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Physicochemical and biological tests to determine water quality in the San Luis Ayucan River, Municipality of Jilotzingo, Estado de Mexico State

Pruebas fisicoquímicas y biológicas para determinar la calidad del agua en el Rio San Luis Ayucan, Municipio de Jilotzingo, Estado de México

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Abstract

Jilotzingo is one of the 125 municipalities that make up the Estado de Mexico State, which has a wealth of flora and fauna thanks to its rivers and springs. Unfortunately, the bad practices of society damage the hydrography of the area, as part of the 2030 agenda, the priorities of Today's Society are established on various current issues such as Sustainable Development, within this agenda, Goal 6 talks about the importance of clean water and its sanitation, this work focuses on the analysis of water quality as it is essential for public health and the sustainability of aquatic ecosystems. Physicochemical and biological tests were carried out to determine critical parameters such as hardness, acidity, alkalinity, flocculation, total chlorides and microorganisms, all tests are based on Mexican Standards such as NMX-AA-072-SCFI-2001, NMX-AA -036-SCFI-2001, NMX-AA-073-SCFI-2001 and the obtained results are compared with NOM-127-SSA1-2021 to verify the permissible limits of water quality for human use and consumption since the inhabitants they use for their daily activities.

Water quality, Pollution, Mexican standards

Resumen

Jilotzingo es uno de los 125 municipios que conforman el Estado de México, el cual cuenta con una riqueza en flora y fauna gracias a sus ríos y manantiales, lamentablemente las malas prácticas de la sociedad dañan la hidrografía de la zona, como parte de la agenda 2030 se establecen las prioridades de la Sociedad Actual sobre diversos temas de actualidad como lo es el Desarrollo Sostenible, dentro de dicha agenda el Objetivo 6 habla sobre la importancia del agua limpia y su saneamiento, el presente trabajo se centra en el análisis de la calidad del agua ya que es esencial para la salud pública y la sostenibilidad de los ecosistemas acuáticos. Se realizaron pruebas fisicoquímicas y biológicas para determinar parámetros críticos como dureza, acidez, alcalinidad, floculación, cloruros totales y microorganismos, todas las pruebas estas basadas en las Normas Mexicanas como lo son la NMX-AA-072-SCFI-2001, NMX-AA-036-SCFI-2001, NMX-AA-073-SCFI-2001 y comparando los resultados obtenidos con la NOM-127-SSA1-2021 para verificar los limites permisibles de calidad del agua para su uso y consumo humano ya que los habitantes la utilizan para sus actividades cotidianas.

Calidad del agua, Contaminación, Normas mexicanas

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Introduction

Natural waters obtained from different media such as rain, the sea, rivers, and lakes, even drinking water, contain dissolved chemical compounds from the environment (air and soil). Chemical compounds in natural waters are essential in determining important properties of water. Some of these compounds are vital for aquatic plants and animals. However, several of these chemical compounds can interfere with the intended use of water, and are therefore considered contaminants (Paucar Cruz, J. 2019). A pollutant is defined as any substance or energy that is introduced into the environment and that has unwanted effects or that negatively affects the usefulness of a resource (Prada, D., López, G, 2020). Pollutants can cause long- or short-term harm by changing the growth rate of plant or animal species, or by interfering with human services, comfort, health, or property values (Prada, D., López, G, 2020).

Wastewater, which is liquid bodies of water with a varied composition, coming from municipal, industrial, commercial, agricultural, or other public or private use, can suffer a degradation in its original quality (Akpor, O. B., & Muchie, B., 2011). This wastewater can contain a variety of contaminants that can alter or modify the natural composition of the water and degrade its quality. This can hinder the use of water and prevent it from fulfilling its ecological function (Akpor, O. B., & Muchie, B., 2011).

The hardness of the water, which refers to the concentration of calcium and magnesium ions. Hardness is responsible for the formation of scale in containers and pipes, which can cause failures and losses of efficiency in different industrial processes such as heat transfer units (Guzmán Rivera, H. J. 2020).

Acidity and alkalinity are critical factors that affect the pH balance in water. Acidity refers to the presence of dissociable substances in water that generate the hydronium ion, such as strong acids, weak acids, and medium strength; also, the presence of certain metal cations that contribute to the acidity of the medium.

