



Analysis of Variables in the River Suarez Basin using Data Mining (Colombia)

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Abstract : This paper presents the assessment of the concurrent environmental quality evaluated in the conditions in the Watershed of the Suarez River, integrating the variables of the water quality (BOD₅, TSS, N-NO₂ y P_{total}) and precipitation. Using the data mining technique establishes membership functions and describes data and analyzed variables. In the body of surface water, there is a detriment of the environmental quality in the medium and low basin, which is an obvious contamination of the river and therefore the need to do short-term intervention actions in the basin.

Key Words : Watershed, data mining, environmental quality.

Introduction

The applications of computational systems for making decision and prediction of the behavior of natural phenomena have been increased in terms of the techniques that may represent the conditions and abstraction of the phenomenon (Refonaa J, 2015). The information obtained from different natural phenomena have been used in different computational techniques such as machine learning, likewise databases are widely used to find important information in processes known as data mining (Pulvirenti, 2014; Karim, 2016).

Data mining or knowledge discovery in databases, consists to extract information from the data, to give it meaning and to draw useful conclusions from it, by describing patterns in large data sets provided for finding intelligible models from them (Benítez, 2013; Medina, 2014; Escobar H. , 2016; García M. , 2007). It provides a response according to the linguistic and verbal information of data, considering the assignment of the partial belongings of any object to different subsets of a universal set, instead of belonging to a single set and this membership function assume values between zero and one. The purposes of this technique, consist in the prediction through the classification (associated a discrete value and the objective is to maximize the predictive power of the classification), regression (it has associated a real value and the objective is to learn a real function, with that can minimize the error between the predicted value and the actual value) through a set of

input and output attributes, the value of which can be a category or numerical value, i.e. predict the output value; additionally another purpose, is the description through grouping (to obtain groups of natural form when applying criteria of similarity data), this one presented without labeling or enumerate, which only possess attributes of entrance and the objective is to describe data (García M., 2007; Riquelme, 2006; Ruiz, 2006; Itati, 2012).

Among the different fields, the search for missing parameters and estimation of parameters is considered (Ssali, 2008). This computational technique can cover several areas of knowledge where one has a way of acquiring data or a determined database to which can be made studies of different types (Zhun, 2016) with the aim of obtaining a relation or prediction of one or various variables of the data with which it is counted. Many models describe the behavior of different physical phenomena that require complicated calculations and are not adaptive models (Chapra, 1987; Chapra S, 2008). However, with data mining, relevant information can be obtained to estimate missing data and, of course, to approximate the knowledge and behavior of the analyzed natural phenomena.

This technique, is a method of approximation where there are no mathematical equations, however the uncertainties and complications of the model are included in the procedure of descriptive diffuse inference (Erkan, 2009). The applications of techniques are usually in the modeling of surface and ground water quality, estimation of water quality through satellite imagery, prediction of earthquakes, prediction of basin levels (Bonansea, 2015; Harvey, 2015); recognition of water quality patterns and sustainable use of water, identification of ecosystem functioning models, improvement of management and control of wastewater treatment plants, urban planning (Ay, 2014; Sari, 2013; Pai, 2011; Ross, 2010).

This paper presents the analysis of the variables of precipitation and water quality (BOD, TSS, N -NO₂ y P_{total}) in order to understand the patterns of behavior, extract attributes, consider membership functions and describe significant data in the watershed of the Suarez River (Colombia).

Materials and Methods

The method used is a combination between the real and exact observation and the knowledge of an empirical, complex situation and inductive reasoning, which would consist in deriving a new knowledge from particular phenomena and knowledge already obtained, and establishing propositions analyzed from their causes and real effects, that is, from the particular to the general (Vergel, 2010; Balestrini, 2001). It is worth mentioning that according to the analysis and scope of the results, the type of research is analytical - quasi experimental, since it analyzes an event and understands it, in terms of its obvious aspects and discovers the elements that make up the totality and the connections that explain its integration, that is, it facilitates the study and deeper understanding of the event under study (Hurtado J., 2000; Vergel G., 2010; Hernández, 2010).

Precipitation information was obtained from the climatological stations of the Cundinamarca's Autonomous Regional Corporation (CAR) located in each of the municipalities belonging to the watershed of the Suarez River; information of the water quality parameters DBO, SST, N -NO₂ and P_{total}, related to the surface water quality as the wastewater treatment plants (including treatment flow) located in towns in to the basin in question, were taken from the Cundinamarca's Environmental Laboratory of the Regional Autonomous Corporation (CAR).

The analysis period for precipitation and water quality information is from year 2012 to 2015. A database was developed with the estimation or replacement of missing data, thus a database of 150 is constructed with 5 different variables and for this the mean and variance for each analyzed variable is determined, then it is ordered upwards with respect to the calculated variance.

