Chapter 8 Comparative study of inorganic pollutant (Chromo) in a surface body water in frontera, Centla, Tabasco

Capítulo 8 Estudio comparativo del contaminante inorgánico (Cromo) en un cuerpo de agua superficial de frontera, Centla, Tabasco

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Abstract

Human activity has been increasing, generating more contamination in air, soil and particularly in water, which is the reason for the following work that aims to measure the levels of heavy metal contamination such as chromium, considering other factors of the vital liquid such as pH and Total Suspended Solids (TSS); to know some characteristics of the body of water analyzed. The water body of study is a lagoon called Fonapo I in the city of Frontera, Centla, Tabasco, which has an 80% population around the lagoon, who are influencing the concentration levels of heavy metals, particularly chromium. The work consisted of two rainy season samplings in the lagoon, in September 2019 and September 2020. An increase in chromium concentration was observed in sampling number two in September 2020, with a direct relationship between chromium concentrations in 2019 and 2020, with a confidence level of 95% between both samplings. This statistically demonstrates that there are significant increases of chromium in this water body, and even though they are within the permissible limits of the NOM-001-SEMARNAT-1996 standard, this increase can lead to damage to society, which uses this water body for fish farming, likewise the pH recorded in the first and second samples are bases as indicated in the pH table, the Total Suspended Solids (TSS) in both samples are above what is indicated by the standard.

Heavy metal, Chromium, Physicochemical parameters, Water pollution, Pollutant

Resumen

La actividad humana ha ido en creciente aumento, generando así mayor contaminación de aire, suelo y en particular agua motivo por el cual se realiza el siguiente trabajo que tiene como propósito medir los niveles de contaminación del metal pesado cromo, considerando así otros factores del agua como son pH y solidos suspendidos totales, para conocer algunas características propias del cuerpo de agua analizado, el cuerpo de agua de estudio es una laguna llamada Fonapo I de la cuidad de Frontera, Centla, Tabasco la cual cuenta con un 80% de población al contorno de la laguna, quienes están influyendo en los niveles de concentración de metales pesados en particular cromo, en trabajo consistió en dos muestreos en temporadas de lluvias en la laguna, en el mes de septiembre del 2019 y septiembre 2020. Observándose incremento de la concentración de cromo en el segundo muestreo del 2020, existiendo una relación de incremento de las concentraciones del cromo del año 2019, en relación con el año 2020, con un nivel de confianza del 95% entre ambos muestreos. Lo que demuestra estadísticamente que se tienen incrementos significativos de cromo en dicho cuerpo de agua, y aun que están dentro de los límites permisibles de la norma NOM-001-SEMARNAT-1996, este incremento puede llevarnos a daños a la sociedad, que utiliza dicho cuerpo de agua para cultivos de peces, así mismo el pH registrado en el primer y segundo muestreos son bases como lo indica la tabla de pH, los sólidos suspendidos totales en ambos muestreos están por arriba de lo que indica la norma.

Metal pesado, Cromo, Parámetros fisicoquímicos, Contaminación de agua, Contaminante

8.1 Introduction

The various chromium (Cr) compounds represent a great threat to the environment and to man due to their harmful effects. Intoxications manifest themselves in renal, gastrointestinal, liver, kidney, thyroid gland and bone marrow lesions, and the body's elimination rate is very slow. Porras, A. C. (2010). Considering the above, chromium requires very detailed studies to remove it from water bodies since water is the main recipient of this pollutant and one of the main problems today is contamination by heavy metals, particularly in this project we will work with chromium, compounds or elements that normally would not be without the action of man, or by an increase or decrease in the normal concentration of already existing substances due to human activity (Ramalho, R. S. 2021). Some of the most potentially toxic chemical components are heavy metals, including As, Cu, Hg, Pb, Cr, Zn. The contribution of these metals to the hydrological cycle comes from various sources, one of them being of lithogenic or geochemical origin from minerals that, due to erosion, rainfall, among others, are dragged to the element.

Currently, the greatest concentration is of anthropogenic origin or due to human activity. Mining, industrial processes and domestic waste are an important source of contamination, which contribute metals to the air, water and soil especially. (Londoño, 2016).

In recent decades the world has been showing concern and is trying to solve the problems related to the disposal of liquid effluents from domestic, commercial and industrial use of water supply (Rincón R. D. and Sanabria G. J. 2021). The study of the presence of heavy metals in river waters and sediments is a contribution to the availability of environmental information on these rivers and will contribute to the diagnosis of each of their basins and, consequently, to facilitate decision making, especially of a governmental nature. Heavy metals constitute a serious environmental problem due to their toxicity and physiological repercussions in both humans and animals, as is the case of fish. Research on the presence of heavy metals in certain waters allows us to know the routes of contaminants and their interaction with other substances present in the water. (Contreras, et al, 2004).

