International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.15, pp 371-378, 2017

Influence of the physicochemical composition of wáter on algae cover in an area of the Gulf of Morrosquillo, Colombian Caribbean

Severiche-Sierra C.[1,2], Bedoya-Marrugo E. [2], Vargas-Ortiz L.[2]*, Marrugo-Ligardo Y.[1]

[1]University of Cartagena, MAAS Research Group. Cartagena of indias, Colombia.

[2]University Foundation Technological Comfenalco, CIPTEC Research Group. Cartagena of indias, Colombia.

Abstract : The influence of the physicochemical composition of the water on the cover of algae in an area of the Gulf of Morrosquillo was analyzed. The temperature, pH, salinity and dissolved oxygen were measured; Different species of red, green and brown algae, the mosaic chart for algae species was used, then the canonical correspondence analysis to measure associations between quantitative variables, as well as to measure association between two categorical variables and to characterize individuals with categorical variables and not Categorical. The P-value indicates that the null hypothesis between sampling zones and algal species is rejected, showing a relationship between sampling areas and algal abundance, characterizing algal species with respect to sampling areas and Environmental variables. There are no significant relationships between the physicochemical variables and the environmental variables for the abundance of algae species in the studied area.
Keywords : Canonical correspondence analysis, Water quality, Algae cover, Descriptive statistics, Physicochemical variables.

Introduction

Due to the reduction of light intensity, marine macroalgae have a vertical distribution limited by depth. Algae form the basis of the food chain in the sea, are a trophic resource important for invertebrates and fish and can even significantly control their composition and abundance[1,2,3,4]. Marine algae are of particular importance as they are also a biotic resource that can be exploited[5,6,7,8], in addition to participating in the establishment of favorable equilibria for aquatic biota. The fact of presenting short life cycles and rapid responses to disturbances emphasizes the importance of these communities allowing to detect environmental alterations, in addition they are a source of organic material both used by the heterotrophic bacteria, and particulate, which comes from the abrasion of thallus by The effect of the waves[9,10,11,12].

Macroalgal communities perform a series of ecosystem services on shallow coastal systems such as providing food, forming substrates for settlement, providing protection against predators and protecting themselves from disturbance. Macroalgal communities are sensitive to anthropogenic disturbances and are therefore used to assess the status of coastal ecosystems[13]. The main consequences of macroalgae blooms include depletion of oxygen in still waters, resulting in changes in the zoobentonic community, the reduction of seagrass populations and the production of hydrogen sulfide. In all cases, nutrient enrichment due to anthropogenic activity is the main cause of these macroalgae blooms[14].

According to Rodríguez et al[15], notes that the elemental composition of various types of macroalgae is of great interest and has been reported worldwide. Likewise, the concentrations of the elements in the macroalgae depend on the environmental parameters of the sampling sites (salinity, temperature, pH, light, nutrient concentration, oxygen, etc.) and structural differences in algae.

The immense diversity of fauna and flora found in the Colombian coastal zone is vital for biochemical cycles and is an important source of food and possible pharmaceuticals. However, the accelerating, increasing and irreversible effects of human activities are dramatically altering the diversity of marine life [16,17,18].

Canonical Correspondence Analysis (ACC) allows ecologists to relate the variation between the structure of a community and a set of measured environmental variables. To establish the possible correlations between these two groups of variables, where an abundance table (Y) was analyzed, taking into account a set of environmental variables (X), forcing the axes to be linear combinations of the variables X; (Null hypothesis) that there are no significant correlations between the physico-chemical variables and the biological variables[19,20].

It is necessary to know the behavior of the macroalgal communities associated with the different physicochemical characteristics of the water of the Gulf of Morrosquillo, since, despite having this wealth, there is still not enough knowledge of the biological species that make it up, besides the most Adequate forms of exploitation and implementation of sufficient conservation strategies. For this reason the main objective of this work was to analyze the influence of the physicochemical composition of the water in the algae cover in an area of the Gulf of Morrosquillo, through a statistical study supported by descriptive statistics and canonical correspondence analysis.

