Electronic Supplementary Information.

CMAS: fully integrated portable Centrifugal Microfluidic Analysis System for on-site colourimetric analysis

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Table of Contents

I. Scheme of CMAS platform components

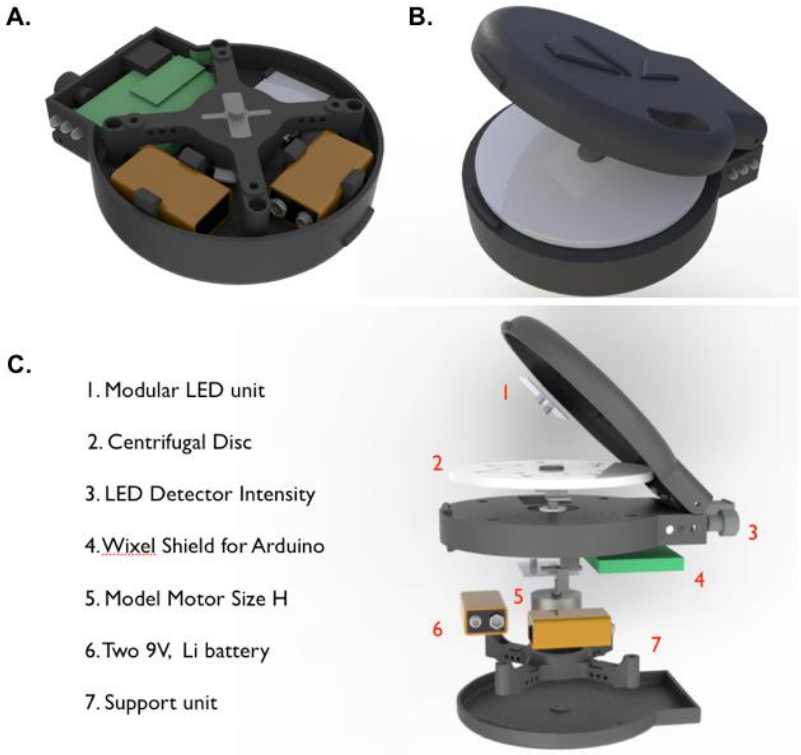

Fig. S1. a) Bottom side view of CMAS with the components in place, b) CMAS with loaded CD and c) exploded view of CMAS and components.

II. CMAS Graphical User Interface.

The following section is a guide to the graphical user interface of the CMAS application designed for an Android tablet. A brief description of each screen is provided in the figure caption.

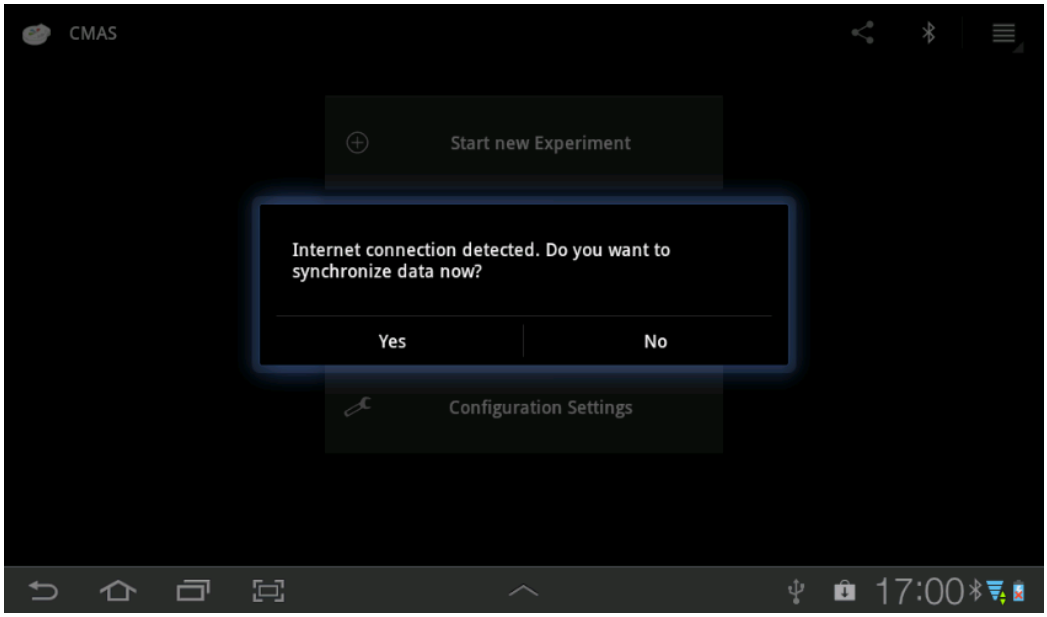

Fig. S2. Upon startup the user has the option to upload previous collected data to the cloud (in this instance dropbox) if an Internet connection is available.

