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Short-range forecast of Shershnevskoie (South Ural) water-storage algal blooms: preliminary results of predictors' choosing and membership functions' construction

Anna Gayazova (1) and Sanjar Abdullaev (2)

(1) South Ural State University, Chelyabinsk, Russian Federation (why.ann@mail.ru), (2) South Ural State University, Chelyabinsk, Russian Federation (sanjar@mail.ru)

Short-range forecasting of algal blooms in drinking water reservoirs and other waterbodies is an actual element of water treatment system. Particularly, Shershnevskoie reservoir - the source of drinking water for Chelyabinsk city (South Ural region of Russia) - is exposed to interannual, seasonal and short-range fluctuations of blue-green alga Aphanizomenon flos-aquae and other dominant species abundance, which lead to technological problems and economic costs and adversely affect the water treatment quality.
Whereas the composition, intensity and the period of blooms affected not only by meteorological seasonal conditions but also by ecological specificity of waterbody, that's important to develop object-oriented forecasting, particularly, search for an optimal number of predictors for such forecasting.
Thereby, firstly fuzzy logic and fuzzy artificial neural network patterns for blue-green alga Microcystis aeruginosa (M. aeruginosa) blooms prediction in nearby undrained Smolino lake were developed. These results subsequently served as the base to derive membership functions for Shernevskoie reservoir forecasting patterns.
Time series with the total lenght about 138-159 days of dominant species seasonal abundance, water temperature, cloud cover, wind speed, mineralization, phosphate and nitrate concentrations were obtained through field observations held at Lake Smolino (Chelyabinsk) in the warm season of 2009 and 2011 with time resolution of 2-7 days. The cross-correlation analysis of the data revealed the potential predictors of M. aeruginosa abundance quasi-periodic oscillations: green alga Pediastrum duplex (P. duplex) abundance and mineralization for 2009, P. duplex abundance, water temperature and concentration of nitrates for 2011.
According to the results of cross-correlation analysis one membership function "P. duplex abundance" and one rule linking M. aeruginosa and P. duplex abundances were set up for database of 2009. Analogically, for database of 2011 three rules, linking membership functions of temperature, P. duplex abundance, nitrate concentration and M. aeruginosa abundance were set up. Developed fuzzy logic rules were good to predict M. aeruginosa intense outbreaks.
For ANN method of forecasting specially written program was used to train the fuzzy artificial neural network on number of input selected predictors' values and output predicted factor's values to set up the predictive rules and membership functions automatically. As a result, two models based on mineralization and P. duplex abundance were developed for 2009. For 2011 four patterns were developed, the best result was obtained for model based on temperature and P. duplex abundance.
Developed methods of forecasting were applied to predict outbreaks of Aphanizomenon flos-aquae and M. aeruginosa abundance in Shershnevskoie reservoir. For this purpose long-term data of chemical parameters, measured once in a month, data of dominant species abundance, measured fifth in a week and data of turbidity, water color, alkalinity, pH, obtained each day, were analyzed. Based on these empirical data significant factors were determined, membership functions were set up and preliminary models for Shershnevskoie reservoir were developed. As expected, these models differ significantly from developed for Smolino lake ones and should be tested on new data sets.