On the other hand, alkalinity refers to the presence of hydrolysable substances in water that generate the hydroxyl ion, such as strong bases and hydroxides of alkaline earth metals; Carbonates and phosphates also contribute significantly to alkalinity (Rogel Bueno, A. E., & Toala Pin, A. A., 2020).

The presence of total chlorides in water can arise from various sources, including saline pollution and the use of disinfectant chemicals. A high chloride content can damage metal structures and prevent plant growth. High concentrations of chloride in wastewater, when used for irrigation in agricultural fields, significantly deteriorate soil quality.

Microbiological analysis is an essential tool to evaluate the health safety of water and detect the presence of contaminants early. In this case, culture techniques were used in a specific medium (CompactDry EC) for the detection of coliforms and E. coli. The procedure ensured adequate growth of the microorganisms, facilitating their subsequent identification.

Jilotzingo is a municipality belonging to the State of Mexico that is in the central area of the state, it is a forested area that has a temperate subhumid climate, with several hills and multiple rivers and streams which make it a site with abundant flora among which the pines, oaks and firs stand out (Jilotzingo, 2023)

Methodology

To determine the quality of the water in the San Luis Ayucan River, sampling was carried out at strategic points of the tributary, which were, Paraje de La Cuesta, Montaña de San Luis Ayucan and Tributary of the San Luis River and with the help of the students from the Polytechnic University of Cuautitlán Izcalli who are currently studying Biotechnology Engineering, the Physicochemical and Biological tests were carried out.

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Figure 1 Sampling in the San Luis Ayucan River

Materials and methods

Analytical grade chemicals without the need for additional purification and distilled water were used in all tests. For the magnesium and calcium tests, EDTA, NH3, NH4Cl and Eriochrome black T were used as shown in the diagram in Figure 2.

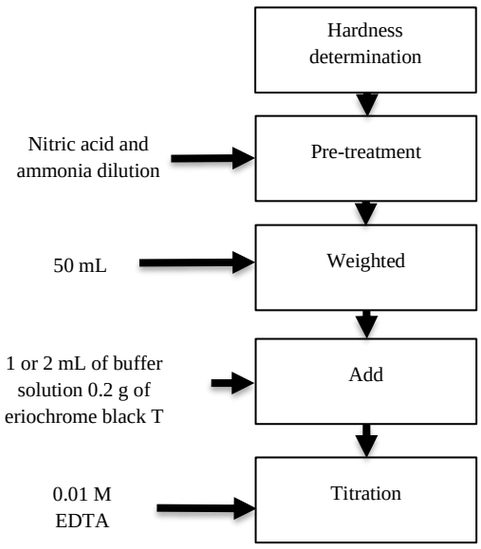

Figure 2 Block diagram for hardness determination

The determination of alkalinity and acidity involved the use of solutions of NaOH, HCl, phenolphthalein and methyl orange as seen in Figure 3.1 and 3.2.