Experimental

Study area

The Gulf of Morrosquillo is located in the south of the Caribbean Sea, on the north coast of Colombia, belonging to the departments of Sucre and Cordoba. It has, from west to east, approximately 80 kilometers, from the Mestizos point, Cispatá Bay and the mouth of Tinajones, mouth of the Sinú River in Cordoba, to San Bernardo Point, in Sucre[21]. The energy of the swell is predominantly low, because the bodies of water are semi-enclosed, Gulf of Morrosquillo and Bay of Cispatá. The sediments of the area are mostly fine textured and mangroves are observed in the various lagoon-estuarine systems[22,23]. Phanerogamous prairies are characteristic of the region[24]. As shown in Figure 1, sampling areas were selected at random (Puerto Bello, Puerto Braw and Porvenir).

Figure 1. Location of the study area and sampling stations

Sampling

In order to cover different climatic periods (dry season and rainy season), the sampling was carried out during the months of December (2014), June (2015) and March (2016), obtaining samples of water and quantity Of algae of different species (red, green and brown) found, which are called biological variables.

Laboratory Stage

At this stage measurements were made of the physico-chemical variables Temperature, pH, Salinity and Dissolved Oxygen, using the methodology recorded in Edition 22 of the Standard Methods for the Examination of Water and Wastewater[25].

Statistical Analysis

From the biological and environmental variables measured in the field and laboratory stage, the statistical analysis of the same as defined below is carried out.

For the descriptive part, the mosaic chart for algae species is initially produced, which is obtained from the profiles of the species with respect to the sampling areas; Then the descriptive measures for the environmental variables (Mean, median, fashion, maximum, minimum and Coefficient of variation)[26] are calculated for the characterization of the variables and finally the matrix of correlations between said variables Variables, to observe the linear association that exists between them.

In this paper, we can obtain the canonical correspondence analysis (ACC)[27], which is an analysis that allows the merging of simple correspondence analysis (ACS)[28] (ACP)[29], the ACC seeks to measure associations between quantitative variables, as well as to measure association between two categorical variables and characterize individuals from categorical and non-categorical variables.

Results and discussion

Descriptive Analysis

Table 1 contains information on the Biological and Environmental variables associated with the presence of algal populations in different sampling areas of the Gulf of Morrosquillo ecoregion.

Table 1. Matrix of data of biological and environmental variables for the respective sampling areas

Date	Biological variables			Environmental variables			
	Reds	Green	Brown	pH	Salinity	Temperature	Oxygen
DiciPB	4.0	8.0	5.0	8.3	31.2	31.5	7.1
JunioPB	0.0	1.0	4.0	8.3	27.5	30.0	6.5
MarzoPB	2.0	21,0	19.0	8.1	31.3	27.5	6.1
SeptiPB	0.0	6.0	0.0	8.3	30.0	33.7	6.4
DiciPG	18.0	13.0	0.0	8.4	32.2	33.4	7.1
JunioPG	21.0	7.0	0.0	8.3	29.1	31.9	6.3
MarzoPG	22.0	24.0	3.0	8.4	32.2	31.4	6.0
SeptiPG	1.0	9.0	0.0	8.6	31.1	33.3	6.2
DiciPB	29.0	39.0	34.0	8.4	31.4	33.3	7.0
JunioPB	30.0	87.0	35.0	8.3	29.5	32.5	6.3
MarzoPB	15.0	32.0	50.0	8.4	31.6	31.0	5.8
SeptiPB	73.0	57.0	43.0	8.5	31.0	33.1	6.0

From this information the descriptive statistics are made for both biological and environmental variables, as well as the matrix of correlations for the latter, and later it is performed in analysis of canonical correspondence to identify relationships between variables and influences of environmental variables and Sampling areas on algal populations.

Descriptive analysis for biological variables

The mosaic chart is used to identify the behavior of the biological variables (algal species) with respect to the sampling areas, as shown below.