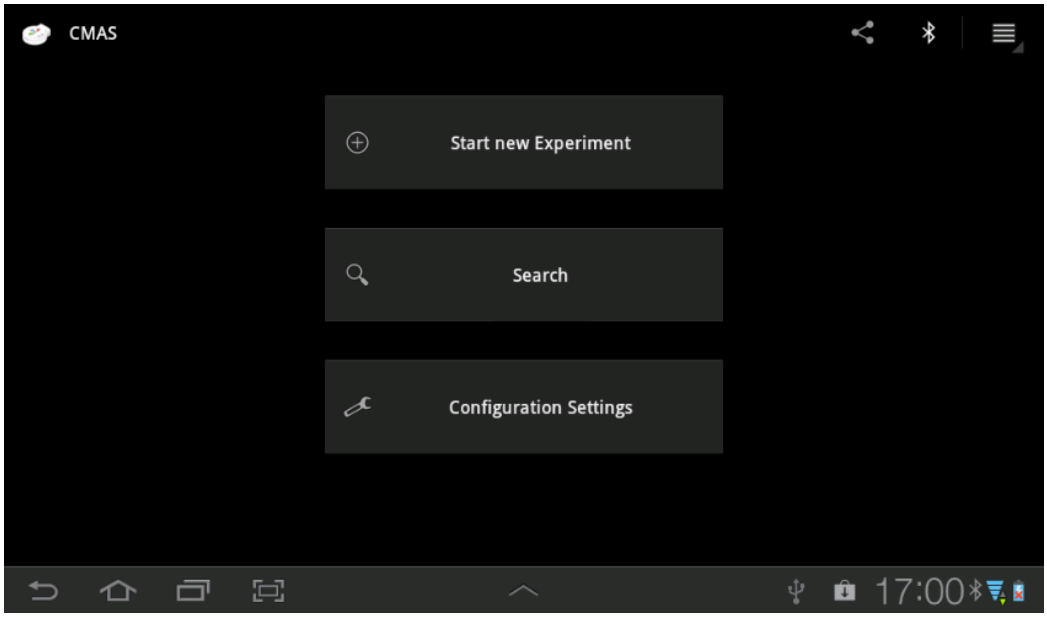

Fig. S3. Homescreen of CMAS. The user can a) start a new experiment, b) search previous collected data locally on the tablet device or on the cloud and c) configure the settings of the CMAS system.

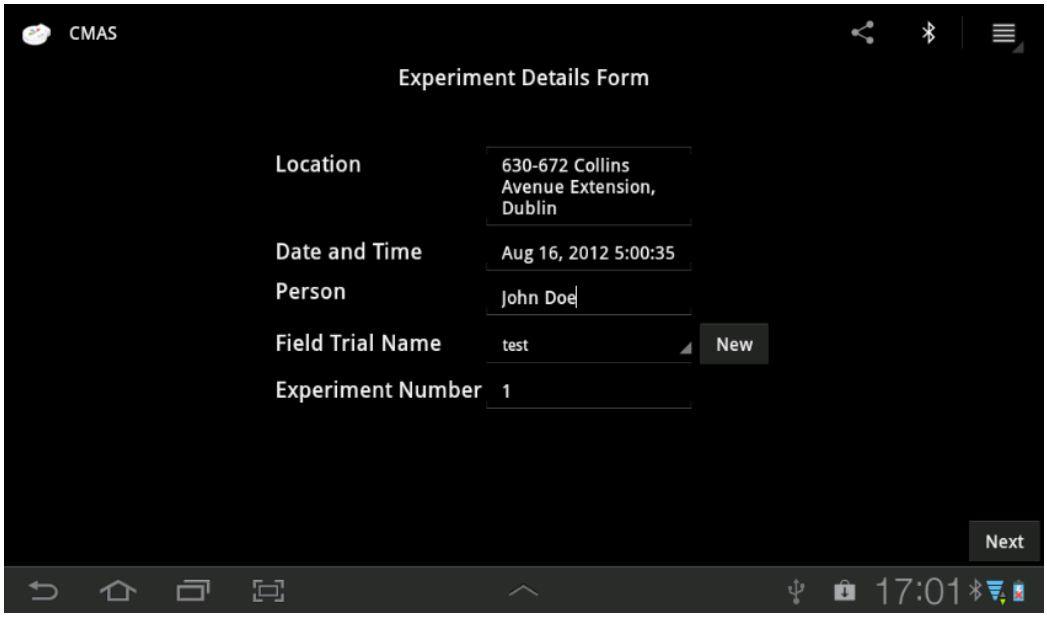

Fig. S4. If the user selects to start a new experiment, certain information such as the current location, date and time are determined automatically. If an Internet connection is available, the GPS location is mapped to the associated geo name using the Google API. This information is used to provide additional information about the experiment, *i.e.*, it is the metadata. In addition, the user can manually enter the name of the researcher. Once this information is provided, the user has to choose whether the planned experiment is part of an already existing trial or if it is the first experiment of a new trial.

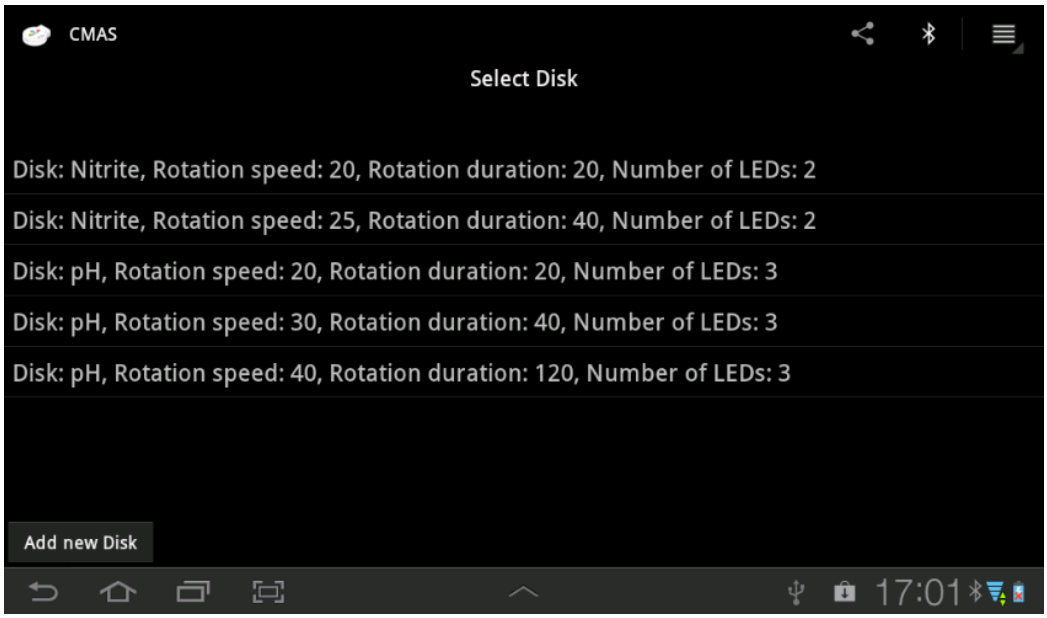

Fig. S5. Further, the user has to register the disk that will be used within this experiment. The interface allows them to either select pre-defined disks or to enter a

new disk into the system. In this case, the user is asked to define a disk ID, the number of LEDs that are required for the new disk and to set the disk speed that is required in the initial spinning task.

