Development of Low Cost NavIC Based Environment Monitoring (NEMo) Drifters

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Why NEMo Drifters?

- **Coastal properties:** Extreme temporal and spatial variability.
- **Traditional Techniques:** Localised, Expensive and Risky
- **Available drifters:** Experimental and unavailable for purchase
- Commercial drifters costs more than US $1 million each and have only GPS.
- Basic measurements of temperature, salinity, DO and pH – unavailable
- These parameters are key **Water quality indicators.**
- To monitor pollution in rivers, lagoons, beaches etc.
- More number of drifters required for detailed maps - Low cost!
Drifter designed @ ISRO

- Design was inspired from a Roly-poly toy.
- Drifter was made from off-the-shelf PVC parts and low-cost GNSS receiver (EMLID Reach®).
- GNSS receiver stores raw carrier phase and pseudo range internally from GPS, GLONASS, GALILEO, Beiduo, SBAS etc.
- Flanges were introduced to increase the current drag and bottom circular disc to reduce the wave impact.
- Minimum surface area above sea surface to reduce the wind impact.
- Very simple design but efficient at sea...
- Also attempted with the NavIC receiver.
Experiments carried out

 RK Beach, Visakhapatnam one of the dangerous sites of Rip currents in India

Professional Swimmer released the drifter in mid surf zone

Rhodamine-B dye patch along with drifter in the rip current
Rip current measurements from GNSS drifters

Calangute, Goa

NavIC drifter experiment

Max Vel = 0.6 m/s

NavIC vehicle tracker is customized to take measurements at 2Hz interval

30 May 2019

Calangute, Goa
Proposed solution

**Hardware**

- Low-cost multi-GNSS chip connected serially with a micro-controller to provide NMEA data.
- Low-cost pH, temperature, Dissolved oxygen (DO), conductivity (salinity) sensors
- Location and sensor data sent by Sim800 Module/ Satellite Terminal.
- DATA stored to microSD card
- Battery: 12V
- Electronics water-proofed in specially designed PVC enclosure (IP65/67)

**Software**

- Code: C++ (Arduino IDE).
- Sampling Frequency: 1 Hz.
- NMEA Data: Date & Time, Latitude, Longitude, Speed extracted and transferred via SPI protocol.
- Data sent via Sim800 when GSM network is available (5 s).
- Data sent via MSS satellite terminal when GSM network is lost/unavailable (1 min) - optional.
- Client application for real-time visualisation and data downloading.
**Miniature Water quality sensors (Atlas Scientific®)**

- **Temperature probe**
  - Parameters: Temperature
  - Life expectancy: ~15 years+
  - Accuracy: ±0.1°C +0.0017x °C (±0.1°C)
  - Resolution: ±0.001 (±0.1°C)
  - Range: -200°C – 850°C (25-40°C)

- **Dissolved Oxygen probe**
  - Parameters: Dissolved Oxygen
  - Life expectancy: ~5 years+
  - Accuracy: ±0.05 mg/L (±0.1 mg/L)
  - Resolution: ±0.001 (±0.1 mg/L)
  - Range: 0.01 – 100 mg/L
  - Max Pressure: 3447 kPa (101.3 kPa)
  - Max depth: 343 m (0.5 m)
  - Temp range: 1 – 50°C (25-40°C)

- **Conductivity probe**
  - Parameters: Conductivity, TDS, Salinity, Sp. gravity
  - Life expectancy: ~10 years+
  - Accuracy: ±2% or 0.004 – 4000 µS/cm (±5%)
  - Resolution: ±0.01 to 100 µS/cm (±0.1 to 100 µS/cm)
  - Range: 5 – 200,000 µS/cm
  - Max Pressure: 3447 kPa (101.3 kPa)
  - Max depth: 343 m (0.5 m)
  - Temp range: 1 – 110°C (25-40°C)

- **pH probe**
  - Parameters: pH
  - Life expectancy: ~2.5 years+
  - Accuracy: ±0.002 (±0.1)
  - Resolution: ±0.001 (±0.1)
  - Range: 0.001 – 14.000
  - Max Pressure: 690 kPa (101.3 kPa)
  - Max depth: 60 m (0.5 m)
  - Temp range: 1 – 99°C (25-40°C)

