v. 4, n. 22, 2024

Journal of
Engineering
Research

IMPACT OF CLIMATE CHANGE AND ANTHROPOGENIC ACTIVITIES ON WATER CALITY FOR HUMAN CONSUMPTION

Terreros Jesus
Technological University of the Valley of Toluca, Highway of the Department of the DF, Lerma, State of Mexico

Martinez Ricardo
UAEMex Valle de Chalco, Hermenegildo Galeana, ``Valle de Chalco Solidaridad``, State of Mexico

Gutiérrez Guadalupe
Technological University of the Valley of Toluca, Highway of the Department of the DF, Lerma, State of Mexico

Abstract: Water is a basic need, indispensable to maintain life. We cannot survive without it and, therefore, its qualities are of vital importance for human consumption because our health depends directly on it. Good quality water has a pleasant flavor and odor, which makes consumption more pleasant. Therefore, it is essential to ensure that the water we drink is free of impurities or contaminants and is safe for consumption. On the other hand, low-quality drinking water can contain bacteria, viruses, parasites and harmful chemical substances that can cause a variety of illnesses, such as diarrhea, cholera, dysentery, typhus and polio. Access to safe and clean drinking water can help prevent these illnesses and promote general health and well-being. Poor quality water can contain high levels of minerals, such as soil and mercury, which can have long-term harmful effects on health, including damage to the nervous system and developmental problems in children. Consuming contaminated water can cause a variety of illnesses, many of them serious. Furthermore, low-quality water can also affect agriculture and food production. It can contaminate crops and livestock, which can contribute to food insecurity and economic losses. Therefore, it is essential to guarantee the quality of drinking water. This implies the implementation of effective water treatment and purification systems, the protection of water sources against contamination and regular monitoring of water quality, which will help to promote economic development and allow agriculture and food production safer and more efficient.
Keywords: Water crisis, Potable water quality, Water contamination, human health, Climate Change.

INTRODUCTION

Water is a natural resource, of great relevance for health, essential for life, for the development of societies, economic growth, preservation and conservation of the environment, and for achieving human well-being, sustainable development and world social peace. However, the production and consumption of goods and services in the soil has brought with it a greater demand for liquid, but also a greater generation of waste water, which occurs without any prior treatment in surface water bodies and as a result many freshwater ecosystems and mariners show signs of degradation, which has reduced the age and quality of its environmental services, in addition to the irremediable loss of its biodiversity.

Addressing the issue of water, as well as safeguarding it to guarantee food security, energy production, economic development and poverty reduction, is of special global attention, because only 70% of the world is covered by water, of which Of the 1400 million km^3 that exist on the planet, 2.5% corresponds to freshwater, of which around three-fourths are contained in glaciers and ice sheets. 97% in Antarctica, Arctic and Greenland.

While surface waters (lakes, reservoirs, rivers, streams and wetlands) contain less than 1% of non-frozen freshwater; Soil in the world's lakes is stored more than 40 times in rivers and streams (91,000 versus 2,120 km^3) and approximately 40 times more in wetlands and wetlands (UNEP-GEMS, 2007). Therefore, of the estimated 38 million cubic kilometers of fresh water, little more than 75% is concentrated in polar caps, eternal snows and glaciers; 21% is stored underground. Groundwater constitutes the majority of the volume of water extracted for domestic uses globally and approximately 25% of the water extracted for irrigation. All over the world there are areas where groundwater is running low, often in areas where intensive extraction is practiced for irrigation or water supply in large cities (United Nations, 2022). The remaining 4% corresponds to bodies and surface water courses (lakes and rivers). With increasing use worldwide, at approximately 1% per year over the last 40 years, due to the combination of demographic growth, socioeconomic development and changes in consumer spending (Aquastat, s.f, 2022).

The impacts of climate change will be channeled mainly through the water cycle, with consequences that could be large and uneven throughout the world. Water-related climate risks are transmitted cascading through food, energy, urban and environmental systems (World Bank. 2016). Causing at the same time natural disasters, extreme phenomena and climate variability that have far-reaching repercussions on agricultural and food production systems. The most direct impact is the reduction of production, which has repercussions throughout the value chain, affecting agricultural growth and rural livelihoods, and putting at risk all dimensions of food security and nutrition (FAO, 2021) It contributes to the transmission and propagation of vector-borne diseases, and its effects are likely to be worse. Faced with the ongoing climate change, we must intensify efforts to prevent and control vector-borne diseases (Rocklöv et al., 2020). The climate change is affecting and will continue to affect the quality, quantity and availability of water for basic human needs.

The increase in precipitation and the intensity of rainstorms can cause wastewater collection systems from domestic and industrial sources to become overloaded and release untreated wastewater directly into water courses. This will cause an excess of contaminants to enter rivers and lakes and also a greater risk of pathogenic contamination (UNEP, 2021). The scientific evidence is clear: the climate is changing and will continue to change, affecting societies and the environment. This occurs directly through changes in hydrological systems that are affecting the availability and quality of water; lower quantity of oxygen disuelto and consequently, lower self-depuration capacity of freshwater deposits, (IPCC, 2018a). It can directly and indirectly affect ecosystems, human societies and economies in different ways (Table 1). The impacts of climate change related to water also include negative effects on food security, human health, energy production and biodiversity. It is estimated that approximately 505,000 km^3 of water evaporated from the oceans each year. However, most of it falls over the oceans, unable to be used as a fresh water resource. Annual precipitation on dry land is estimated at 120,000 km^3 (Fernández, 2012). Around a million animal and plant species are facing extinction. Fresh water species have suffered the greatest decline, decreasing by 84% since 1970. Human beings are also affected: around 4 thousand million people are currently experiencing a serious physical shortage of water for at least a month year, a situation that has been worsened by the climate crisis. As the planet warms, water has become one of the main ways we experience climate change. Which is manifested, among other aspects, in the increase in the frequency and magnitude of extreme phenomena, such as heat waves, unprecedented precipitation, storms and cyclonic tides, floods and greater concentrations of contaminants, during droughts will increase the risk of water pollution and pathogenic contamination due to the expansion of fecal heces, protozoa and viruses that constitute a serious health and cross-contamination risk (WWDR, 2020), as well as damage to health (Oyarzún et al., 2021).

Direct effects	Indirect effects	Social effects	Impacts on Health
Storms	Water quality	Health	Allergies and Respiratory Illnesses
Droughts	Air pollution	Socio-economic	Cardiovascular Diseases
Flooding	Use of ground	Public services	Infectious Diseases
Heat Waves	Ecological change	Mobility	Malnutrition and others*

Table 1: Direct and indirect effects of climate change on human health and well-being.

*Mental health; injuries; intoxications.

Source: Oyarzún et al., 2021.

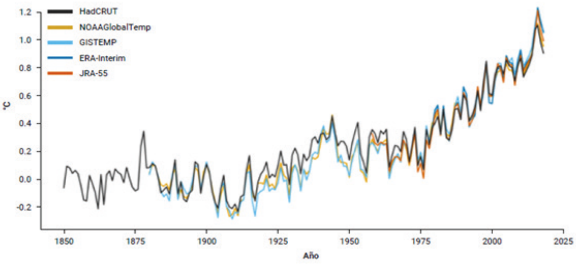

Figure 1: Anomalies in the global temperature average, compared with the 1850–1900 baseline in the five global temperature data collections (dataset).

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With the climate change, the predictability of the availability of the water resource is reduced. Previous studies predict that water scarcity (water stress) and the impact on its quality will continue to increase in the future, reaching 52% of the global population by 2050 (Kölbel et al., 2018). Currently, there is a strong scientific consensus regarding human influence on the climatological system and the role of anthropogenic winter gas emissions (GEI) in global warming. The GEI emissions rate is at an all-time high. Anthropogenic GEI emissions have increased steadily since the pre-industrial era and atmospheric concentrations of carbon dioxide, methane and nitrous oxide are at levels unprecedented in the last 800,000 years (IPCC, 2014a; 2018a; WMO 2019). At a global level, the average temperature of the planet's surfaces has increased by around 0.9 °C since the 19th century (Figure 1). Most of this warming occurred in the last 35 years, five of the hottest years were recorded after 2010.

It is clear that, since the middle of the twentieth century, the average temperature on Earth has increased steadily and progressively. In recent decades, climate change has been associated with an increase in the emission of "winter-effect gases", mainly carbon dioxide: CO_2, methane: CH_4 and nitrous oxide: N2O generated by human activities and progressive industrialization (Oyarzún et al., 2021). The scientific community is convinced that after 2030, the average global temperature will exceed pre-industrial levels by at least 1.5°C (IPCC, 2018a). Current trends and future projections estimate greater changes in the climate, and more extreme climate events in many parts of the world (IPCC, 2014a). Climate projections indicate with great confidence that extreme precipitation events will be more intense and frequent in many regions, heat waves will occur more frequently with a longer duration, and a greater risk of global flooding (Hirabayashi et al., 2013) and more intense droughts (Trenberth et al., 2014). Sweet water ecosystems are among the most threatened in the world (Vári et al., 2021). The vast majority of ecosystem and biodiversity indicators have experienced rapid deterioration around the world due to multiple human factors. For example, 75% of lands have suffered profound changes that have led to the loss of 85% of natural wetlands.

Since 1970, the change in land use has been the factor that has had the greatest impact on both terrestrial and freshwater ecosystems (IPBES, 2019).

Mexico, like Bogotá, Colombia, Latin American countries have suffered during the last few years the impact of climate change, water crisis, problems of environmental contamination and quality of drinking water for human consumption, as a consequence of anthropogenic and industrial activities. Mexico has reported public data on water quality since 1990; However, the way in which the government has measured it has varied, thus causing great difficulty in understanding how it has evolved and the damage to its quality

Mexico, has a territorial extension that comprises 1,960,189 km², of which 1,959 million km² correspond to the continental surface and the remainder to the island areas. The third parts of the territory are considered arid or semi-arid, with annual rainfall less than 500 mm, while the southeast of the country is humid with annual rainfall exceeding 2000 mm per year. Furthermore, in the majority of the national territory, the rain is more intense in summer, mainly torrential (CONAGUA, 2016a). However, during the period from 2011 to 2013, Mexico was severely affected by a drought that covered 90% of the national territory, the most vulnerable regions were; the north, northwest and center of the country; mainly in the states of Chihuahua, Coahuila, Nuevo Leon, Durango and Zacatecas (CONAGUA, 2012; CONAGUA, 2016a). Its supply comes from hydrological basins, water bodies, rivers, wetlands, lakes, etc. To meet water demand, in Mexico, on December 31, 2015, the availability of 731 hydrological basins, 8 transboundary basins and 51 main rivers was reported (CONAGUA, 2016a). Of the 731 hydrological basins, 627 are in a situation of availability according to the Official Mexican Standard (NOM-011-CONAGUA-2000). These 731 basins are organized into 37 hydrological regions, grouped into 13 hydrological-administrative regions (RHA) CONAGUA, (2016c). An analysis carried out by the National Climate Data Center of the United States, reveals that the global average of land precipitation in the year 2010 was 52 mm more than the average of 1033 mm corresponding to the period 1961-1990. However, in Mexico, normal precipitation during the period 1981-2010 was only 740 mm, with accumulated precipitation in the Mexican Republic from the 1st of January to the 31st of December 2015 of 872 mm, being 17.8 % higher than normal for the period from 1981 to 2010 (CONAGUA. 2016b). With an approximate reception of 1,489,000 million cubic meters of water in the form of precipitation, of which it is estimated that 71.6% evapotranspires and returns to the atmosphere, 22.2% runs down rivers or streams, and 6.2% The remaining % infiltrates the subsoil naturally and recharges the water bodies.

