Using real-time telemetry system for assessing water quality and improving routine monitoring

By

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Introduction and Problems Definition.
Rainfall and Floods 1.00
Groundwater in the Valley and the Delta 4.8
Groundwater in the Deserts and Sinai 0.57
Agriculture drainage water reuse in the Delta 5.20
Wastewater 0.70
River Nile 55.5

Total 67.77 BCM
20% of urban areas are not caught in sewers

92% of rural areas are not caught in sewers

Many industries discharge inadequately treated / untreated wastewater into the system

CHALLENGES
In General, water quality data are needed to

- Assess compliance with standards;
- Facilitate impact assessment studies;
- Validate & calibrate models and establish a databases;
- Conduct research;
- Define WQ problem;
Monitoring Sites in Upper Egypt and Nile Branches

Outfalls to Northern Lakes
15 sites

Nile Delta
Irrigation Canals 50 sites
Drains 116 sites

Nile River
Nile Water 48 sites
Irrigation Canals 9 sites
Drains 43 sites

Lake Naser
4 sites

Monitoring Sites in Fayoum

Irrigation Canals 4 sites
Drains 8 sites

Monitoring Sites in Upper Egypt and Nile Branches

Outfalls to Northern Lakes
15 sites

Nile Delta
Irrigation Canals 50 sites
Drains 116 sites

Nile River
Nile Water 48 sites
Irrigation Canals 9 sites
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Lake Naser
4 sites
NAWQAM Baseline Phase

Irrigation Canals: 16 Sites
Drains & Outfalls: 39 Sites

Irrigation Canals: 21 Sites
Drains & Outfalls: 48 Sites

DRI/MADWQ

Recommended

DE (Drains – Eastern Delta)
IE (Irrigation network – Eastern)
DM (Drains – Middle Delta)
IM (Irrigation network – Middle)
DW (Drains – Western Delta)
IW (Irrigation network – Western)
MONITORED PARAMETERS

**Chemical**
- EC, TDS, pH
- Na, K, Ca, Mg
- Cl, SO₄, HCO₃, CO₃

**Physical Parameters**
- Temperature
- Odor, Color
- Turbidity

**Microbiology**
- Total Coliform
MONITORED PARAMETERS

**Nutrients**
- N - (NH₄,NO₃)
- P - (P₂O₅)

**Heavy Metals**
- Fe
- Mn
- Pb
- Cu
- Zn

**Oxygen budget**
- O₂
- BOD
- COD
Sampling frequency is a function of the statistical objective of the monitoring program.

More measurements will increase the precision, reduce the bias, and increase the power of the statistical component of the program but will increase the overall monitoring cost.

The MWRI take 12 samples per year.
Routine Monitoring Program

Discharge measurement using current meter

Automatic water quality monitoring station

Sampling and in-situ water quality measurements
Disadvantage of Routine Water Quality Monitoring

- In routine WQM, water samples are typically collected and stored for shipment to a laboratory, where they are analyzed.
- The time interval between data records is too long.
- The system cannot detect the pollutions in the same time.
- The decision maker has not enough knowledge to take the fast solution to solve any sudden problems in the water quality.
Research Objectives
Objectives

The objectives of this study are to:

- Introduce the RWQM technology for Egypt.
- Assess the water quality changes in selected strategic points that represent the River Nile water system using Real Time monitoring.
- Using (WQI) to evaluate the suitability of water bodies for various uses such as drinking, irrigation, livestock, etc.
- Evaluate different sampling frequencies for selected water quality parameters and propose the most efficient (economic) sampling frequency that may be used for routine monitoring within the NWQMN.
Advantages of Real Time Data:

1) *Increasing data-collection frequency provides an improved understanding of cause-and-effect relations that result in observed water-quality characteristics.*

2) *Notifying water resource managers in real time, eliminating delay between sample collection and lab analysis may be critical for warning the public.*

