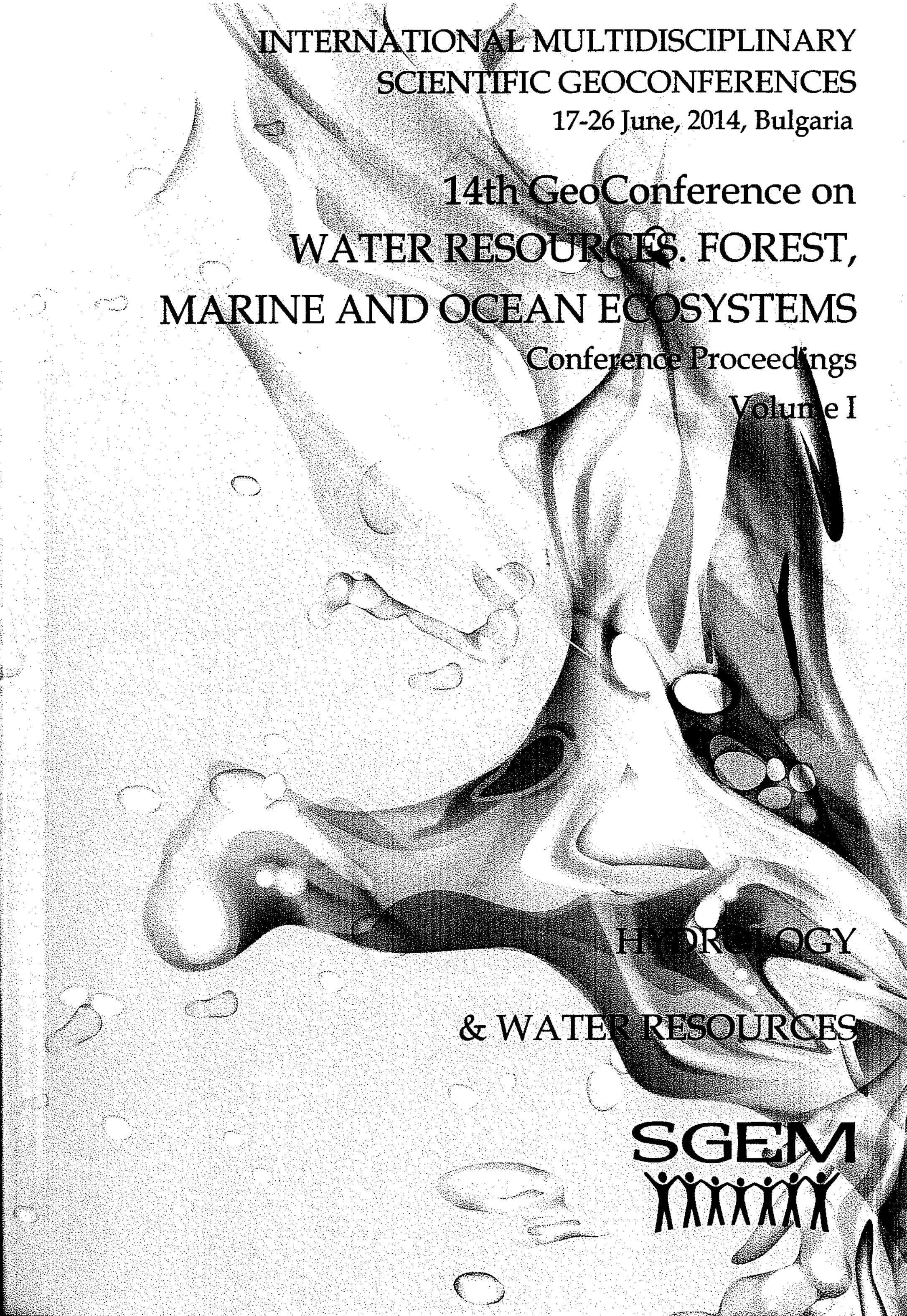

INTERNATIONAL MULTIDISCIPLINARY
SCIENTIFIC GEOCONFERENCES
17-26 June, 2014, Bulgaria

14th GeoConference on WATER RESOURCES. FOREST, MARINE AND OCEAN ECOSYSTEMS

Conference Proceedings

Volume I

HYDROLOGY & WATER RESOURCES

SGEM

[14] Duan Q., Sorooshian S. & Gupta V.K. Optimal use of the SCE-UA global optimization method for calibrating watesher models, Journal of Hydrology, vol. 158, pp 265-284, 1994.