Taking into account the outflows (exports) and inflows (imports) of water with the previous countries, the country annually accounts for 471.5 thousand m^3 of renewable fresh water, with an availability of renewable water per capita in 2015 in 3692 m^3/inhabitant/day. Despite this, there are basins in the country with a water deficit and are located in the central and northern zone, particularly in RHA VI Rio Bravo and XIII Aguas del Valle de México (CONAGUA, 2016a).

Other supply sources; son of the rivers and streams of the country, which constitute a hydrographic network 633 thousand km long, which highlights fifty and one main rivers for which flow 87% of the country's surface darkness and whose basins cover 65% of it continental territorial surface. However, with demographic growth, industrialization,

Journal of Engineering Research ISSN 2764-1317 DOI https://doi.org/10.22533/at.ed.3174222421086

energy generation and the increasingly greater demand for water in the agricultural sector, there has been an increase in water extraction from basins and aquifers, for different consumptive uses, particularly in in the central and northern zones of the country, where the indicator reaches a value of 55%, which is estimated to continue increasing if current trends continue. The increase in water extraction in the country's reservoirs and water bodies has caused a situation of overexploitation in 115 of the 653 water bodies and in 69 of the 731 hydrological basins the concessional flow or designated sea greater of renewable water (deficit situation). Currently, water recharge is between 23 and 27 m^3/s, according to different sources of information, which creates a deficit of 29 m^3/s between what is extracted by pumping and what is recharged to the system. It is difficult to accurately predict demand trends in the future, however, with global water demand increasing at an annual rate of 1%, it will result in an increase of between 20% and 30% in 2050, with a margin of error of more than 50% Burek et al. (2016). The growth of the population, the economic development, the changes in consumer spending, the intensification of agricultural production and the expansion of cities, have betrayed as a consequence, the need to have greater volumes of water, to supply them urban areas, for energy generation and productive activities, mainly agriculture and industry (Wada and Bierkens, 2014; SEMARNAT, 2020), while water availability becomes more erratic and uncertain (UNU-INWEH/CESPAP, 2013; FAO, 2017a;

It is worth noting that water demand will continue to grow, from 1950 to 2020, the country's population will increase with growth, and will go from being mostly rural to predominantly urban, with a population of 126,014,024 (INEGI, 2016d). In 2016, a population of 122.7 million was estimated, and it is expected that in 2030, it will reach 138.1 million and by 2050, the population in Mexico will be 148.2 million people (Muradás et al., 2018). In the literature it is reported that the global use of water has multiplied by six in the last 100 years and that it will continue to increase at a constant rate of 1% annually due to demographic growth, economic development and change in consumption patterns. According to current trends, feeding a mostly urban population requires increasing local food production by 70% (Godfray et al., 2010), which implies that water extraction will increase by 55% by the year 2050 (FAO, 2011; Guijarro & Sánchez, 2015; On the other hand, the lack of access to quality water for consumption and sanitation has an enormous human cost, both in social and economic terms, as well as in health (UNESCO, 2009).

The degradation of surface water quality due to anthropogenic effects has been a cause for concern for some decades. Global freshwater resources are increasingly contaminated with organic waste, pathogenic microorganisms, fertilizers and pesticides, heavy metals and emerging contaminants. Water contamination by organic matter is increasing due to the increase in the discharge of municipal and industrial waste water, the intensification of crops (including livestock) and the reduction in the dilution capacity of rivers due to the decrease in runoff and water extractions (Zandaryaa and Mateo-Sagasta, 2018).

On the other hand, the extraction of "Potable Water", from the subsoil waters, which is the result of a long and slow process of accumulation of surface waters, which penetrate through the soil particles, becoming stationary at the levels lower than sedimentary substrates over time.

The speed of percolation of surface water, on some occasions contaminated by various anthropogenic activities, is naturally led to the subsoil (water recharge), which is of vital importance to consider in terms of quality and water balance between pump and recharge; The difference between what enters the water supply and what is extracted from it must be considered as a measure of exploitation and renewal of the water resource. Historically, the first drilling of wells in Mexico dates back to 1847, marking the beginning of the history of the uses of groundwater extracted from the subsoil (Domínguez & Carrillo, 2007). It houses a total of 653 water bodies, which contribute 38.9% of the total volume allocated for consumptive uses (33,311 hm^3 per year in 2015). Of the total number of water bodies, 105 are in overexploitation conditions, 32 with saline soils and brackish waters and 18 with marine intrusion. However, in a large part of the country, the extraction of groundwater is greater than the recharge, which means that the water heritage is being undermined by approximately 9500 million m^3/year. In addition to the loss of important areas for recharge due to deforestation, the change in soil use, the disorderly expansion of human settlements and the replacement of green areas by paved areas that impede infiltration (CONAGUA, 2016a).

Just as superficial bodies of water, as well as "poor" underground sources, present a deterioration in their quality, this is a major problem that is increasing, and is considered one of the main environmental problems. The main causes, both for sweet water and salad, are uncontrolled spills of urban and industrial waste water, often without treatment, as well as poor agricultural practices. Atmospheric contamination, the accumulation of chemical substances in soils and sediments, excess pumping of groundwater, mining and other extraction industries, the destruction of swampy areas, also contribute to their deterioration.

The main effects that produce contaminated water in the environment are: microbiological contamination of water, with the waterborne transmission of diseases; loss of aquatic ecosystems; risk of chronic infections in men, associated with chemical contamination; loss of productive capacity in irrigated soils, the cause of salinization processes, loss of the protein reserve of crops; loss of soil due to erosion (Fernández, 2012). It is relevant to take into account the quality of water given its essential ecological value for health and economic growth (Villena, 2018). Water quality promotes human condition and is a first level of environmental health intervention at the level of family units. Precisely, the World Health Organization (W.H.O.) establishes that "providing access to clean water is one of the most effective instruments to promote health and reduce poverty. Therefore, it is necessary to carry out Water Security Plans (PSA), which contain a guide promoted by the World Health Organization for its implementation (Bartram et al., 2009). Pharmaceutical and cosmetic products are important elements in modern life, and are used in both human and veterinary medicine. These substances are incorporated into surface waters through sewage waste, which may be untreated or previously treated, in direct form. This is due to the presence of persistent, emerging or volatile organic compounds such as phenol, which is a consequence of both natural actions and anthropogenic input, fundamentally of an agricultural and industrial nature (Terreros et al., 2022). In addition to chemical contaminants, mostly non-polar, toxic, persistent and bioaccumulable, such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls or dioxins and the presence of potentially dangerous contaminants, generically called emerging (Barceló and López de Alda, 2007). According to UNESCO, more than 500 million tons of heavy metals, solvents and toxic sludge enter the water each year (UNESCO, 2020). For its part, on Red Earth Day, I report that 14 million people in the United States regularly drink water contaminated with carcinogenic herbicides. And that arsenic levels in drinking water across the globe are putting more than 140 million people in 70 countries at risk of lung disease and cancer.

Arsenic is used in agriculture and is also a byproduct of carbon mining and copper smelters. It has been extended to the point that "American industries release thousands of pounds of arsenic into the environment each year, according to the Natural Resources Defense Council.

The efficiency of wastewater treatment does not allow this type of compounds to be completely eliminated; Therefore, you can reach surface waters with relative ease.

Some of the potential problems that could cause this contamination, called silent, are: abnormal physiological processes, decrease in reproduction capacity, increase in cancer cases, development of bacterial strains with extreme resistance to antibiotics, potential increase in toxicity of compounds present in the environment through synergistic effects. The effects can accumulate slowly without being able to detect themselves, hence their silent name, up to a certain level where the effects become evident and produce irreversible changes through a cascade effect (Fernández, 2012). Water contamination affects public health, the environment and the economic well-being of all nations. Given that the origins of contamination are diverse and their mitigation is very complicated, public policy makes this issue one of the most difficult environmental problems to manage. Despite the progress observed in the last forty years, poor water quality is one of the most serious problems facing the planet. Demographic growth and industrial development have led to the extraction and consumption of large volumes of water and at the same time the generation of large volumes of waste water. Data from the World Health Organization indicate that more than 80% of the water used in the world does not receive any prior treatment, which in most cases is poured into natural bodies of water, which contributes to environmental contamination, climate change and health damage. This deficiency in the regulation of wastewater discharges of all types is due to the fact that governments have as a priority rapid economic development above any environmental cost (Pedrozo, 2020).

The discharge of wastewater directly generates 11.8% and 4.2% of global methane emissions (CH4 and N2O) respectively (Crippa et al., 2019. Lack of access to quality water and sanitation It has an enormous human cost, both in social and economic terms (UNESCO, 2009). maintaining the ecological and water balance (Terreros et al., 2023; 2024)), the lack of drinking water and environmental sanitation services in some communities that do not have access to The fundamental services of distribution systems, in alcantarillado networks, cause problems of scarcity and contamination of water for human consumption. The UN reports that at the beginning of the 1981 decade, 1.9 million inhabitants lacked access to potable water and 2 thousand million had no access to adequate sanitation. According to the World Health Organization for the year 2000, two figures were around 1.1 thousand million (one sixth of the world's population without access to potable water) and 2.4 thousand million (one third of the world's population without sanitation suitable). It is estimated that probably around 10,000 children under the age of five and 14,000 adult human beings could die each day due to water-related illnesses. The main diseases that can be contracted when consuming contaminated food or water are: cholera, diarrheal diseases, dysentery, hepatitis A, fiebre tifoidea and poliomyelitis.

It is estimated that about 65% of the rural population lacks potable water and that more than 80% lacks a sewer network; situation that favors the contamination of the various supply sources, which, despite lacking control over its management and quality, is an important factor in the spread of diseases of gastrointestinal origin due to the presence of pathogenic bacteria, such as: *Coliformes fecales*, *Estreptococos fecales, Salmonella typhi*.

The spill of dangerous chemical substances from industry, emerging contaminants, including microplastics, persistent compounds, volatiles and pharmaceutical substances, represents a major contamination problem (WWAP, 2017; United Nations, 2021).

In Mexico, 2 million tons of DB05 were generated on soil in 2017, with industries contributing the most organic contaminants and 340% more contamination than those generated by municipalities (CONAGUA, 2018). Of the municipal wastewater collected in drainages, 30% does not receive any type of treatment. Pathogenic contamination is the most widespread problem of water quality in developing countries, due to unsafe water and sanitation (WHO/UNICEF, 2017). In 2021, more than 251 million people required preventive treatment for schistosomiasis, a serious and chronic illness caused by helminths caused by exposure to infested water. With the recognition of the General Assembly of the United Nations on the human right to water and sanitation, on July 28, 2010 through Resolution 64/292, it was reaffirmed that sanitation is clean, healthy, accessible drinking water and accessible to all, it is essential for the realization of all human rights (UN, 2015). It is estimated that around a million people die each year due to diarrheal illnesses contracted as a result of unsafe water, insufficient sanitation or poor hand hygiene. However, in most cases these illnesses can be prevented: if these risk factors are addressed, each year it will be possible to prevent 395,000 children under the age of five from dying.

Emerging contaminants present a new global challenge to water quality in developing and developing countries, with potentially serious threats to human health and ecosystems. According to a report from the United Nations on the Development of Water Resources in the World, 2 million tons of waste are released daily into natural bodies of water (sea, rivers, lakes, etc.), including industrial waste, households y of agricultural origin (UNESCO-UN-Agua, 2020).

