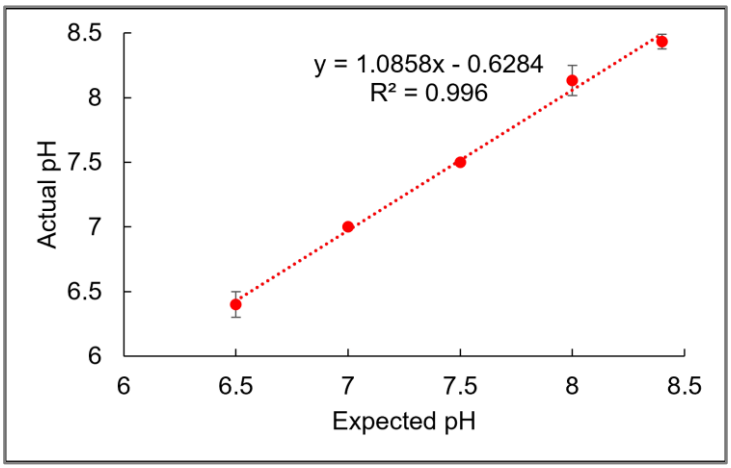
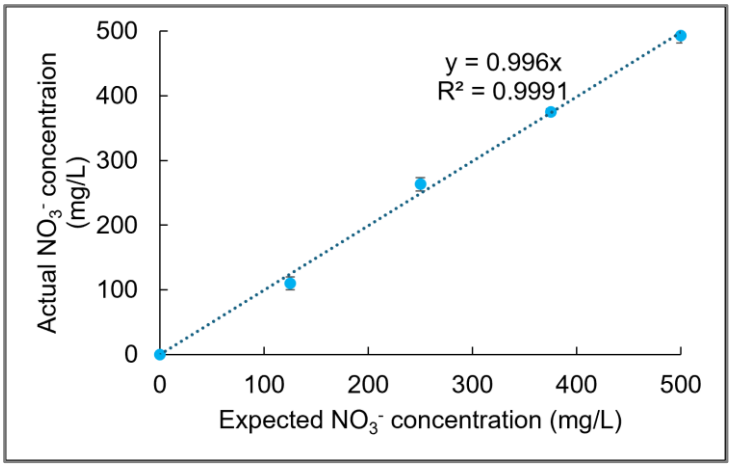
SUPPLEMENTARY MATERIAL TO: Mayet et al. S Afr J Sci. 2026;122(9/10), Art. #23287

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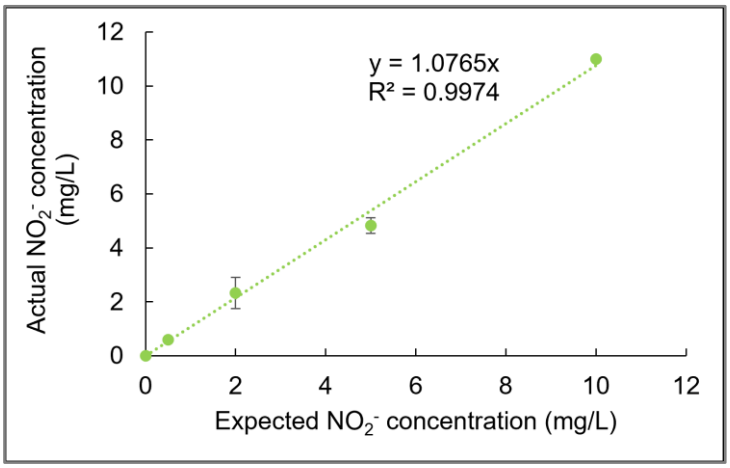
Measured versus expected values for standard solutions were first assessed in triplicate to validate the reference analytical methods. Strong agreement between measured and expected values confirmed that the prepared standard solutions were appropriate and that the pH meter (Supplementary figure 1) and spectroscopic measurements (Supplementary figures 2–4) provided suitable benchmarks for evaluating the test strips. These measurements were the reference measurements for the data presented in Figures 1–4 of the main text.



