JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

TROPHIC STATUS INDEX OF THE WATERS OF THE PANTANOS DE VILLA PROTECTED NATURAL RESERVE, CHORRILLOS, PERÚ

Elmer Benites-Alfaro[1], Zuleima del Pilar Tito Quispe[2], Jorge Jave Nakayo[3], Eusterio Acosta Suasnabar[4], Verónica Tello Mendivil[5], Eduardo Espinoza Farfán[6], Ciro Rodriguez[7]

[1,2,3,4,5,6]Universidad César Vallejo, Lima, Perú
[3,7]Universidad Nacional Mayor de San Marcos, Lima, Perú
[2,3]Universidad Científica del Sur, Lima, Perú
ebenitesa@ucv.edu.pe[1], titozuleima@gmail.com[2],
jorge.jave@unmsm.edu.pe[3],jjave@ucientifica.edu.pe[3],eacostas@ucv.edu.pe[4], vtellom@ucv.edu.pe[5],
eespinozaf@ucv.edu.pe[6],crodriguezro@unmsm.edu.pe[7]

ABSTRACT: The objective of the investigation was to determine the trophic state index of the waters of the protected nature reserve "Pantanos de Villa", located in Chorrillos Lima Perú. Likewise, were evaluated the most important physicochemical characteristic parameters of the waters of the main lagoon of the area called "Genesis". For the study, it obtained 24 liters of water of the Genesis lagoon from three strategic points taken at the convenience, finding that it had an electrical conductivity at point 1 of 4315 uS/cm, for point 2 a value of 4340 uS/cm. At point 3, a value of 4320 uS/cm, all values exceeded what is established by the Environmental Quality Standard (ECA), which is 1000 uS/cm for the water of category 4 (Conservation of the aquatic ecosystem) subcategory E1 (Lakes and lagoons). As for another parameter, such as dissolved oxygen, in point 3, it resulted in the value of 6.55 mg/L, lower than ECA for water (12.22 mg/L). The total phosphorus concentration, nitrates, suspended solids, and chlorophyll concentration were also analyzed to determine the trophic state index (TSI) of the Genesis lagoon. With the data found and by calculating the Carlson TSI index, it was determined that the Genesis lagoon was in a mesotrophic state according to the Chlorophyll A parameter, according to the "transparency level" parameter, the Genesis lagoon had a eutrophic state. According to the total phosphorus parameter, it was in a hypereutrophic state.

KEYWORDS: Eutrophication, trophic status index, water, natural reserve, swamp

I. INTRODUCTION

Aquatic ecosystems are important because of the biological diversity they contain, including wetlands, which are fundamental for the conservation of species of flora and fauna as well as water resources. However, these ecosystems are progressively disappearing due to anthropogenic activities that use these bodies as receptors for urban and industrial effluents with high pollutant loads without adequate purification, which causes variations in the physicochemical parameters of the water [1].

An example of the problem of water pollution in Peru is Lake Titicaca. Studies conducted in 1981, 1983, and 2011 indicate the advance of eutrophication in the interior bay of Puno and the variation of its physicochemical parameters as a result of the discharge of domestic effluents from the sewage system of the city of Puno without treatment [2]. A similar case occurs with Conococha lake in Ancash, which as a result of a study in 2012 found a eutrophic to hypereutrophic level, with total phosphorus concentration of 129.0 µg/l to 131.9 µg/l and nitrate in the range of 201.8 µg/l to 229.9 µg/l. Here the causes are livestock activity and direct discharge of domestic effluents and solid waste into the lake [3]. The excessive proliferation of plant species such as Lemna (duckweed) can also cause environmental problems, as is the case in the Bay of Cohana in Lake Titicaca at a eutrophic level, covering an area of 2,792 ha in the autumn of 2015 [4].

Studies have also shown that the dynamics of the trophic connection between the planktonic communities and the wild avifauna in Pantanos de Villa, correlating to physicochemical factors and the population dynamics of these species [6].

Trophic status evaluations are carried out by different methods, from remote sensing to the use of the Toledo-modified Carlson Trophic Status Index (ITEM) used in the investigation of the main lagoon of the Middle World Albuquerque conservation area, Huaura - Lima, which found a eutrophic status [7].