In Mexico, the use of water in agricultural water is a widespread practice that began in 1896; But it was until 1920 when he began to visualize the economic importance of using them for agricultural purposes. Because the quality of the water before use is crucial and of great relevance. In some groundwater systems in the country, the presence of chemical and biological contaminants has been detected that, when incorporated or added to the air, water can alter or modify its characteristics, which has resulted in an erroneous estimate of the value of the fund. the natural concentration in groundwater, which significantly limits the knowledge of the evolution in time and space of its quality, and in not being able to differentiate between natural water of poor quality and that which has been contaminated by the effects of policies and inadequate management of hydraulic resources and drainage of all types are often highly contaminating.

This implies that the knowledge of evolution in the time and space of water quality is limited. Which could lead to a misinterpretation between water of poor quality (natural) and water contaminated due to anthropogenic activity. Part of this problem is due to the fact that the media through which groundwater flows are anisotropic and heterogeneous, with a geological structure that is rarely considered. Reason why, in most cases, it is difficult to delimit in detail the areas of contaminated water and the character of such contamination. However, we are unaware of the degree of contamination due to an inadequate exploitation policy and the infiltration of contaminated waters. In 1913 and 1914, French chemists Gautier and Clausmann were the first to analyze fluorides in water, soil and food products and biological specimens. The most common forms of fluorine in natural waters are the fluoride ion, the hydrofluorhydric acid without dissociating and its complexes with aluminum, iron and boron (Pitter, 1985).

The Pan-American Health Organization has established that the amount of fluoride must not exceed one part per million in public water supplies to avoid damage to tooth enamel, with an optimal concentration range of 0.7 to 1.2 mg/L If there is It has been proven that optimal levels of fluoride in drinking water can prevent up to 65% of dental caries (McClure, 1970). A study reveals that the drinking water of the city of San Luis Potosí contains concentrations of fluoride between 0.4 and 4 mg/L. In this study, the analysis of water samples extracted from 59 wells was carried out, finding in 38 of the 59 wells studied, fluoride concentrations of 0.4, 3.0 and 4.0 mg/L, values above the recommended limit. It is known that its low concentration as well as its excess causes health problems in human beings.

Consumption of drinking water with a fluoride concentration greater than 4 mg/L causes dental fluorosis, whereas chronic consumption of water containing high levels of fluoride between 4 and 15 mg/L causes skeletal fluorosis associated with severe bone abnormalities. If the fluoride concentration is lower than 0.5 mg/L, the incidence of dental diseases such as cavities increases considerably. The World Health Organization recommends a fluoride concentration in drinking water of 1.5 mg/L (Leyva et al., 2008). In other regions of the country, underground water is contaminated with toxic elements. For example, in the Comarca Lagunera, in the northeast of the state of Durango and southeast of Coahuila there are areas where the water supply is contaminated with arsenic. The arsenic (As) problem is a multidisciplinary theme that encompasses aspects of its geographic and geological distribution, impacts on health and social concerns for its resolution. The presence of arsenic (As) in drinking water has caused the spread of arsenicosis, known as chronic regional endemic hydroarsenicism (HACRE), a chronic disease that is manifested mainly by dermatological changes and some types of cancer (Bundschuh et al., 2008; Litter et al., 2009).

In regions where high temperatures prevail, from the chemical or isotopic compositions of the water, the vapor or the gas that emanates from geothermal systems, within an area and a reaction between the type of rock and hot water can be derived there presence of constituents such as Li, Cs, B, NH_3, As and Hg in water or vapors that reach the surface (Fournier, 1974). Its presence is considered as evidence of magmatic waters. Experiments by Ellis and Mohan (1977) proved that it is possible to obtain concentrations similar to those detected in geothermal fields by reacting encasing rocks with hot water solutions. Salazar et al (2023), mention that the Water Quality Index (ICA) indicates the level of water contamination at the end of the museum and is expressed as a percentage of pure water; Therefore, highly contaminated water will have a value close to 0%, while water in excellent conditions will have a value of this index close to 100%. Sharma & Chhipa (2012), mention that water quality can be classified as excellent, good, poor, very poor, or in its defect, not suitable for various purposes, such as: drinking water, water used in agriculture, water used for leisure (fishing, swimming) or water used in industry according to the value of the ICA. The type of water quality is defined based on the values of physical, chemical and biological parameters Mititelu (2010).

For the analysis of surface water quality, CONAGUA (National Water Commission, in Mexico), considered 8 indicator parameters: Biochemical Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Total Suspended Solids (SST), *Coliformes fecales, Escherichia coli, Enterococos fecales* which is of great relevance due to its impact on the proliferation of illnesses mainly of the gastrointestinal type, percentage of oxygen saturation (OD%) and acute toxicity (CONAGUA, 2023).

However, procedures have been implemented to evaluate water quality. The first is based on the Water Quality Index or ICA (Table 2). The Water Quality Index (ICA) indicates the level of water contamination at the end of the museum and is expressed as a percentage of pure water; Therefore, highly contaminated water will have a value close to 0%, while water in excellent conditions will have a value of this index close to 100% (Salazar et al., 2023). This method was used by some countries but was quickly abandoned in most of them due to the lack of physical meaning. Despite this, in Mexico the ICA was used between 1990 and 2001 by the National Water Commission. The second method, implemented since 2002, takes into account only one type of contaminant: organic matter. Although this can be measured in many ways. CONAGUA considers only two of them: biodegradable organic matter (BOD5) and chemically oxidable organic matter (COD). The first form of measurement, as its name expresses it, indicates the fraction of organic matter that can be degraded biologically, while the second encompasses more than that fraction of the material that is not biodegradable. Therefore, the values of organic matter measured as COD are always higher than those measured in BOD5. COD is useful for measuring, apart from biodegradable organic contaminants, those that are of industrial origin, often toxic.

According to CONAGUA (2005), 8% of the country's surface water is of excellent quality or good if measured as BOD5, or well, 19% is measured as COD, while contaminated or severely contaminated water is 72 % measured as BOD5 or 69% measured as COD. Although these results are not clear, it is worth reflecting that every third part of the country's surface water is contaminated (Jiménez, 2007).

As far as Colombia is concerned, this country has an extension of 1,142 million square kilometers, of which 1,587 square kilometers correspond to the city of Bogotá, which makes it one of the largest cities in Latin America. It was founded on August 6, 1538 in the Cundi-Boyacence altiplano region in central Colombia (Valera, 2015). Located on the savannah of its name at the foot of the hills of Guadalupe and Monserrate, at 4º35, 56", 6 north latitude and 74º04, 51", 3 longitude west of Greewich. At an average height of 2600m above sea level. The original city was located between the valleys of the San Francisco and San Agustín rivers (Blanco, 2023). In 1950, the population of Bogotá, Colombia was 630,315 inhabitants, the census in 2005, estimated a population density of approximately 4,310 people per square kilometer. For 2018, it had an estimated population of around 8 million people in the Capital District and around 11 million people in the metropolitan area. Meanwhile, by 2024, the population of Bogotá is estimated at 11,658,211 inhabitants. These population estimates and projections

Parameter	Effect
Temperature	This is a crucial factor for all aquatic organisms and can affect the solubility and toxicity of chemical compounds in the water.
Turbidity	Turbidity refers to how clear or dark the water appears. High concentrations of particles can reduce the effectiveness of water disinfection treatments and are a measure of contamination
pH	This parameter refers to the acidity or alkalinity of the water. A balanced pH (generally between 6.5 and 8.5) is crucial to prevent corrosion of pipes and the growth of harmful microorganisms.
Total disuel solids (TDS)	This indicator measures the total amount of minerals, salts or other diluted elements in the water. High TDS values can affect the flavor of the water and even be harmful to health.
Nitrates and nitrites	These compounds can infiltrate well water through fertilizers and animal waste. High levels of nitrates and nitrites can be harmful, especially for breastfeeding women.
Presence of heavy metals	Metals such as pollution, mercury, arsenic and cadmium can contaminate water and have serious effects on human health.
Water hardness	The hardness of the water is due to the dilute minerals, this parameter is crucial to evaluate the amount of calcium and magnesium in the water. If the hardness is too high, it can cause problems with pipes and appliances due to the formation of scale.
Diuelto Oxygen Level (DO)	Distilled oxygen is vital for aquatic organisms and a low level can be a sign of contamination.
Electrical conductivity	It is a measurement of charged ions in the water. High levels may indicate the presence of contaminants.
Microbiological and chemical contaminants	These include bacteria, viruses, nitrates, phosphates, lead, copper, pesticides and other harmful substances.

Table 2: Well water quality parameters

<table>
<tr><th>Scale</th><th>ICA</th><th>ICA compressed</th><th>Modified ICA</th><th>With BOD$_5$ values from 0 to more than 120</th><th>With COD values from 0 to over 200</th></tr>
<tr><th></th><th>Classification Used between 1990 and 1999</th><th>Used between 2000-2001</th><th>Used 2001</th><th>2002-2003</th><th>2002-2003</th></tr>
<tr><td>95-100</td><td rowspan="2">Excellent</td><td rowspan="4">Excellent</td><td rowspan="3">Excellent</td><td>Excellent</td><td rowspan="2">Excellent</td></tr>
<tr><td>90-95</td><td rowspan="2">Acceptable</td></tr>
<tr><td>85-89</td><td rowspan="2">Acceptable</td><td rowspan="2">Acceptable</td></tr>
<tr><td>80-84</td><td rowspan="2">Acceptable</td><td rowspan="6">Acceptable</td></tr>
<tr><td>70-79</td><td>Slightly contaminated</td><td rowspan="3">Acceptable</td><td rowspan="2">Acceptable</td></tr>
<tr><td>60-69</td><td rowspan="2">Contaminated</td><td rowspan="2">It requires prior treatment</td></tr>
<tr><td>50-59</td><td rowspan="7">Contaminated</td></tr>
<tr><td>40-49</td><td rowspan="8">Heavily contaminated</td><td rowspan="8">Heavily contaminated</td><td rowspan="4">Soil for industrial and agricultural use</td></tr>
<tr><td>33-39</td></tr>
<tr><td>30-32</td><td rowspan="2">Contaminated</td></tr>
<tr><td>23-29</td></tr>
<tr><td>20-22</td><td rowspan="4">Heavily contaminated</td><td rowspan="4">Heavily contaminated</td></tr>
<tr><td>16-19</td></tr>
<tr><td>10-15</td><td rowspan="2">Heavily contaminated</td></tr>
<tr><td>0-9</td></tr>
</table>

Table 3: Classification of water quality based on the "ICA" method and organic material content.

Source: Information of INE-SEDESOL, 1992; CNA, 2000, 2003, 2004 y 2005; SEMARNAT, 2002.

come from the latest revision of the World Urbanization Perspectives of the United Nations (WPR, 2024). With a water demand of around 17 m^3/s, which gives a daily figure of around 1,468,800 m^3/d, that's around 133 L.p/d (including industrial, agricultural and commercial uses). The water management problem, on the other hand, is framed by the accelerated urban expansion and the proliferation of industrial and agroindustrial complexes in the periphery, which increases water demand. The essential role that plays water in the development processes and the difficulties inherent in its management, including the competence for its use (Lasserre and Descroix 2002, Brun and Lasserre 2006). This tradition is combined with a more recent perspective on urban governance and different scenarios for resource management in the city. Therefore, we find it useful to examine water management in the Functional Metropolitan Area of Bogotá from these two perspectives (Figure 2).

