Examining water quality parameters' interactions related to Cyprus coastal eutrophication based on the Kohonen Self-Organizing Map.

Abstract

The coastal waters of Cyprus are characterized as ultra-oligotrophic while the marine environmental status is good based on the COMMISSION DECISION 2008/915/EC pursuant to Directive 2000/60/EC. A remarkable finding is the fact that Cyprus has the highest proportion of excellent water quality for bathing waters among the EU members for the decade 2011-2020. The maintenance and continuity of this high statuses dictate the need to facilitate monitoring for good water quality through intelligent management tools. Machine Learning algorithms and more specifically Artificial Neural Networks (ANNs) provide the basis for advancing data analysis within management tools dedicated to water quality governance. This work proposes the Kohonen Self-Organizing Map (SOM) model, an unsupervised ANN for advanced water quality analysis. For the development of the SOM, surface coastal data were used from samples that were collected from coastline locations around Cyprus between 2006 and 2021. The monitored parameters included sea surface temperature, nitrogen species (NH4+, NO2-, NO3-), phosphorus (PO43-), pH, salinity, electrical conductivity, dissolved oxygen, and chlorophyll-a. The SOM was able to cluster the samples into three different groups with different trophic status. The vast majority of the data samples (including those related to aquaculture units) appeared in the first two clusters, associated with good water quality; while few data samples appeared in the third cluster, associated with less good water quality. Based on this evidence, Cypriot aquaculture units are not altering negatively the local marine environment. Without a doubt, these SOM's findings are reflecting the strict monitoring programs applied by the Cyprus Republic. Based on the SOM's component planes, the interactions between all the parameters can be visualized, allowing the extraction of useful conclusions and the creation of several possible management scenarios. One such possible scenario is based on the data samples corresponding to higher chlorophyll-a values (Group 3) during the warmer spring months, which can be associated with higher sea surface temperatures and metabolic spins on the ecosystem. Elevated values of nutrients are also observed in this group and are probably related to the increased nutritional needs of the caged fish populations. Therefore, in this case, the SOM not only managed to capture the general tendency of the measured water quality parameters, but also managed to simulate the algal production mechanisms behind sporadic instances of elevated chlorophyll-a values. Despite the fact that Cyprus coastal waters are ultra-oligotrophic and not highly endangered by anthropogenic activities, some precautionary management scenarios must be taken into consideration to offset global warming and climate change effects. Therefore, it is recommended that during the hot spring months the nutrient loads remain below the specified threshold, estimated by the model. In addition, typical interactions between parameters are also observed, like the strong correlation between salinity and electric conductivity. Hence, the SOM not only helps us to understand the water quality parameters' interactions and extract useful information regarding the coastal algal production mechanism, but can also serve as an excellent managerial tool.

Keywords

self-organizing map; coastal parameters; eutrophication

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