II. METHODOLOGY

2.1 Sample collection criteria

The study was carried out in Genesis Lagoon, which covers an area of 2,100 m2 in the Pantanos de Villa Reserve, located at coordinates 12° 12′ 49.32″ S and 76° 59′ 20.4″, in June 2019, the low rainfall season. The MINAM water quality monitoring protocol was used, according to the design indicated in Table 1, to collect samples for analysis as in table 1, both at the surface and the bottom, of the parameters: pH, electrical conductivity, dissolved oxygen, total solids, nitrate, total phosphorus, and Chlorophyll (the last two are linked to eutrophication).

The parameters of pH, temperature, dissolved oxygen, and electrical conductivity were measured on-site [7]. The nomenclature used was S1 and P1 to indicate sampling point 1 at the surface and the depth or bottom, and so on for points 2 and 3, as shown in Figure 1. The samples were preserved at 6 °C and in darkness following the recommendations of the Water Quality Monitoring Protocol. The Secchi disk was used to measure the transparency of Genesis Lagoon at each sampling point.

Nitrate concentration (mg/L) was measured by EPA method 300.0, total phosphorus concentration (mg/L) by APHA_4500P method, and total suspended solids concentration (mg/L) measured by EW_APHA2540B method.

2.2 Location area

The study area of Los Pantanos de Villa is a protected natural area that is located on the coast of the Chorrillos district in the province of Lima, department of Lima, in Peru, with an area of 2.63 km² and has a degree Protection of Wildlife Refuge as shown in figure 1.

Table 1: Criteria for sample collection.

Sampling point (UTM coordinates)	Reference	Level	Depth (cm)
P1 X 0283583 Y 8649222	Lagoon entrance Boat area	Surface level	30 cm
		Bottom level	30 cm from the bottom
P2 X 0283708 Y 8649321	Second boat area	Surface level	50 cm from the bottom
		Surface level	a 50 cm from the bottom
P3 X 0283855 Y 8649240	Presencia de macrofitas/ Cercanía a la zona de amortiguamiento	Surface level	30 cm
		Bottom level	a 50 cm from the bottom

Figure 1: Study area. Source: Google maps

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

III. RESULTS

3.1 Initial physicochemical parameters of the waters of the Génesis-Pantanos de Villa lagoon.

The results obtained from the in-house measurement were contrasted with the values established in the current regulations (DS N ° 004 -2017 MINAM) of the Environmental Quality Standards of water, category 4 (Conservation of the aquatic ecosystem), subcategory E1 (lakes and lagoons).

It can be seen for the pH parameter; the values obtained ranged from 7.35 to 8.18 at the 3 sampling points, these values are in the range of maximum values allowed in the ECA WATER, the values obtained for oxygen dissolved (mg / L) in point 1 was 17.38 mg / L, for point 2 a value of 12.75 was obtained and for point 3 a value of 6.55 mg / L was obtained, the value established minimum for dissolved oxygen according to the ECA WATER is 12.22 mg/L, point 1 and point 2 are above this value, but point 3 obtained a value of 6.55 mg/L.

The electrical conductivity as shown in figure 2 and table 2, the values at the 3 sampling points exceed the maximum value established in the ECA WATER (DS N ° 004 -2017 MINAM), which is 1000 uS/cm for lakes and ponds

Table 2: Initial results of physicochemical parameters.

Sampling point	Sub points	**pH**	**T°C**	Electrical conductivity (us/cm)	Dissolved oxygen (mg/L)
P 1	Surface level	8.14	20.2	4320	18.68
	Bottom level	8.21	20	4310	16.07
	Average	**8.18**	**20.10**	**4315**	**17.38**
P 2	Surface level	7.91	20.2	4340	12.98
	Bottom level	7.81	20.2	4340	12.51
	Average	**7.86**	**20.2**	**4340**	**12.75**
P 3	Surface level	7.22	21.7	4330	4.93
	Bottom level	7.48	21.1	4310	8.17
	Average	**7.35**	**21.4**	**4320**	**6.55**
ECA AGUA		**6.5 a 9**	**Δ 3**	**1000**	**12.22**

Figure 2: Shows sample points and electric conductivity and water ECA values (red line ECA level).