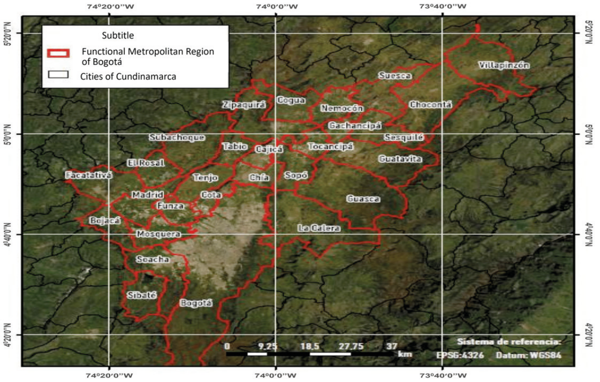

Figure 2: Functional Metropolitan Area of Bogotá.
Data: Montañez Gómez (1994) and SDP (2015)

The physical-geographical particularities that surround Bogotá and its neighboring municipalities create a water scenario of abundance, but also of political complexity due to their environmental sensitivities and difficulties in managing highly intervened and contaminated bodies of water. On the one hand, stopover systems such as Guerrero, Chingaza, Guacheneque and Sumapaz contain important water supply sources for the city and its surrounding municipalities. On the other hand, the orographic characteristics with stops facing the eastern slope, much more humid, as well as a pattern of winds, allows a rain regime with precipitation of between 500 and 1,500 mm/year, distributed in a very regular manner throughout year, guaranteeing constant supply. Which reflects a storage capacity exceeding 1,100 hm^3, as a result of the construction, since 1938, of a network of reservoirs and dams (Table 4).

Water body	Storage volume (hm^3)
North Aggregate (embalse del Neusa, Sisga and Tominé)	900
Embalse de Chuza	254
Embalse Chisacá	6,7
Embalse La Regadera	3,7
Laguna Los Tunjos	1
Total	1,165.4

Table 4: Storage capacity of embalses.

Source: EAB (s.f.).

The water captured and stored in surface water bodies is submitted to a potabilization system prior to its distribution, while the waste water that is generated is subjected to a treatment system before being discharged again into the water bodies. superficial, for self-depuration and repeat the cycle (Figure3).

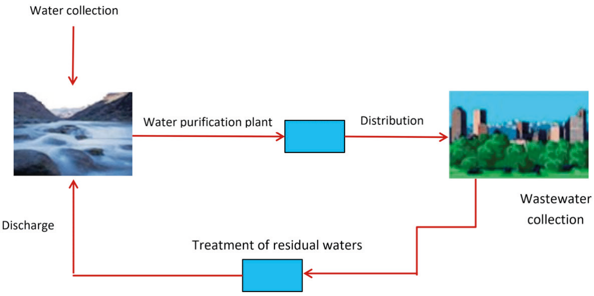

Figure 3: Cycle of availability, consumption and treatment of wastewater.

The water management problem is framed by the accelerated urban expansion and the proliferation of industrial and agroindustrial complexes in the periphery, which increases demand and contamination. With this problem, several mechanisms were incorporated that seek to articulate multiple actors to make eventually sustainable, equitable, innovative and responsible decisions. These mechanisms, moreover, are conditioned in the soil by the use of water and its availability, as well as by environmental changes that affect the resource, in particular droughts or floods; the drain of groundwater; changes in the use of soil on the ecosystems of Paramo, "producers" of water; o the high contamination of the Bogotá river, which has an excessive cost of water supply and use, especially in the middle basin of Cota-Salto de Tequendama (Garavito et al., 2018).

The contamination of the Bogotá River, starting from the upper part, to the lower part of the basin. The upper basin of the Bogotá river, since its birth up to the Tequendama jump, has an extension of 4,304 square kilometers of which 1453 are within the Bogotá savanna. The lower basin comprises 1691 square kilometers from the saint of Tequendama to the mouth of the Magdalena river and corresponds to the Tocaima and Girardot valley. Historically, the Bogotá river had great recreational value for Bogotanos and Sabaneros until the end of 1930. Families went to Santandercito, Apulo, Tena, Tocaima and Girardot to enjoy the river walks.

However, due to the high degree of industrialization and population growth, it contributed significantly to the river contamination process, generating major problems of environmental contamination, generation of bad smells, attraction vectors and health damage due to a decrease in its capacity of self-depuration, causing a decrease in the extension, permanent input of solid and liquid waste with high loads of contaminants, organic matter, heavy metals and dangerous substances, a situation that led to us being considered one of the most contaminated rivers in the world today. From its birth to the Guacheneque stop in the municipality of Villa Pinzón, Cuenca Alta del río, there are papaya cultivations that release large quantities of chemical substances used for fumigation and pest control. In the municipality of Villapinzón, artisanal curtiembres are present, making this industry a first source of contamination. (Approximately 180 tanning companies that discharge substances such as tannins, sulfur and chromium). While the river basin receives discharges of contaminating substances such as formaldehyde and carbonates from water activity and suspended solids, chlorine and mercury from the company Álcalis de Colombia and more than 5000 industries located in the Capital District and 2000 of the urban perimeter contributing 14 m^3/s of wastewater and a load of solid waste of 1500 tons/day that reaches the river through its tributaries Salitre, Fucha, Tunjuelo and Arzobispo. The last section, Cuenca Baja del Rio, which runs from Alicachín to its mouth at the Magdalena River, has a length of 62 kilometers, receives the contribution of water produced by the municipalities of Anapoima, Apulo and Tocaima.

Due to the contamination index of the Bogotá River, ecological, environmental and human health damage, in 1994 the construction of the first phase of the El Salitre Plant took place, with a treatment capacity of 4.0 m^3/s of wastewater from it. Cuenca del Río Juan Amarillo in the North Zone of the city, located at the mouth of the River Salitre. It is expected that in its first phase it will remove 40% of organic matter and 60% of suspended solids by sedimentation and in a second phase incorporating biological treatment, its efficiency will reach 95% (Figure 4).

With the sanitation of the Bogotá River and in order to guarantee the water availability of its inhabitants, Bogotá has three water supply

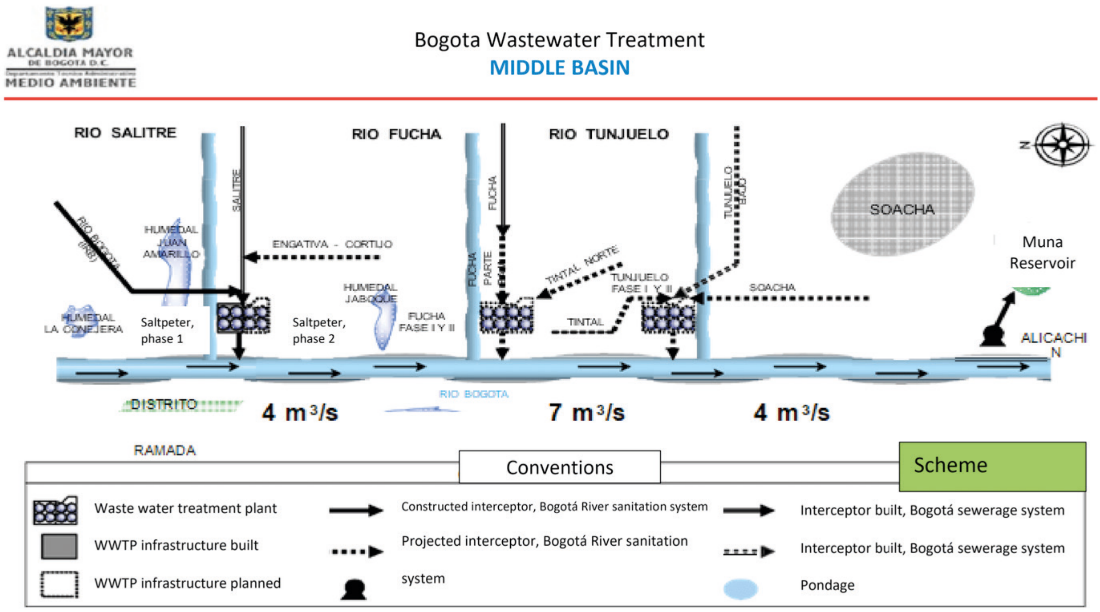

Figure 4: Configuration of the wastewater treatment system.

systems; 1) Surface water coming from the Tibitoc-Agregado Norte system located in the north of the city obtaining water from the basins of the rivers Neusa, Blanco and the reservoirs of Neusa, Sisga, Tominé and Aposentos. 2) Chingaza System, located to the east of the city with the reservoirs of Chuza, Chingaza and San Rafael and 3) Sumapaz System, upper basin of the Tunjuelo River, formed by the reservoirs of Regadera, Chisacá, the Los Tunjos and Chisacá lagoons, how to show in Figure 5.

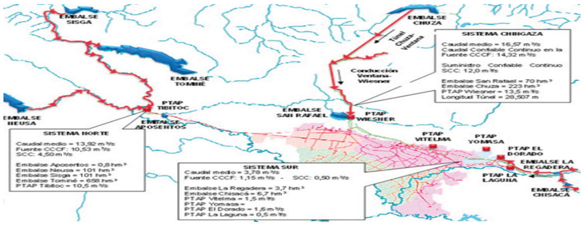

Figure 5: Water reservoirs that support Bogotá and neighboring municipalities.

Source: Water pipeline and Alcantarillado company in Bogotá.

Each system has several drinking water treatment plants, resulting in the generation of drinking water of excellent quality that maintains safety parameters for human consumption of over 95% (PMAA, 2006). These systems have the following components: 1) Supply source: This is the place where water is collected, which is generally a hydrographic basin or a water source. The selection of the same depends on factors such as accessibility, location, quantity and quality, 2) Capture works.

The type of structure to be used depends on the type of source used. If the source is superficial, the capture is done through a "bocatoma" structure and if the source is underground it is done through "wells", 3) Adduction Works: Son the works for the transportation of water from the capture site to there treatment plant. Generally, the conduction is carried out through a pressure pipe or gravel and/or through open or closed channels and 4) Water treatment and potability: This is the process by which the quality of the water present at the supply source is transformed into one adequate quality for human consumption in accordance with current regulations (Lopez, 1995), which together gives the region a high net water capacity (Table 5).

Treatment plant	Quantity of potable water (m^3/s)
La Laguna	0.5
El Doradal	1.6
Yomasa	0.025
Vitelma	1.5
Francisco Wiesner	14
Tibitoc	12
Total	29.625

Table 5: Treatment and Potability Capacity.

Source: E.A.B (s.f.).

On the other hand, Table 6 shows the existence of a white water treatment plant, PTAB, in the vast majority of municipalities in the department (95% of the total sample). Of these plants, according to departmental records in 92 municipalities that have PTAB, this is in operation, which has an effectiveness of 97%.

Municipalities with PTAB Treatment Plant		
Cities with PTAB	110	95%
Cities without PTAB	3	3%
Total of Mpios with Data	113	97%
Total of Mpios	116	100%

Table 6: White water treatment plants (PTAB)

Of a total of 116 municipalities, 29 of them have a white water treatment plant, which represents around 25%. For the water supply of its population, in Bogotá a series of water sources were incorporated that are located outside its administrative perimeter, located in areas that belong to local municipalities, to allow the development of society, contribute to equitable distribution, social justice and combating poverty, relating water management to economic development (Hinrichsen et al., 1998; Velázquez, 2010). The water flows available for the current supply of the capital and attached municipalities are captured by the Tibitoc, Chingaza, Tunjuelo systems. The different supply sources and their respective average flow rates are shown in the following table.

System	Sources	Flow rate (m^3/s)
Tibitoc	Sisga-Tominé-Neusa	8,10
	Achury	2,80
	Espino	2,51
	Río Frío	1,74
	Río Teusacá	1,80
Chingaza	Embalse de Chuza	6,20
	Río La Playa + Río Frío	4,57
	La Playa and Guatiquía River Pozos de Río Blanco	1,44 3,00
	Embalse San Rafael	1,19
Tunjuelo–San Cristóbal	Río San Cristóbal	0,64
	Río Tunjuelo	3,10
TOTAL MEDIO		**37,19**

Table 7: Supply Sources

Source: EAAB ESP. Study for the Update of the Potable Water Supply Master Plan (PMA) for the Median and Large Plaza. March 2001.