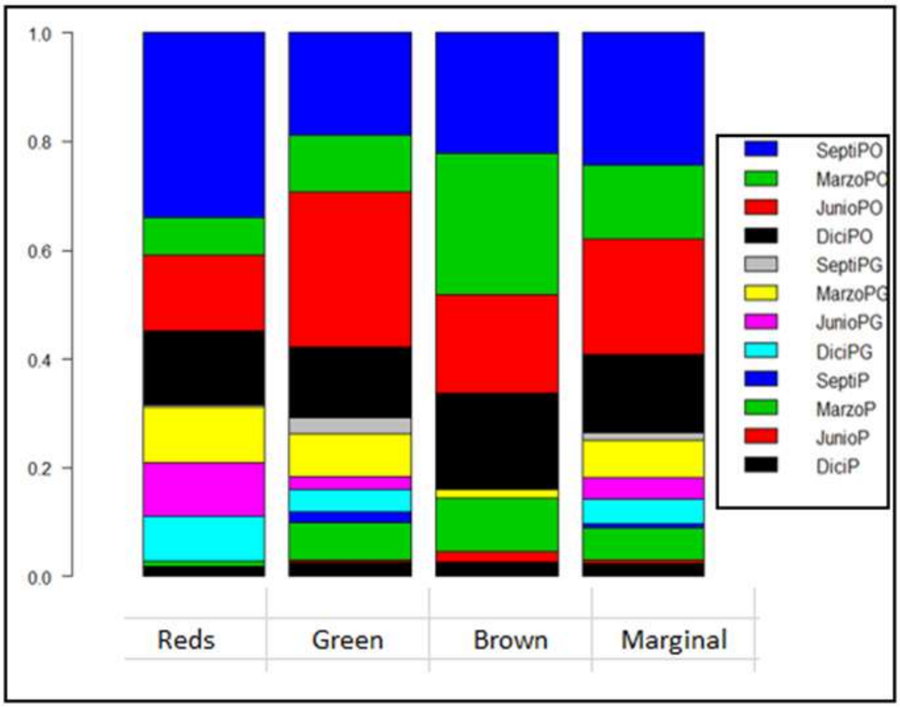

Figure 2. Algal profiles with respect to the sampling areas

According to the mosaic chart, it is observed that there is no red algae in the months of September in any of the sampling areas considered except Porvenir (SeptiPO), it is also observed that the greater frequency of red algae is mainly On sampling dates in the future zone, followed by Grawn Harbor. With regard to green algae, it is observed that they are present in the different sampling areas, with the future zone showing the highest frequency of these algae in each one of the sampling dates. Finally, the brown algae show greater presence in the sampling dates of Porvenir, followed by Bello port; While in the area of Port Grawn there is little presence of these algae (only in the sampling done in December).

From the above it is observed that in general the zone of future is the one that presents / displays greater presence of the different algae, followed by Port Grawn; While Puerto Bellos is the zone that presents less presence of the different algae.

Descriptive analysis of the environmental variables according to the sampling areas

Table 2 presents the descriptive measures of the different biological variables considered in the study.

Table 2. Descriptive statistics for environmental variables

	pH	**Salinity**	**Temperature**	**Oxygen**
Half	8.36	30.68	31.88	6.40
Median	8.37	31.15	32.20	6.30
Mode	8.30	32.20	33.30	7.10
Maximum	8.60	32.20	33.70	7.10
Minimum	8.10	27.50	27.50	5.80
CV	1.41%	4.35%	5.39%	6.66%

For the different variables, coefficient of variation (CV) values lower than 7% are obtained, which indicates the low variability of the pH, Salinity and Oxygen Temperature levels within the areas considered.

With respect to the measures of central tendency, it is observed that the average, average and modal values are very similar for the Environmental variables, except for the variable Oxygen, where there is a bias towards the right, which indicates high degrees of oxygen in Some samples considered.

(Here you should include a comment on the levels of each of the variables and how they are with respect to the rules), with respect to the average values and the maximum and minimum values.

Correlation between environmental variables

The Pearson correlation coefficient between the Environmental variables is calculated as shown in Table 3, to identify the level of linear association that exists in them. Accordingly, an important association between pH and Temperature is observed; Ie samples of water with high temperatures, show a high pH or higher temperature, higher pH level in the water samples considered.

Table 3. Matrix of Correlations between Environmental Variables

	pH	**Salinity**	**Temperature**	**Oxygen**
pH	1.00	0.22	0.67	-0.08
Salinity	0.22	1.00	0.14	0.04
Temperature	0.67	0.14	1.00	0.3
Oxygen	-0.08	0.04	0.3	1.00

Canonical Correspondence Analysis (ACC)

This analysis considers the relationship between species abundance with sampling areas and environmental variables; So the response variable is the concentration of algae, explained by the sampling areas and environmental variables considered.

Initially a test is performed to determine the linear relationship between algal abundance and a set of explanatory variables (in this case environmental variables), a measure of the relationship between both sets of variables is the "inertia of the restricted space ", Which explains how much the environmental variables affect the distribution of algae during sampling. The variability of biological data (inertia) can be found in the inertial distribution of the restricted space under the null hypothesis "algae frequencies are not linearly related to environmental variables". This result is verified by the Montecarlo permutation test, as shown below.