The present study consists of evaluating the concentrations of chromium in the Fonapo I lagoon, located in the city of Frontera, Centla, Tabasco (closed body of water), to determine if there is the presence of heavy metals, which can affect the inhabitants of the area who fish and have ponds with fish. If heavy metals are found, measures will be taken to protect the population and avoid future consequences.

8.2 Problem Statement

It is worth mentioning that chromium is found in water bodies in soluble form, can be stable enough to be transported, precipitates rapidly and adsorbs on suspended particles and bottom sediments. It has been found to accumulate in many biotic organisms, especially in bottom-feeding fish such as catfish (Ictalujrusnebulosus), bivalves such as the oyster (Crassostreavirginica), blue mussel (Mytilusedulis) and soft-shell clam, Porras, Á. C. (2010), the aquatic fauna mentioned is mainly used for human consumption, therefore, the ingestion of these species is an effective chain of affectation to human health.

One of the main sources of heavy metal contamination, particularly chromium (Cr), is derived from domestic wastewater (Martínez, et al., 2019). The study area is surrounded by houses that generate the aforementioned water; therefore, it is observed that the inhabitants of the area fish and capture aquatic organisms, and it is also observed that there are fish hatcheries or nurseries in the area; For all of the above reasons, the study of chromium concentrations is considered important in order to propose mitigation and control strategies for the health of the population (Guzmán, et al, 2011).

8.3 Methodology

a) Description of the sampling site

The Fonhapo I lagoon is in the town of Frontera, Municipality of Centla, in the State of Tabasco, Mexico, at the following coordinates: 18° 31' 19" North (N) and 92° 38' 42" West (W) and is adjacent to the Palapa de Chilapa. The predominant climate is hot and humid with abundant rainfall in the summer, with an average annual temperature of 20.5°C (68°F). Its zip code is 86750 and its area code is 993.

Figure 8.1 Location of Fonhapo I lagoon, Frontera, Centla, Tabasco, Mexico

b) Tour of the study area

Prior to the sampling, the Fonapo I Lagoon area was visited, the type of surrounding vegetation was identified, predominantly Sword grass (Typha latifolia) and red (Haematoxylum campechianum), as well as critical points of domestic water discharges to the water body to define the specific sampling points.

It was observed in the field that there are floating cages in the area where fish and other crustaceans are cultivated, and that there are human settlements around Fonapo I lagoon that discharge domestic water into the area.

It is worth mentioning that the surveys were carried out by boat with all the corresponding safety measures.

Design and implementation of the sampling plan

Based on the NMX-AA-121/1-SCFI-2008 standard, a sampling plan was designed to collect water samples based on the criteria and the aforementioned standard and the size of the lagoon, 20 sampling points (20 water samples) were defined. Sampling was carried out on the dates mentioned in the following table.

Table 8.1 Sampling dates

First sampling	Second sampling
September 1, 2019	September 1, 2020

8.4 Collection and processing of water samples

Samples were obtained using sterile 500 ml plastic bottles, placed in a cooler and preserved with ice at 4 °C with their proper label to preserve the physical and chemical characteristics of each of the samples. It is worth mentioning that after the cooler they were placed in a refrigerator with the adjusted temperature.

For site selection, the indications established in the NMX-AA-121/1-SCFI-2008 standard were followed, considering discharge zones and an average distance of 5 meters between sampling points. Site 1 was the first sampling point.

Figure 8.2 Preservation of samples in the refrigerator

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Laboratory sample procedure for chromium determination, established by the Official Standard NMX-AA-044-SCFI-2014.

- Bring the samples to room temperature.
- The sample was filtered through a 0.45 µm membrane. Using a portion of sample to rinse the filtration unit, collect the required filtrate volume. The pH was adjusted between 9.3 and 9.7 by adding 1 mL of the buffer solution plus 0.6 mL of the 5 mol/L sodium hydroxide solution per 100 mL of sample to bring the pH in the indicated range.

- For each 100 mL of sample, 0.25 mL (5 drops) of phosphoric acid was added. According to the pH of the sample, sulfuric acid was used, and the pH was adjusted to 2.0 ± 0.5 and mixed.

- Measured 100 mL of sample or a suitable aliquot according to the Cr content in the sample and brought to 100 mL with water, added 2 mL of diphenylcarbazide solution, mixed and let stand for 5 to 10 min for complete color development, after this time, read immediately.

- The wavelength was set on the spectrophotometer at 540 nm and adjusted with the reagent blank to zero absorbance using a cell of 1 cm or greater optical path length of light.

- The absorbance of the samples and reference solutions were measured.

8.5 Data analysis and interpretation

To demonstrate that there is a significant increase in the concentration of chromium in the Fonapo I lagoon, a statistical analysis was performed to compare the chromium deposits between the two years, 2020 and 2019. The following assumptions were applied:

a) The sample size is n = 20.

b) Being a small sample size, the use of the T-Student test statistic was considered.

c) Confidence interval of 95%, and a significance of $\alpha = 0.05$.

d) The difference between the 2020 data minus the 2019 data is taken.