Results

The following are the results of applying data mining in the Suarez River Basin.

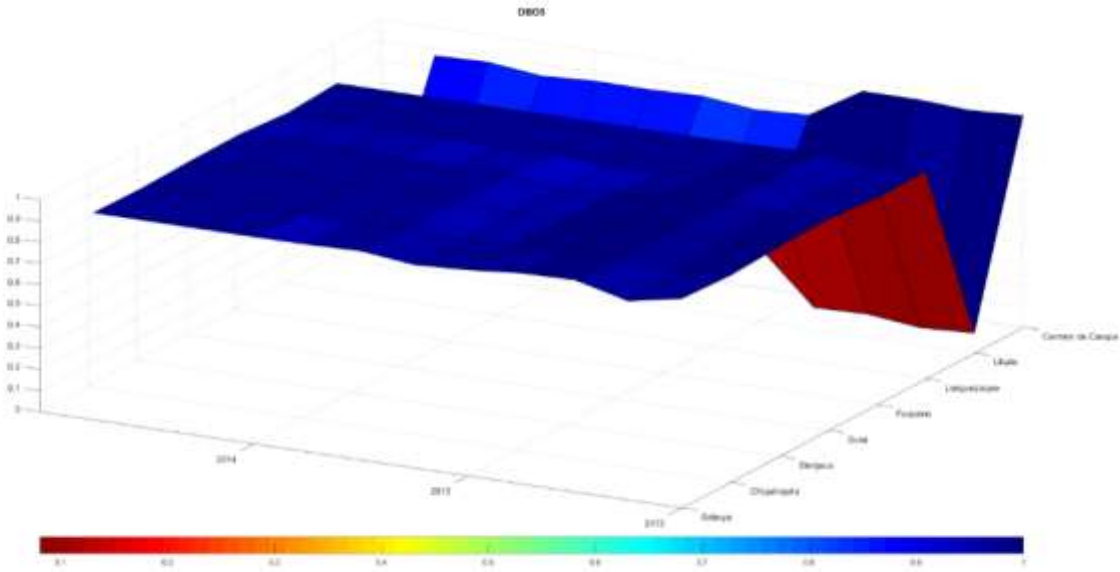


Figure 1. Three-dimensional diagram for BOD.

In the three-dimensional figure, the behavioral pattern of the environmental quality of the BOD is observed in the period 2012 to 2015, where the function of belonging between the station and the analyzed period shows a correlation indicating a low environmental quality in the medium basin, evidenced by the accumulated wastewater discharge of the upstream populations and of course by the considerable volume of these discharged by the populations of Ubaté and Lenguazaque. The rest of the basin in the middle and low basin presents a good environmental quality behavior.

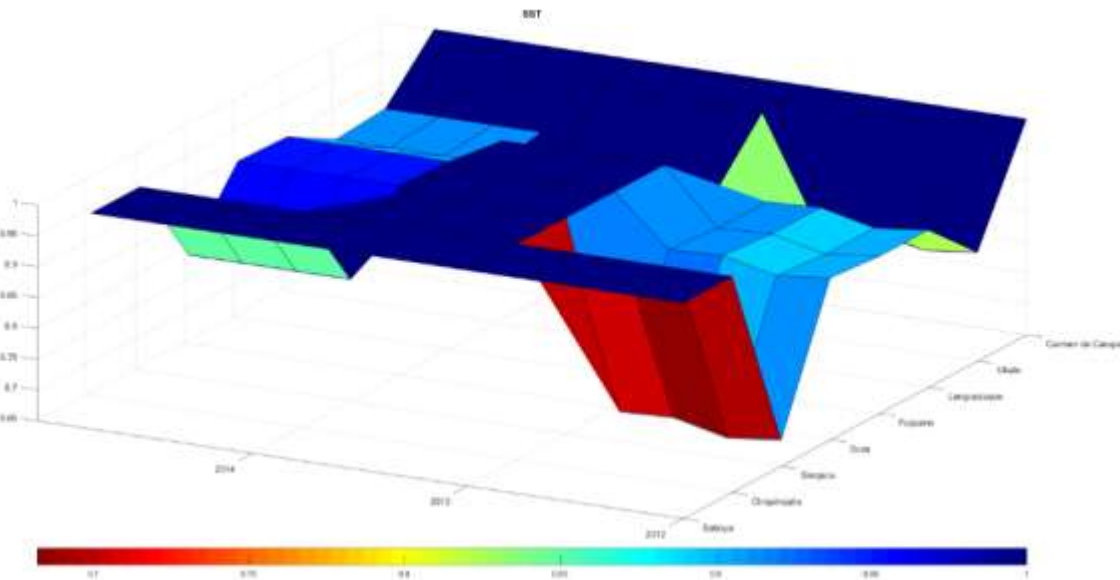


Figure 2. Three-dimensional diagram for TSS.