Table 4. Test of significance of the model

	Df	Chisq	F	N Perm	P-Value
Model	4	0.0617	0.6922	999	0.829
Residual	7				

999 permutations are made for the Monte Carlo test, where it is observed Table 4 when comparing the p value of 0.892 with a significance level α = 0.05, that the value of the F statistic for the restricted space is not significant, Thus from the data analyzed, it can be concluded that there is no statistical evidence to infer that the distribution of algae is influenced by environmental variables.

On the other hand, the independence test is performed to determine if there is a relationship between the species and the sampling areas, the results are verified below.

According to the test as shown in Table 5, the P-value (2.20E-16) indicates that the null hypothesis of independence between sampling zones and algae species is rejected, thus, there is a relationship between the sampling zones And the abundance of the algae and proceed to characterize the species of algae with respect to the sampling areas and the environmental variables through the analysis of canonical correspondence.

Table 5. Independence test between sampling areas and algae species

Df	Chisq	P-Value
22	155.08	2.20E-16

Figure 3 shows the first factorial plane associated to this analysis, in which the behavior of the different species of algae is observed, with respect to the sampling areas and the physico-chemical variables obtained in the study.

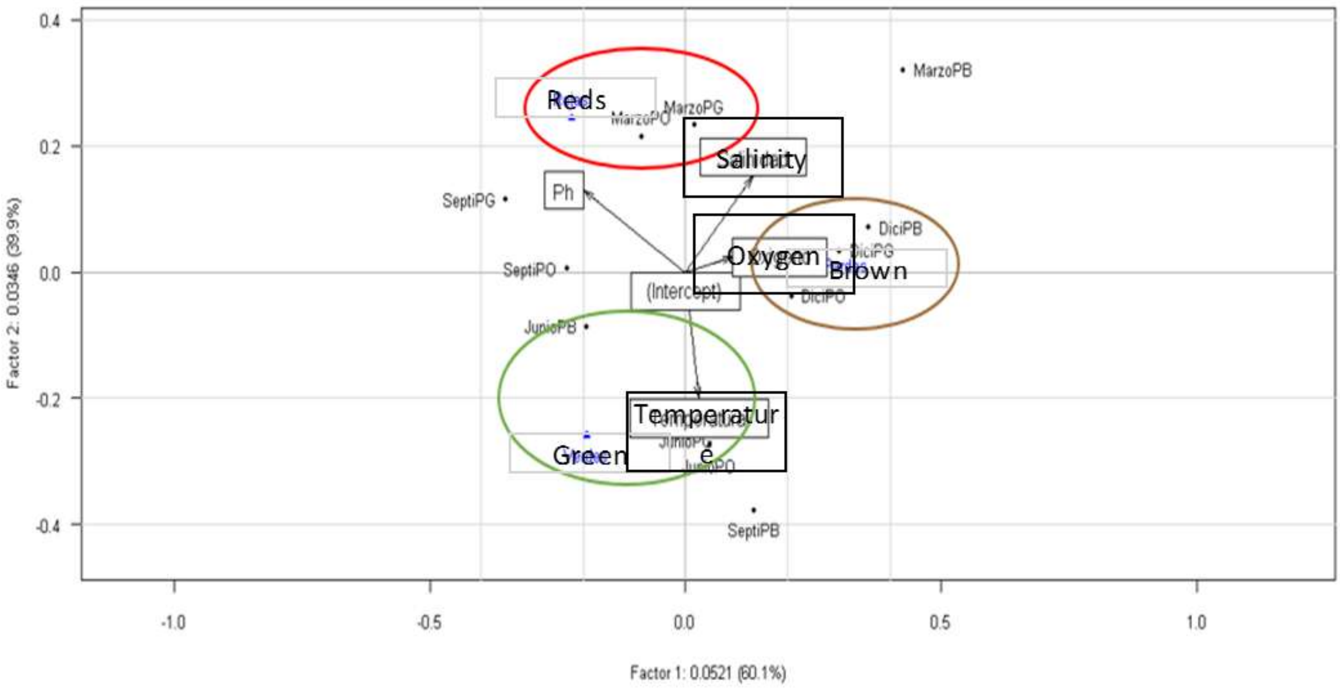

Figure 3. Factorial Plan for Canonical Correspondence Analysis (ACC) of algae species

There are only two factor axes that accumulate 100% of the inertia explained by the environmental variables, which accumulate 60.9% and 39.1%, respectively. In Figure 3 for the positions of the explanatory variables (Environmental variables) the correlation coefficients with the axes were used to determine their positions.

