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An Multivariate Interpretation of Quality Water in Atoyac River: In Dry and Rain Season: Puebla-Tlaxcala, Mexico

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Abstract

This paper presents the results of multivariate analysis to generate factors that represent an assessment which allows us to distinguish the anthropogenic contribution of the natural behavior of the mass of water and environmental identities with a representation of the variance of 80.71 % for the dry season and of 68.34 % for the rainy season .The graphs of the first two factors are reversed and have three inter - intersecting areas of polynomials, reflecting the conditions of natural and anthropogenic origin with predominance of the second and the third component represents the combination of parameters that accurately reflect the anthropogenic impact on the mass of the river with a clear rising trend of this factor in the region corresponding to Atoyac river upstream of the confluence and accentuated after the confluence with the river Zahuapan, where his maximum.
This, as part of the determination of environmental signature of Atoyac River, one of the most polluted rivers in Mexico, for which we proceeded to characterize the water through 11 physicochemical parameters: temperature (T) , potential hydrogen (pH), dissolved oxygen (DO), spectral absorption coefficient (SAC), oxide reduction potential (ORP), turbidity (TURB), biochemical oxygen demand in 5 days (BOD5), chemical oxygen demand(COD), conductivity (λ) , total suspended solids (TSS) and total dissolved solids (TDS) , which were evaluated in 49 sites for the dry season and 47 for the rainy season in the Zahuapan and Atoyac river basin High Atoyac, Puebla - Tlaxcala, Mexico.
All this for the measurement and monitoring of water quality as an emerging trend in the field of applied science focused on the improvement of urban rivers that traverse rural and industrial areas.
Keywords: Water quality, Physicochemical parameters, Multivariate analysis.

1. Introduction

This project is part of the study: "STUDIES NETWORK MONITORING STATIONS FOR THE PRESERVATION, CONSERVATION AND IMPROVING WATER QUALITY IN THE UPPER BASIN ATOYAC" funded by the Government of Puebla State to promote the clean up the High Atoyac basin.

Surface waters are most vulnerable to contamination due to its easy accessibility for the disposal of wastewater sources, both natural processes and anthropogenic influences, together determine the quality of them (Singh et al, 2004;. Simeonov et al ., 2003). Rivers play an important role in the assimilation and transport of municipal and industrial water, and runoff from agricultural land (Shrestha, S. and Kazama, F., 2007). The assessment of water quality is of great importance because it is directly related to public health and aquatic life (Noori, R., 2010). The problem is exacerbated in urban and industrial areas that discharge directly into water bodies. The effects of dilution and transport of pollutants into waters of the rivers establish a premise variability not be measured continuously can hardly approach the problem holistically. Below is a table with some important cases of application of multivariate statistical methods analysis is presented.

Table-1. Application of multivariate statistics methods

Author(s), year and study area.	Multivariate statistics methods	Achievement
Facchinelli, A., et al., 2001	Principal component analysis (PCA) and cluster analysis (CA)	Predict potential non-point heavy metals sources in soil on the regional scale.
Simeonov, J.A., et al., 2003. Northern Greece	PCA, CA and principal component regretion (PCR)	Effective pollution control management for the surface water.
Gangopadhyay, S., et al., 2001. Bangkok, Thailand	PCA and principal factor analisis (PFA)	Identify importance of monitoring wells predicting the dynamic variations related to potentiometric head.
Terrado, M., et al., 2006. Ebro River	PCA and GIS	Analized the main contamination sources of heavy metals, organic compounds, and other physicochemical parameters.
Ouyang, Y., 2005	PCA and PFA	Identify important water quality parameters in twenty - two stations.
Sherestha, S. and kazama, F., 2007. Fuji River Basin	CA, PCA, PFA, and discriminant analysis tecniques	Evaluate temporal and spatial variations of a largecomplex water quality data
Noori, R., et al., 2010. Karoon river, Iran	PCA and canonical correlation analysis (CCA)	Relationship between physical and chemical parameters.
Papaioannou, A., et al., 2010. Thessaly, central Greece.	CA, discriminant analysis (DA),	Application for groundwater physicochemical and biological quality assessment in the context of public health

2. Methodology

2.1 Study Area

The Atoyac River is the main river in basin of Alto Atoyac, which is coforming mainly by the State of Tlaxcala and Puebla (see Figure 1). According to the CNA, is the third most polluted in the country and is part of the Administrative Hydrological Region Balsas, which drains into the Pacific Ocean (CNA, 2010). The basin has 4395.61 km2 and both states provide over two thousand square kilometers. The state of Puebla has 2320.62 km2 equivalent to 6.76% of its land on which sits 41.44% of the population and the state of Tlaxcala has 2,075 km2 equivalent to 51.66% of its territory on which sits 77.62 % of its population. However, Puebla has in this basin, a population 2.6 times that of Tlaxcala.

