Development of an autonomous algal-toxin analytical platform for aquatic monitoring

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- Microcystin toxins of the cyanobacterial family are notoriously ubiquitous, and typically bloom in fresh or brackish water [1].
- Microcystin-LR is the most frequently occurring toxin of the microcystin family presents a major threat to freshwater resources.
- Consequently, integrated monitoring solutions for causative algal-species with a sensitivity target of 1 µg/L of microcystin-LR in drinking water are critically needed [2].
- Here we present a low-cost fully integrated and portable *ToxiSense* microcystin detection system. The system uses LED-photodiode top-down detection technique to detect microcystin in freshwater samples.
- We developed a competitive assay using recombinant antibodies for the detection of free microcystin toxin, and integrated this assay onto a 7-layered centrifugal microfluidic cartridge for sample incubation, flow control and detection.

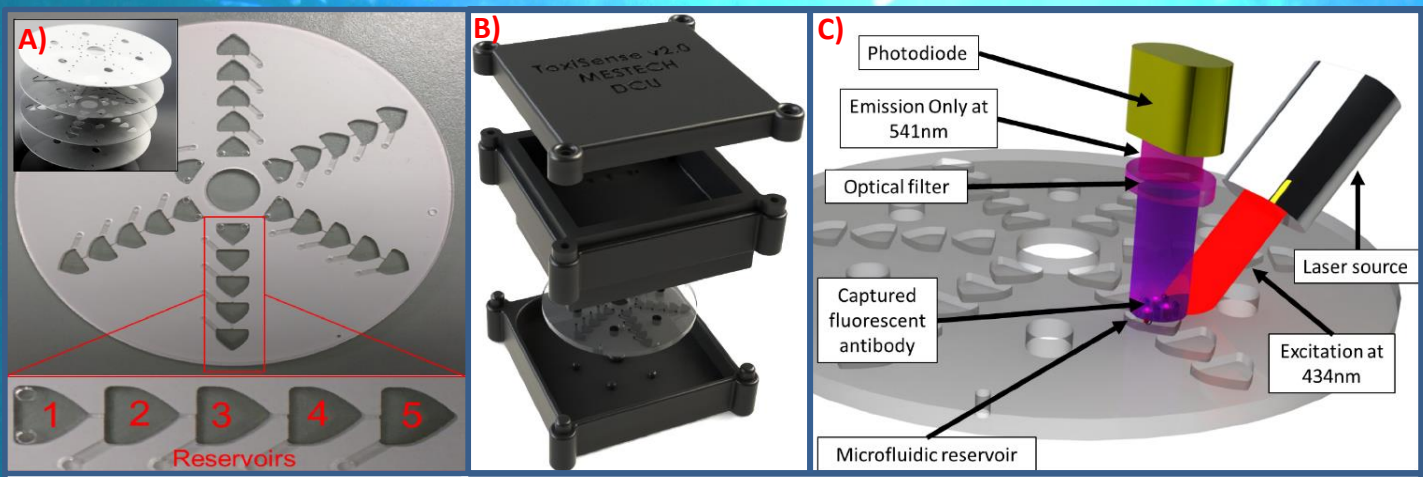


Figure 1. The ToxiSense detection system. **A)** The *ToxiSense* centrifugal microfluidic disc with five reservoirs; Load (1), Mixing (2), Test (3), Control (4), and Waste Collection (5). **B)** The 3D–printed *ToxiSense* microfluidic disc holder with an integrated *Alexa Fluor 430* fluorescent detection system (**C**), configured for top-down reservoir recognition.

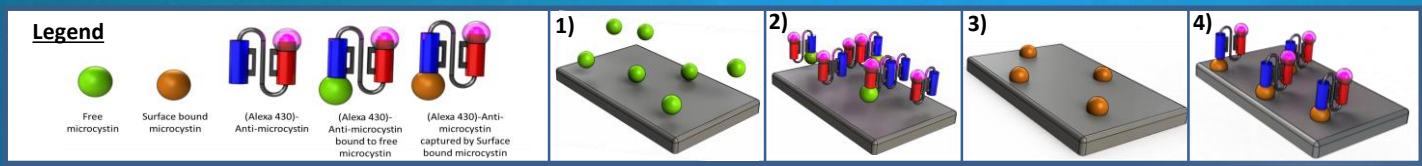
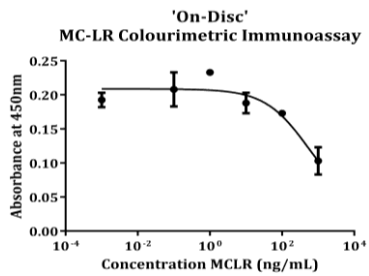


Figure 2. Microcystin-LR 'on-disc' inverse assay protocol. 1) **Reservoir one** is loaded with free, pre-lysed microcystin. 2) **Reservoir two** consists of anti-microcystin Alexa-Fluor 430 , where only a **fraction** mixes with **all** free microcystin. 3) **Reservoir three** has microcystin-BSA pre-bound to the surface. 4) The remaining, unbound anti-microcystin from **reservoir two** will bind in **reservoir three** for detection, where **fluorescence will be inversely proportional to the loaded free microcystin population**. **Reservoir four** replicates this protocol, but with a control antibody to confirm antibody reservoir pass-through.

By using the above inverse protocol, the *ToxiSense* system can detect high fluorescence at low microcystin concentrations. This was confirmed by conducting a colourimetric immunoassay study, as shown by the graph (**right**). This indicates a very clear inverse trend between the recorded signal against microcystin population, as expected.



Conclusion: Here, we have presented a novel, portable toxin-detection system, *ToxiSense*, which has been adapted to detect low concentration levels of microcystin (ng/mL) in samples of water. This cost-effective system can be further modified to allow for autonomous, *in-situ* detection and 'real-time' monitoring of fresh or brackish water sources.

References:

[1] C. MacKintosh, K. a. Beattie, S. Klumpp, P. Cohen, and G. a. Codd, "Cyanobacterial microcystin-LR is a potent and specific inhibitor of protein phosphatases 1 and 2A from both mammals and higher plants," FEBS Lett., vol. 264, no. 2, pp. 187–192, 1990.
[2] World Health Organization, "Guidelines for Drinking-water Quality.", 4th Edition, WHO chronicle 38 (2011): 104-8.

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