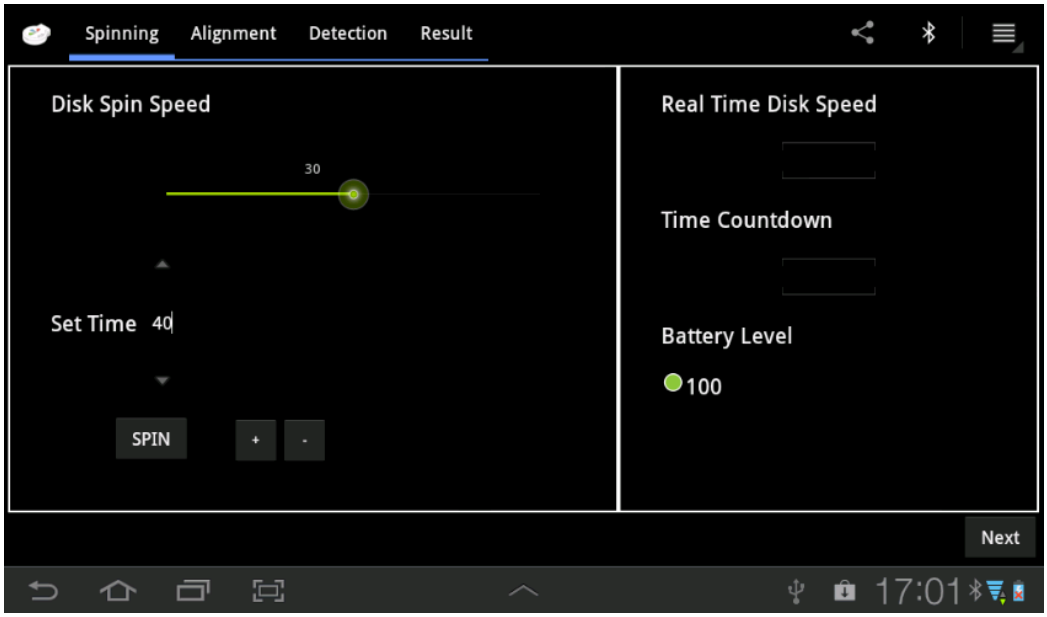

Fig. S6. After providing all required information, the first step of the experiment, the spinning of the disk, can begin. Here, a screenshot of the spinning interface is shown. As can be seen, the users can trigger the disk spinning by tapping on the SPIN button. On the top right side of the interface, the real time disk speed is displayed. The spinning speed can be modified using the spinning controller. Once the disk reaches the requested speed, a count down starts. At the end of the count down, the spinning task is completed and the user can start the second task by clicking on the 'Next' button on the bottom right corner of the screen.

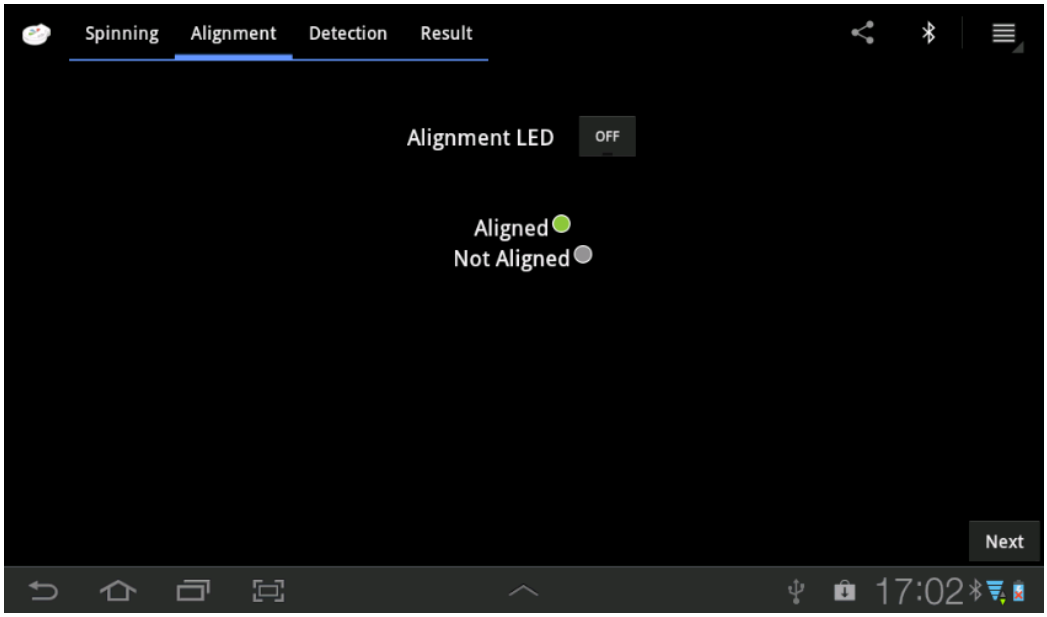

Fig. S7. The next task is the correct alignment of the disk, *i.e.*, the correct positioning of the disk so that the LEDs can be used to measure the sample. The alignment LED can be activated by using a switch button on the interface, the actual alignment has to be performed manually by moving the disk in the CMAS. The alignment status is indicated on the interface with a red or green light, respectively. Once the disk is properly aligned, the user can reach the detection screen by clicking on the 'Next' button in the bottom right corner of the interface.