The water pipeline system of the city of Bogotá has six drinking water treatment plants: Tibitoc Plant, Francisco Wiesner Plant, Vitelma Plant, La Laguna Plant, El Dorado Plant and the San Diego Plant, currently. Table 8 shows the installed capacity of the treatment plants, without considering the internal consumption of the plants, without the restrictions on the concession and the sources corresponding to 29,475 m^3/s (PMAA, 2006).

System	Plant	Installed capacity	Location	Type
Chingaza (Norte)	Wiesner	14 m^3/s	La Calera	Direct Filtration
Río Bogotá	Tibitoc	12 m^3/s	From 40km of Bogotá – Tocancipá	conventional
Río Tunjuelo (Sur)	Vitelma	1,4 m^3/s	San Cristóbal	conventional
	La Laguna	0,45 m^3/s	Upper part of Usme	conventional
	El Dorado	1,6 m^3/s	Vereda el Uval – Usme	conventional
	Yomasa	0,025 m^3/s	District: Juan Rey	Conventio-nal-compact

Table 8: Installed capacity for water treatment in Bogotá and Alejandro area.

Source: Directorate of Abstecimiento EAAB – ESP. Population and demand studio.

With the operation of these plants, a reliable and continuous supply of flow of 17.84 m^3/s and a maximum daily flow of 26.15 m^3/s are associated, considering the maximum daily production flow of the plants minus the internal consumption of them. The drinking plants of the EAAB ESP are of conventional type and only the Wiesner plant has direct or contact filtration. Conventional plants include coagulation, flocculation, sedimentation (conventional or high-speed), filtration and disinfection processes. Direct filtration does not include the sedimentation process, thus eliminating decanters within its structural and hydraulic configuration, as a result of having raw water with high quality parameters from a physical-chemical and bacteriological point of view. Figure 6 shows potable water coverage with acceptable quality. On the other hand, of these 29 existing plants, 17 (58% of existing PTARs) are in operation. The remaining 42% corresponds to plants that are well under construction or are not operating (PMAA, 2006).

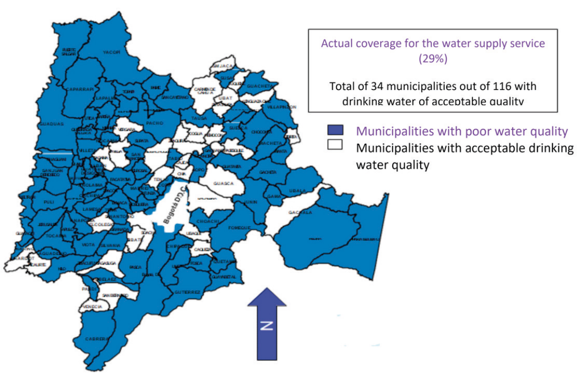

Figure 6: Potable water coverage.

Source: Regional planning table, 2005.

Based on what has been described, the objective of this research work is to evaluate the quality of drinking water in the City of Mexico and the conurbated area of the municipality of Chalco, state of Mexico in order to carry out a comparative analysis of water quality potable that is consumed in Bogotá, Colombia, as a consequence of the impact of climate change and anthropogenic activities in both countries, and implementing the best biotechnological alternative for its improvement.

MATERIALS AND METHODS

SAMPLING

The 1L samples of water (n=12 batches) were taken in completely clean containers, from the purge of the drinking water distribution line, purging and flushing the mixture, to guarantee its total homogenization and avoid its contamination; transported at 4°C for preservation and subsequent characterization. Geo-positioning each monitoring point, with a GPSmap 76CSx equipment, from the GARMIN brand.

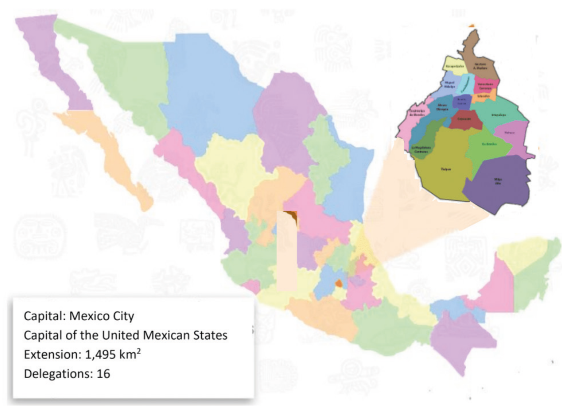

Figure 7: Area of study

CHARACTERIZATION OF THE DEMONSTRATIONS

To characterize the wastewater sample, the main parameters were evaluated: pH using a potentiometer (Corning pH/ion Analyzer 455). Chemical Oxygen Demand (COD) according to NOM-030-SCFI-2001.

The BDO_5 was determined according to NMX-028-SCFI-2001. The determination of Solid Disuels Totals (SDT), was determined according to NMX-AA-034-SCFI-2015. Total hardness is carried out according to

Journal of Engineering Research ISSN 2764-1317 DOI https://doi.org/10.22533/at.ed.3174222421086

NOM-127-SSA1-2021, Appendix B-10. The analysis of detergents was determined using the Active Substances in Methylene Blue (SAAM) technique according to NMX-AA-039-SCFI-2001, the analysis of electrical conductivity (m) was carried out using a table conductimeter Model "Thermo scientific" with Orión electrode, True Color measurement was carried out using a DR/890 colorimeter using the Platino/Cobalt (Pt/Co) technique. Turbidity is carried out using a Hanna Turbidimeter, Model: HI98713 ISO Turbidimeter with measurement scales: 0-1000 FNU (NTU) and precision: ± 2% of the reading plus 0.1 FNU. Fecal Coliformes were determined according to NOM-112-SSA1-1994. Normative Appendix B y *Salmonella spp* based on NOM-114-SSA-1994.

RESULTS ANALYSIS AND DISCUSSION

Before addressing the results, Table 9 shows the LMP for NOM-127-SSA1-2021 for drinking water. It is important to evaluate essential parameters to determine the quality of the water that is extracted from well, such as the concentration of chemical elements (Fe, Mg, Ca and Na), presence of contaminants (bacteria, viruses), analysis of different chemical substances (pesticides, heavy metals and volatile organic compounds) pH, turbidity, temperature, odor and flavor to detect the presence of unwanted substances. In Table 10, the results of the analyzed samples are shown.

Parameters	Permissible limit	Units
Total hardness	500.00	mg/L of $CaCO_3$
Total Disabled Solids	1000.00	mg/L
Active substances in methylene blue	0.50	mg/L
Turbidity	3.0	UNT
pH	6.5 to 8.5	pH units
True color	16	UPC
E. coli or Thermotolerant coliforms	<1.1 or Not detectable	NMP/100 mL
	<1	UFC/100 mL
	Absence	Absence or Presence/100mL
**Salmonella Spp*	N.A.	NMP/100 mL
		UFC/100 mL
		Absence or Presence/100mL
*DQO	N.A.	mg/L
*DBO_5	N.A.	mg/L
Electrical conductivity	N.A.	ms/cm

Table 9: Maximum permissible limits (MPL) established in the **NOM-127-SSA1-2021**.

***Not applicable**

Table 11 shows the maximum permissible limits (MPL) in drinking water according to the provisions of Resolution 2115 of 2007, of Bogotá, Colombia.

Table 12 shows the results of the quality of drinking water distributed to the inhabitants of Bogotá, Colombia, once the surface water is subjected to a purification process, as mentioned above.

THE pH EVALUATION RESULTS

The pH determination in water indicates the tendency towards acidity or alkalinity, which allows to establish its degree of corrosiveness. In addition, pH is an indicator of the trophic capacity of the water body. Acidic waters are known as oligotrophic and alkaline waters as eutrophic. Most natural waters have a pH between 4 and 9, although many of them have a slightly basic pH due to

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Sampling point	Parameter evaluated										
	Total hardness mg/L of $CaCO_3$	SDT mg/L	SAAM mg/L	Turbidity UNT	pH	True Color UPC	*E. coli* NMP/ 100 mL	Dimensionles *Salmonella*	DQO mg/L	DBO_5 mg/L	µ ms/ cm
Cocotitlan	134,01	285,91	0	1,62	8,0	0	< 1,1	Not available	0	0	404
Tlachique	88,54	198,16	0	1,12	7,2	0	< 1,1	Not available	0	0	280
Cabecera Atlautla	84,44	185,7	0	0.98	7,4	0	< 1,1	Not available	0	0	262,1
Caja Atlautla	41,70	96,3	0	0,68	7,1	0	16.1	Not available	0	0	137,7
Iztapalapa	96,06	234,78	0	1,19	7,2	0	< 1,1	Not available	0	0	348,0
Milpa Alta	111,44	228,6	0	1,44	7,8	0	< 1,1	Not available	0	0	323,0
Cuauhtémoc	84,5	164,6	0	0,98	7,2	0	< 1,1	Not available	6.75	2,9	231,8
Coyoacán	84,4	216,56	0	1,14	7,4	0	< 1,1	Not available	14,75	5,98	306,0
Azcapotzalco	95,8	305,85	0	1,75	7,5	9	< 1,1	Not available	37,25	14,97	438,0
Benito Juarez	88,05	198,5	0	1,12	7,7	0	< 1,1	Not available	7,25	2,94	280,5
Alvaro Obregón	80,1	171,26	0	0,96	7,2	0	< 1,1	Not available	37,25	14,95	242,2
Tlalpan	85,5	190,37	0	1,076	7,5	0	< 1,1	Not available	4,75	1,96	269,0

Table 10: Parameters evaluated in drinking water samples from CDMX and the metropolitan area (n=12).

Sample	Definition	Acceptable values according to Resolution 2115 of 2007
CRL Insitu	It is that portion that remains in the water after a defined contact period, which reacts chemically and biologically as hypochlorous acid or as hypochlorite ion. RES 2115/2007	0.3-2.0 mg/L
pH Insitu	The value for the pH hydrogen potential of water for human consumption. RES 2115/2007	6.5 - 9.0
Temperature (°C)	Magnitude referring to the notion of heat measurable by a thermometer	
In situ conductivity (µS/cm)	The maximum acceptable value for conductivity can be up to 1000 microsiemens/cm. This value may be adjusted according to the usual averages and the risk map of the area. An increase in the usual conductivity values of more than 50% in the source water indicates a suspicious change in the quantity of dissolved solids and its origin must be immediately investigated by the competent health and environmental authorities and the provider who supplies or distributes water for human consumption.	< 1000 µs/cm
Color (UPC)	It is the color of the water at the time of its collection without having passed through a 0.45 micron filter.	< 15 UPC
Turbidity (UNT)	Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted unchanged in the direction of the flow rate through the sample: in other words, it is the optical property of a suspension that causes light to be re-emitted and not transmitted through the suspension. The higher the intensity of light scattering, the greater the turbidity. IDEAM	< 2 NTU
Total hardness (mg/L)	Chemical characteristic that has economic and indirect consequences on human health. Resolution, number: 2115/2007	< 300 mg/L $CaCO_3$
Alkalinity total (mg/L)	Chemical characteristic that has economic and indirect consequences on human health. Resolution, number: 2115/2007	< 200 mg/L $CaCO_3$
Total iron (mg/L)	Chemical characteristic that has economic and indirect consequences on human health. Resolution, number: 2115/2007	<0.3 mg/L Fe
Manganese (mg/L)	Chemical characteristic that has economic and indirect consequences on human health. Resolution, number: 2115/2007	< 0.1 mg/L
Total Chloride (mg/L)	Chemical characteristic that has economic and indirect consequences on human health. Resolution, number: 2115/2007	< 250 mg/L
Lead (mg/L)	Chemical characteristic that has a recognized adverse effect on human health. RES 2115/2007	< 0.01 mg/L
Total coliforms in water	Gram-negative bacteria in rod-shaped form that ferment lactose at a temperature of 35 to 37ºC, producing acid and gas (CO2) within 24 to 48 hours. They are classified as aerobic or facultative anaerobic, are oxidase-negative, do not form spores and present β galactosidase enzymatic activity. It is an indicator of microbiological contamination of water for human consumption.	0 UFC/ 100 cm^3
Escherichia coli in water	Non-spore-forming, Gram-negative aerobic bacillus characterized by having specific enzymes such as β galactosidase and β glucuronidase. It is the precise microbiological indicator of fecal contamination in water for human consumption.	0 UFC/ 100 cm^3

Table 11: Acceptable limits of drinking water quality in Bogotá, Colombia, according to Resolution 2115 of 2007.

