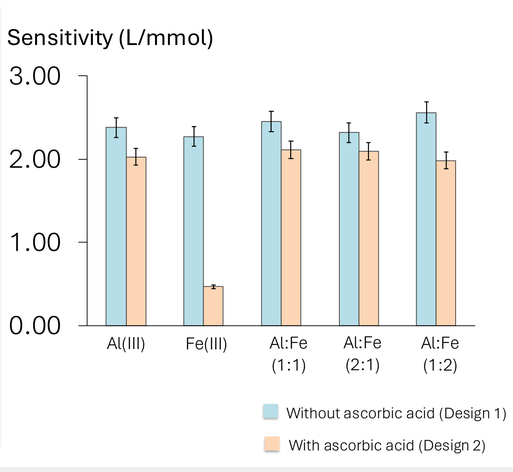
Optimization studies	Conditions tested	Optimized conditions
Chromogenic reagent	CAS and ECR	CAS
Filter paper type (R layer)	Qualitative, Ashless, Hardened low ash and Hardened ashless	Qualitative
Paper porosity (R layer)	2.5, 11 and 20-25 µm	11 µm
CAS concentration	0.2 - 2.0 g/L	1.0 g/L
Acetate buffer concentration ($NaCOOOCH_3$ / CH_3COOH)	0.17 - 1.25 M $NaCOOOCH_3$ 0.004 - 0.030 M CH_3COOH	0.84 M $NaCOOOCH_3$ 0.02 M CH_3COOH
Paper thickness (E layer)	0.18 and 0.39 mm	0.39 mm
Sample volume	10 - 20 µL	15 µL
Interference assessment	Cd^{2+}, Co^{2+}, Mn^{2+}, Ni^{2+}, Zn^{2+}, Mg^{2+}, Ca^{2+}, Cu^{2+}, Fe^{3+}, NH_4^+, PO_4^{3-}, NO_3^-, NO_2^-, SO_4^{2-}	Fe^{3+}
Masking agent (Fe^{3+})	Ascorbic acid, HMPP ligand and KSCN	Ascorbic acid
Ascorbic acid concentration	2 - 15 g/L	15 g/L

Analytical features of the developed paper-based device:

Configuration	Linear Range (µM)	Calibration curve A = slope ± SD x [Me] + Intercept ± SD	LOD	LOQ	RSD (%)
With ascorbic acid (Design 2: Al^{3+} determination)	4.0 - 34	$A = 2.56 \pm 0.09 \times [Al] + 0.002 \pm 0.001$	1.2	3.9	4.3
Without ascorbic acid (Design 1: Al^{3+} + Fe^{3+} determination)	2.5[a] - 34	$A = 2.95 \pm 0.01 \times [Me] + 0.007 \pm 0.001$	0.66[a]	2.2[a]	2.6

[a] These values should only be considered for Al(III) determination if Fe(III) is absent from the sample





➢ Conclusions

Efficient µPAD development
Bi-parametric paper sensor for Al(III) and Fe(III) monitoring

Ascorbic acid (15 g/L) successfully masked Fe(III) interference in Al(III) detection

High analytical performance
Low detection limits for Al(III) determination

Cost-effective & portable
Safety tool for early detection of metal contaminants in domestic well waters

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