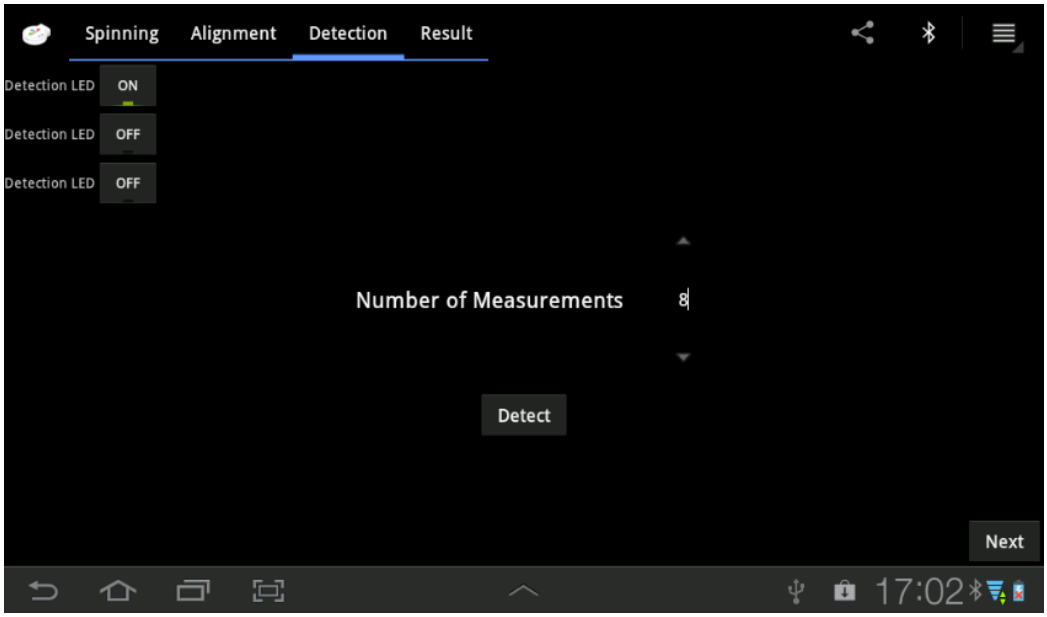

Fig. S8. Before the user can start the detection, they can activate the LEDs and the number of measurements that are required during this experiment. The detection will

start after the user then clicks the ‘Detect’ button. During the experiment, the readings from the CMAS system will be displayed in real time in a graph on the display. If more readings from other experiments during this trial that have been performed with this device, they will be displayed as well in the same graph. This allows the user a direct comparison with different experiments.

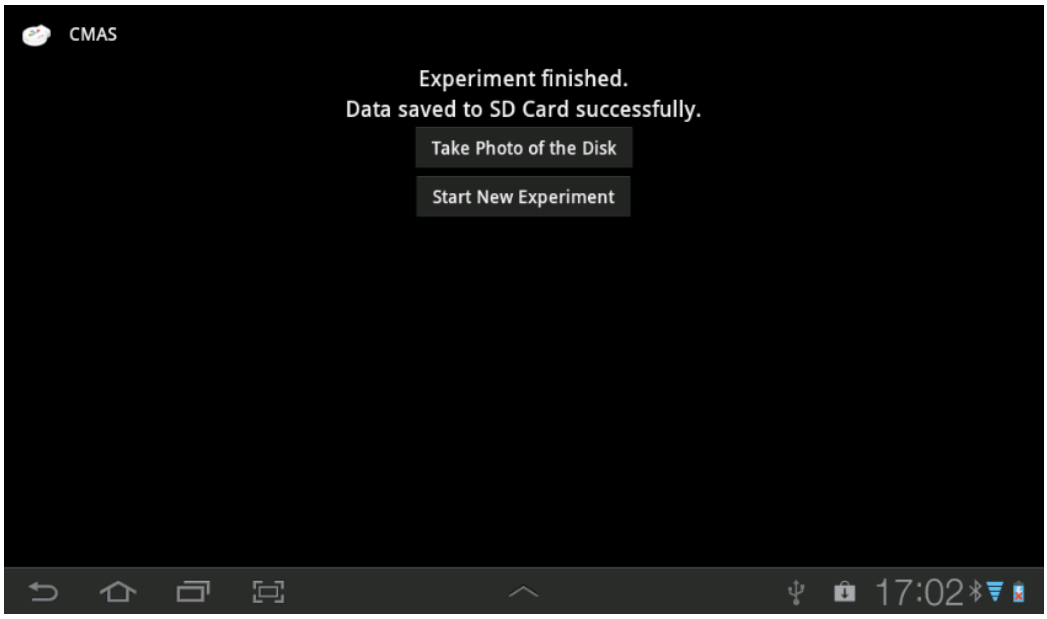

Fig. S9. At the end of the experiment, the interface provides the option to take a picture of the disk, which will be stored on the SD card of the device. As mentioned above, the user can inspect the results of previous trials by selecting the corresponding option on the main screen. This will open a new screen where all locally stored trials and experiments are listed. Further, small icons indicate whether a picture of the experiment is available and whether the results have already been uploaded to the cloud. Data synchronisation with the could will either happen on start up if an internet connection is available, or if the user presses on the cloud icon. Various generous online hard drive services are available. In our system, we opted for the service provided by Dropbox since it allows easy sharing with other users.

III. Griess Reaction Scheme

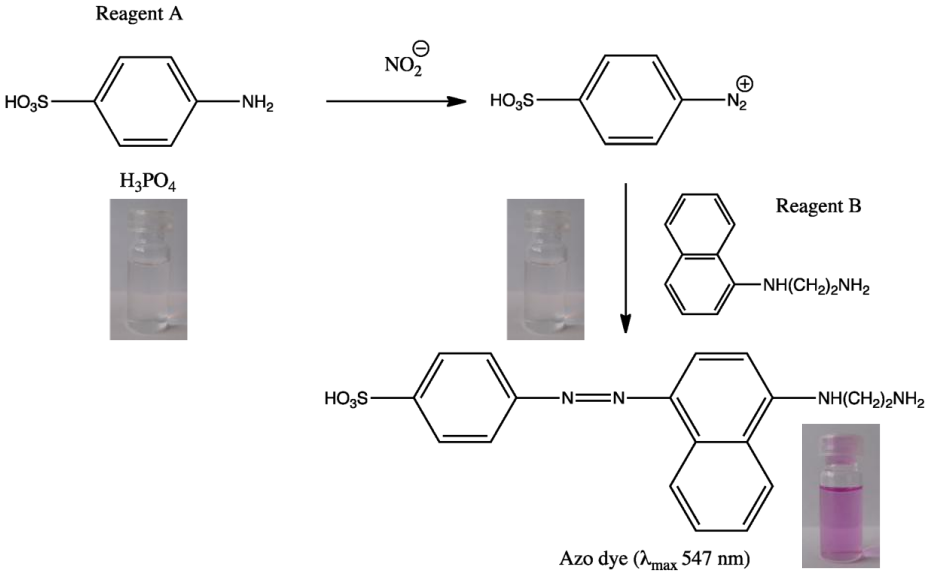

Fig. S10. Mechanism of the nitrite detection employing the Griess reaction method[1].