Place of start	CRL Insitu	PH Insitu	Temperature (C)	Conductivity in situ	Color (UPC)	Turbidity	Total hardness	Total alkalinity	Total iron	Manganese (mg/L)	Total chloride (mg/L)	Lead (mg/L)	Total coliforms in water	Escherichia coli in water
4032 PILETA EL PEÑON	1.08	6.96	19.5	119	3	0.4	31.88	15.94	<0,100		13.53	Not requested	<1	<1
4029 PILETA SIERRA MORENA II	1.61	6.84	17.7	67	3	1.61	23.96	12.29	0.121		7.15	Not requested	<1	<1
0128 TANQUE CASABLANCA	1.32	6.83	18.1	91	3	0.98	28.71	14.88	<0,100		10.36	Not requested	<1	<1
3016 PILETA ZONA FRANCA	1.2	6.79	20.8	106	4	1.74	31.68	16.13	0.204		12.92	Not requested	<1	<1
3018 PILETA BATALLON SANIDAD	1.76	6.84	18.5	62	2	0.63	24.75	12.19	<0,100		7.61	Not requested	<1	<1
3002 PILETA EAAB	2.03	6.81	18.5	62	3	2.14	24.95	12.67	0.106		6.13	Not requested	<1	<1
3012 PILETA MODELIA	1.39	6.75	19.2	179	3	0.42	30.49	14.98	<0,100		11.49	Not requested	<1	<1
2039 PILETA NORMANDIA	0.96	6.88	20.1	114	3	0.52	32.87	16.8	<0,100		13.83	Not requested	<1	<1
2031 PILETA BOSQUE POPULAR	1.17	6.87	20.1	126	3	0.4	32.47	15.94	<0,100		12.51	Not requested	<1	<1
2011 PILETA FERIAS	1.44	6.84	19.8	127	3	0.57	31.68	14.78	<0,100		10.92	Not requested	<1	<1
2040 PILETA SAN FERNANDO OCCIDENTAL	1.74	6.75	17	70	3	1.44	25.74	12.48	0.13		6.43	Not requested	<1	<1
2022 PILETA SANTA SOFIA	1.87	6.73	16.9	68	5	3.47	26.14	12.38	0.16		6.07	Not requested	<1	<1
4030 PILETA SAN CRISTOBAL SUR II	1.69	6.77	18.6	60	3	0.46	23.96	12.38	<0,100		6.99	Not requested	<1	<1
0113 TANQUE VITELMA	1.98	6.82	15.8	58	3	0.46	23.56	12.1	<0,100		7.25	Not requested	<1	<1
0102 TANQUE EL CONSUELO	1.78	6.84	15.5	58	3	0.54	23.76	11.81	<0,100		6.18		<1	<1
0101 TANQUE SAN DIONISIO	1.69	6.81	15.6	59	3	0.48	23.76	12.19	<0,100		6.53	Not requested	<1	<1
3034 PILETA SAN DIONISIO II	1.58	6.76	16.1	58	3	0.45	24.16	12.19	<0,100		6.08	Not requested	<1	<1
5549 PILETA SOCORRO	1.54	6.9	19.2	140	3	0.34	34.06	16.22	<0,100		16.03	Not requested	<1	<1
5541 PILETA ROMA	1.46	6.88	19.3	137	4	0.34	34.65	16.51	<0,100		14.96	Not requested	<1	<1
5529 PILETA ATALAYAS	1.53	6.88	19.4	137	4	0.34	34.45	16.61	<0,100		15.11	Not requested	<1	<1
5535 PILETA NUEVA ZONA DE DESARROLLO	1.47	6.93	19.7	136	3	0.34	34.45	16.51	<0,100		15.42	Not requested	<1	<1
5543 PILETA TIMIZA	1.75	6.92	19.8	134	3	0.36	33.26	15.36	<0,100		14.5	Not requested	<1	<1
3009 PILETA LAS CRUCES	1.61	6.82	16.9	73	3	0.75	23.96	12.38	<0,100		6.99	Not requested	<1	<1
3025 PILETA CANDELARIA	1.79	6.9	16.3	70	3	0.57	23.56	12.1	<0,100		7.25	Not requested	<1	<1
3025 PILETA CENTRO II	1.95	6.94	18	71	3	0.53	23.76	11.81	<0,100		6.18	Not requested	<1	<1
0104 TANQUE EGIPTO	1.68	6.93	16.4	69	3	0.73	23.76	12.19	<0,100		6.53	Not requested	<1	<1
2029 PILETA CONTROL SANTAFE	1.51	6.9	19	68	4	0.82	31.88	11.62	0.134		<5,10	Not requested	<1	<1
3008 PILETA COUNTRY SUR	1.57	6.81	17.4	63	3	0.9	29.9	11.62	<0,100		5.68	Not requested	<1	<1
3038 PILETA GUSTAVO RESTREPO II	1.55	6.89	17.1	59	3	0.71	28.91	11.81	<0,100		12.72	Not requested	<1	<1
2038 PILETA ALAMOS INDUSTRIAL	1.27	6.8	20	112	6	1.66	42.57	17.57	0.209		11.17	Not requested	<1	<1
2024 PILETA AEROPUERTO	1.8	6.83	19.3	94	3	0.38	39.4	15.65	<0,100		<5,10		<1	<1

Table 12: Results of water quality supplied to the inhabitants of Bogotá, Colombia

the presence of carbonates and bicarbonates. A balanced pH (generally between 6.5 and 8.5) is crucial to avoid corrosion of pipes and the growth of harmful microorganisms in the event of microbial contamination.

It is reported in the literature that small variations in the pH level affect the development of bacteria, because each consortium of microorganisms has different optimal pH ranges. The optimal pH level for acidogenic bacteria ranges between 5.5-6.5, for acetogenic and methanogenic bacteria it ranges between 7.8 and 8.2. The former being the least sensitive and the latter the most sensitive to the effects of variation. (Núñez, 2017). In general, well water is considered neutral, with an ideal pH between 6.5 and 8.5. However, many wells may have a pH below 6.5, which is acidic, or above 8.5, which is alkaline, depending on the local geology and human contaminants present. Based on the results obtained from the samples analyzed in the conduct of this investigation, the results revealed a minimum pH of 7.1 with a maximum of 8.0 (Figure 8), considered within the maximum permissible limits established in NOM-127-SSA1-2021. In this regard, it is important to regularly test your well water to ensure that the pH and other key parameters are within safe limits. If the pH of your well water is outside the ideal range, there are water treatment solutions available to help balance it and prevent the development of microorganisms.

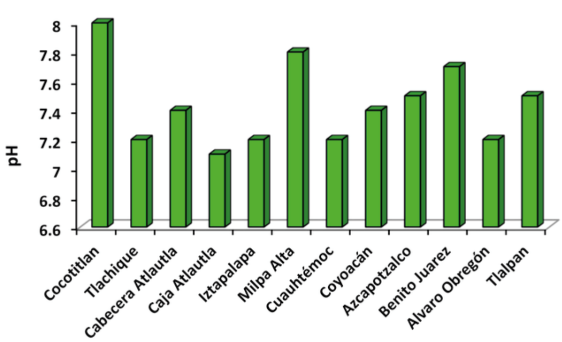

Figure 8: pH of drinking water

ELECTRICAL CONDUCTIVITY MEASUREMENT (CE)

Conductivity is the ability of water to conduct electricity. It is a measure of the charged ions in the water due to the dissolved salt content. High levels may indicate the presence of contaminants. Conductivity is affected by the type of terrain the water passes through and by the presence or absence of wastewater discharges, since the ions they contain are not eliminated by purification processes. This parameter is used to determine the existence of some discharges and the possibility of reusing the water for irrigation. In the International System of Units, EC is expressed as siemens per meter (S/m), but for simplicity it is used as a measure of conductivity µS/cm at a temperature of 25°C. The conductivity of water is related to the concentration of salts in solution, whose dissociation generates ions capable of carrying electric current. Where the solubility of salts in water depends on the temperature, so the conductivity varies according to the temperature of the water. The drinking water that we normally know contains many ions of dissolved metals and minerals. It is estimated that the conductivity of drinking water is 10 thousand times more than that of pure water. With respect to sea water, due to the large amount of ions and electrolytes dissolved in it, it is estimated that its electrical conductivity is 100 times greater than that of drinking water. Distilled water has an electrical conductivity in a range of 0.5 to 0.3 (mS/cm), Drinking water between 200 to 800 (mS/cm) and the water of the Sea of 50 mS/cm.

The figure 9 shows the results of the conductivity analysis in the drinking water samples studied. An electrical conductivity value of 137,7 ms/cm in the water sample taken from the Atlautla box once it passes through a filtration system, while the rest of the samples analyzed presented values in a

Journal of Engineering Research ISSN 2764-1317 DOI https://doi.org/10.22533/at.ed.3174222421086

range of 200 to 500 ms/cm. With values of 404 and 438 ms/cm in drinking water samples from Cocotitlan and Azcapotzalco, higher than the rest of the sampling points. Values that fall within the LMP established in NOM-127-SSA1-2021.

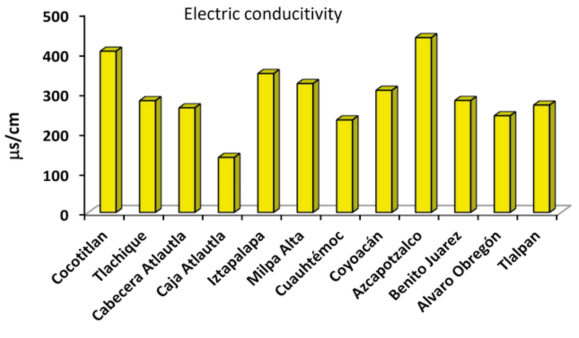

Figure 9: Electrical conductivity

TURBIDITY MEASUREMENT

Turbidity gives an idea of how clear or dark the water appears and is a parameter commonly used in natural waters as an indicator of the presence of solids, especially colloidal solids. Turbidity comes from the erosion and transport of colloidal matter (clay, rock fragments, bed substances, etc.) by rivers along their course, from contributions of plant fibers and from contributions of domestic or industrial wastewater that may be received and infiltrate the aquifer (source of groundwater). Rain and runoff dissolve extremely fine matter (<5 NTU) "Nephthalomeric Units" in the soil, salts, fertilizers, pesticides, minerals from rocks, industrial waste, garbage leachates, which remain in suspension and cause turbidity. These particles can serve as a refuge for pathogenic microorganisms attached to the suspended particles. And it is observed that in the analyzed drinking water samples (Figure 10), the Atlautla box presents a minimum value of 0.68 UNT as expected due to the filtration system it has, while the drinking water sample taken in the Tlalpan municipality in Mexico City, showed a maximum of 1.076 UNT, probably due to the industrial sector established in its surroundings.