4) *Decreasing time and costs associated with routine sampling.*

5) *Measuring water quality changes at night and during storms when samples are seldom collected and when storm events can have major effects on concentrations and loads.*
Methodology

*RTWQM System Set up*

*Assessing water quality on the Nile River*

*Sampling frequency*
RTWQM System Set up
Real Time Water Quality Monitoring Sites

1. **NL03A**: Aswan
2. **NL34**: Ismailia Intake
3. **NL39**: El Salam Intake (Damietta Branch)
4. **NL42**: Benowvar (Rosetta Branch)
Monitoring Location NL03A in Aswan
Monitoring Location NL34 at Ismailia Intake in Cairo.
Monitoring Location NL39 on the Damietta branch.
Monitoring Location NL42 on the Rosetta branch
1. Station Design

The station contains two main parts:

- Hydrolab sonde
- Data logger to record data
2. **Sampling Equipment**

The equipments can be categorized in three parts:

- **Sensors.**
- **Power Source.**
- **Data retrieval system.**
3. Sensor Deployment

The water quality instrument is placed in the downstream end of a 3 to 6 m length and 7 to 10 cm diameter of PVC pipe that has the lower 1.5 m slotted Sensors.
4. Communication System

**Real-time Water Quality Monitoring for the River Nile**

**Installed Sensor Types**

- Water Quality
  - pH
  - Turbidity
  - Dissolved Oxygen
  - Total Dissolved Solids
  - Conductivity
  - Percent Saturation
  - Water Temperature
  - Ammonium
  - Nitrate
  - Chlorophyll
  - Hydrochloric

- Climate
  - Air Temperature
  - Relative Humidity
  - Air Pressure
  - Wind Speed
  - Wind Direction
  - Solar Radiation

**User with a computer and internet access**

- Cellular Access
- Regular Intervals
- Dial Up Access
- New graphs at regular intervals
- NWRC Intranet Web Server
5. Monitored Parameters

- Temperature.
- Specific Conductivity (SC).
- Dissolved Oxygen (DO).
- pH.
- Total Dissolved Solids (TDS).
- Turbidity (Tur).
- Ammonium.
- Nitrates.
Calibration Work
WATER QUALITY INDEX
Water Quality Index

\[ WQI = 100 - \left( \frac{\sqrt{f_1^2 + f_2^2 + f_3^2}}{1.732} \right) \]

- **Scope (F1)** - number of variables not meeting water quality objectives
- **Frequency (F2)** - the number of times the objectives are not met
- **Amplitude (F3)** - the extent to which objectives exceeded.
## WQI Categorization

<table>
<thead>
<tr>
<th>RANKING</th>
<th>WATER QUALITY VALUE</th>
</tr>
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<tbody>
<tr>
<td><strong>Excellent</strong></td>
<td>95 - 100</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>80 - 94</td>
</tr>
<tr>
<td><strong>Fair</strong></td>
<td>65 - 79</td>
</tr>
<tr>
<td><strong>Marginal</strong></td>
<td>45 - 64</td>
</tr>
<tr>
<td><strong>Poor</strong></td>
<td>0 - 44</td>
</tr>
</tbody>
</table>
### Water Quality Index Results During Low Flow

**WQI Scores and Rankings for Nile River Site NL39**

<table>
<thead>
<tr>
<th>Data Summary</th>
<th>Drinking</th>
<th>Irrigation</th>
<th>Livestock</th>
</tr>
</thead>
<tbody>
<tr>
<td>WQI</td>
<td>73</td>
<td>69</td>
<td>72</td>
</tr>
<tr>
<td>Category</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
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<tr>
<td>F1(Scope)</td>
<td>33</td>
<td>40</td>
<td>33</td>
</tr>
<tr>
<td>F2(Frequency)</td>
<td>19</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>F3(Amplitude)</td>
<td>28</td>
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<td>16</td>
<td>14</td>
</tr>
<tr>
<td>F3(Amplitude)</td>
<td>21</td>
<td>47</td>
<td>21</td>
</tr>
</tbody>
</table>
Sampling frequency
Six (6) data subset were developed as following:

- **Subset A** (n = 6 samples/year) measurements started at 20 February 2009.
- **Subset B** (n = 6 samples/year) measurements started at 20 January 2009.
- **Subset C** (n = 12 samples/year) measurements started at 20 February 2009.
- **Subset D** (n = 24 samples/year) measurements started at 20 February 2009.
- **Subset E** (n = 36 samples/year) measurements started at 20 February 2009.
- **Subset F** (n = 48 samples/year) measurements started at 20 February 2009.
Median Changes at different sampling frequencies for WQPs at NL39

- **pH**:
  - 7.94 to 7.96 (6 samples per year)
  - 7.98 to 8.00 (12 samples per year)
  - 8.02 to 8.04 (24 samples per year)
  - 8.06 to 8.08 (36 samples per year)
  - 8.10 to 8.12 (48 samples per year)

- **DO (mg/l)**:
  - 0.00 to 3.00 (6 samples per year)
  - 3.02 to 6.00 (12 samples per year)
  - 6.02 to 9.00 (24 samples per year)
  - 9.02 to 12.00 (36 samples per year)
  - 12.02 to 15.00 (48 samples per year)

- **Turb. (NTU)**:
  - 0.267 to 0.268 (6 samples per year)
  - 0.269 to 0.270 (12 samples per year)
  - 0.272 to 0.273 (24 samples per year)
  - 0.274 to 0.275 (36 samples per year)
  - 0.276 to 0.277 (48 samples per year)

- **TDS (mg/l)**:
  - 1.12% change
  - 6.4% change
  - 9% change
  - 2.77% change
Range values at different sampling frequencies for WQPs at NL39

- **pH**
  - 1.08 (6 sample per year A)
  - 1.16 (6 sample per year B)
  - 1.24 (12 sample per year)
  - 1.32 (24 sample per year)
  - 1.40 (36 sample per year)
  - 6 sample per year (A)
  - 6 sample per year (B)

- **DO (mg/l)**
  - 11.6 (6 sample per year A)
  - 12.0 (6 sample per year B)
  - 12.4 (12 sample per year)
  - 12.8 (24 sample per year)
  - 13.2 (36 sample per year)
  - 13.6 (48 sample per year)

- **Turb. (NTU)**
  - 0.0600 (6 sample per year A)
  - 0.0640 (6 sample per year B)
  - 0.0680 (12 sample per year)
  - 0.0720 (24 sample per year)
  - 0.0760 (36 sample per year)
  - 0.0800 (48 sample per year)

- **TDS (mg/l)**
  - 9.34% (6 sample per year A)
  - 8.74% (6 sample per year B)
  - 8.10% (12 sample per year)
  - 8.00% (24 sample per year)
  - 7.80% (36 sample per year)
  - 7.60% (48 sample per year)
Conclusion

- The final output obtained proved that the RTWQ water quality monitoring system is a powerful tool in tracking the water quality status in near real time conditions.
- The system allows detecting any sudden changes in the quality and permits to have fast reactions based on accurate information.
- The optimal sampling frequency for the measured water quality parameters is six (6) samples per year. This will significantly reduce the overall cost of the monitoring program facilitating financial resources for better network management.
Conclusion (cont.)

- The drinking water quality category for the River Nile site (NL39) was fair for low and high flow rates, respectively.
- The irrigation and livestock water quality category was fair in both cases (low and high flow rates).
Recommendations

- The system is strongly recommended to be expanded to cover other strategic water quality monitoring locations.
- It is recommended to follow the QC/QA that describes the life time for each sonde. This may be achieved by finding more funds, this will also ensure system sustainability.
- The performance of the already existed real time water quality stations can be improved through adding more sensors to detect more physical and chemical parameters.
Thanks