Figure-1. High Atoyac Basin

Hi

2.2 Principal Component analysis

Multivariate Statistical Analysis, also known as Principal Components (PCA) or Factor Analysis or Eigenvector Analysis (FA) was performed using the STATISTICA software version 8.0. This analysis is a technique for identifying auxiliary primary source of contamination in the analysis of the quality of water. FA is also used to find associations between parameters in a way that the number of measurements of parameters can be reduced, so that by knowing the association can be used to predict unmeasured parameters water quality (PapaioannouAngelos et al., 2010). By Factorial Analysis of correlation matrices, the eigenvalues, loadings factor and score factor are obtained. To obtain the Factor Loadings, the rotation VARIMAX for more efficient and better grouping between elements deduction parameters was used (Noori, R. et al., 2010).

3. Results

The information presented here correlated in space and time leading multi-correlation of the results of the variables studied in each of the sampling sites of water in the regions Zahuapan Rivers, Atoyac and Manuel Avila Camacho Dam (Valsequillo). The variables for water samples are: 1) Physicochemical instrumental parameters: temperature (T), potential hydrogen (pH), conductivity (λ), dissolved oxygen (DO), spectral absorption coefficient (SAC) oxide reduction potential (ORP), turbidity (TURB) and 2) Physicochemical laboratory parameters: Biochemical Oxygen Demand 5 days (BOD5), chemical oxygen demand (COD), total suspended solids (TSS) and total dissolved solids (TDS). The results obtained in seasons of drought and rainfall during 2013 are included. The information provides an overview of the origin and transport of pollutants, using water as transport of these pollutants, which are discharged from the rural and urban populations that lives on the catchment. Additionally, studies of multivariate integration allow conditions to discern elements of natural and anthropogenic origin; approach also allows determine routes and transport purposes.

In Figure 2, the x axis corresponds to the representation of the sequenced of the 74 sampling sites in the following order of sites sampled location: Zone I) high Zahuapan River Basin, Area II) high Atoyac River Basin (before the confluence with the river Zahupan) Zone III) Low Atoyac river Basin (after confluence with river Zahupan) and Zone IV) Vasequillo Dam (where the sampling sites ranging from mouths of rivers Alseseca and Atoyac until curtain). Different regions are represented in the graphs by four vertical lines. In the y-axis, corresponding to each factor score values for each sampling site, which are represented by their values obtained through multivariate mathematical treatments and a polynomial that fits the trend observing.

Figure-2. Composite graph representing the behavior of water quality in the study area.