[15] Maca, P, Vizina, A, Horacek, S. The ASVH. The parameter optimisation of hydrological model BILAN using the SCDE method. VTEI, 2013, 55, 4, s. 1-4.

THE APPLICATION OF FUZZY LOGIC TECHNIQUES TO THE CHARACTERISATION OF TREATMENT SYSTEMS IN TWO SEWAGE PLANTS

Prof. Dr. Jose Antonio Grande[1]
Prof. Dr. Maria Luisa de la Torre[1]
Prof. Dr. Teresa Valente[1,2]
Prof. Dr. Javier Aroba[3]
Dr. Juan Sanchis[4]
Prof. Maria Santisteban[1]

[1]Centro de Investigación para la Ingeniería en Minería Sostenible. Escuela Técnica Superior de Ingeniería. Universidad de Huelva. Ctra. Palos de la Frontera. **Spain.**

[2]CIG-R (PEst-OE/CTE/UI0697/2011). Centro de Investigação Geológica, Ordenamento e Valorização de Recursos, Universidade do Minho, Campus de Gualtar, **Portugal**

[3]Departamento de Tecnologías de la Información. Escuela Técnica Superior de Ingeniería. Universidad de Huelva. Ctra. Palos de la Frontera, **Spain**

[4]Diputación de Valencia. Area de Medio Ambiente. Valencia, **Spain**

ABSTRACT

The alternatives for treating urban waste water are many and very varied. The choice depends not only on the characteristics of the water to be treated, but also on other factors such as the size of the town it serves, the economics, environmental factors, etc.

While many works have dealt with the subject of the treatment of waste water from small towns, various industrial processes or inflow from towns with a large industrial load, not many have carried out comparative studies of various types of Waste Water Treatment Plants (WWTPs) in towns with inflows which are predominantly domestic using statistical processes.

This work aims to carry out a study, using Fuzzy Logic, of the various analytical parameters analysed in the water at the inlet (inflow) and at the outlet (outflow) of two different WWTPs which receive domestic contributions, once the water has undergone purification treatment. Two waste water treatment plants serving different towns in the province of Valencia (Spain) and which treat the inflowing waters using different purification systems were selected for this. The Utiel WWTP treats the waters using activated sludge and a prolonged aeration process with a "two-stage" purifier, while the Cheste plant uses a treatment involving bacteria beds with trickling filters.

An analytical series is available from these WWTPs covering some 10 years with a frequency of two weeks. The parameters available, at the inlet and the outlet, are: rain (Lluv), daily input volume (VolD), pH, conductivity (Cond), Solids in Suspension (SS), DBO_5, DQO, total Nitrogen (Nt), total Phosphorus (Pt) and a sampling period expressed in months.

The PreFuRGe (Predictive Fuzzy Rules Generator) tool was used to process the data, allowing us to obtain an immediate qualitative analysis of the information contained in the resulting volume of data. Thus, dependency relationships were established between the parameters, not numerically, but logically, by also analysing the various times of the year with the various parameters to establish a probable seasonality.

Keywords: Sewage plant; fuzzy logic; activated sludge; bacteria beds.

INTRODUCTION

This work aims to carry out a study, using Fuzzy Logic, of the various analytical parameters analysed in the water at the inlet (inflow) and at the outlet (outflow) of two different WWTPs which receive domestic contributions, once the water has undergone purification treatment. Two waste water treatment plants serving different towns in the province of Valencia (Spain) (Fig. 1) and which treat the inflowing waters using different purification systems were selected for this. Thus, the Utiel WWTP treats the waters using activated sludge and a prolonged aeration process with a "two-stage" purifier, while the Cheste plant uses a treatment involving bacteria beds with trickling filters. Both WWTPs comply with the current legal guidelines which govern the treatment of waste water on a community, state and local level.