3.2 Dissolved Oxygen

The dissolved oxygen (DO) at the 3 sampling points are indicated in Figure 3, compared to the minimum value established in the ECA WATER of 12.22 mg / L, it can be seen that in the sampling point 3 where it was evidenced presence of aquatic macrophytes, the value is 6.55 mg / L, which is well below the value established in the ECA water.

3.3. Nitrate level, total phosphorus, suspended solids, Chlorophyll

The average nitrate concentration obtained at point 1 (0.053 mg / L), point 2 (0.058 mg / L) and point 3 (0.0520 mg/L) were below the range of values established in the water ECA.

Regarding the average values of the concentration of suspended solids in point 1 was 1,359 mg / L, in point 2 1,417 mg / L, and in point 3 1,127 mg / L, values were in the established range at the ECA Agua.

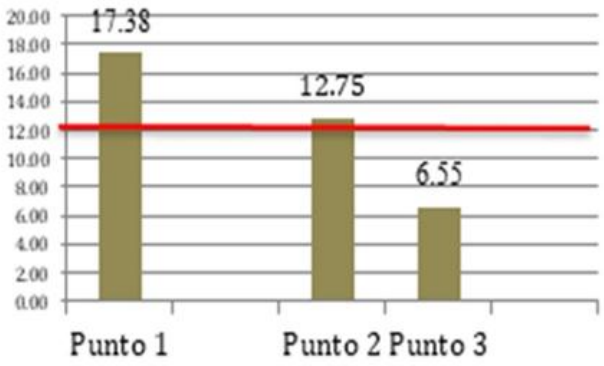

Figure 3: Dissolved oxygen, and sample points with water ECA values (red line ECA level).

Table 3: Result of nitrates, phosphorus, SST, and Chlorophyll.

Sampling point	Level	Nitrate (mg/L)	Total phosphorus (mg/L)	Total suspended solids (mg/L)	Chlorophyll A (mg/L)
P1	Surface level	0.068	0.124	1.417	0.007
	Bottom level	0.037	0.122	1.300	0.006
	Average	0.053	0.123	1.359	0.007
P2	Surface level	0.073	0.126	1.524	0.011
	Bottom level	0.042	0.127	1.310	0.006
	Average	0.058	0.127	1.417	0.008
P3	Surface level	0.070	0.126	1.010	0.004
	Bottom level	0.034	0.130	1.243	0.004
	Average	0.0520	0.128	1.127	0.004
Water ECA		13	0.035	≤ 25	0.008

Nitrate level sampling point
(mg / L) Total phosphorus (mg / L) Total suspended solids (mg / L) Chlorophyll A (mg / L)

For the average concentration of chlorophyll A, the values of 0.007 mg / L, 0.008 mg / L and 0.004 mg / L were found for points 1, 2 and 3 indicated, values within the established range (0.008 mg / L) of the ECA Agua DS N ° 004 -2017 MINAM.

Regarding the total phosphorus concentration, the values obtained in the 03 sampling points exceeded the value established in the Water ECA (0.035 mg / L), the average values being 0.123 mg / L for point 1, 0.127 mg / L stop point 2 and 0.128 mg / L for point 3. See Table 3. Then the significant presence of phosphorus allows it to be a conditioner for the eutrophication that occurs in the water source.

3.4 Level of Transparency (Ds)

The total average of the level of transparency (m) of the data obtained from the measurement of the Secchi disk was 0.6 m, the result obtained with Equation 1, the Carlson's trophic state index was calculated to find the level of eutrophication in the Genesis gap presented in Table 4.

Table 4: Level of Transparency.

Sample points	**Secchi disk (m)**
P 1	0.7 m
P 2	0.8 m
P 3	0.5 m
Total average	**0.6 m**

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

Carlson's Trophic Status Index (TSI): Taking transparency into account. Equation (1) was used.

$$TSI = 60\text{-}14.41 \text{ Ln (Ds)} \ldots\ldots. (1)$$

According to the Carlson index (TSI), the average obtained from the transparency in the 03 sampling points was 66.1 TSI, and, according to the scientific literature, this result indicates that Laguna Genesis is at a Eutrophic level (50 < TSI <70).

For the three points taking transparency into account, we have that the Trophic Status Index (TSIDS) was the values presented in Table 5 for the three points monitored.