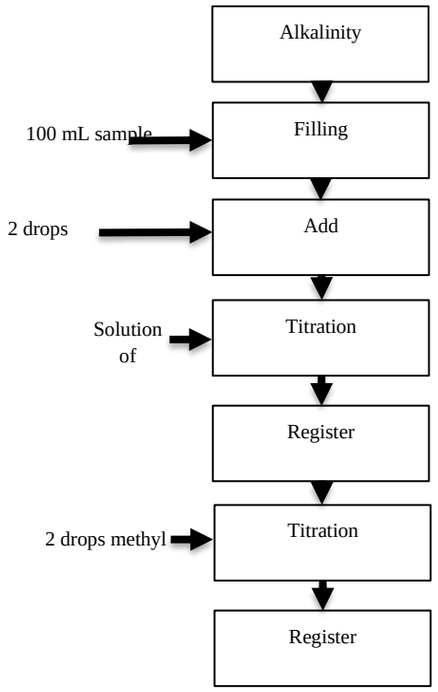

Figure 3.1 Block diagram for alkalinity determination

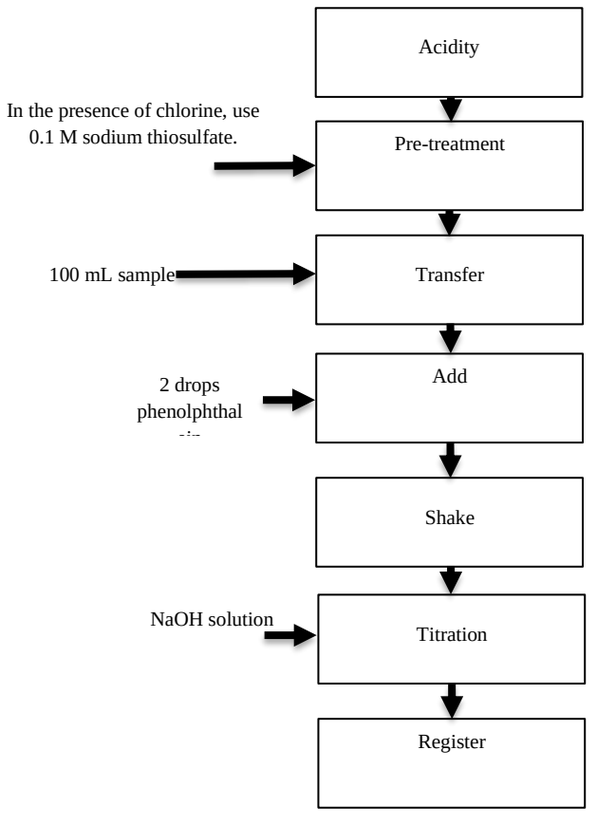

Figure 3.2 Block diagram for acidity determination

For the jar test, a 6-unit PHIPPS AND BIRD shaker was used, and aluminum sulfate was used as a flocculating agent (Figure 4). For the determination of chlorides, K_2CrO_4, $AgNO_3$, $CaCO_3$ and CH_3COOH were used (Figure 5).

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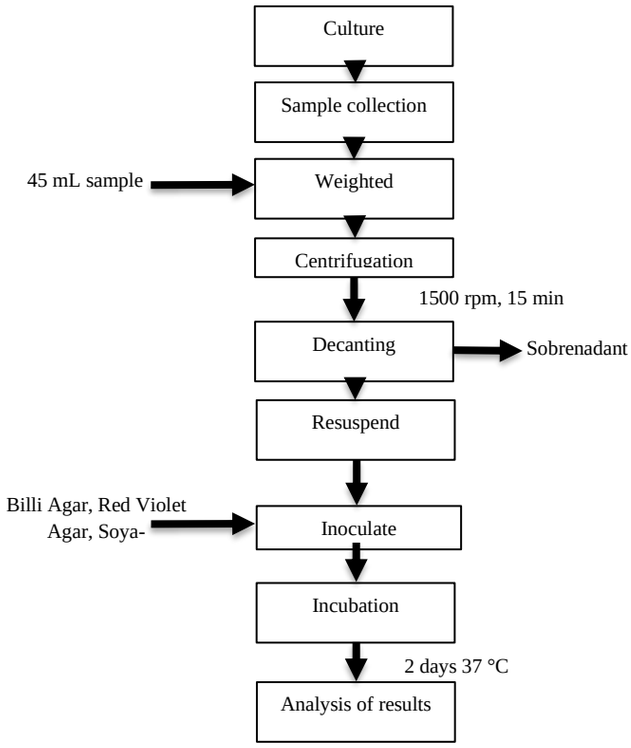


Figure 4 Block diagram for the Jars test

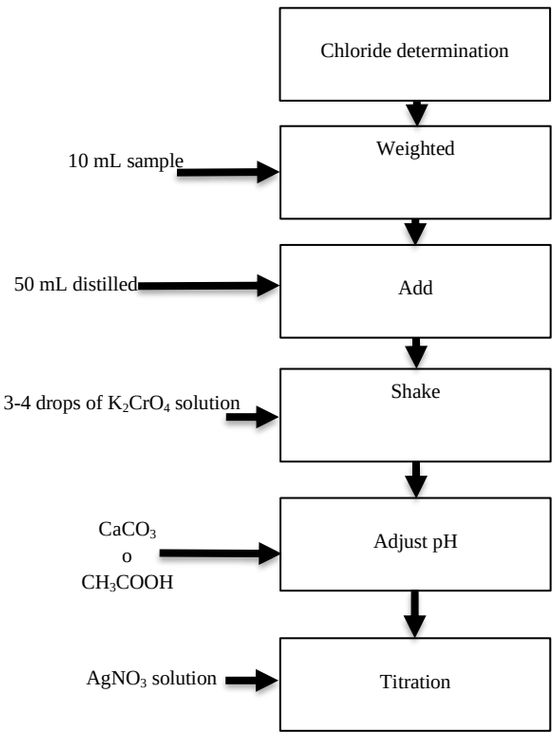


Figure 5 Block diagram for the determination of chlorides

Finally, for the determination of coliforms, the CompactDry EC, lighter and bacteriological loop tests were used (Figure 6).