The PreFuRGe (Predictive Fuzzy Rules Generator) [1] tool was used to process the data. This is a data-mining computer tool based on the previously described methodology [1].This software allows us to obtain an immediate qualitative analysis of the information contained in the resulting volume of data.

Many authors use fuzzy logic techniques to characterise pollution processes [2], [3], [4], [5].

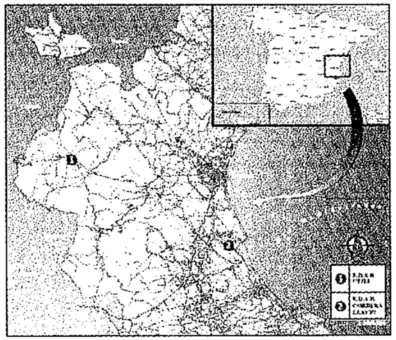

Fig. 1. Map showing the location of Utiel and Cheste WWTPs.

MATERIALS AND METHODS

Data pertaining to the period from February 2002 to December 2011 are available for the Utiel treatment plant, while data from the Cheste treatment plant refer to the period from January 2002 to December 2011 – both with two-weekly measurements.

The parameters corresponding to both the water entering the treatment plant and leaving it following treatment are: rain (Lluv), daily input volume (VolD), pH, conductivity (Cond), Solids in Suspension (SS), DBO_5, DQO, total Nitrogen (Nt), total Phosphorus (Pt) and a sampling period expressed in months.

The analytical methods used to determine the variables relating to the waste water in the WWTPs follow the procedures established by the American Public Health Association A.P.H.A. in 1999.

RESULTS AND DISCUSSION.

Figures 2 to 7 show the fuzzy rules obtained from the mass of data from the Utiel and Cheste plants, describing the behaviour of the variables in the study. The physico-chemical variables were modelled both at the inlet (E) and at the outlet (S) of the treatment system (e.g. pH Eu, pH S,...).

UTIEL Plant.

The DBO_5 and DQO at the outlet of the system present practically identical behaviour if they are taken as consequents, why is why only the figure in which DBO_5 is shown as the consequent has been represented (Fig. 2). DBO_5 takes its highest values when the rain takes values from low to extreme-low, while DQO takes its highest values when there is no precipitation and the volumes contributed are at their lowest. This is a consequence of having a single sewerage network for both waste water and rainwater. However, the fact that there is a spillway which diverts the excess that is produced at times of intense rainfall means that the WWTP's waste water intake capacity produces an undeniable dampening effect on these results, despite the fact that they continue to be very clear.

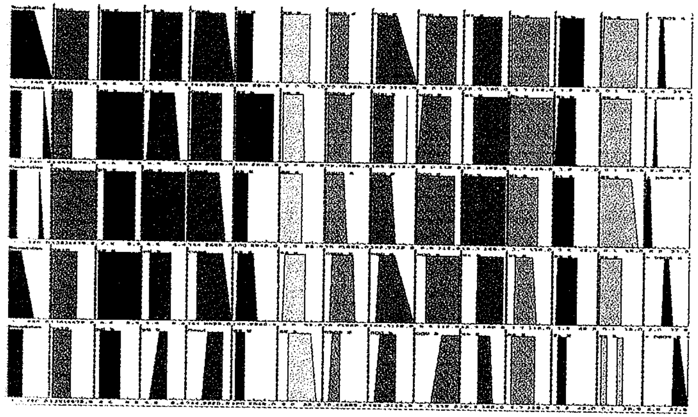

Fig. 2. Fuzzy rules taking DBO_5 S as the consequent and the rest of the variables at the Utiel plant as the antecedent.

When DBO_5 and DQO present extreme-high values in the outflow, the other variables measured also present more concentrated values than the rest at the outlet. Specifically, it is worth pointing out that pH has medium values, Nitrogen between low and medium, and phosphorus very specific low or medium values.

The relationship between DBO_5 S and solids in suspension at the outlet is observed to be such that the latter remain at low to minimum values at all values of DBO_5, except at their maximum, when the solids shift to higher values.

At the outlet nitrogen behaves as follows: with DBO_5 S values from low to medium, nitrogen can take any value. At the same time, when DBO_5 S values are at their lowest, nitrogen takes values from medium-high to extreme-low, and when DBO5 S rises above average values, nitrogen appears contained within low ranges.