Table 5: TSI DS Transparency trophic Status Index

Sample points	Chlorophyll trophic state index A (TSI chl)
P 1	65.1
P 2	63.2
P 3	70.0
Average	66.1

Carlson's Trophic Status Index (TSI): Taking Chlorophyll into account.

Equation (2) was used.

$$TSI = 9.81 \text{ Ln (chlorophyll A)} +30.6 \ldots\ldots (2)$$

The chlorophyll parameter must be expressed in mg / m3. The results obtained are shown in Table 6. According to the Carlson index (TSI), the average result obtained at the 3 sampling points was 48.28 TSI, so according to scientific theory this result indicates that Laguna Génesis is found at a mesotrophic level (30 <TSI <50)

Table 6: Carlson TSI chl Trophic Status Index

Sample points	Chlorophyll trophic state index A (TSI chl)
P 1	49.68
P 2	50.99
P 3	44.19
Average	48.28

Carlson's Trophic Status Index (TSI): Having total phosphorus

Equation (3) is taken into account:

$$TSI = 14.42 \text{ Ln (P total)} + 4.15 \ldots\ldots (3)$$

According to the Carlson index (TSI), the average result obtained in the 03 sampling points was 73,887 TSI; therefore, the result indicates that Laguna Génesis is at a hypereutrophic level (70> TSI). See Table 7.

Table 7: Carlson TSI Trophic Status Index (Total Phosphorus)

Sample points	Phosphorus trophic state index A (TSI chl)
P 1	73.542
P 2	74.003
P 3	74.116
Average	73.887

IV. DISCUSSION OF RESULTS

Scientific studies recommend that in the case of evaluating the eutrophication of lakes, a minimum of two points be carried out, for the study carried out was carried out in three points, thus complying with the recommendations of the National Protocol for Monitoring the Quality of Surface Water Resources. Similar investigations [8] evaluated the level of eutrophication of Llopangoano Lake in 2015, establishing 8 monitoring points for 2 months; Likewise, in the study "Trophic state of a high mountain tropical lake: the Cocha lagoon case", they indicate that the measurements of the parameters involved were carried out for 9 months and 10 sampling points were taken throughout the entire lagoon. [9].

On the other hand, the presence of macrophytes influences the value of Carlson's trophic status index, as in the case of the Sembrong reservoir [10], however, in the study in the Genesis lagoon, not many macrophytes were found. The presence of these macrophytes is indicators of high concentrations of macronutrients, as in the case of the San Pablo and Yahuarcocha lagoons in Ecuador [11].

Also, studies carried out indicate that there are phytobiological indices for the evaluation of a trophic state, such as that performed in Lake Auracanos [12].

On the other hand, the presence of Chlorophyll and dissolved oxygen are inversely proportional as in a study carried out in the Yambo lagoon, Ecuador [13], in the investigation carried out in the Genesis lagoon, no coincidence was found in two points.

The high presence of nitrates, phosphates and electrical conductivity in the Genesis lagoon of Pantanos de Villa is due to the pouring of detergents on the site, according to the results of the investigations carried out on the site [14,15,16], some parameters exceed the ECAS and others They are still maintained, in the study, it was determined that the pH has a basic value like the one that existed in 2016.

V. CONCLUSIONS

According to the result obtained for the Carlson index for the total phosphorus parameter, the Genesis lagoon was classified in a hypereutrophic state, according to the Chlorophyll A parameter, the lagoon was classified in a mesotrophic state, and according to the parameter The level of transparency corresponded to the classification of a eutrophic state.

The physicochemical parameters temperature, dissolved oxygen, pH, suspended solids, and nitrate of the waters of the Genesis lagoon were found below the limits of the environmental quality standards for water. Total phosphorus exceeds the environmental quality standards for water, and total oxygen exceeds the standard at some monitoring points, as for Chlorophyll, it remains at some point at the limit and other points low.

It is concluded that the presence of elements entered in an anthropogenic way results in a probable alteration of aquatic ecosystems, being eutrophication one of the main environmental problems that must be faced if preventive measures are not taken.