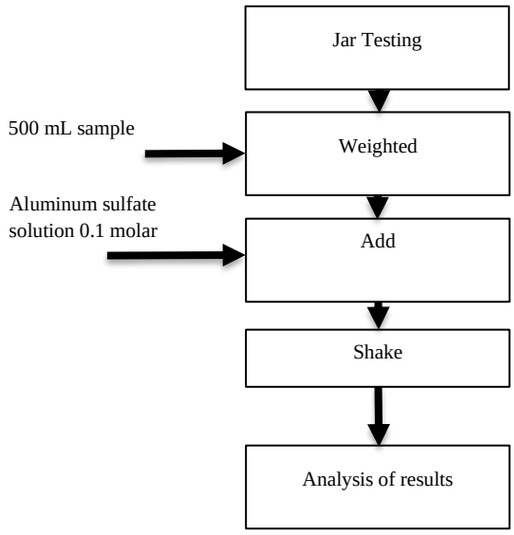


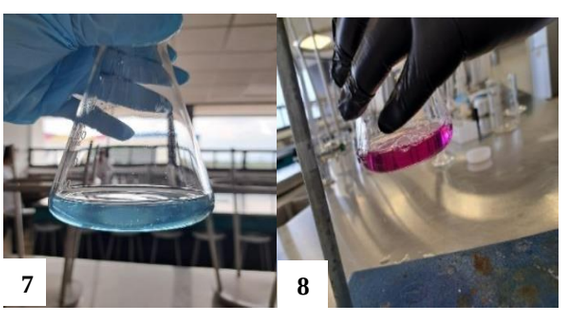
Figure 6 Block diagram for the determination of biological tests

Results

Magnesium and Calcium Tests

The determination of the total hardness in a water sample was carried out, following the analysis method established by the Mexican standard NMX-AA-072-SCFI-2011. This method involves titration with a visual endpoint indicator, using Eriochrome black T.

During the analysis, a color change of the indicator was observed to red in the presence of calcium ions and then blue by magnesium ions. The results obtained were 650.0 mg/L, which are shown in Figure 7 and 8 where the change in the color of the samples can be seen and comparing with NOM-127-SSA1-2021 we can examine that the value obtained exceeds the limits. permissible maximums by 30%.



Figures 7, 8 Magnesium and Calcium Tests

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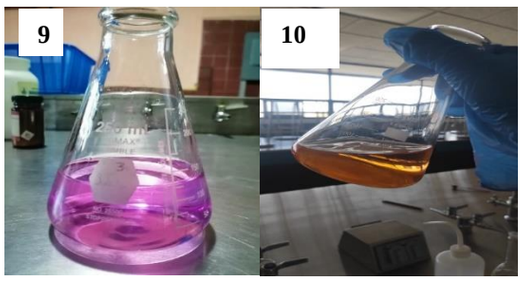
Determination of Acidity and Alkalinity

Tests were carried out to determine the acidity and alkalinity in the water samples, following the analysis method established by the Mexican standard NMX-AA-036-SCFI-20011. This method involves titration with a visual endpoint indicator, using phenolphthalein and methyl orange as indicators.

During the analysis, a color change of the indicator was observed from colorless to pink in the acidity titration with sodium hydroxide with a pH of 6.5, and from tan to orange or yellow in the alkalinity titration with hydrochloric acid with a value of 8.5 pH, as seen in Figure 9 and 10.



Figures 9, 10 Alkalinity and acidity tests

Flocculation Test

In the laboratory, the Flocculation Test, also known as the Jar Test, was carried out with the purpose of determining the Total Dissolved Solids (TDS) in a water sample, using the reagent Aluminum Sulfate as a flocculating agent, in accordance with the standard. Mexican NMX-AA-051-SCFI-2001.

However, when analyzing the results obtained, a behavior according to its pH was observed (Figure 11).