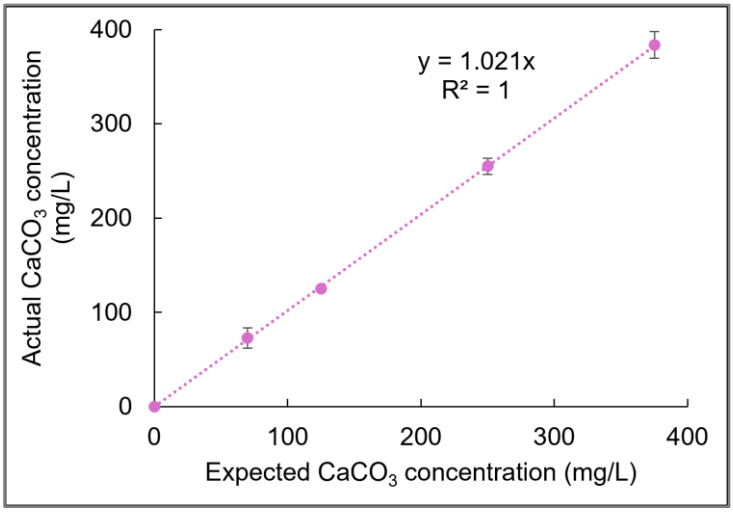
Supplementary figure 1: Measured versus expected pH values for standard solutions, demonstrating agreement between pH meter readings and reference values. Linear regression analysis was performed to assess this relationship. Measurements were performed in triplicate; error bars represent one standard deviation of the mean.



Supplementary figure 2: Measured versus expected nitrate concentrations for standard solutions, demonstrating agreement between spectroscopic measurements and reference values. Linear regression analysis was performed to assess this relationship. Measurements were performed in triplicate; error bars represent one standard deviation of the mean.



Supplementary figure 3: Measured versus expected nitrite concentrations for standard solutions, demonstrating agreement between spectroscopic measurements and reference values. Linear regression analysis was performed to assess this relationship. Measurements were performed in triplicate; error bars represent one standard deviation of the mean.



Supplementary figure 4: Measured versus expected calcium carbonate concentrations for standard solutions, demonstrating agreement between spectroscopic measurements and reference values. Linear regression analysis was performed to assess this relationship. Measurements were performed in triplicate; error bars represent one standard deviation of the mean.

For each analyte and concentration, the mean and standard deviation of five replicate measurements were calculated to evaluate precision, under indoor and outdoor lighting conditions. These data are presented in Supplementary tables 1 and 2. The standard deviation provides a measure of variability between test strip replicates and is represented as error bars in Figures 1–4 of the main text.

Supplementary table 1: Mean ($\bar{x}$) and standard deviation (σ) of test strip measurements for all analytes across concentrations under ***indoor*** conditions

	Product A		Product B		Product C		Product D		Product E	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
pH	6.40	0.14	6.38	0.11	6.48	0.04	6.48	0.22	6.56	0.13
	6.76	0.17	6.80	0.24	7.06	0.26	6.92	0.18	6.92	0.11
	7.50	0.22	7.18	0.11	7.42	0.04	7.28	0.22	7.38	0.16
	7.80	0.24	7.72	0.18	8.08	0.18	7.92	0.18	8.04	0.17
	8.16	0.17	8.20	0.14	8.32	0.11	8.24	0.17	8.32	0.11
Nitrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	95.00	20.92	95.00	20.92	130.00	27.39	110.00	22.36	135.00	22.36
	170.00	51.23	155.00	27.39	235.00	33.54	210.00	57.55	160.00	54.77
	275.00	55.90	220.00	41.08	350.00	104.58	310.00	92.87	400.00	55.90
	350.00	55.90	325.00	68.47	450.00	68.47	425.00	111.80	475.00	55.90
Nitrite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.25	0.43	0.25	0.25	0.30	0.27	17.00	4.47	21.00	5.48
	1.25	0.75	1.85	1.87	2.60	1.71	30.00	7.07	38.00	4.47
	3.50	1.50	3.50	1.50	5.30	3.49	56.00	16.73	60.00	14.14
	5.90	3.01	5.50	1.12	6.50	2.24	60.00	14.14	72.00	10.95
Hardness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	70.00	0.00	70.00	0.00	92.00	30.12	395.00	480.04	205.00	67.08
	86.50	24.60	158.50	73.50	169.50	115.49	400.00	104.58	395.00	173.57
	162.50	55.90	175.00	52.29	237.50	27.95	575.00	167.71	550.00	189.57
	225.00	55.90	337.50	55.90	287.50	34.23	440.00	326.73	750.00	250.00

The standard deviations correspond to the error bars shown in Figures 1–4 of the main text and represent replicate-level variability (precision) from five measurements.