The data observed in Figure 2 of the SST parameter in the Suarez River Basin establish that in the upper basin the environmental quality is good, however a considerable deterioration is observed in the middle and lower basins, especially influenced by the discharge of Wastewater from the municipalities of Simijaca and Chiquinquirá. There is considerable variation in environmental quality in municipalities where there is no

installation of wastewater treatment systems (WWTS / WWTP), which causes a contamination of the water body. During the period analyzed from 2012 to 2014, there is a deterioration of the environmental quality, especially in the low basin of this river.

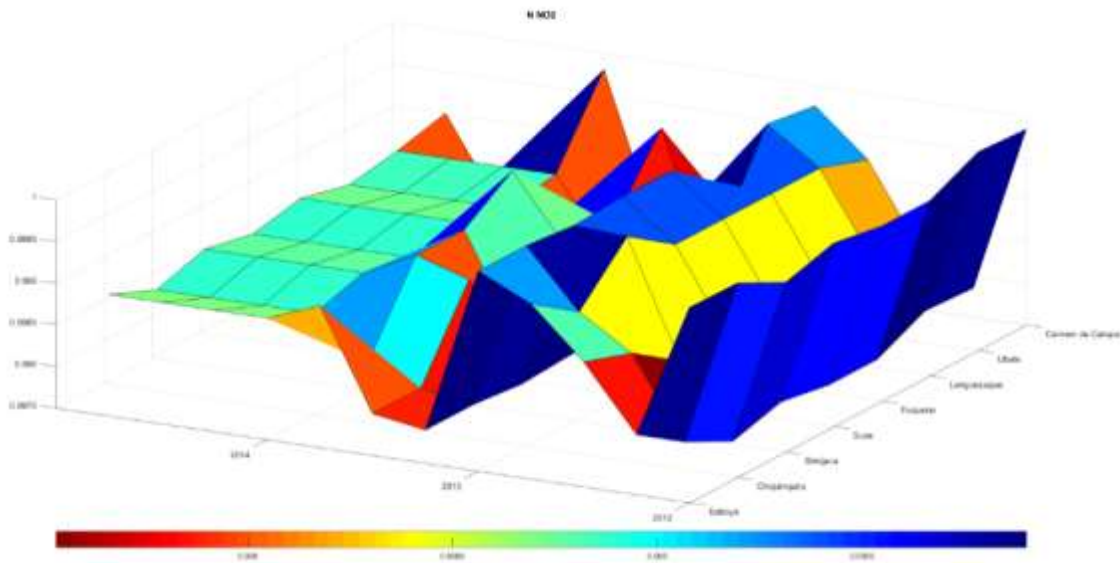


Figure 3. Three - dimensional diagram for N-NO₂.

In Figure 3, line entities are observed as indicators of environmental quality in the Suarez River, with a volatile fluctuation with recurrent frequency in the analyzed period from 2012 to 2014, which presents a high dispersion of the N-NO₂ of the environmental quality data conditions in the upper, middle and lower basins, which converge in a structure caused by discharges of waste water with nitrogen content that directly affect the quality of the water body.