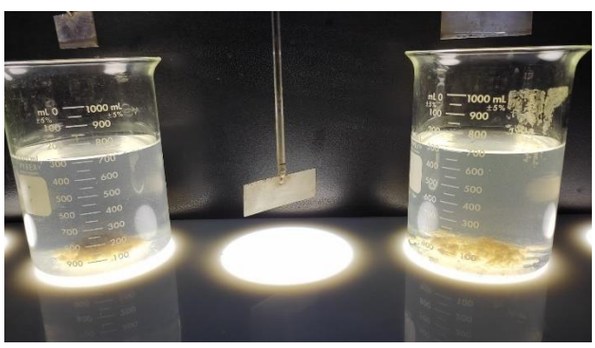


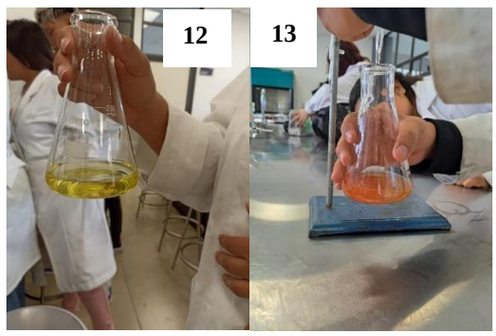
Figure 11 Jar Test

Determination of Total Chlorides (Mohr Method)

Within the framework of the research on water quality, the quantification of Total Chlorides was carried out using the Mohr Method.

To carry out this measurement, the following reagents and materials were used: K_2CrO_4 (Indicator), $AgNO_3$ (Titration solution), $CaCO_3$ and CH_3COOH (Buffer Solution Components). During the titration process, a color change was observed in the solution, going from a yellow tone to a red/orange color, which indicated the formation of silver chromate.

The results obtained were in accordance with expectations and adjusted to the values in accordance with the NOM-127-SSA1-2021 standard. Images 12 and 13 clearly show the color change in the solution, which validates the reliability of the data obtained.



Figures 12, 13 Determination of total chlorides

Biological Determination

Microbiological analysis is an essential tool to evaluate the health safety of water and detect the presence of contaminants early. In this case, a specific test that identifies the presence of coliform bacteria and *E. coli* was used (CompactDry EC). The procedure ensured adequate growth of the microorganisms, facilitating their subsequent identification.

The results showed the growth of *E. coli* colonies in the corresponding test. In addition, other colonies of coliform, pink-stained bacteria were observed. Among the bacteria that we can find in this group of coliforms we can mention: *Klebsiella pneumonia*, *Citrobacter spp*, *Enterobacter spp*., all of them causing various infections in humans.

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Therefore, the detection of its presence is an important indicator of water quality, especially if this water is used for human consumption.

In figure 14 you can see the tests applied to the water samples, the points in pink-red tones represent colonies of coliform bacteria and the points in blue represent the presence of *E. coli* colonies.

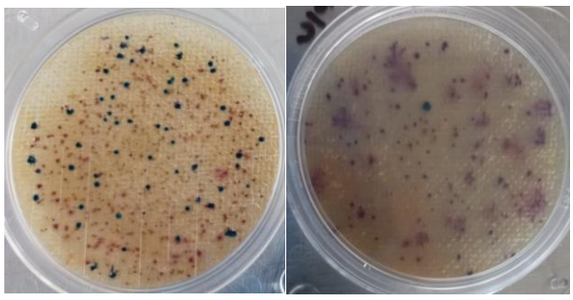

Figure 14 Biological Determination

Acknowledgment

Sincere thanks are offered to the municipality of Jilotzingo in the Estado de Mexico State for their support in carrying out sampling in their water bodies, as well as to the municipal president Ms. Ana Teresa Casas González and the director of ecology, Dr. Rubén Mayen González, for their interest and support in carrying out these studies to promote the care of the municipality's natural resources.

Conclusions

For the correct interpretation of the information obtained, repetition of tests and increasing the number of sampled areas is required to obtain a more definitive conclusion given that the current results show an irregularity between the pH values, dissolved organic matter and chlorides with the hardness values. and microbial growth. According to the above, it can be complemented with tests to determine metals, oils and greases, and determination of emerging contaminants using analytical and physicochemical methods. The studies and analyzes of this type of tests are essential to understand and ensure water quality, which contributes to the protection of public health and the environment.

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