Supplementary table 2: Mean ($\bar{x}$) and standard deviation (σ) of test strip measurements for all analytes across concentrations under ***outdoor*** conditions

	Product A		Product B		Product C		Product D		Product E	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
pH	6.50	0.07	6.50	0.07	6.50	0.07	6.50	0.00	6.56	0.13
	7.06	0.26	7.10	0.26	7.00	0.14	7.00	0.14	7.00	0.00
	7.46	0.09	7.48	0.13	7.48	0.04	7.50	0.00	7.44	0.13
	7.92	0.30	8.00	0.14	8.00	0.00	8.12	0.11	8.16	0.17
	8.16	0.17	8.36	0.09	8.40	0.00	8.40	0.00	8.36	0.09
Nitrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	130.00	27.39	130.00	27.39	130.00	27.39	135.00	22.36	125.00	0.00
	275.00	55.90	260.00	72.02	235.00	33.54	275.00	55.90	220.00	41.08
	375.00	88.39	375.00	88.39	400.00	55.90	350.00	55.90	350.00	55.90
	500.00	0.00	475.00	55.90	475.00	55.90	500.00	0.00	500.00	0.00
Nitrite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.35	0.22	1.85	1.87	0.40	0.22	21.00	5.48	19.00	2.24
	2.30	1.64	4.00	2.76	2.90	1.34	38.00	4.47	42.00	10.95
	6.50	2.24	7.00	2.09	6.20	2.56	60.00	14.14	56.00	8.94
	5.00	0.00	4.90	1.95	8.00	2.09	80.00	0.00	76.00	8.94
Hardness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	117.00	75.61	81.00	15.06	64.70	8.00	205.00	67.08	275.00	55.90
	139.00	45.68	144.50	60.17	119.50	12.30	475.00	55.90	525.00	136.93
	239.00	133.10	262.50	52.29	300.00	68.47	570.00	284.17	475.00	162.98
	337.50	34.23	312.50	62.50	312.50	44.19	850.00	136.93	700.00	209.17

The standard deviations correspond to the error bars shown in Figures 1–4 of the main text and represent replicate-level variability (precision) from five measurements.

Linear regression analyses were performed for each analyte to assess the relationship between test strip measurements and reference values. For all variables except pH, the linear regression intercept was set to zero because the test strips consistently produced a zero reading when the standard concentration was zero. The associated error metrics (Supplementary table 3) provide quantitative insight into proportional agreement and linearity under indoor and outdoor conditions. The regression lines have been shown in Figures 1–4 of the main text.

Supplementary table 3: Linear regression parameters and error metrics for all analytes under indoor and outdoor lighting conditions