It can be observed in the factorial plane that the abundance of the brown algae is associated to the months of December (in the three localities), these sampling zones are associated with waters that have a high level of oxygen; While the red ones are in the month of March in the localities of Port Graw and the future (MarchPG and MarxoPO), where they are important levels of pH.

Green algae are most abundant in June for the three localities (Porvenir, Puerto Graw and Puerto Bello), and can occur in high temperature waters.

On the other hand, for the different sampling sites (Porvenir, Puerto Graw and Puerto Bello) in the month of September there is no abundance of any of the species of algae studied; This result corroborates that obtained in the descriptive statistics, which shows the little abundance of the algae in the samples made in the month of September.

Conclusions

From the results shown, from its analysis and its discussion, the following conclusions can be obtained on the influence of the physicochemical composition of the water on the algae cover for the Morrosquillo Ecoregion: 1) The area of the future is the one that presents Greater protuberance in the presence of the different classifications of algae, whereas the zone of beautiful port presents / displays the smaller abundance of the species; 2) There is a high and positive linear association between the pH and Temperature variables; 3) According to the data studied, there are no significant relationships between the physico-chemical and environmental variables for the abundance of algae species in the Gulf of Morrosquillo ecoregion; 4) In the three localities of the Morroquillo (Porvenir, Puerto Bello, Puerto Graw), the abundance of brown algae is associated with the month of December (dry season) and waters with a high level of oxygen, while the abundance of red Associated with the months of March (Transition) and waters with high salinity and the green algae are related to the month of June (Rainy season) and waters with low temperature.

References

1. Delgado J, Palacio J, Aguirre R. Vertical and seasonal variation of the macroalgae community on the northwestern and north-eastern sides of the Gulf of Urabá, Colombian Caribbean. Management and Environment., 2008, 11(3), 27-42.
2. Sangil C, Guzman H. Macroalgal communities on multi-stressed coral reefs in the Caribbean: Long-term changes, spatial variations, and relationships with environmental variables. Journal of Sea Research., 2016, 117, 7-19.
3. Çelekli A, Kap E, Soysal C, Arslanargun H, Bozkurt H. Evaluating biochemical response of filamentous algae integrated with different water bodies. Ecotoxicology and Environmental Safety., 2017, 142, 171-180.
4. Ravindiran G, Elayaraja S, Navaneethan P, Rajeshkannan R, Abinaya S. Assessment of Physicochemical Characteristics of Municipal Wastewater by Microalgae. International Journal of ChemTech Research., 2014, 6(1), 515-520.
5. Mohamed S, Borik R. Modern Trends in Using Marine Algae for Treatment of Aquatic Pollution. International Journal of ChemTech Research., 2013, 5(6), 2863-2889.
6. Restrepo J, Park E, Aquino S, Latrubesse E. Coral reefs chronically exposed to river sediment plumes in the southwestern Caribbean: Rosario Islands, Colombia. Science of The Total Environment., 2016, 553(15), 316-329.
7. Ammar R, Kazpard V, El Samrani A, Amacha N, Chou L. Hydrodynamic influence on reservoir sustainability in semi-arid climate: A physicochemical and environmental isotopic study. Journal of Environmental Management., 2017, 197, 571-581.
8. Jagadeeswari B, Ramesh K. Water Quality Index For Assessment Of Water Quality In South Chennai Coastal Aquifer, Tamil Nadu, India. International Journal of ChemTech Research., 2012, 4(4), 1582-1588.