At the outlet phosphorus and pH function in a very similar way to nitrogen at the outlet.

If we consider the Pt at the outlet the consequent (Fig. 3), the fact that Pt S values do not present any apparent relationship with the time of year stands out, with the clear exception of the months of April to June, in which Pt takes the highest values.

It is in this scenario of maximum Pt S, that the clearest definition of the ranges taken by all the variables considered in their respective universes of discourse is produced, with all of them having limited very concentrated groupings around a point. Thus, this maximum value for Pt corresponds to very concentrated and extreme-low values for solids at the inlet and the outlet, and for rain that is non-existent. The volume treated, pH at the outlet, conductivity, N at the outlet and DBO_5 and DQO also take very concentrated values in the low and medium-low ranges, with no variable being found in this study with high or extreme-high values. Consequently, it must be admitted that the process of eliminating phosphorus in the Utiel WWTP is hindered in spring, coinciding with the absence of precipitation, with a low volume of waste water, a very low quantity of solids in suspension and with very low DBO_5 and DQO, all relating to the inflow. The explanation may be found in the fact that the elimination of insoluble phosphorus by means of decanting is hindered by the lower concentration of solids in suspension and therefore the lower level of decanting. Furthermore, low temperatures obstruct the biological elimination of compounds of phosphorus, so that in winter a larger quantity of iron chloride is added, with it being spring when the dosage is reduced. If the spring is cold, the elimination of nitrogen is even lower. Note that in the Pt Eu duple the value is medium for this situation.

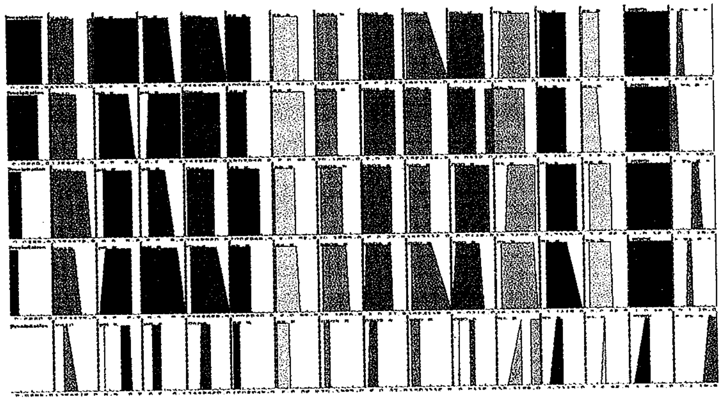

Fig. 3. Fuzzy rules taking Pt S as the consequent and the rest of the variables at the Utiel plant as the antecedent.

The graphic which deals with Nt at the outlet (Fig. 4) as a consequent is not significant, although it should be pointed out that the highest Nt values at the outlet correspond to the highest DBO_5 values at the system inlet, which co-exist with pH values in concentrated ranges from low to medium and rainfall from low to extreme-low. Although with a much lower degree of precision in the tuples, it can be considered that the behaviour of the high concentrations of Nt and Pt in the outflow display a certain similarity. In fact, in both cases periods of very low or no rainfall, concentrations of solids in suspension from medium to very low and very low at the inlet, and DQO from medium to very low and very low at the inlet all coincide.

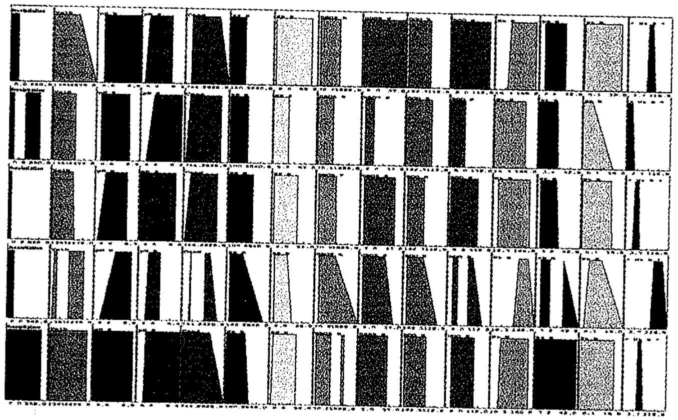

Fig. 4. Fuzzy rules taking Nt S as the consequent and the rest of the variables at the Utiel plant as the antecedent.