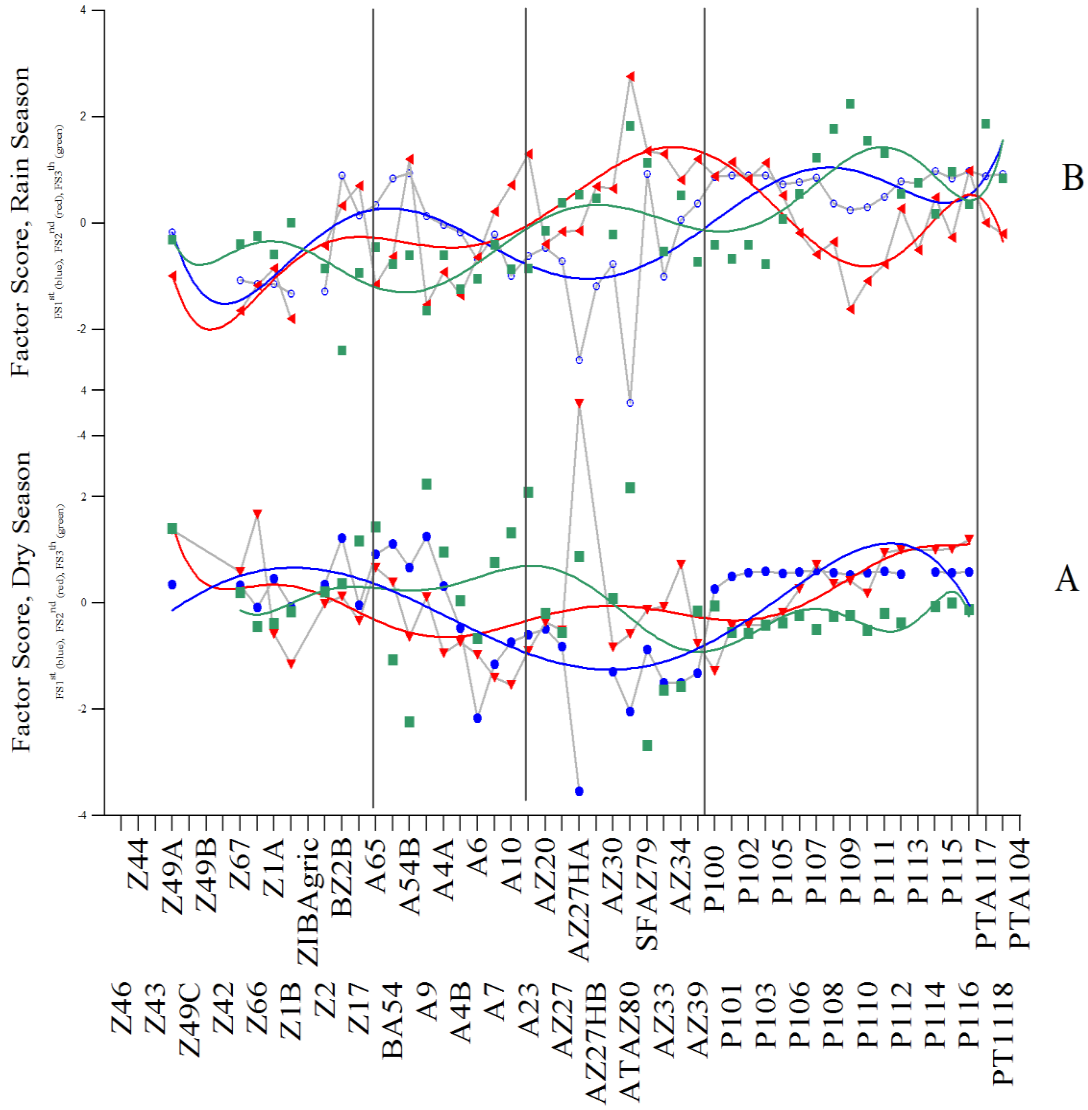
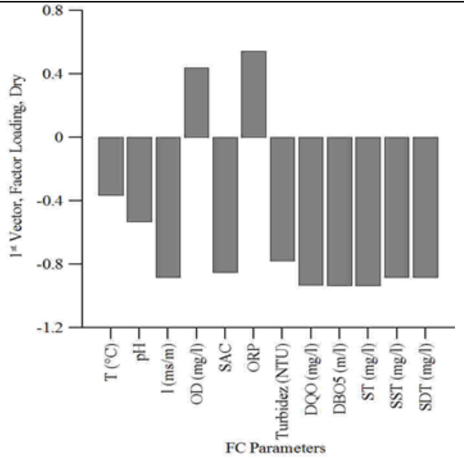
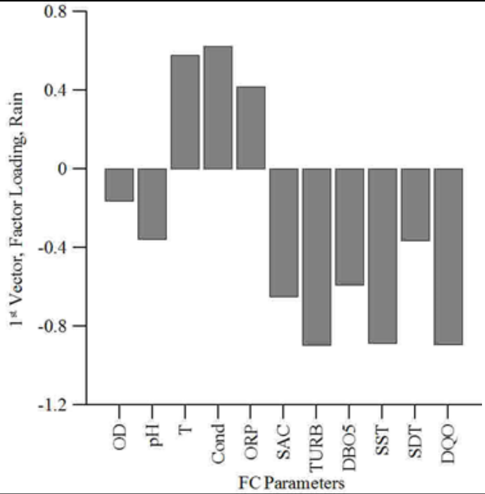
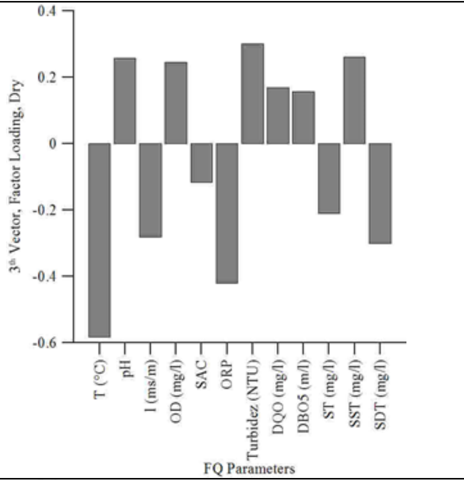
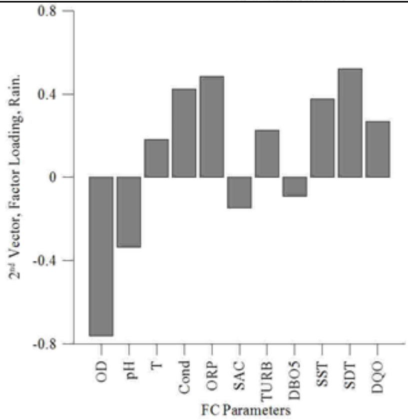
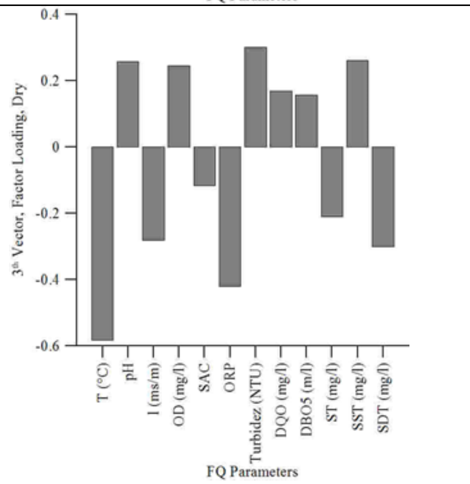
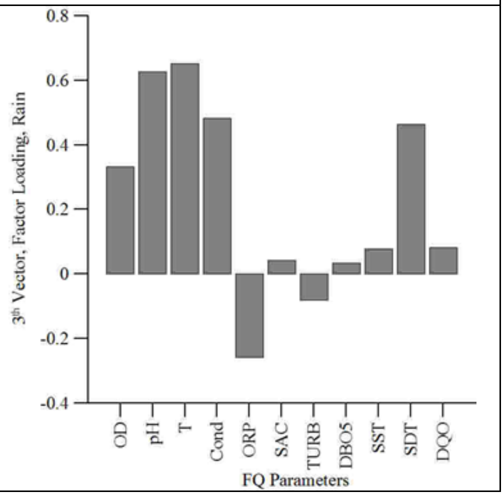


