Monitoring, environmental emergencies management and water treatment improvement of CHAOHU LAKE, China

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Introduction

Severe eutrophication conditions within freshwater basins, with the subsequent risk of algae blooms, deeply affects the safety of drinking water supplies in China and stands as one of the main environmental emergencies of the country. Located in central area of Anhui Province, on a tributary of Yangtze River, Chaohu lake is one of five largest freshwater lakes in China (figure 1). Since the '90s water quality has been deteriorated, badly affecting all water-related activities and drinking water supply.

Figure 1: On the left, map of China with, in red, Lake Chaohu (N 31°43'10''-31°25'35'' - E 117°17'20''-117°51'05''); on the right, the 7 stations in the lake east part, where monitoring is carried out at present (only one, *Guishan Mountain*, is automatic).

This poster presents the analysis of Chaohu lake case, developed in the framework of the Sino-Italian Cooperation Program for Environmental Protection,

valuing efforts of local authorities and coordination among different stakeholders.

Figure 2: Algae bloom situation at Hefei Yicheng on June 5th 2007.

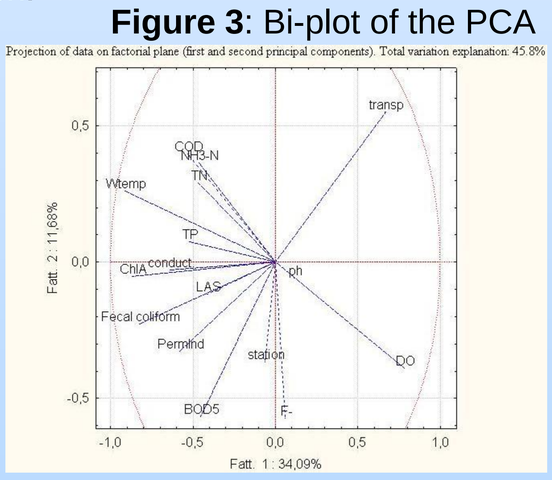
From January to November 2009, Progetti e Ambiente S.p.A. - an Italian engineering company - led the MITIC (*Monitoring Improvement and Treatment Improvement of Chaohu lake*) project, focusing the action on Chaohu City. As multi-tasking feasibility study, the project aimed at a) upgrading the monitoring system at lake and water treatment plant levels, also applying remote sensing to develop a SCADA (*Supervisory Control And Data Acquisition*) using *neural networks* to support prompt and effective management of emergency situations; b) upgrading water collection and treatment technologies; c) controlling trophic levels by pinpointing critical loads and pursuing to improve lake health in a integrated watershed view.

Results & Discussion

MONITORING

Data collection and analysis. Analytical data have been analysed by Principal Component Analysis (PCA); the evaluation on the basis of OECD criteria, Trophic State Index and Morpho-Edaphic Indices lead to assess lake Chaohu trophic state ranging between eutrophic and hypertrophic. External loads have been calculated and a check was done using OECD regression for shallow lakes and reservoirs, relating external phosphorus loads to in lake phosphorus concentration.

Figure 3: Bi-plot of the PCA



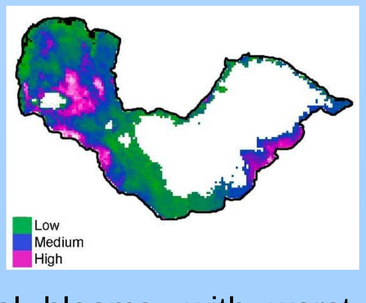
PCA shows chlorophyll concentration strictly related to main indicators of domestic pollution (ammonia nitrogen, tot. P, LAS, faecal coliforms) – fig. 3 - and supports the general assessment that P loads causing eutrophication are mainly of domestic origin. Evaluation of natural P concentrations, according to Morpho-Edaphic indices, confirms the existence of important loads also from nonpoint sources.