IV. First generation PEDD system *versus* CMAS.

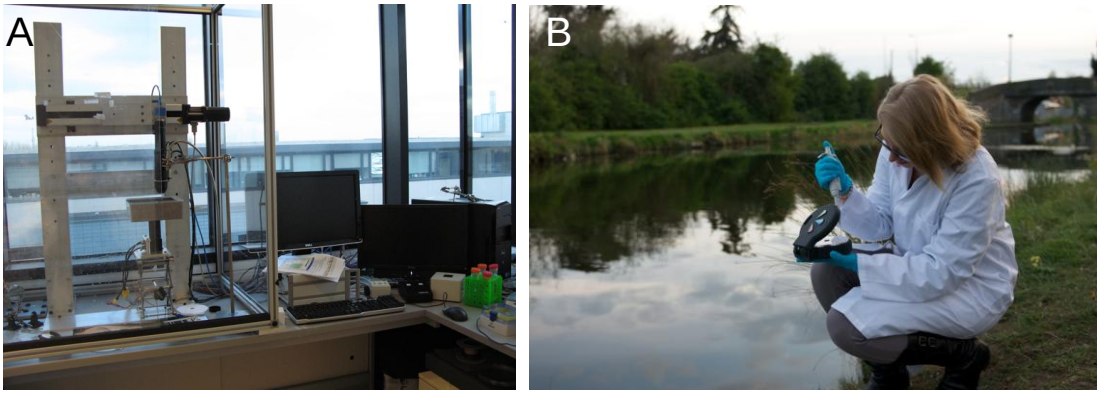

Fig. S11. A) Motor stand used for fluid manipulation for the first generation PEDD device as reported by Czugala *et al.*[2] After fluid manipulation the sample was measured in a dark room. B) Second generation PEDD device, CMAS, being used in the field for freshwater analysis. A video of the system can be found at http://tinyurl.com/dyoumds.

V. UV-Vis spectra

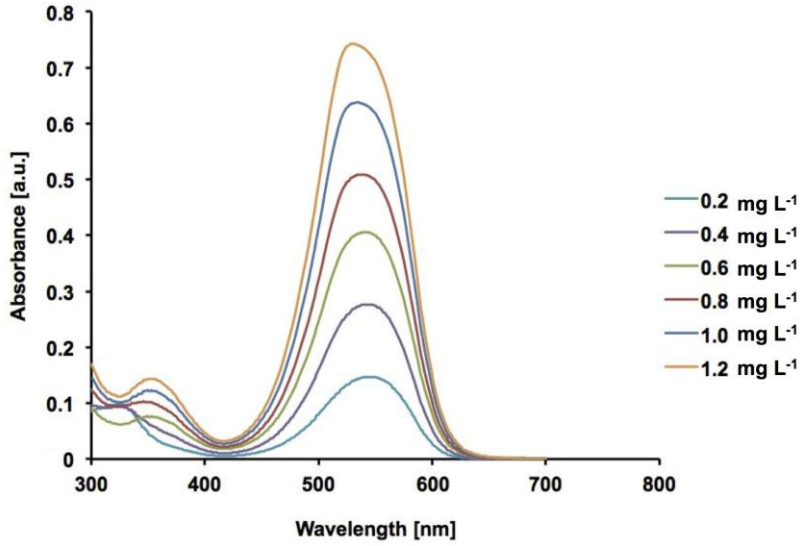

Fig. S12. Absorbance spectra of nitrite Griess reagent complex at different concentrations of nitrite (λ_{max} = 537 nm).

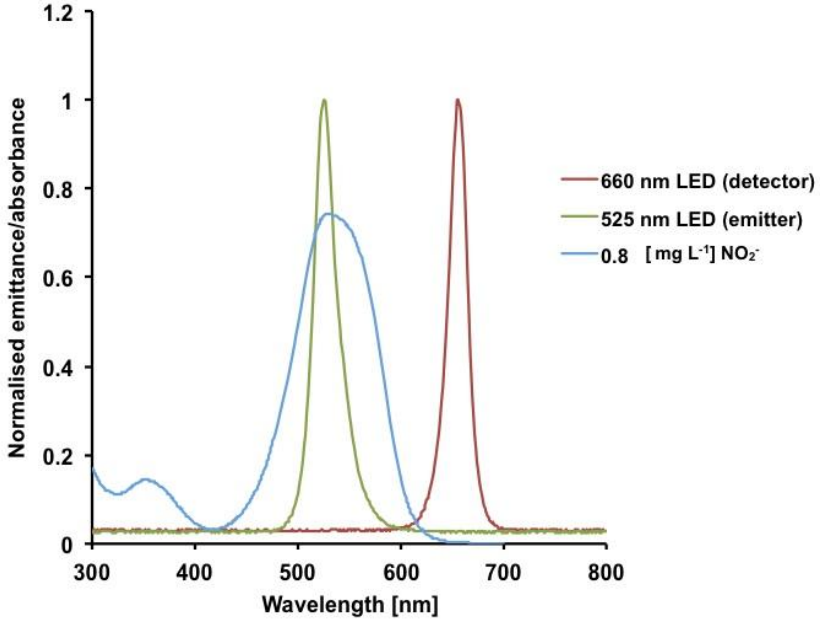

Fig. S13. Emission spectrum (λ_{max} = 525 nm) of the emitter LED (green line) used in the integrated CMAS device, absorption spectrum (λ_{max} = 537 nm) of 0.8 mgL^{-1} NO_2^- and Griess reagent (blue line).