8.6 Results

The following are the results of the sampling carried out in the months of September 2019 and September 2020 (Table 8.2) where the behavior of the concentrations of the heavy metal chromium can be observed, the determination of chromium concentration was analyzed under the NMX-AA-044-SCFI-2014 standard.

Table 8.2 Chromium concentration measurements for the September 2020 versus September 2019 sampling periods of the samples taken in the Fonapo I lagoon supported by the methodology

N	2020 Cromo mg/L (1)	2019 Cromo mg/L (2)	Diferencia
1	0.174	0.19	-0.016
2	0.135	0.046	0.089
3	0.137	0.061	0.076
4	0.245	0.06	0.185
5	0.074	0.096	-0.022
6	0.141	0.086	0.055
7	0.169	0.081	0.088
8	0.082	0.081	0.001
9	0.12	0.073	0.047
10	0.145	0.07	0.075
11	0.255	0.097	0.158
12	0.157	0.075	0.082
13	0.085	0.073	0.012
14	0.118	0.08	0.038
15	0.076	0.074	0.002
16	0.12	0.089	0.031
17	0.08	0.08	0
18	0.158	0.074	0.084
19	0.098	0.089	0.009
20	0.214	0.09	0.124

Table 8.2 shows that in the first sampling the chromium concentrations vary from 0.046 mg/L to 0.109 mg/L, on average the chromium concentrations are 0.07 mg/L. In the second sampling the lowest chromium concentration was 0.074 mg/L and the highest concentration was 0.255 mg/L. On average the chromium concentration is 0.13 mg/L. In both samplings, the concentrations of the heavy metal chromium are below what is established by NOM-001-SEMARNAT-1996, since this standard establishes a maximum permissible limit of 0.5 mg/L.

Table 8.3 Data averages

Medias Muestrales (μ)	μ
2020 Cromo mg/L (1)	0.139
2019 Cromo mg/L (2)	0.083

We proceeded to generate the null hypothesis (H0) and the alternative hypothesis (Ha), which are defined as follows.

H0: $\mu 1 = \mu 2$ or, H0: $\mu Cr\text{-}2020 - \mu Cr2019 = 0$

Ha: $\mu 1 > \mu 2$ or, Ha: $\mu Cr2020 - \mu Cr2019 > 0$

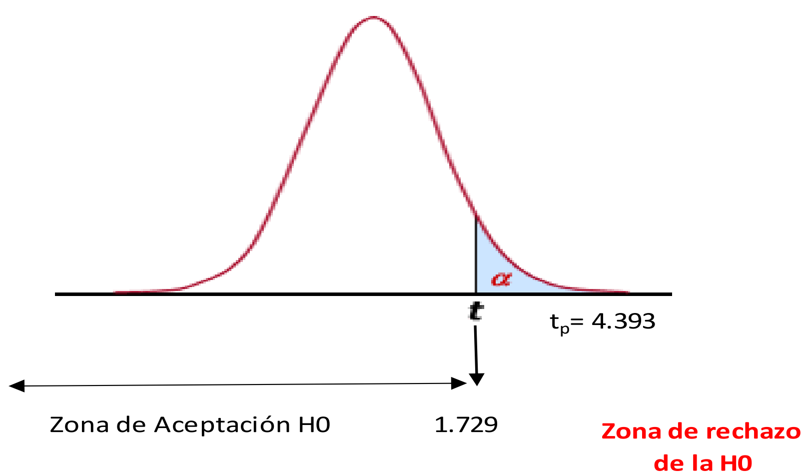
The critical value of tables (T-Student) is found, with a significance $\alpha = 0.05$ and 19 degrees of freedom. As well as the critical value of the test statistic, we found the following results

Critical value of tables = 1.729

Critical value of test = 4.393

The critical values of tables and test statistic are shown in the following graphic 8.1.

Graphic 8.1 Comparison of critical values of tables versus test statistic



8.7 Conclusion

Based on the results obtained in the samples taken in September 2019 and September 2020, an increase in chromium concentrations from the first to the second sampling of 0.06% can be observed at a glance, indicating that the positive value is given because the test statistic is precisely to the right of the critical value of tables, which shows that the alternative hypothesis is true. This may be due to the fact that the main sources of chromium emissions are wastewater and domestic water, domestic water, agricultural use and livestock activities that are observed in the area surrounding the lagoon where the samples were taken.

The probability associated with the test statistic, p-value: yields the following result:

p-value: 0.000156 < 0.05.

This shows that the data analyzed are statistically consistent.

According to the results shown in graph 1 and the associated probability p-value, the null hypothesis H0 must be rejected, accepting the alternative hypothesis Ha, concluding that there is a significant increase in the concentration of Chromium for the period 2020, with a significance $\alpha = 0.05$.

8.8 References

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