CHESTE Plant.

DBO_5 and DQO at the outlet present similar behaviour if taken as consequents, which is why only the figure in which DBO_5 is shown as consequent (Fig. 5) has been included. In general, it is observed that values from extreme-low to medium for DBO_5 correspond to wide ranges for the rest of the variables, which can take very dispersed values. Conversely, when DBO_5 takes its highest values, all the variables take very specific values in very clearly defined ranges within their universe of discourse. Thus, the maximum DBO_5 values occur when the variables daily Volume, solids in suspension at the inlet, DBO_5 outlet, DBO_5 inlet, Nt outlet, Pt at the inlet and the outlet take very clearly defined values in ranges from low to extreme-low.

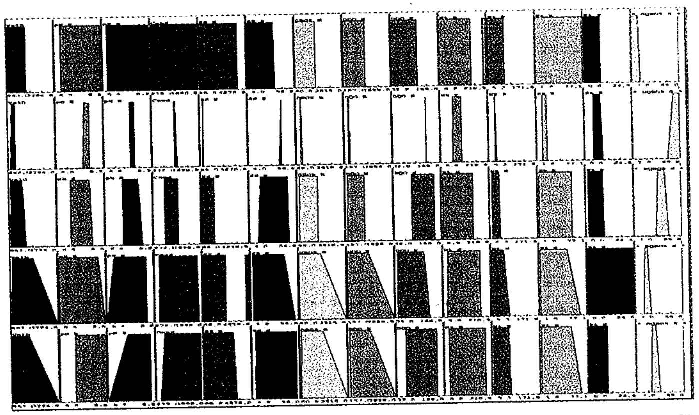

Fig. 5. Fuzzy rules taking DBO_5 S as the consequent and the rest of the variables at the Cheste plant as the antecedent.

Taking Pt at the outlet as consequent and the other parameters as antecedents (Fig. 6), it is also observed in this treatment plant, just as in Utiel, that for the highest Pt values at the outlet, the values for the other variables are found to be more concentrated, although no very significant relationship is observed between the evolution of the concentration of P at the outlet of the plant, and the consequent evolution of the values in the rest of the variables. In general pH values stay close to the maximum, except when the values for PT S are low, when pH can have any value. As for DBO_5 Eu, DQO Eu and Nt S, the values for these remain constantly low, regardless of the Pt S value while DBO_5 S, DQO S and Nt Eu keep quite dispersed values.

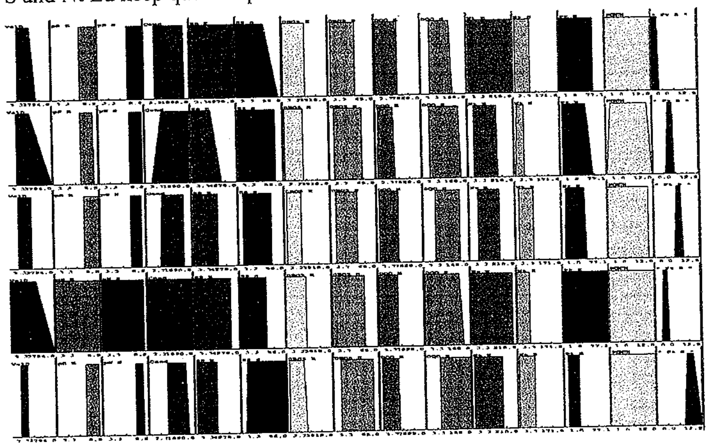

Fig. 6. Fuzzy rules taking Pt S as the consequent and the rest of the variables at the Cheste plant as the antecedent.

As described in the case of PtS, when Nt at the outlet is considered the consequent (Fig. 7), it is observed that, when the latter is at its highest, the other variables are found to be

more concentrated around a value for almost all the low or extreme-low cases, except conductivity and N Eu, which take medium-high values. However, in this case, and unlike Pt S, pH, both at the inlet and the outlet, is always kept at extreme-low values, whatever the Nt value at the plant outlet.