Remote Sensing. When deterioration of water quality is caused by optically active substances, the effect of these changes can be observed with remote sensing.

Satellite-Sensor	N° images	Application	Spatial Resolution
ENVISAT-MERIS	35	Water quality (chlorophyll and cyanobacteria)	300 m
TERRA-ASTER	2	Water Surface temperature (thermal input of the tributaries)	15 m
LANDSAT-TM	3	Dynamics of algal blooms	30 m
MODIS	664	Water Surface temperature	1000 m

Table 1: List of satellite images used with their applications.

Figure 4



MERIS maps reveal that the worst water quality conditions are mostly occurring in the lake northern part, with some dates showing alarming conditions related to algal bloom events (figure 4: probability of finding *phycocyanin* pigments in the algal bloom observed for scene acquired by MERIS on 13 May 2008: in white the water types in better status).

MERIS maps also indicate a seasonality of algal blooms, with worst conditions occurring in summer and general improved states in the first part of the year. In the eastern basin, results suggest to move caption stations towards pelagic waters since these were generally of better quality. Multi-sensor analysis between MERIS and MODIS indicate a positive correlation between surface temperature and phytoplankton, even if this relation faults in case of massive algal blooms of cyanobacteria.

DRINKING WATER TREATMENT TECHNOLOGIES

This activity was mainly focused on two topics:

a) evaluation of different options of **water intake**, to reduce quantity of Total Suspended Solids, algae included, entering the treatment process;
b) feasibility of different possibilities to upgrade **treatment processes** within the two DWTPs (drinking water treatment plants) operating at Chaohu.

With reference to *water intakes* three different solutions were evaluated (bank filtration, levee filtration and HRFs (Horizontal Roughing Filters), both in terms of expected quality results and costs. At this step the use of HRFs was considered the most promising one.

The *upgrading* of the two DWTPs, displaying different layouts and treatments, was considered on the basis of two steps: a priority one, focused on implementing better coagulation-flocculation techniques (after a jar-test campaign to optimize the choice of chemicals and their doses), and on the pre-oxidation step, where the current pre-chlorination has to be discarded. Further steps, aimed at optimizing the other units - namely filtration and disinfection - and at a thorough revision of DWTP hydraulics must be provided.

MANAGEMENT OF CYANOBACTERIA-BLOOM EMERGENCIES

Data collected during the monitoring campaign and in normal operation were analyzed by means of Neural Networks by two different methodologies:

1. the regression one lead to discover discrepancies in data that can mean irregular behaviour of monitoring instruments;
2. the time series one can single out an increase of chlorophyll concentrations even before it happens in reality, thus allowing countermeasures to start before water quality worsens too much.

Thresholds were proposed for pre-alert and emergency situation indicators (table 2): in case of pre-alert, toxicity should be considered as a prevailing parameter (if observed value is over 25%, pre-alert is automatically defined). For the remaining indicators, it is likely that their values do not vary simultaneously and only some of them become critical at the same time.

Table 2

Parameter	Value
Ratio Chlorophyll-a concentration / baseline chlorophyll-a concentration	**5**
Ratio P-PO_4/TP at the surface	**< 0.5**
Dissolved oxygen saturation at the surface	**> 100%**
Toxicity	**25 %**

1st pre-alert level should be set when one indicator reaches the critical value. 2nd pre-alert level should correspond to critical values for all indicators.

Conclusions

The presented *MITIC* project moved on two synergic views: giving feasible and easily applicable solutions to water supply managers and lake and treatment plant monitoring technicians in Chaohu city, in the short term; giving sustainable and comprehensive suggestions to public institutions to improve sustainable management of watershed and eventually lake health, in the medium and long terms. If at present need for improving quality of drinking water must be faced as soon as possible, the real solution of the problem is compulsorily the implementation of a recovery strategy of the overall lake conditions. This will require to keep enhancing coordination among different local and government public institutions and private stakeholders and therefore to make accessible proper and updated data and information management infrastructures.