VI. Repeatability of PEDD measurements

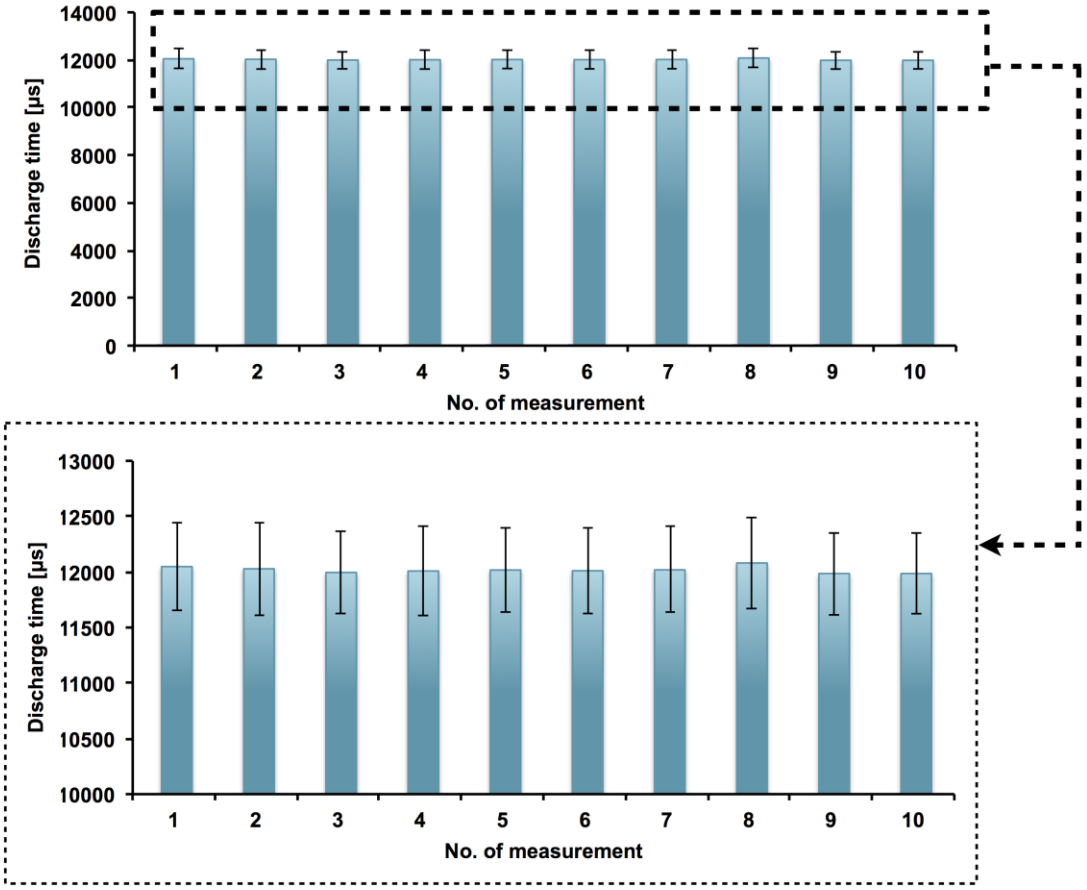

Fig. S14. Determination of the PEDD repeatability for the detection of 1.0 mg L^{-1} NO_2^- Griess reagent complex (n = 10).

Masurement no.	Discharge time [µs]	Std. Dev.	% RSD
1	12047	401	3.32
2	12028	418	3.48
3	11995	369	3.07
4	12008	403	3.35
5	12017	378	3.15
6	12011	385	3.20
7	12019	387	3.22
8	12080	410	3.39
9	11985	372	3.10
10	11985	361	3.01
Average (n = 10)	12018	29	0.24

Table S1. Repeatability of the PEDD measurements by detection of discharge time of 1.0 mg L^{-1} nitrite standard solution premixed with Griess reagent loaded to the same microfluidic structure for 60 s (3 data points per second, n = 10).

Microfluidic structure no.	Discharge time [µs] – red food dye			Avg. discharge time [µs]	Std. Dev.	% RSD
	Run 1	Run 2	Run 3			
1	17291	17256	17240	17262	26	0.15
2	16388	16359	16237	16328	80	0.49
3	17035	17035	16805	16958	133	0.78
4	17592	17525	17420	17512	87	0.50
5	16858	16849	16866	16858	8	0.05
6	15658	15314	15742	15571	227	1.45
7	17476	17519	17862	17619	212	1.20
Average (n = 21)				16873	693	4.11

Table S2. Study of the repeatability of the microfluidic structures within one CD using a coloured dye solution (n = 3).

CD no.	Discharge time [µs] – red food dye			Avg. discharge time [µs]	Std. Dev.	% RSD
	Run 1	Run 2	Run 3			
CD 1	16858	16849	16866	16858	8	0.049
CD 2	16875	16763	16963	16867	100	0.59
CD 3	17033	17240	16624	16966	314	1.85
Average (n = 9)				16897	173	1.02

Table S3. Study of the repeatability of the output signal across three different CDs using a coloured dye solution (n = 3).