	pH					Nitrate				
Indoors										
	Product A	**Product B**	**Product C**	**Product D**	**Product E**	**Product A**	**Product B**	**Product C**	**Product D**	**Product E**
***Y*-intercept**	0.21	0.17	0.13	0.33	0.21	0.00	0.00	0.00	0.00	0.00
Slope	0.95	0.95	0.98	0.94	0.97	0.71	0.63	0.92	0.84	0.95
***Y*-intercept 95% CI**	0.72–1.13	0.59–0.93	0.59–0.85	0.54–1.20	0.47–0.89	0.00	0.00	0.00	0.00	0.00
Slope 95% CI	0.83–1.10	0.85–1.05	0.89–1.08	0.83–1.06	0.88–1.06	0.66–0.76	0.58–0.68	0.84–0.99	0.76–0.93	0.87–1.03
DF	23.00	23.00	23.00	23.00	23.00	24.00	24.00	24.00	24.00	24.00
R^2	0.92	0.94	0.95	0.93	0.96	0.91	0.90	0.90	0.85	0.90
Adjusted R^2	0.91	0.94	0.95	0.92	0.95	0.91	0.90	0.90	0.85	0.90
Sum of squares	0.93	0.63	0.57	0.83	0.51	38 233	33 421	71 875	100 108	79 913
Sy.x	0.20	0.17	0.16	0.19	0.15	39.91	37.32	54.72	64.58	57.70
RMSE	0.20	0.16	0.15	0.19	0.15	39.91	37.32	54.72	64.58	57.70
AICc	-75.02	-84.76	-87.19	-78.08	-90.40	187.90	184.50	203.60	211.90	206.30
Outdoors										
	Product A	**Product B**	**Product C**	**Product D**	**Product E**	**Product A**	**Product B**	**Product C**	**Product D**	**Product E**
***Y*-intercept**	0.89	0.28	0.00	-0.18	0.07	0.00	0.00	0.00	0.00	0.00
Slope	0.87	0.96	1.00	1.03	0.99	1.02	0.98	0.99	1.00	0.96
***Y*-intercept 95% CI**	0.01–1.78	0.41–0.97	0.32–0.31	0.58–0.22	0.57–0.70	0.00	0.00	0.00	0.00	0.00
Slope 95% CI	0.75–0.99	0.87–1.06	0.96–1.04	0.97–1.08	0.91–1.08	0.95–1.08	0.91–1.05	0.93–1.04	0.95–1.05	0.92–1.01
DF	23.00	23.00	23.00	23.00	23.00	24.00	24.00	24.00	24.00	24.00
R^2	0.91	0.95	0.99	0.99	0.96	0.94	0.91	0.95	0.96	0.97
Adjusted R^2	0.91	0.95	0.99	0.99	0.96	0.94	0.91	0.95	0.96	0.97
Sum of squares	0.88	0.52	0.11	0.18	0.45	49 496	70 313	39 583	33 713	23 838
Sy.x	0.20	0.15	0.07	0.09	0.14	45.41	54.13	40.61	37.48	31.52
RMSE	0.19	0.15	0.07	0.09	0.14	45.41	54.13	40.61	37.48	31.52
AICc	-76.66	-89.55	-128.60	-116.60	-93.56	194.30	203.10	188.70	184.70	176.00

	Nitrite					Hardness				
Indoors										
	Product A	**Product B**	**Product C**	**Product D**	**Product E**	**Product A**	**Product B**	**Product C**	**Product D**	**Product E**
***Y*-intercept**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slope	0.61	0.59	0.75	0.81	0.94	0.63	0.87	0.87	0.62	0.75
***Y*-intercept 95% CI**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slope 95% CI	0.50–0.73	0.50–0.69	0.58–0.92	0.72–0.90	0.87–1.01	0.56–0.70	0.77–0.98	0.74–0.10	0.43–0.82	0.65–0.85
DF	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
R^2	0.71	0.76	0.59	0.83	0.91	0.82	0.82	0.70	0.15	0.76
Adjusted R^2	0.71	0.76	0.59	0.83	0.91	0.82	0.82	0.70	0.15	0.76
Sum of squares	49.43	32.77	103.90	2621.00	1621.00	31 831	67 494	97 593	2055 850	536 496
Sy.x	1.44	1.17	2.08	10.45	8.22	36.42	53.03	63.77	292.70	149.50
RMSE	1.44	1.17	2.08	10.45	8.22	36.42	53.03	63.77	292.70	149.50
AICc	21.59	11.31	40.16	120.90	108.80	183.30	202.10	211.30	287.50	253.90
Outdoors										
	Product A	**Product B**	**Product C**	**Product D**	**Product E**	**Product A**	**Product B**	**Product C**	**Product D**	**Product E**
***Y*-intercept**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slope	0.68	0.72	0.91	1.00	0.96	0.95	0.92	0.95	2.39	2.08
***Y*-intercept 95% CI**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slope 95% CI	0.5–0.84	0.48–0.96	0.76–1.05	0.94–1.05	0.90–1.02	0.81–1.09	0.83–1.02	0.85–1.04	2.08–2.70	1.72–2.45
DF	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
R^2	0.49	0.08	0.74	0.95	0.94	0.72	0.84	0.87	0.77	0.53
Adjusted R^2	0.49	0.08	0.74	0.95	0.94	0.72	0.84	0.87	0.77	0.53
Sum of squares	99.65	205.30	76.69	1024.00	1221.00	123 320	58 228	56 529	605 399	845 702
Sy.x	2.04	2.93	1.79	6.53	7.13	71.68	49.26	48.53	158.80	187.70
RMSE	2.04	2.93	1.79	6.53	7.13	71.68	49.26	48.53	158.80	187.70