Tabla-2. Bar graphs for each loading factor variables correlated

<table>
<tr><th>Variable</th><th>Dry Season</th><th>Rain Season</th></tr>
<tr><td>1° Factor Loading</td><td></td><td></td></tr>
<tr><td>2° Factor Loading</td><td></td><td></td></tr>
<tr><td>3° Factor Loading</td><td></td><td></td></tr>
</table>

3.1. Physicochemical Parameters of Water Quality Dry Season

The physicochemical parameters of water quality for the dry season are shown in Figure 2 - A, the results are reported in units of factor that integrates multi-correlations of 11 parameters, including instrumental physicochemical parameters and laboratory , made to 48 sites or sampling stations. The main associations of correlation between the parameters studied are shown in the graphs of the first three components or factors are presented. Scores factors of the corresponding parameters for each sampling site are shown in Figure 2-A. The two factors that describe two trends along its route by Atoyac Zahuapan rivers to reach the curtain Valsequillo Dam are represented by the 1st and 2nd factor. Table 2 shows the composition of these two plotted factors, we refer to the 1st and 2nd load factor of Physicochemical Parameters, on the 1st factor a partnership of the following parameters we observed: Dissolved Oxygen and ORP, while in Figure 2A the blue curve represents the above described factor, with a very homogeneous tendency stressing properties little variability of water, that is a characteristic of the properties of water in the majority of its travel. Due to the the demand that exists of DO for this due to excess organic matter in the water entering the urban zone, the answer is directly proportional to the ORP. The features described above are reversed in the second factor representing predominantly in an association both own physicochemical parameters of the water body which reflect the conditions of anthropogenic effects. The second factor is shown in graph 2A in red. The physicochemical parameters listed here are temperature, pH, dissolved oxygen and ORP again, the association of these parameters generates a factor with a positive influence over the river. The graphs of the two factors represented are reversed and have three inter-zone of intersection of the plotted polynomials, showing an coexistence of these parameters in water features. The interpretation of such behavior indicates that they are groups of parameters that reflect the conditions of natural and anthropogenic origin, dominated the second, which coexist in the sampled sites.

