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Determination of physical and chemical parameters in water for irrigation for agricultural use in Tepatepec, Hidalgo

Determinación de parámetros físicos y químicos en agua para riego de uso agrícola en Tepatepec Hidalgo

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Abstract

The Mezquital Valley is a region of the state of Hidalgo dedicated to agriculture with 456,855.69 hectares of which, 20% is irrigated and the rest is seasonal; Precipitation is low, so it is necessary to reuse wastewater from the Valley of Mexico, currently treated to eliminate pathogenic microorganisms, toxic metals, fats, oils, nutrients and organic matter. Given the fertilizer crisis, it is necessary to evaluate water quality in relation to nutrient content: nitrogen, phosphorus, potassium, magnesium, sulfur, calcium, pH and EC after treatment. Weekly sampling was carried out during April-August 2021. EC represents a medium to high risk since it can cause salinity problems in soils in the long term and affect crops with low or no tolerance although the presence of Ca^{2+} and Mg^{2+}, counteract the effect of the Na+ ion and reduce the risk of sodicity. The water has a high variation in its ionic composition, however, magnesium, nitrogen, phosphorus and potassium are at an adequate level as well as the pH, their contribution through irrigation water reduces the cost of fertilization to obtain high yields.

Wastewater, Quality, Nutrients, Fertilizers

Resumen

El Valle del Mezquital es una región del estado de Hidalgo dedicada a la agricultura con 456,855.69 ha de las cuales, 20% es de riego y el resto de temporal; la precipitación es baja, por lo que es necesario reutilizar las aguas residuales del Valle de México, actualmente tratadas para eliminar microorganismos patógenos, metales tóxicos, grasas, aceites, nutrientes y materia orgánica. Dada la crisis de fertilizantes es necesario evaluar la calidad de agua en relación al contenido de nutrientes: nitrógeno, fósforo, potasio, magnesio, azufre, calcio, pH y CE después del tratamiento. Se realizó un muestreo semanal durante abril-agosto de 2021. La CE representa un riesgo de medio a alto ya que puede provocar problemas de salinidad en suelos a largo plazo y afectar a los cultivos con baja o nula tolerancia aunque la presencia de Ca^{2+} y Mg^{2+}, contrarrestan el efecto del ión Na+ y disminuyen el riesgo de sodicidad. El agua presenta alta variación en su composición iónica, sin embargo, el magnesio, nitrógeno, fósforo y potasio se encuentran en nivel adecuado al igual que el pH, su aporte a través del agua de riego disminuye el costo de fertilización para obtener altos rendimientos.

Agua Residual, Calidad, Nutrientes, Fertilizantes

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Introduction

The Mezquital Valley, located in the state of Hidalgo, is an agricultural area, with more than 90,000 ha, where 59% of the state's total production is obtained (García-Salazar, 2019). It is a semi-arid region, where annual rainfall varies from 350 to 500 mm, resulting in a low amount of water available for plants. This area mainly produces crops such as maize (Zea mays) with 41,950 hectares, alfalfa (Medicago sativa) 41,526 hectares, beans (Phaseolus vulgaris) with 4,398, fodder oats (Avena sativa) 3,146 hectares, barley (Hordeum vulgare) and wheat (Triticum spp), all irrigated with residual water (RA) since 1912. It should be noted that according to the National Water Commission (Conagua, 2009), MV crops fall into the category of crops conditioned for irrigation with wastewater. Currently, the Mezquital Valley is known as the second region in the world with the highest use of wastewater in the agricultural sector, as well as the largest sewer in the country for the amount of water it receives, water that comes from the metropolitan area of the Valley of Mexico (ZMVM) and is sent to Hidalgo without any prior treatment.

Currently, part of this water reaches the main irrigation districts (DDR) of the state, 003 Tula, 100 Alfajayucan and 112 Ajacuba, its distribution is shown in Figure 1 and is considered the largest in the world (Islas, 2011) to be distributed in the region. The amount of RA amounts to 1,467,993.8 thousand cubic metres per year (García-Salazar, 2019), however, the installed capacity for urban water treatment is 8,655 L/s and only 4,353 L/s are processed. For industrial treatment, there is an installed capacity of 1,297 L/s, of which 851 L/s are treated, so large amounts of RA are generated, of which only 11.3 % are treated. In Hidalgo, an average volume of 31 to 56.6 m3/s of untreated RA is received (CONAGUA, 2009; Jiménez-Cisneros et al., 2004). In 2016 CONAGUA started the operation of the Wastewater Treatment Plant (WWTP) in Atotonilco de Tula, with a capacity of 35 thousand L/s, although on average only 23 thousand L/s are treated and an additional 12 thousand L/s in the rainy season (CONAGUA, 2016-2017, García-Salazar, 2019), considered one of the largest in Latin America and worldwide, with the objective of treating up to 60% of the water received through primary, secondary and tertiary treatment.