CI, confidence interval; DF, degrees of freedom; Sy.x, standard deviation of the residuals; RMSE, root mean square error; AICc, Akaike's corrected information criterion

Statistical analyses were performed to assess differences in normalised root mean square error (nRMSE) values across analytes, measurement methods and environmental conditions. The nRMSE values are shown in Figure 5 of the main text. One-way ANOVA with Tukey's post-hoc test was used to assess differences among analytes (Supplementary table 4), while unpaired two-tailed *t*-tests and F-tests were used to evaluate differences in means and variances between measurement methods (Supplementary table 5) and between lighting conditions (Supplementary table 6).

Supplementary table 4: Results of ordinary one-way ANOVA assessing differences among analytes, followed by Tukey's post-hoc test for multiple comparisons

ANOVA summary	
F	8.952
p-value	0.0001
p-value summary	***
Significant difference among means ($p < 0.05$)?	Yes
R^2	0.4273

Brown–Forsythe test	
F (DFn, DFd)	2.080 (3, 36)
p-value	0.12
p-value summary	ns
Are SDs significantly different ($p < 0.05$)?	No

Bartlett's test	
Bartlett's statistic (corrected)	10.39
p-value	0.0155
p-value summary	*
Are SDs significantly different ($p < 0.05$)?	Yes

ANOVA table	SS	DF	MS	*F* (DFn, DFd)	*p*-value
Treatment (between columns)	1526	3	508.7	F (3, 36) = 8.952	0.0001
Residual (within columns)	2046	36	56.82		
Total	3572	39			

Tukey's multiple comparisons test	**Summary**	**Adjusted *p*-value**
pH vs. Nitrate	ns	0.732
pH vs. Nitrite	ns	0.1293
pH vs. Hardness	***	0.0001
Nitrate vs. Nitrite	ns	0.6197
Nitrate vs. Hardness	**	0.0024
Nitrite vs. Hardness	ns	0.0546

DFn, degrees of freedom of the numerator; DFd, degrees of freedom of the denominator; SD, standard deviation; SS, sum of squares; DF, degrees of freedom; MS, mean square
*ns, not significant; **p<0.01; ***p<0.001*

Supplementary table 5: Results of unpaired two-tailed *t*-tests and *F*-tests comparing measurement methods (smartphone versus visual interpretation), assessing differences in means and variances, respectively

Unpaired *t*-test	
p-value	0.0382
p-value summary	*
Significantly different ($p < 0.05$)?	Yes
One- or two-tailed *p*-value?	Two-tailed
t, DF	*t*=2.147, DF=38

***F*-test to compare variances**	
F, DFn, Dfd	2.163, 15, 23
p-value	0.093
p-value summary	ns
Significantly different ($p < 0.05$)?	No

DFn, degrees of freedom of the numerator; DFd, degrees of freedom of the denominator; DF, degrees of freedom
*ns, not significant; *p<0.05*

Supplementary table 6: Results of unpaired two-tailed *t*-tests and *F*-tests comparing environmental lighting (indoors versus outdoors), assessing differences in means and variances, respectively

Unpaired *t*-test	
p-value	0.0354
p-value summary	*
Significantly different ($p < 0.05$)?	Yes
One- or two-tailed *p*-value?	Two-tailed
t, DF	*t*=2.181, DF=38

***F*-test to compare variances**	
F, DFn, Dfd	1.039, 19, 19
p-value	0.9348
p-value summary	ns
Significantly different ($p < 0.05$)?	No

DFn, degrees of freedom of the numerator; DFd, degrees of freedom of the denominator; DF, degrees of freedom
*ns, not significant; *p<0.05*