A centrifugal lab-on-a-disc device for the \textit{in situ} determination of dissolved reactive phosphate in water

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- Centrifugal microfluidics
- Analytical method on disc
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- Integrated system
Phosphorus in water

- Growth limiting nutrient:
  - algal bloom
  - hypoxic waters
  - death of aquatic animals
  - toxic blooms

http://serc.carleton.edu/microbelife/topics/redtide/general.html

http://sites.duke.edu/biology217_01_s2011_mkg14/ecological-impacts/eutrophication/


http://serc.carleton.edu/microbelife/topics/redtide/general.htm
Traditional analysis

- Time intensive
- Labour intensive
- Expensive instrumentation
- Low sampling frequency
- Contamination
Centrifugal microfluidics
Analytical method

- **Four methods:**
  - High sensitivity
  - Selectivity
  - Simplicity
  - LOD and LOQ
  - Linear range
Analytical method

Absorbance (AU) vs. Concentration (μg L⁻¹ PO₄-P)

- Green triangle = ascorbic acid method
- Blue diamond = stannous chloride method
- Red square = stannous chloride-hydrazine method
- Yellow square = yellow method

R² values:
- 0.9983
- 0.9583
- 0.9872

Concentration (μg L⁻¹ PO₄-P) range: 0 to 600

Sensitivity (AU (μg L⁻¹)) range: 0 to 0.0018
Analytical method

1. \[
\text{PO}_4^{3-} + 2(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O} \xrightarrow{\text{H}_2\text{SO}_4} \text{H}_3\text{PMo}_{12}\text{O}_{40}
\]

2. \[
\text{H}_3\text{PMo}_{12}\text{O}_{40} + 2\text{C}_6\text{H}_8\text{O}_6 + \text{C}_8\text{H}_4\text{K}_2\text{O}_{12}\text{Sb}_2 \cdot 3\text{H}_2\text{O} \rightarrow \text{H}_7\text{PMo}^\text{V}_4\text{Mo}^\text{VI}_8\text{O}_{40} + 2\text{C}_6\text{H}_6\text{O}_6 + 4\text{H}^+
\]
Detection system

\[ A = \varepsilon \cdot C_1 \]

increase
Microfluidic disc

- Air vent
- Reservoir
- Microchannel
- Detection chamber
Detection system

Roithner 880 nm laser

Radionics 880 nm LED

Radionics photodiode
Optical path length study

LED (B)
Laser (A)

Optical path length

Photodiode B
Photodiode A
Optical path length study

R² = 0.9985

Sensitivity (AU L µg⁻¹)

Optical path length (mm)

R² = 0.9098

Sensitivity (AU L µg⁻¹)

Optical path length (mm)
Integrated NutriSense system

- Black 3D printed container
- Motor to be incorporated for disc rotation
- Optical detection system is aligned on the stage
- Electronics stored beneath, away from wet chemistry
Conclusion

• Analytical method

• Disc design optimised
  • Mixing
  • bubble formation
  • Optical path length

• Integrated system designed – first prototype fabricated
Future work

• Incorporate motor into system

• Investigate system robustness *in situ*

• Adapt disc design for other analytes for water quality analysis
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