NuLAB wet chemistry nutrient analyser

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In 2018
MBT - Meerestechnisches Büro Turla GmbH
became
MacArtney Germany GmbH, Kiel

www.macartney.com

Key facts:
• located in Kiel
• part of the MacArtney Group – with over 400 employees and offices or partner on all continents
Co-operation with Green Eyes Environmental LLC:

- Since 2001 co-operation, service and support for former EnviroTech and later Green Eyes nutrient analysers
- Since 2016 sales representation of Green Eyes products in Europe
- 2017 – setting up of facilities at MacArtney Germany to test and service Green Eyes nutrient analysers and prepare reagents
- Nutrient analyser training, installations and workshops

Green Eyes Environmental LLC:

- Based in Easton, Maryland, United States
- Founded in 2006 by Vincent Kelly, Chemical Oceanographer
- Further development into state of the art analysers
Three NuLAB versions for various applications

Basic NuLAB
• smaller size (1-2 channels)

NuLAB Plus
• Included touch screen controller, relays for pump and water2web data posting
• Up to 3 channels

NuLAB Submersible (buoy or shallow water monitoring station)
• Up to 10 m water depth
• Up to 4 channels
What NuLAB does:

- Application of established wet chemical methods (US EPA) to a field chemical analyser (for Nitrate, Phosphate, Ammonia and Silicate)
- Precise volumes of sample
- Data is calibrated via an On-Board-Standard (OBS)
- Reagents connected to a rotary valve and mixed by a syringe pump
- Analysed in high precision colorimeters.
- Operates with 8 pre-defined macros that determine how analyses are carried out
NuLAB Plus Set-up

- Controller
- Inlet with filter
- Reagent bags (gas tight)
- Detector
- 8-port rotary valve
- Syringe
## Specification of NuLAB

### Standard Ranges (detection limit to linear range, micro M)

<table>
<thead>
<tr>
<th>mg/L:</th>
<th>N+N</th>
<th>Nitrite</th>
<th>Phosphate</th>
<th>Ammonium</th>
<th>Silicate</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Sensitivity Detectors (2 mm)</td>
<td>0.003 to 0.70</td>
<td>0.002 to 0.5</td>
<td>0.006 to 0.8</td>
<td>0.004 to 0.3</td>
<td>0.008 to 1.7</td>
</tr>
<tr>
<td>Low Sensitivity Detectors (10 mm)</td>
<td>0.01 to 2.8</td>
<td>0.008 to 2.1</td>
<td>0.025 to 2.0</td>
<td>0.02 to 1.0</td>
<td>0.04 to 2.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>micro mol/L:</th>
<th>N+N</th>
<th>Nitrite</th>
<th>Phosphate</th>
<th>Ammonium</th>
<th>Silicate</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Sensitivity Detectors</td>
<td>0.2 to 50</td>
<td>0.15 to 35</td>
<td>0.2 to 25</td>
<td>0.3 to 20</td>
<td>0.3 to 60</td>
</tr>
<tr>
<td>Low Sensitivity Detectors</td>
<td>0.8 - 200</td>
<td>0.6 - 150</td>
<td>1.0 - 75</td>
<td>1.5 to 75</td>
<td>1.5 to 100</td>
</tr>
</tbody>
</table>

- Precision (one SD @ midrange of scale): Nitrate 3%, Nitrite 2%, Phosphate 3%, Ammonium 3%, Silicate 3%
- Expanded Ranges: Up to 5 mg/l through auto-dilution
- Accuracy: Based on the accuracy of the preserved on-board standard and sample replicate precision
- Analyses: Typically 1000 per channel, per deployment. Controlled by reagent payload and chemistry
- Analysis Time: N+N 13 min, Nitrite 9 min, Phosphate 14 min, Ammonium 17 min, Silicate 16 min
- Consumption: Sample ~ 2 ml, each reagent ~ 0.1 ml and DIW
Analysis definition NuLAB

Aim: Turning mass equivalents into colours

- Macros can be customized to specific requirements and to third party analysis protocols i.e.
  - Change of the sample and reagent volumes
  - Change of the mixing times and volumes
  - Change of the flushing
  - Change of temperature and heating duration etc,
NuLAB Software

- NuLAB is operated via a software running on the controller
- Software includes two different modes ("Manual" & "Logging")
- Analyses are executed by macros
- Macros can be selected via the software interface
- Individual channels can be selected
- Deployment mode is defined
Development of the NuLAB for FerryBox:

- The NuLAB was originally designed for fixed station monitoring with sample intervals of two hours or longer.
- In contrast, FerryBox application often desire higher sample frequencies to resolve sharp spatial gradients

The following adjustments were introduced:
Elevated reaction temperatures:

- By raising reaction temperatures, the influence of ambient and sample water temperature on color development will be minimized.
- This will stabilize the on-board standard (OBS) results used for sample calibration and reduce the necessary OBS analysis frequency.
- This will reduce analysis time
- Elevating reaction temperature required simple hardware and software changes
Maintain detector heaters and LEDs for extended periods:

- To reduce detector warm up times, the heaters and LEDs can be left ON between analyses. This will also improve instrument precision.