In the other scenarios, no consequence is noticed in the values of the other parameters with the evolution of Nt at the outlet.

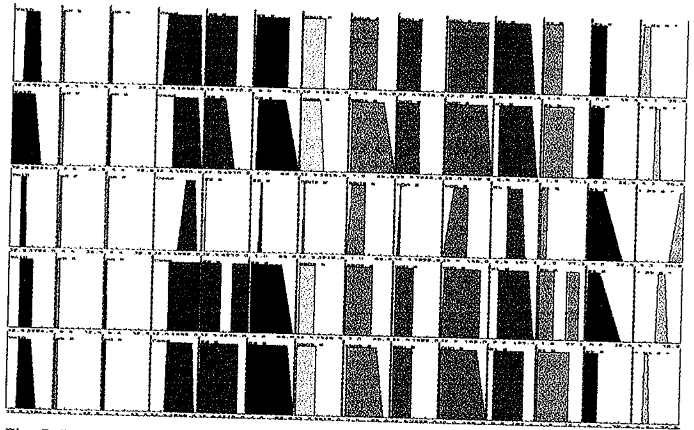

Fig. 7. Fuzzy rules taking Nt S as the consequent and the rest of the variables at the Cheste plant as the antecedent.

CONCLUSIONS

Differences in behaviour can be observed between the Utiel and Cheste plants, marked by the different purification methods used in each

When DBO5 and DQO are extreme-high at the outlet (i.e. the treatment process has worked more inefficiently and the water sample at the outlet from the plant is therefore more polluting), the values for the rest of the parameters are more concentrated around a value, with the low or very low values for phosphorus and nitrogen at the outlet standing out. This means that it is when the values of N and P are successfully reduced that the demand for oxygen at the outlet has been reduced less. Conversely, when DBO5 and DQO are very low, the values for P and N at the outlet are found to be quite dispersed. In terms of DBO5 at the outlet in Utiel, its relationship with SS, also at the outlet, must be pointed out; for any value of DBO5 the values of the latter remain low, except when DBO5 is at its maximum, which is when SS at the outlet increase. In this regard, it is worth pointing out that solids in suspension are eliminated in the decanting process, which, in practice, is independent of the biological process of activated sludge and, probably, when DBO5 is at its maximum, when it was necessary to recirculate a greater quantity of sludge (solids) to attempt to improve the process.

The value of Phosphorus is extreme-high at the outlet of both plants that a greater concentration is evident in the tuples of the rest (more significant in Utiel). No relationship is observed between the evolution of the concentration of phosphorus and the other parameters in Cheste, a fact which is, however, evident in the case of Utiel, where extreme-high values for phosphorus coexist with an absence of rainfall, extreme-low values for SS at the inlet and outlet, low or medium-low values for pH S, conductivity, N S, DBO5 Eu, DBO5 S and DQO Eu, while no parameter is found at high or extreme-high values.

These results provided by the PreFuRGe tool allow us to conclude that in the case of a treatment plant which uses activated sludge processes in a two-stage system, in order to prevent phosphorus reaching maximum concentrations, the action that needs to be taken to modify the outlet parameters must be considered in the treatment plant by means of the appropriate treatment, since no action can be taken to modify the inlet parameters. It must also be borne in mind that, in practice, a high proportion of DQO Eu and consequently also of DBO5 Eu, in relation to PtEu, is positive for the elimination of phosphorus, especially if the former have undergone a process of anaerobic degradation while being transported through drains and the sewerage system. In fact, a DBO5 Eu soluble/Pt Eu soluble ratio that is greater than 15 favours a reduction in phosphorus, and increasingly as this ratio rises. As can be seen, both in Cheste and, especially in Utiel, in those cases in which the antecedent is Phosphorus at the outlet, the maximum values for Pt S coincide with the minimum values for DQO Eu and DBO5 Eu, which corroborates what has been said and reveals the usefulness of the fuzzy logic tool.

It remains clear, therefore, that the precipitation and the composition of the inflow water, which in turn is regulated by the presence or otherwise of wine-producing industry, with seasonal action caused by the wine-making process, translate, finally, into values for P and N which are clearly affected by the factor of dilution and are contrastable with those tuples with values taken mainly by pH, DBO5 and DQO and, to a lesser extent, the other variables.