This area is traffic and generation pollutant due to its proximity to two major sources of discharge of residential and industrial areas. Regarding polynomials, represented general trends of these two multi-associations and show a crossing area on their way in, exactly in the region of Atoyac River after the confluence with the Zahuapan River before it flows into the Valsequillo Dam . The intersection highlights that this region is a mixing zone and dilution zone showing a new generation of pollutants. This area is generating, mixing and transport of contaminants, which we see reflected in the physicochemical parameters correlated far. Finally, in the Valsequillo Dam region both load factors in the sampling sites show a similar trend. A third component loading factor for this section is described information integration resulting from the present study. The graph presented in 2A dark green color, in which the association of the following physicochemical parameters are represented: pH, dissolved oxygen turbidity, COD, BOD5 and total suspended solids are conducted primarily in laboratory. The third component represents the combination of parameters that most closely reflects anthropogenic impact on the water body of the river in which predominate, as shown in the graph of green, a clear rising trend of this factor in the corresponding region Atoyac river upstream of the confluence and accentuated after the confluence with the river Zahuapan, where is his maximum. The trend of this important factor, shows how decreases pollution to the region of the Valsequillo Dam where for purposes of biofiltration and precipitation of contaminants associated with the sediment fraction significantly decreases its value, showing a clear improvement in water qualityIt is worth mentioning here that the data reported in the Valsequillo Dam are referred to the sailing area, corresponding after the consortium macrophyte (Lily) living in the water first area of the dam area. The data resulting from this section are biofilter water by the effect of wetland.

3.2. Physicochemical Parameters of Water Quality Rain Season

The main associations of correlation between the studied parameters that are represented in the graphs of the first three components or factors are presented. Score factors corresponding parameters for each sampling site are shown in Figure 2B.

However, concerning graph 2B, the two factors that describe two trends along its route by Atoyac Zahuapan rivers to reach the Valsequillo Dam are represented by the 1st and 2nd factor. In Table 2 we can see the composition of these two plotted factors, we refer to the 1st and 2nd load factor of Physicochemical parameters for the rainy season. In the 1st factor we can observe the association of the following parameters: temperature, conductivity and ORP correspond to the graph 2B and it is represented by blue curve, with a tendency to reflect conditions as it moves upstream river. The interpretation is that it reflects conditions of a typical rainy season where natural cumulative effects such as turbidity due to the large amount of suspended solids are conditions more normal state of water, pollution, for this factor reflects the rising values with a maximum in the Valsequillo Dam. The features described above are reversed in the second factor representing predominantly in an association of physicochemical parameters reflecting a condition of contamination on wet conditions. The factor graph is shown in 2B with red. The physicochemical parameters listed here are temperature, conductivity, ORP, turbidity, total suspended solids and dissolved COD, the association of these parameters generates a factor with a positive influence over the trend presented a maximun after the confluence of the rivers Zahuapan Atoyac. The graphs of the two factors represented are reversed and have three main areas of inter-intersection of the plotted polynomials increasing until the Valsequillo dam region falling by water biofiltration process with macrophytes, wetland process. The interpretation of such behavior indicates that it is a group of parameters that reflect the conditions of predominantly natural cleansing in the region of the Valsequillo Dam, and showing areas of generation and movement of contaminants due to its proximity to two major sources of download of Industrial and residential areas in Puebla city.Polynomials, representing the general trends of these two multiasociaciones in which there are a crossing on their way in, and exactly in the region of Atoyac River after the confluence with the Rio Zahuapan and before it flows into the Valsequillo Dam. The intersection highlights that this region is an area of generation of new contaminants. This area is generating, mixing and transport of contaminants we see reflected in the physicochemical parameters correlated far. The graph 2B is presented in dark green curve, in which the association of the following physicochemical parameters associated are represented and are those conducted primarily in the laboratory (see Table 2). The third component represents the combination of parameters that more accurately reflect the condition of discharges and the importance of the impact of trawl sedimentary conditions and contaminant dilution materials contained in the body of water of the river. It is important to note that the effect of wetland not attenuate this set of parameters, decreases but does not disappear as a result of the hydrodynamics and hydrochemistry caused by the threshold of San Baltazar Tetela. The Valsequillo dam region pollution attenuates but does not go away by the effects of biofiltration and deposition associated with sedimentary fraction, significantly reduces its value, but increases, perhaps influenced by the river Alseseca download. It is worth mentioning here that the data reported in the Valsequillo Dam are referred to the waterway, corresponding to the consortium after macrophyte (lilies).

4. Conclusions

Temporal and spatial variations in the parameters reflects the quality of the river water indicating the influence of natural and anthropogenic factors and the environmental signature own characteristic Basin High Atoyac which generate different management scenarios.

Statistical analysis of main components through variances and major associations can display stations where there is similarity in the behavior of pollutants and those points which do not in the basin like Barranca Honda (where municipal trail download without any treatment).

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