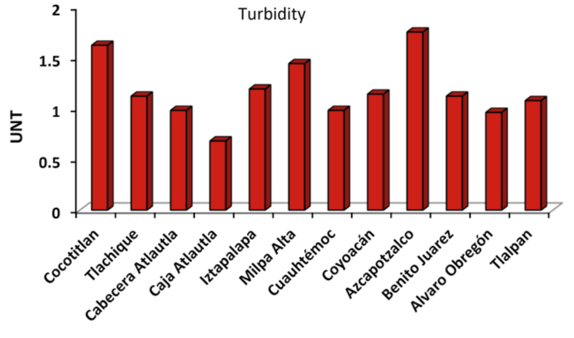

Figure 10: Turbidity in drinking water

DETERMINATION OF TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids (TDS) is the amount of organic and inorganic materials, such as metals, minerals, ions, salts or other elements dissolved in water. High TDS values can affect the taste of water and even be harmful to health. In general terms, water is considered contaminated if it contains more than 1000 ppm of total dissolved solids (TDS). For human consumption, it is preferable that the TDS level is below 500 ppm. In determining the quality of groundwater, one of the parameters that allows evaluating the salinity of groundwater is total dissolved solids (TDS). In other words, TDS includes salts, minerals, metals and any other organic or inorganic compound that is dissolved in the water, or that has passed through the filter with an opening of 1.5 microns. Salts from the environment carried by rain or snowmelt can also contribute to the increase in TDS in water supplies. TDS or TDS concentrations from natural sources vary from 30 mg/L to 6000 mg/L, depending on the solubility of the minerals in the geological area.

In this context, and according to their concentration, groundwater is classified as: fresh (Less than 1,000 mg/L), slightly brackish (1,000 to 2,000 mg/L), brackish (2,000 to 10,000 mg/L) and saline (Greater than 10,000 mg/L). In Mexico, the official Mexican standard for drinking water NOM-127-SSA1-2021 establishes the limit as 1,000 ppm. In a study done by the World Health Organization (WHO), it mentions that the levels of total dissolved solids TDS recommended in drinking water (in mg / l or ppm) to establish its quality are: 1) 0 - 300 as Excellent, 2) 300 - 600; Good level, 3) 600 - 900; Acceptable level, 4) 900 - 1200; Poor or not recommended level and 5) 1,200 or more as Unacceptable. Another classification according to mg / L is the following: 1) Less than 50, is considered as low quality, because some vital and healthy minerals are missing, 2) 50 - 300; Excellent – perfect TDS level in drinking water, 3) 300 – 500 – as in good quality with a sweet spot for TDS in drinking water, 4) 600 – 900 – just right – where a reverse osmosis system must be considered to remove them, 5) 900 – 1200 – poor – not recommended or safe for use and 6) Above 1200 – unacceptable – completely unsafe and possibly too much to handle for home filters. The results of the analysis of the drinking water shown at various points in the municipalities of CDMX and the Chalco metropolitan area, in the State of Mexico (Figure 11), revealed a minimum in the Atlautla box in the order of 96.3 mg / L with a maximum of 305.85 mg / L in the Azcapotzalco municipality with respect to the rest of the drinking water samples studied, complying with NOM-127-SSA1-2021. According to the recommendation made by the WHO, the drinking water sample from the Azcapotzalco municipality presents a good level (from 300 to 600 mg / L) as well as according to what is mentioned in the other classification; values of 300 to 500 mg / L, establishes it as of good quality considering it with the optimum of total dissolved solids "TDS" in drinking water, compared to the rest of the drinking water samples that were studied. According to the recommendation made by the WHO, from 0 to 300 mg/L, it is of excellent quality and according to the other classification of 50 to 300 mg/L, it is also considered as excellent quality, given that it presents a perfect level of TDS.

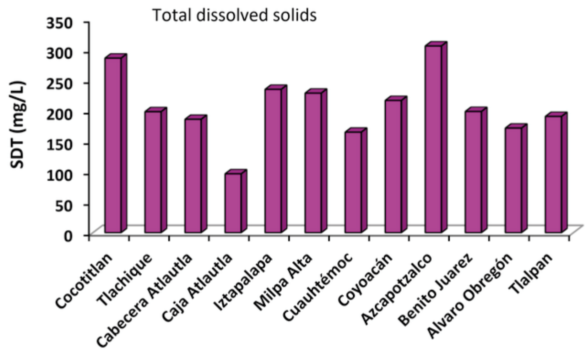

Figure 11: Total Dissolved Solids Concentration in Drinking Water

COLOR DETERMINATION (Pt-Co TECHNIQUE)

The presence of colour indicates the presence of foreign substances. Part of this may be due to suspended matter and part to the presence of dissolved substances. It is mainly produced by organic compounds of natural origin (tannins, humic acids, etc.) or artificially produced by industrial discharges. Natural waters may contain dissolved compounds that give them odour and flavour. These parameters are very sensitive to personal assessments and it is difficult to systematise the measurements. Therefore, the colour of water, together with turbidity, odour and flavour, represent the group of organoleptic parameters that are indicative of the quality of water for human consumption. And it is due to the presence of natural organic matter (NOM) such as humic substances (HS) from humic and fulvic acids, as well as the presence of certain metals such as iron, manganese and copper, which are dissolved or in suspension. The formation of color in water involves, among other factors, pH, temperature, contact time, available matter and the solubility of the colored compounds. A quality criterion to judge the suitability as drinking water, the consumer demands that the water be colorless. Water colors can be classified as follows: 1) Natural of mineral origin "iron", 2) Natural of Animal Origin "Urochromes",

3) Natural of Vegetable Origin "Humic acids" and 4) Artificial of industrial origin "Wastewater". The results found around the color of the analyzed drinking water samples, in all a value of 0 platinum/cobalt units (UPt/Co) was found, which shows that there is no presence of dissolved substances, organic compounds, as well as any type of contamination by industrial discharges. What makes drinking water suitable for human consumption according to NOM-127-SSA1-2021.

TOTAL HARDNESS ANALYSIS

Water hardness (hard water) is a characteristic caused mainly by calcium and magnesium salts dissolved in water, in the form of bicarbonate, carbonate, sulphate, chloride and nitrate. Water is considered hard when it exceeds 60 mg/l (WHO, 2024). Too high or too low a level of hardness can affect both human health and the functioning of household appliances and plumbing systems. If the concentration of these minerals is too high, it can lead to scale formation in pipes and household appliances. It can also affect the effectiveness of soaps and detergents. On the other hand, the presence of these minerals can have health benefits, as they are essential nutrients for the human body. In the context of water hardness, it is an indication (measure) of the amount of dissolved minerals it contains, which can have both advantages and disadvantages depending on its specific use. Also determined as: 1) Carbonated or temporary hardness: is the one that refers specifically to that produced by hydrogen carbonates and carbonates of calcium and magnesium and 2) Non-carbonated or permanent hardness: is the one produced by chloride, sulfate and nitrite salts of calcium and magnesium.

Water hardness can be measured based on the amount of dissolved minerals it contains, specifically calcium and magnesium. Generally speaking, an ideal hardness level for water is between 100 and 150 ppm (parts per million), which is considered to be an appropriate balance between health benefits and taste. So-called "hard water" contains a high level of minerals and varying amounts of compounds, particularly magnesium and calcium salts, which are responsible for hardness (more than 150 mg/L). Furthermore, the degree of hardness is directly proportional to the concentration of these salts (Rodríguez, 2009). On the other hand, "soft water", if it contains less than 100 mg/L of these minerals, may have a reduced buffering capacity and therefore be more corrosive to pipes, so certain heavy metals such as copper, zinc, lead and cadmium may be present in drinking water. However, these recommendations may vary depending on factors such as personal health needs, the use we give to water, and the particular characteristics of our environment. Classified according to the amount of $CaCO_3$ it contains; in: 1) Soft water: < 60 mg/L, 2) Moderately soft water: (60-120) mg/L, 3) Moderately hard water: (120-180) mg/L and 4) Hard water: > 180 mg/L. The World Health Organization (WHO) indicates that hard water can generate incrustations in the distribution systems and that, on the contrary, soft water can corrode them. Acceptability may vary according to the population; it is said that the taste threshold of the calcium ion is between 100 mg/L and 300 mg/L depending on the associated anion and that the magnesium threshold is lower than that of calcium. However, some consumers can tolerate hardness greater than 500 mg/L. In Mexico, the Mexican Official Standard NOM-127-SSA1-2021 establishes the permissible quality limits that water for human use and consumption must meet. This Standard is mandatory throughout the national territory for the organizations responsible for public and private water supply systems, where a permissible limit of 500 mg/L is set for the Total Hardness parameter as CaCO3. The results of the hardness analysis in the water samples studied revealed the following: Caja Atlautla (soft water), Tlachique, Cabecera Atlautla, Iztapalapa, Milpa Alta, Cuauhtémoc, Coyoacán, Azcapotzalco, Benito Juarez, Alvaro Obregón and Tlalpan (moderately soft water). While the drinking water sample from Cocotitlan turned out to be moderately hard. In general, drinking water is considered adequate between health benefits and taste, complying with the quality according to what is established by the World Health Organization (WHO, 2017) and NOM-127-SSA1-2021 for human consumption.

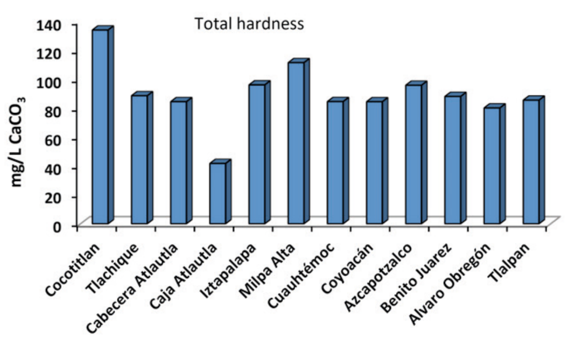

Figure 12: Hardness of drinking water

ANALYSIS OF ACTIVE SUBSTANCES WITH METHYLENE BLUE (SAAM)

Surfactants are organic compounds capable of altering the surface or interfacial tension of a system; they alter the hormonal system of aquatic organisms and can penetrate porous materials, disperse solid particles, emulsify oils and fats or produce foam when shaken. They are used in the manufacture of a wide range of cleaning and personal hygiene products, manufacturing of products with agricultural, industrial and commercial applications. However, they are highly polluting due to their special chemical composition, causing eutrophication problems in natural bodies of water due to the amount dumped and the frequency with which they are dumped, in addition to affecting ecosystems. Impacting the chemical parameters of water, increasing the levels of nutrients such as phosphorus, nitrogen, excess chlorophyll, variation in hydrogen potential, changes in physical parameters (temperature, pH, conductivity, dissolved oxygen and transparency); affecting the biota of lakes and rivers (Cheng et al., 2020).

And due to their chronic and sublethal toxicity, they affect aquatic life, hindering oxygen transfer at concentrations greater than 0.1 mg/L, inhibiting coastal organisms at 30 mg/L, affecting fish, where the less active species can tolerate severe hypoxia, reaching levels close to 0.5 mg O2/L, while the most active species may incur functional limitations due to moderate hypoxia at concentrations of 4.5 mg O2/L (Vaquer-Sunyer & Duarte, 2008). The toxic effects of surfactants on cells are very complex, they penetrate the membrane causing its rupture and, consequently, the partial solubility of its structural components (Wagener and Schink, 1988), depolarization of cell membranes or interaction with vital enzymatic proteins (Badmus, 2021). In addition to altering the permeability or integrity of the skin causing skin irritation, anionic surfactants being the most irritating followed by cationic, nonionic and amphoteric surfactants, they cause eye and respiratory tract irritation, apart from the irritating effects, there is no evidence of acute toxicity in humans (Lavoué et al., 2003). In water, the surfactant concentration is usually less than 0.1 mg/L except in the vicinity of a mouth or other point source of entry. A high content of detergents in water can cause foam formation, toxicity to aquatic life and excessive growth of aquatic flora due to the contribution of phosphates. According to the Mexican Official Standard (NOM-127-SSA1-2021), the detergent concentration must be in the order of 0.5 mg/L of active substances to methylene blue in water for human use and consumption. This limit applies to all forms of water for consumption, including drinking water, bottled water and packaged water. The results showed the absence of detergents in all water samples analyzed, resulting in water of quality for consumption without posing any human health problems.