- These changes are limited to the analytical macros and an additional “detector warm-up” command from the controller.
Addition of a solenoid switching valve:

- Currently all channels other than nitrate (when also measuring nitrite) have deionized water (DIW) connected to the eight-port rotary valve that is used for flushing and reagent blanks.

- Users are now able to add an optional solenoid valve to the nitrate channel so that all channels will be equipped with DIW.

- The valve will switch be-tween imidazole buffer and DIW and be controllable via terminal commands, the NuLAB controller and NuLAB macros.

- This option requires an additional solenoid valve and relays
New controller:

- New microprocessor based controller allow one serial port of a computer or datalogger to run and collect data from up to four Nu-LAB channels simultaneously.

- This is better option than present Linux controller for FerryBox or other heavily integrated applications with master computers.
Conclusion: Strengths of NuLAB

- NuLAB determines a reagent blank before each sample
- An OBS can be measured before each sample and NuLAB uses the most recent OBS for concentration calculation
- NuLAB macros are customizable
- NuLAB is easy to operate and easy to integrate into other systems (e.g. Ferry Box)
- Data can be transmitted via internet to web gateways (like MetOcean Gateway)
- Support, development (improvement), compact, manageable but also affordable
Thank you for your attention!

Contacts:
Dr Verena Dauben – MBT GmbH  ⌛️  ved@macartney.com
Dr Alexander Davidov – MBT GmbH  ⌛️  ad@macartney.com
Chemical Methods used:

- Ortho-phosphate P-PO4 – Molybdenum reaction
  - J. Murphy and J. P. Riley: A modified single solution method for the determination of phosphate in natural waters, Analytical Chimica Acta, 27 (1962) p. 31

- Nitrate (N-NO3) plus Nitrite (N-NO2) Analysis

- Ammonium (NH4) Analysis

- Silicate (SO4) Analysis
  - Determination of Dissolved Silicate in Estuarine and Coastal Waters by Gas Segmented Continuous Flow Colorimetric Analysis
  - Jia-Zhong Zhang, Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School of Marine and Atmospheric Science.
  - Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, University of Miami, Miami, FL 33149
  - George A. Berberian, National Oceanic and Atmospheric Administration, Atlantic Oceanographic and Meteorological Laboratory, Ocean Chemistry Division, Miami, FL 33149
NuLAB installation at Helgoland

- Installation of a 2-channel NuLAB system (Nitrate & Phosphate) next to Ferry Box based at “Helgoland Einlaufbauwerk”
- Continuous test measurements since mid-July 2017
- Hourly samples of NO$_3$+NO$_2$ and PO$_4$ from Ferry Box sampling water
### NuLAB Phosphate Concentration (µM)

#### Helgoland Island

<table>
<thead>
<tr>
<th>Date</th>
<th>Manual method</th>
<th>Auto Analyser</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9.17 0:00</td>
<td>0.001</td>
<td>0.006</td>
</tr>
<tr>
<td>9.9.17 0:00</td>
<td>0.006</td>
<td>0.001</td>
</tr>
<tr>
<td>14.9.17 0:00</td>
<td>0.011</td>
<td>0.016</td>
</tr>
<tr>
<td>19.9.17 0:00</td>
<td>0.016</td>
<td>0.011</td>
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<tr>
<td>24.9.17 0:00</td>
<td>0.021</td>
<td>0.026</td>
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<td>29.9.17 0:00</td>
<td>0.026</td>
<td>0.021</td>
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<tr>
<td>4.10.17 0:00</td>
<td>0.031</td>
<td>0.036</td>
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<tr>
<td>9.10.17 0:00</td>
<td>0.036</td>
<td>0.031</td>
</tr>
</tbody>
</table>

#### NuLAB PO4 On-board Standard (1.0 µM) and sample Absorbance

Helgoland Island

- **Filtered OBS abs**
- **Sample abs**

**OBS Avg. 0.0127, St. Dev.=0.00056 (+/-0.04µM)**
<table>
<thead>
<tr>
<th>Date</th>
<th>Manual method</th>
<th>Auto Analyser</th>
<th>OBS_abs</th>
<th>Smp_abs</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9.17 0:00</td>
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<td>0.01</td>
<td>0.015</td>
<td>0.02</td>
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<tr>
<td>9.9.17 0:00</td>
<td>0.02</td>
<td>0.025</td>
<td>0.03</td>
<td>0.035</td>
</tr>
<tr>
<td>14.9.17 0:00</td>
<td>0.03</td>
<td>0.04</td>
<td>0.04</td>
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</tr>
<tr>
<td>19.9.17 0:00</td>
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<td></td>
</tr>
<tr>
<td>24.9.17 0:00</td>
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</tr>
<tr>
<td>29.9.17 0:00</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.10.17 0:00</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Diagram: NuLAB Nitrate concentration**

- **Date:** 9.4.17 0:00 to 10.5.17 0:00
- **NO3 (µmol/L):**
  - NO3 NuLAB
  - Manual method
  - Auto Analyser
- **Backflush activated**

**Diagram: NO3 OBS Absorbance**

- **Date:** 4.9.17 0:00 to 9.10.17 0:00
- **Absorbance:**
  - OBS_abs
  - Smp_abs