9. Quirós J, Arias J, Ruiz R. Estructura de las comunidades macroalgales asociadas al litoral rocoso del departamento de Córdoba, Colombia. Caldasia., 2010, 32(2), 339-354.
10. Acevedo R, Severiche C. Identification of Di-Bromine-Mercury Resistant Bacteria Isolated from Sediments in Cartagena de Indias, Colombian Caribbean Beaches. Revista Avances Investigación En Ingeniería., 2013, 10(2), 73-79.
11. Acevedo R, Severiche C, Jaimes J. Toxic effects of paracetamol on human health and the environment. Agricultural and Environmental Research Journal., 2017, 8(1).
12. Haloi N, Sarma H. Ground Water Quality Assessment of some parts of Brahmaputra Flood plain in Barpeta district, Assam with special focus on Fluoride, Nitrate, Sulphate and Iron analysis. International Journal of ChemTech Research., 2011, 3(3), 1302-1308.
13. Tomaszewska B, Rajca M, Kmiecik E, Bodzek M, Tyszer M. The influence of selected factors on the effectiveness of pre-treatment of geothermal water during the nanofiltration process. Desalination., 2017, 406, 74-82.
14. Porzio L, Buia M, Hall J. Effects of ocean acidification on macroalgal communities. Journal of Experimental Marine Biology and Ecology., 2011, 400(1–2), 278-287.
15. Perrot T, Rossi N, Ménesguen A, Dumas F. Modelling green macroalgal blooms on the coasts of Brittany, France to enhance water quality management. Journal of Marine Systems., 2014, 132, 38-53.
16. Rodríguez L, A. Ramírez A, Solé M, Palmiotto J. Composición elemental en macroalgas marinas del estado Nueva Esparta, Venezuela. Acta Biol. Venez., 2013, 33(1), 43-60.
17. Díaz M, Zea S. Distribución de esponjas sobre la plataforma continental de la Guajira, caribe colombiano. Boletín de Investigaciones Marinas y Costeras – INVEMAR., 2008, 37(2), 27-43.
18. Acevedo R, Severiche C, Jaimes J. Bacteria resistant to antibiotics in aquatic ecosystems. Cleaner Production Journal., 2015, 15(2), 160-172.
19. Dray S, Dufour A. The ade4 package: implementing the duality diagram for ecologists. Journal of statistical software., 2007, 22(4), 1-20.
20. García M, Aboal M. Environmental gradients and macroalgae in Mediterranean marshes: the case of Pego-Oliva marsh (East Iberian Peninsula). Science of The Total Environment., 2014, 475(15), 216-224.
21. Paramo J, Perez D, Acero A. Estructura y distribución de los condrictios de aguas profundas en el Caribe colombiano. Lat. Am. J. Aquat. Res., Valparaíso., 2015, 43(4), 61-69.
22. Severiche C, Baldiris I, Acosta J, Bedoya E, Castro I, Pacheco H. Multivariate Analysis of Water Quality in Rosario Islands National Park (Colombia). American Journal of Engineering Research., 2017, 6(6), 136-144.
23. Severiche C, Barreto A, Acevedo R. Effect Of Rainfall On Water Quality In The Big Swamp Of Santa Marta, Colombia. Revista Avances Investigación En Ingeniería., 2013, 10(1), 58-67.
24. Quiros J, Dueñas P, Campos N. Poliquetos (Annelida: Polychaeta) asociados a algas rojas intermareales de Córdoba, Caribe Colombiano. Rev. biol. mar. oceanogr., Valparaíso., 2013, 48(1), 87-98.
25. APHA, AWWA, WEF. Standard Methods for the Examination of Water and Wastewater. 22th Ed. American Public Health Association/ American Water Works Association/Water Environment Federation, Washington DC, USA, 2012.
26. Guerra C, Herrera M, Vázquez H, Quintero Y, Bueno A. Contribución de la Estadística al análisis de variables categóricas: Aplicación del Análisis de Regresión Categórica en las Ciencias Agropecuarias. Revista Ciencias Técnicas Agropecuarias., 2014, 23(1), 68-73.
27. Jiménez P, Toro B, Hernández A. Relación entre la comunidad de fitoperifiton y diferentes fuentes de contaminación en una quebrada de los Andes colombianos. Bol. Cient. Mus. Hist. Nat. U. de Caldas., 2014, 18(1), 49-66.
28. Rueda M, Moya L, Aranda M. Aplicación de técnicas estadísticas multivariadas en perflación y segmentación. Univ. Sci., 2011, 16(3), 254-262.
29. Olivares B. Aplicación del Análisis de Componentes Principales (ACP) en el diagnóstico socioambiental. Caso: sector Campo Alegre, municipio Simón Rodríguez de Anzoátegui. Multiciencias., 2014, 14(4), 364-374.

***** *****