VII. Kinetic Study

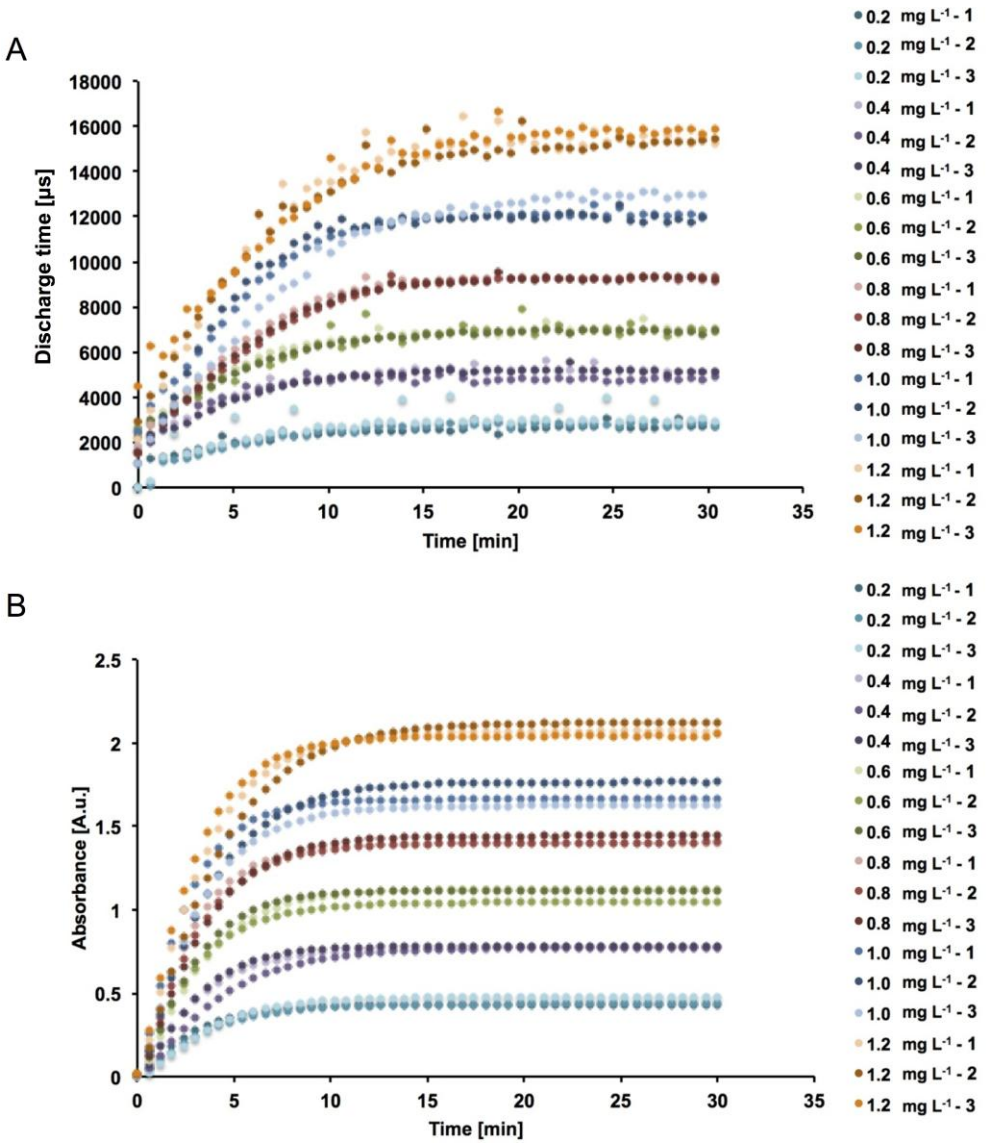

Fig. S15. Kinetic study of the colour formation between NO_2^- and Griess reagent (20.0 ± 0.5 ºC, at 540 nm) using A) CMAS (each 10th point; total: 50 points) and B) UV-Vis (each 36th point; total: 50 points).

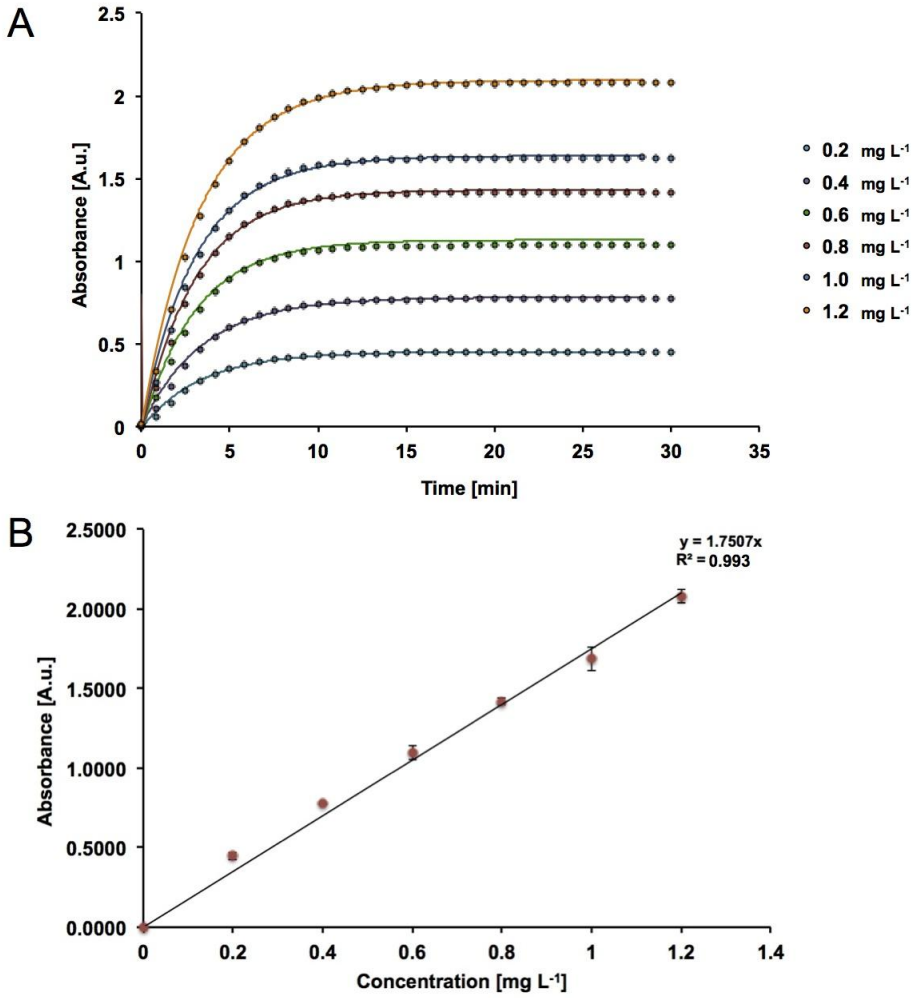

Fig. S16. A) Kinetic study of the colour formation between NO_2^- and Griess reagent (20.0 ± 0.5 ºC, at 540 nm) and (B) absorbance at 540 nm *versus* nitrite Griess reagent complex concentration using a UV-Vis spectrometer (n = 3).