Finally, in relation to the Nitrogen in the outflow, and only in the case of very high values for this pollutant, the PreFuRGe tool indicates that these values occur when pH presents low values in both treatment plants and, in the case of Utiel, when DBO5 presents maximum values.

REFERENCES

[1] Aroba, J., 2003. Avances en la toma de decisiones en proyectos de desarrollo de software PhD Thesis, University of Sevilla.

[2] Aroba, J., Grande, J. A., Andujar, J. M., de la Torre, M. L., Riquelme, J. C., 2007. Application of fuzzy logic and data mining techniques as tools for qualitative interpretation of acid mine drainage processes. Environ. Geol. 53, 135–145.

[3] Grande, J.A., Andújar, J.M., Aroba, J., de la Torre, M.L., 2010. Presence of As in the fluvialnetwork due to AMD processes in the Riotinto mining area (SW Spain): a fuzzy logic qualitative model. Journal of Hazardous Materials. 176, 395-401.

[4] Jiménez, A., Aroba, J., de la Torre, M.L., Andujar, J.M., Grande, J.A., 2009. Model of behaviour of conductivity versus pH in acid mine drainage water, based on fuzzy logic and data mining techniques. Journal of Hydroinformatics, 11, 147-153.

[5] Valente T., Leal Gomes, C., 2009. Fuzzy modelling of acid mine drainage environments using geochemical, ecological and mineralogical indicators Environmental Geology 57, 653-663.

THE ASSESSMENT OF MICROBIOLOGICAL WATER QUALITY OF DRINO AND VJOSA RIVERS, ALBANIA

Çiljeta Piro[1]

Assoc. Prof. Dr. Klementina Puto[2]

[1]Faculty of Technical Medicine Sciences, UMT, Saranda Branch, **Albania**

[2]Departament of Biotechnology, FNS, UT, Tiranë, **Albania**

ABSTRACT

The necessity of environmental protection, public health and tourism development is today one of the main priorities in Albania. Even though our country is very rich with water resources due to wide river nets and mountains direction from east to west, their microbiological water quality has been long discussed. Drino and Vjosa are the main rivers in the southern region of Albania and they are shared between Greece and Albania. In Albania, they are under the influence of anthropogenic pollution, which is connected to the untreated urban discharges, waste effluents, agricultural activities etc. The aim of this study is to assess the microbiological water quality of these rivers in Albania based on the seasonal changes of bacterial parameters. Samples are collected every season from Summer 2012 until Winter 2013 - 2014. Seven sampling stations are established along Drino and Vjosa Rivers for this study. Two of these stations are located in the border points, where the rivers come from Greece to Albania. This is done to study whether the water is contaminated in Greece or it is polluted in Albania. The microbiological examination of water samples is made to determine the quantity of *Faecal coliforms* and *Faecal streptococci* as indicators of fecal pollution. These indicators are detected via Multiple -Tube Fermentation Technique or Most Probable Numbers (MPN) technique. According to preliminary results, there is a high load of Fc (until 1.2×10^7 bacteria/100ml) and Fs (until 2.3×10^4 bacteria/100ml) in water of five sampling stations, above the rates allowed by European Union for surface waters. While the microbiological quality of water in two stations near the border with Greece is within the rates allowed. The human impact on the microbiological water quality of Drino and Vjosa rivers is more than evident. We will notice that this situation will continue to worsen for as long as urban emissions of all kinds are not handled. Uncontrolled use of such waters could have serious environmental and public health implications especially when water is used for agricultural purposes, aquaculture, swimming etc.

Keywords: Faecal coliforms, Faecal streptococci, microbiological water quality, rivers.

INTRODUCTION

Drino and Vjosa rivers are the most important water resources in southern region of Albania and they are shared between Greece and Albania. This importance is related with their environmental, social and economic values. Their water is an invaluable recourse used for irrigation, aquaculture, tourism, swimming etc. Drino is a river in southern Albania and northwestern Greece, tributary of Vjosa. Its length is 84.6 km and its source is in the northwestern part of the Ioannina regional unit, near the village