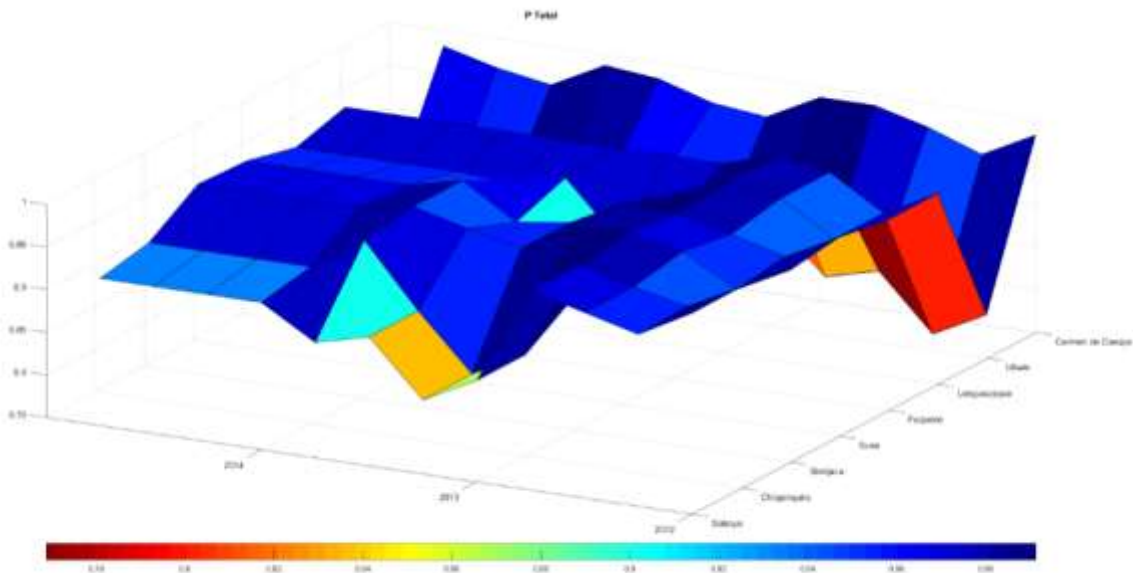


Figure 4. Three-dimensional Diagram for P_{total}.

In Figure 4, it is observed a homogeneity of the studied phenomenon in terms of the good environmental quality in the majority of the basin in the analyzed period 2012 - 2014, nevertheless the connection line entities of the environmental quality between each station, establishes the shedding of the municipalities of Ubate and Languazaque, that influence in the detriment of the environmental quality and therefore of the contamination of

the body of water, given the little reciprocity, oscillation and reduced variability of the behavior and temporal correlation of the environmental quality.

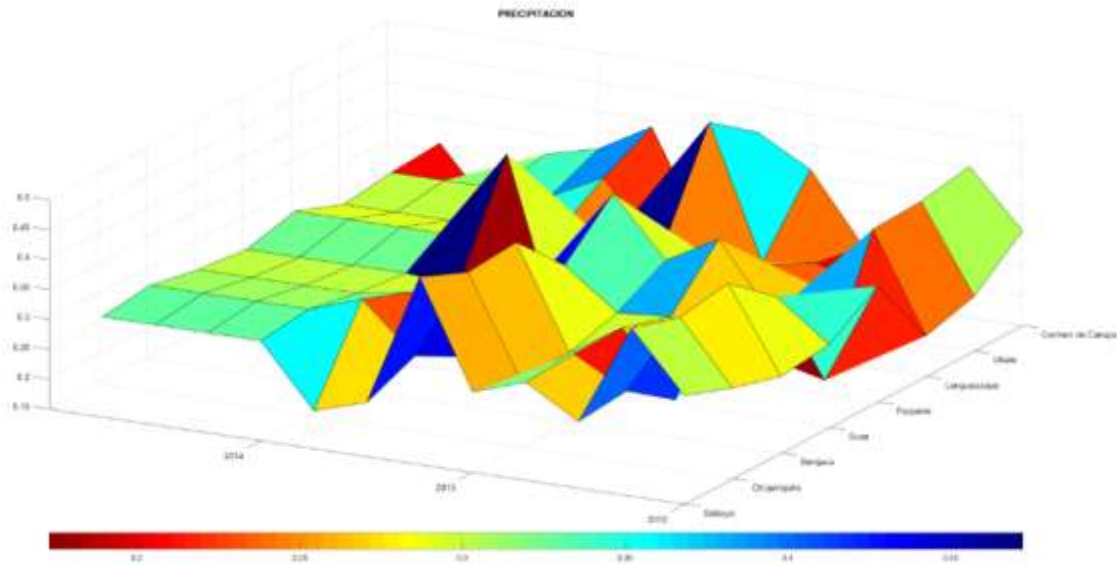


Figure 5. Three-dimensional diagram for precipitation.

Figure 5 for the precipitation variable in the basin, shows a behavior with a correlation pattern of environmental quality that establishes line entities with volatile fluctuation, high dispersion, considerable data traffic and a combined topology, with weak connectors of marked heterogeneity, being this influential in the concentration of the contaminants present in the body of water and caused a detriment in the environmental quality of the river.

Conclusions

Data mining applied to the analysis of the variables of water quality and precipitation in the Negro River basin, considers understand and comprehend patterns of behavior, extract attributes, consider membership functions and describe significant data of BOD, TSS, N -NO₂, P_{total} and precipitation, in order to identify suitable actions in the short term intervention in the basin in terms of spatial identification of scenarios in sections or sectors of the surface water bodies especially in the middle and lower basin, due to the high anthropic pressure, the predominant environmental effect and the evident alteration of the environmental quality in the river. With the membership functions, it is possible to establish a marginal approach to the installation or optimization of wastewater treatment systems (WWTS / WWTP), related to aspects of the sensitivity, adaptability of the technology to be implemented for the increase of quality in the middle and lower basin.

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