ANALYSIS OF CHEMICAL OXYGEN DEMAND "COD" AND BIOCHEMICAL OXYGEN DEMAND "BOD_5"

Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD_5) are indicative of the amount of organic matter present in surface water bodies or, failing that, groundwater in the event of contamination by the presence of wastewater infiltrated into the aquifer, mainly from wastewater discharges of municipal and non-municipal origin. For its part, BOD_5 is an indicator of the amount of biodegradable organic matter, estimates the amount of oxygen required to oxidize it by biological action, and establishes the speed with which organic matter will be metabolized by bacteria (Fischer et al., 1979). It is proportional to the amount of biodegradable organic matter, while COD is the total amount of organic matter present in the water. Monitoring COD is highly relevant as it is a way of estimating the magnitude of organic and inorganic matter in the water. Consequently, the COD of water samples increases with increasing concentration of organic matter, a normal measurement presents a value less than 10 mg/L, while a reading of the order of 60 mg/L can be considered rich in organic matter (kitchen waste, bathroom waste, farms, cheese slaughterhouses, nixtamal factories), which serve as a substrate for the reproduction of microorganisms, consuming dissolved oxygen in water bodies (De la Lanza & Hernández, 2019). Figure 13 and 14 show the findings in the municipalities of Cuauhtémoc, Coyoacán, Azcapotzalco, Benito Juarez, Alvaro Obregón and Tlalpan. values in a range of 4.75 to 37.25 mg / L of COD and 2.9 to 14.97 mg / L BOD_5 respectively, which suggests the possibility of contamination, on the one hand, to the industrial establishment, hospitals, commerce, etc. that despite conducting their discharges through the sanitary network, probably damaged due to a series of seismic events that occurred in the years 1985 and 2017, there is an infiltration of both industrial and domestic wastewater causing contamination of the drinking water extracted from the aquifer, and on the other hand, the surface water from which CDMX is supplied from surface bodies of the Lerma River and the Cutzamala System, where its quality is affected by climate change. It is reported that water quality will be negatively affected by the increase in its temperatures, the lower amount of dissolved oxygen and consequently, the lower self-purification capacity of freshwater deposits.

Flooding and increased concentration of pollutants during droughts will increase the risk of water pollution and pathogenic contamination (Bates et al., 2008; WWDR, 2020). As the world's freshwater resources are increasingly polluted with organic waste, pathogens, fertilizers and pesticides, heavy metals and emerging contaminants, water pollution by organic matter is growing due to increased municipal and industrial wastewater discharge, intensification of crops (including livestock), and reduced dilution capacity of rivers due to decreased runoff and water withdrawals (Zandaryaa and Mateo-Sagasta, 2018). Microbially contaminated drinking water can transmit diarrheal diseases, cholera, dysentery, typhoid fever and polio. According to estimates, this pollution causes 505,000 deaths from diarrheal diseases each year (WHO, 2023).

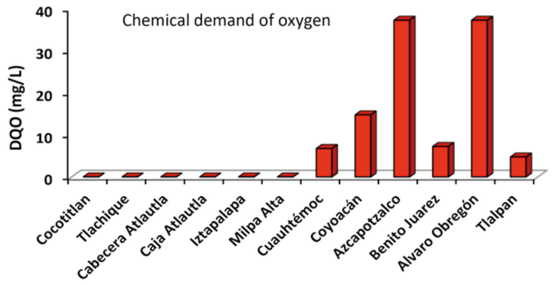

Figure 13: Chemical Dissolved Oxygen Demand of Drinking Water.

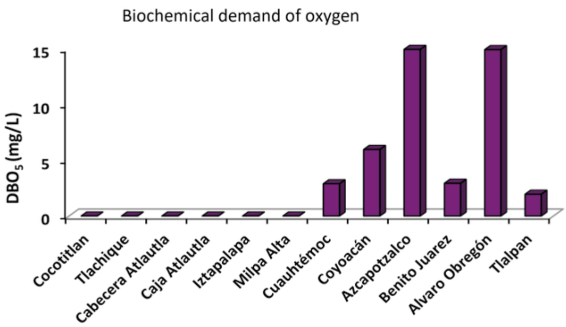

Figure 14: Chemical Dissolved Oxygen Demand of Drinking Water.

FECAL COLIFORM ANALYSIS

The evaluation of microbiological parameters to estimate water quality is of great relevance from the health sector point of view due to its impact on the proliferation of diseases (mainly gastrointestinal) and their possible dissemination in the environment and the population, being a focus of infection in the affected communities or areas. It is reported that many foodborne diseases are related to the poor quality of water used in the production, processing and/or preparation of food (WHO, 2006). Worldwide, approximately 842 thousand people die each year as a result of unhealthy water, poor sanitation and hygiene. The presence of fecal coliforms in water is indicative of fecal contamination of humans and warm-blooded animals and can be divided into total and fecal. Their main difference is the ability of fecal matter to grow at a higher temperature in laboratory conditions and to produce gas from lactose (Madigan et al., 2016; Pelczar, 2010). Among the most used are: encuentran los *Coliformes Totales* y *Termotolerantes*, aunque la abundancia de *Escherichia coli* has been associated more with health risks compared to the rest of the coliforms (Garcia et al., 2007; Farnleitner et al., 2010).

The inadequate disposal of excreta, given by the absence or the deficient sewage and treatment system, are associated with water contamination and cause numerous diseases, such as cholera, amoebiasis, hepatitis, typhoid fever and paratyphoid fever, among others (Chigor et al., 2012). Among the main water-borne diseases are diarrhea, gastroenteritis, typhoid fever, cholera and viral hepatitis. 80% of all diseases and more than a third of deaths in developing countries are due to the consumption of contaminated drinking water and, on average, up to a tenth of the productive time of each person is lost due to water-related diseases. The incidence of acute diarrheal diseases is due to the consumption of contaminated drinking water (Health, 2016). 4 billion cases of diarrhea, causing the death of more than 6 million children, 200 million cases of Schistosomiasis, 6 million people blinded by trachoma, and 500 million people at risk of contracting it, according to the World Bank. The UN also suggests that poor water is the cause of 1.5 million cases of hepatitis A and 133 million cases of intestinal worms. At some point in their lives, 50 percent of the inhabitants of the third world will have to go to the hospital because of one of these diseases. It is estimated that 88% of cases of diarrhea are caused by contaminated water, with childhood being the stage of greatest vulnerability to it. Diarrhea causes the death of between 800 and 1,000 children a day worldwide, and affects

156 million people who suffer from stunted growth or chronic malnutrition. However, it is estimated that 48% of deaths from this cause could be avoided if hygiene measures and quality drinking water were in place. Therefore, diseases related to poor water quality are the second leading cause of death in children throughout the world. Humans have become major carriers of diseases thanks to poor sanitation and undrinkable water. If we take 1 gram of human excrement today, according to UNICEF, we can find about 10 million viruses, 1 million bacteria, 100 cysts and 100 parasite eggs (UNESCO-UN, 2020).

The results of the microbiological analysis revealed values lower than 1.1 NMP/100 mL of fecal coliforms in all the drinking water samples studied, complying with the LMP established in NOM-127-SSA1-2021, except for the drinking water sample taken in the Atlautla box, which, despite having a filtration system, was shown to be insufficient for its elimination.

ANALYSIS OF *Salmonella spp*

Another microorganism of interest in the evaluation of the quality of drinking water for human consumption is the determination of *Salmonella spp*. which is a genus of Gram-negative, facultative anaerobic bacilli associated with diarrheal diseases, which continue to be one of the most important causes of morbidity and mortality, especially in infants, children and the elderly (Parra et al., 2002). The literature reports that the probability of a child dying from diarrheal disease before the age of 7 can reach up to 50% (Mead et al., 1999). In the case of species of greater clinical relevance, the species that stand out are:: *Typhi, Paratyphi* and Entérica, with an estimate of 99% of salmonellosis cases being caused by Salmonella enterica subspecies I (Yim. et al, 2010). Moeller & Ferat (2000), confirmed the presence of high amounts of the genera: *Salmonella* and *Shigella*, protozoa pathogenic to humans such as: *E.* h*ystolitica* and *G. lamblia* and more persistent parasites such as: *Ascaris* and *Strongyloides*. La *Salmonella spp* is the genus with the highest incidence of salmonellosis with doubling times of 23 minutes for *Salmonella typhi* of 150 minutes to *Salmonella pollorus*. With survival times of 2 months in wastewater and up to 8 months in soil. Therefore, the quality and quantity of microorganisms is accompanied by the physical and chemical characteristics of the water, due to the temperature, it makes the presence of organic matter more available. It must be noted that as the temperature increases, the speed with which microorganisms degrade organic matter increases, increasing the presence of these microorganisms in drinking water, resulting in the development of gastrointestinal diseases until death when finding temperature conditions for their development.

Based on the results obtained around the microbiological analysis to determine the presence of Salmonella spp in the water samples, the object of this investigation, the results demonstrated the total absence of this microorganism. Therefore, drinking water is of quality for consumption, not representing any health risk to consumers according to NOM-127-SSA1-2021.

CONCLUSIONS

The presence of *fecal coliforms* and *Salmonella* may be due to the natural presence of microorganisms as they are part of their natural habitat, or to contamination caused by sewage and/or industrial discharges, infiltration of leachates from landfills during the rainy season into the water table, or dragging of excrement in the soil by the action of rain. Based on the results of the microbiological analysis, the drinking water does not present these microorganisms. Regarding the analysis of COD and BOD_5, which are parameters that allow to recognize gradients that go from a relatively natural water condition, without the influence of human activity, to water that shows signs or important contributions of wastewater discharges, as an indicator of contamination of drinking water, finding in this sense, a slight index of contamination in the drinking water samples from the Cuauhtémoc, Coyoacán, Azcapotzalco, Benito Juarez, Alvaro Obregón and Tlalpan municipalities. Finally, with respect to the results obtained for pH, Conductivity, TDS, Turbidity, Hardness, SAAM, Color, they fall within the LMP established by the NOM despite not having a purification or potabilization system, which unlike Bogotá Colombia, does have potabilization systems, which allow generating excellent quality drinking water, once the water captured in the surface bodies is subjected to a potabilization process. In both cases, the quality of water for human consumption is met, according to the LMP established in each country.

However, it is vitally important to consider the impacts of climate change and anthropogenic activities on surface and groundwater in order to mitigate damage to its quality, quantity and availability for human needs, while reducing damage to health and ecological balance.

ACKNOWLEDGEMENTS

The authors acknowledge the support to ``*Universidad Tecnológica del Valle de Toluc*a`` (UTVT) for providing its facilities in the laboratory for the measurements.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no financial conflicts of interest, nor conflicts in personal relationships that could influence the publication of the work presented in this article.

FUNDING

There was no external source of funding for this work.

AUTHORS' CONTRIBUTIONS

All the authors contributed with their experience in the review, analysis and discussion of the results obtained in the study to prepared the manuscript. They read and approved the final manuscript.

CONSENT TO FOR PUBLICATION

All authors agree to publish the findings of the current research.

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