VI. REFERENCES

[1] C. Ordoñez y S. Rodriguez, Tesis Universidad Central del Ecuador, 2019. 54 pp. http://www.dspace.uce.edu.ec/handle/25000/18203

[2] C. Rodriguez, D. Esenarro, P. Ccorimanya, F. Flores, C. Aylas, and J. Lagos. Proposal for a sustainable infrastructure design (ecolodge) in the Quichas Town, Perú. Test Engineering and Management. ISSN: 0193-4120 Page No. 9250 - 9256. Vol. 83, Page 9250–9256 (2020).

[3] A. Medina y L. Sotomayor. Evaluación de la eutrofización de la laguna Conococha – Ancash, agosto de 2012.Tesis. Universidad Nacional Santiago Antúnez de Mayolo, Facultad de Ciencias del Ambiente, 2013.

[4] Sh. La Vieja Braca y J. Rocha. Tesis Universidad Mayor San Andrés, La Paz Boliva, 2018. http://repositorio.umsa.bo/xmlui/handle/123456789/20466

[5] L. Campos. Fitorremediación para la reducción de la eutrofización en la laguna del área natural de los Pantanos de Villa.Tesis, Universidad Alas Peruanas, 2012.

[6] C. Cepeda y J. Ianacone, Revista Biotempo, 15(2) (2018) 175-195.

[7] K.R.Schwarz, J.P.S.Sidhu, S.Tozeb, Y. Li, E.Lee and Y.Gruchli, D.L.Pritcharda Decay rates of Escherichia coli, Enterococcus spp., F-specific bacteriophage MS2, somatic coliphage and human adenovirus in facultative pond sludge. Water Research. Volume 154, 1 May 2019, Pages 62-71.(2019)

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

[8] C. Mena. Establecimiento de mecanismos biorremediadores mediante la identificación del agente causal de eutrofización en los acuíferos superficiales, sector los sectores los Poguios – Isinche de vacas, cantón pujilí, provincia de Cotopaxi, período 2014 – 2015". Tesis, Universidad Técnica de Cotopaxi facultad de Ciencias Agropecuarias, 2015.

[9] M. Lopez y S. Madroneño. Estado trófico de un lago tropical de alta montaña: Caso Laguna de la Cocha. Ciencia E Ingeniería Neogranadina, 25 (2), 21-42. https://doi.org/10.18359/rcin.1430

[10] S.Hashim, S. Talib, M. Abustan y S. Tajuddin. Estudio de calidad del agua y estado trófico en el embalse de Sembrong durante la temporada del monzón. IOP Conference Series: Earth and Environmental Science, Volume 140, Issue 1, pp. 012079 (2018). DOI: 10.1088 / 1755-1315 / 140/1/012079

[11] E. Terneus. Vegetación acuática y estadio trófico de las lagunas abndinas de San Pablo y Yahuarcocha, provincia de Imbabura Ecuador. Tesis, Universidad Internacional del Ecuador, 2014. https://docplayer.es/81597372-Vegetacion-acuatica-y-estado-trofico-de-las-lagunas-andinas-de-san-pablo-y-yahuarcocha-provincia-de-imbabura-ecuador.html

[12] S. Villalobos. Uso de los índices fotobiológicos para la evaluación del estado trofico de lagos Araucanos. Tesis, Universidad Austral de Chile, facultad de Ciencias, 2015.

[13] M. Toapanta. Determinación del estado trófico de la laguna de Yambo a través de la cuantificación de clorofila "a". Tesis, Universidad Central del Ecuador, facultad de Ingeniería en Geología, Minas, Petróleos y Ambiental, 2017.

[14] C. Alvarez. Determinación analítica de detergentes en las aguas de los Pantanos de Villa.Tesis Pontificia Universidad Catolica del Peru, 2016.

[15] Doris Esenarro, Ciro Rodriguez, Karen Huachaca, BetsyCachay & Carmen Aylas, Classification and Characterization of the Sustainable Wetland Bello Horizonte ¨Test Engineering & Management¨, ISSN: 0193-4120 Page No. 13453 – 13458. (2020)

[16] Doris Esenarro, Ciro Rodriguez, Cristian Aquije, Nicasio Obregon, Luis Anicama & Cesar Arguedas. Cable Car with Water Collection for Afforestation of the Solar Hill in Chorrillos, Perú, ¨Test Engineering & Management¨ ISSN: 0193-4120 Page No. 9236 – 9242. (2020)