- **Conductivity probe**
  - Parameters: pH
  - Life expectancy: ~2.5 years+
  - Accuracy: ±0.002 (±0.1)
  - Resolution: ±0.001 (±0.1)
  - Range: 0.001 – 14.000
  - Max Pressure: 690 kPa (101.3 kPa)
  - Max depth: 60 m (0.5 m)
  - Temp range: 1 – 99°C (25-40°C)
Drifter block diagram

- Location
  - NavIC

- Sensors DATA
  - pH, Salinity, temperature, DO

- On-board computer
  - Microcontroller

- Transmission to Server
  - Satellite Terminal

- DATA Storage
  - MicroSD Card

- Battery
  - 12 V

- Transmission to Server (UDP)
  - Sim800
Data collection and transmission

1. Read Location from NavIC
2. Store in microSD card
3. Wait 1s
   - No
4. Is GSM network available?
   - No
   - Yes
   - Have 60s passed?
   - No
   - Yes
5. Send data to satellite terminal for transmission
6. Loop
   - Send Temp to other sensors for compensation

Steps:
- Read Temp.
- Read pH
- Read Conductivity
- Read D.O.
- Send data to Sim800 for transmission
- Store in microSD card
- Wait 1s
NEMo drifter (Side view)

- Space for Styrofoam
- Fins
- Ballast and sensor protector

500 mm
Styrofoam provides additional buoyancy and increases the stability of the drifter in high energetic environments.
Drifter Exploded view
Modules testing

Vikram Hall Pool, SAC (Time series)

- **pH**
  - Mean = 8.16
  - Std. dev = 0.1

- **Water temperature (°C)**
  - Mean = 35.73 °C
  - Std. dev = 0.1°C

- **Salinity (PSU)**
  - Mean = 2.04 PSU
  - Std. dev = 0.01 PSU

- **Dissolved oxygen (mg/l)**
  - Mean = 7.46 mg/l
  - Std. dev = 0.09 mg/l
Modules Testing

Lotus Pond, SAC (Time series)

**pH**
- Mean = 8.49
- Std. dev = 0.01

**Water Temperature (°C)**
- Mean = 35.9 °C
- Std. dev = 0.1 °C

**Salinity (PSU)**
- Mean = 2.87 PSU
- Std. dev = 0.01 PSU

**Dissolved Oxygen (mg/l)**
- Mean = 8.71 mg/l
- Std. dev = 0.28 mg/l
Modules Testing

**Dissolved Oxygen**

- Mean: 9.98 mg/l
- Std. dev: 0.91 mg/l

**pH**

- Mean: 8.36
- Std. dev: 0.1

**Salinity**

- Mean: 2.76 PSU
- Std. dev: 0.47 PSU

**Water temperature**

- Mean: 35.9 °C
- Std. dev: 0.7 °C
External and Internal view of NEMo drifter

- Acrylic cap
- Battery
- Circuit board cage
- Top view
- NavIC Antenna
- GPRS
- Arduino MEGA
- Tentacle Shield
- Micro SD circuit
- Top plate
- PVC pipe
- Fins
- Styrofoam collar
- Sensors

Drifter Side view
NEMO Drifter - Prototype

NEMo (NavIC based Environmental Monitoring) drifter

- Currents
- Temperature
- Salinity/Conductivity
- TDS
- Specific Gravity
- pH
- Dissolved Oxygen
Variability in Water quality parameters

- **Water is GOOD quality**
- **Water is Alkaline (pH~8)**
- **Average Temperature ~25.5 °C**

Date/Time: 2022-02-15/15:52:04
Temp: 25.630
Ph: 7.479
Ec: 162.700
Tds: 88.000
Sal: 0.000
Sg: 1.000
Variability in Water quality parameters
Field Site: Ghuma Lake

Visual observations: Water is greenish in colour, no odour, no flow

Lake water is ACIDIC in nature (pH<7)

TDS is too high (>2000)

Average Temperature ~26 °C
Testing in Beaches (Diu)
Testing in Beaches (Diu)

Testing in shallow water (beyond breaker zone)

Testing in the Surf zone
NEMO Drifter Observations

12, 13, 19 Oct 2022

Currents

Salinity

Temperature

Rip currents
Other major applications of drifters

- Rip current dynamics (spatial & temporal structure)
- Search and Rescue
- Oil spill monitoring
- Bloom tracking
- Pollution dispersion monitoring in the surf zone
- Bathymetry mapping
- Nourishment effects
- River and estuarine flood monitoring
- Forensic investigation
- Military and Naval Coast Guard application