Systematic sampling strategy for monitoring water quality by integrating *in-situ* and remote sensing data

Chawla Sivee[1,2], Nele Desmet[1], Dries Raymaekers[1], Els Knaeps[1], Piet Seuntjens[1,2,3], Bernard De Baets[2] and Niko Verhoest[2]

[1] Flemish Institute for Technological Research (VITO), Boeretang 200, 2400 MOL, Belgium
E-mail: sivee.chawla@vito.be

[2] Faculty of Bioscience Engineering, University Gent, Coupure Links 653, 9000 Gent, Belgium

[3] Dept of Bioscience engineering, University Antwerp, Antwerp, Belgium

Water quality monitoring is an important component of water management activities. Collecting samples is the first step in monitoring and an effective sampling design is important to ensure the quality of end results. The water components are heterogeneously distributed over water surface (Anttila *et al.*, 2007). Also, the samples have spatial dependence or are autocorrelated over the water surface (Hedger *et al.*, 2001). Usually, random sampling techniques are used for monitoring because of its ease of use and unbiased approach, but it ignores the heterogeneity and spatial dependence. Insufficient sample size also, contributes to sampling error. This research focuses on these sampling issues and proposes a systematic sampling strategy considering the spatial dependency, heterogeneity and sample size, to decrease error and increase accuracy.

The methodology proposed in the research utilises geostatistical based techniques to analyse the spatial dependency of water components using variogram analysis on *in-situ* data. To capture heterogeneity, experiments were performed by varying grid size, spatial distribution of samples and number of samples, within the study area. Airborne hyperspectral remote sensing data, at different spatial resolutions, was used to perform the spatial analysis for calibration of the sampling scheme. For further calibration and validation, optical *in-situ* data was used.

Final outcome of this research is an effective spatial sampling design which defines the sample size, the spatial distribution of samples and effective grid size for *in-situ* sampling to minimize error while estimating water quality parameters in a reservoir.

For this study, Broechem drinking water reservoir is selected to monitor algae blooms by estimation chl-a concentration using *in-situ* and remote sensing data. Extensive *in-situ* and remote sensing data set were collected. *In-situ* monitoring was done by autonomous vehicle - Aqua drone (by VITO) by using probes- YSI 6600 V2 data sonde and fluoroprobe. Optical properties were captured using *in-situ* devices – ASD-spectroradiometer and in-house developed camera LICRIS, used for calibration. Also, synoptic view of study area (providing prior information to the input of the system) is available from hyperspectral remote sensing data of APEX, with flight time of around same time as that of *in-situ* data.

The study area is so chosen because of its hydrodynamic simplicity and extensive availability of data set. This has been taken as a test site with the idea to extend this study in more complex water bodies such as coastal waters which are both hydrodynamic ally complex and also, dominated by mixture of water constituents such as phytoplankton and sediment plumes.

References

Anttila S., T. Kairesalo and P. Pellikka. 2007. A feasible method to assess inaccuracy caused by patchiness in water quality monitoring. Enivronment Monitoring and Assessment 142:11-22.

Hedger R.D., P.M. Atkinson and T.J. Malthus. 2001. Optimizing sampling strategies for esitmating mean water quality in lakes using geostatistical techniques with remote sensing. Lakes & Reservoirs: Research and Management 6:279-288.