A)

Sample no.	Nitrite concentration [mg L^{-1}]	CMAS – Kinetic Rates (x 10^{-3}) k_1 [s^{-1}]	k_1 [s^{-1}]	k_3 [s^{-1}]	Avg. k [s^{-1}] (x 10^{-3})	Std. Dev. (x 10^{-3})
1	**0.2**	0.97	1.05	1.05	1.03	0.04
2	**0.4**	1.31	1.31	1.18	1.27	0.08
3	**0.6**	1.18	1.02	1.06	1.09	0.08
4	**0.8**	1.10	0.99	1.02	1.04	0.06
5	**1.0**	1.10	1.37	1.06	1.2	0.2
6	**1.2**	1.07	0.99	0.79	1.0	0.1

B)

Sample no.	Nitrite concentration [mg L^{-1}]	UV-Vis – Kinetic Rates (x 10^{-3})			Avg. k [s^{-1}] (x 10^{-3})	Std. Dev. (x 10^{-3})
		k_1 [s^{-1}]	k_1 [s^{-1}]	k_3 [s^{-1}]		
1	**0.2**	2.00	1.64	1.63	1.8	0.2
2	**0.4**	1.83	1.34	1.86	1.7	0.3
3	**0.6**	1.70	1.70	1.96	1.8	0.2
4	**0.8**	2.10	1.71	1.71	1.8	0.2
5	**1.0**	2.35	1.62	1.69	1.9	0.4
6	**1.2**	1.76	1.40	2.06	1.7	0.3

Table. S4. Kinetic rate constants calculated for triplicate at 540 nm for (A) CMAS platform, (B) UV-Vis spectrophotometer (20.0 ± 0.5 ºC, 540 nm).

A)

Sample no.	Nitrite concentration [mg L^{-1}]	CMAS – Discharge time [µs]			Avg. discharge time [µs]	Std. Dev.	% RSD
		Run 1	Run 2	Run 3			
1	**0.2**	2704.05	2822.46	2946.69	2824	121	4.29
2	**0.4**	5154.54	5077.95	5157.54	5130	45	0.88
3	**0.6**	6993.28	6919.41	6984.10	6966	40	0.58
4	**0.8**	92.99.70	9294.10	9297.54	9297	3	0.03
5	**1.0**	12098.54	12126.63	12740.05	12322	364	2.94
6	**1.2**	15394.59	15334.29	15613.98	15448	147	0.95

B)

Sample no.	Nitrite concentration [mg L^{-1}]	UV-Vis spectrometer – Abs [au]			Avg. absorbance [Au]	Std. Dev.	% RSD
		Run 1	Run 2	Run 3			
1	**0.2**	0.4337	0.4356	0.4752	0.45	0.02	5.22
2	**0.4**	0.7691	0.7746	0.7815	0.775	0.006	0.80
3	**0.6**	1.1249	1.0476	1.1164	1.10	0.04	3.87
4	**0.8**	1.4025	1.4042	1.4433	1.42	0.02	1.63
5	**1.0**	1.6665	1.7667	1.6255	1.69	0.07	4.31
6	**1.2**	2.0694	2.1240	2.0448	2.08	0.04	1.99

Table. S5. Repeat absorbance measurements for the determination of NO_2^- over the concentration range 0-1.2 mg L^{-1} of NO_2^- with (a) CMAS platform, (b) UV-Vis spectrometer at a working wavelength of 540 nm (20.0 ± 0.5 ºC).

Sample no.	CMAS platform [mg L^{-1}]		UV-Vis [mg L^{-1}]	
	Average	Std. Dev.	Average	Std. Dev.
1	0.09	0.02	0.1000	0.0005
2	0.37	0.03	0.370	0.010
3	0.02	0.01	0.0200	0.0002
4	0.29	0.02	0.260	0.006
5	0.05	0.03	0.0500	0.0004

Table. S6. Water nitrite analysis using the CMAS platform and bench-top UV-Vis spectrometer.

VIII. CMAS cost breakdown.

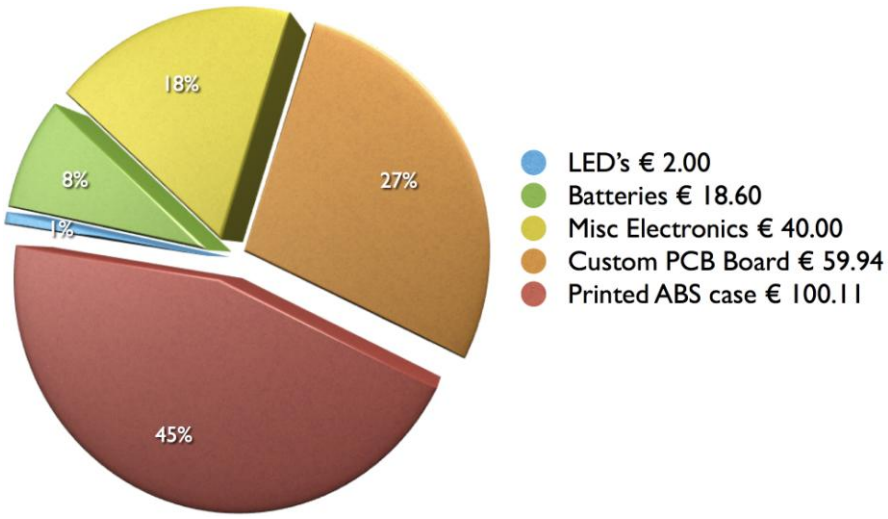

Fig. S17. Cost breakdown of CMAS components.

IX. References:

1. J. MacFaddin, *Nitrate/nitrite reduction tests, In: Biochemical tests for identification of medical bacteria*, 3rd edn., Lippincott Williams & Wilkins, Philadelphia, 2000.
2. M. Czugala, R. Gorkin Iii, T. Phelan, J. Gaughran, V. F. Curto, J. Ducree, D. Diamond and F. Benito-Lopez, *Lab on a Chip*, 2012, **12**, 5069.