For many farmers, it represents a great economic benefit as the supply is permanent, unlike rainwater, which can be seasonal or erratic. While the use of this water on crops is attractive because of its accessibility and the low cost of fertiliser, due to the high content of nutrients and organic matter. As a result, farmers are able to obtain higher yields per unit area at a lower cost. Even after applying a treatment, the RA can supply 225 kg of nitrogen and 45 kg of phosphorus per hectare per year, which reduces or eliminates the need for supplementary fertilisation.

Figure 1 Map of irrigation districts 003, 100 and 112 located in the Mezquital Valley, within the south-central region. 100 and 112 located in the Mezquital Valley, within the south-central region
Source: (Siebe, 2020)

Although there are also multiple negative impacts (Siebe, 1994; Chen et al, 2005; García-Salazar, 2019) in the social, environmental and economic spheres, from health problems, soil contamination by the presence of bacteria, viruses and parasites that pose risks to the crops themselves, if the water comes from industrial effluents, it may present certain chemical contaminants such as heavy metals, as some of them are toxic to plants, soil and of course human health, many of them can be absorbed by crops affecting their productive potential (Hernández-Silva, 2014; Garcia-Salazar, 2019) irrigation can also generate unfavourable effects on the soil, such as salinisation or sodicity due to the excessive accumulation of salts, when the concentrations of some ions are high, which decreases crop yields and makes the soil susceptible to erosion and finally economic inequality among farmers due to wastewater hoarding.

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The operation of the PTAR Atotonilco has generated controversy among farmers, some of them; They consider that the treatment of the RA will imply an increase in the tariffs for the water they use, a reduction in the volume of water they receive and a decrease in the nutrients in the crops derived from the treatment, which will lead them to invest in fertilisers, and loss of harvests, It is therefore proposed to evaluate water quality in relation to the content of nutrients nitrogen (NO^{3-}, N-NO^{3-}), phosphorus (PO_4^{-3}, P_2O_5), potassium (K^+, K_2O), magnesium (Mg^{2+}), sulphur (SO_4^{-2}), calcium (Ca^{2+}), pH and EC after treatment for use in agricultural irrigation.

Methodology

Samples were collected from the main drainage canal that runs through the Polytechnic University of Francisco I. Madero within the DR003 -Tula. Simple sampling was carried out once a week from April to August. Sampling was carried out in accordance with NMX-AA-003-1980. All the analyses mentioned below were carried out in triplicate. For nitrate determination, the APHA-AWWA-WEF (2005) methodology was used, method 4500-NO_3- B; method 4500- SO_4^{2-} E., method 4500-P A, C and E., method 3500-Ca B; 3-83 and 3-84 method 3500-Mg B for pH, a potentiometric method was used (APHA, 1995. 4500-H+B) and finally for electrical conductivity a conductivity meter (APHA, 1995. 25108).

Results

The pH of the water is classified as slightly alkaline and shows a variation between 7.2 and 8 according to figure 2, coincides with that reported by other authors (Pérez-Díaz et al; 2020, Ontiveros-Capurata et al; 2013), which allows the water to be used for agricultural irrigation without effects on the soil.

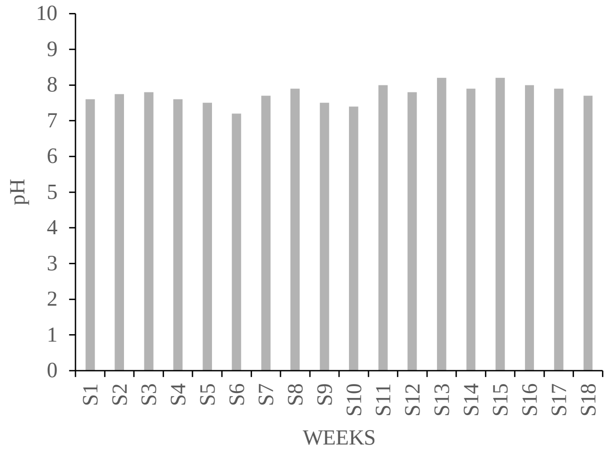

Figure 2 Average hydrogen potential in wastewater
Source: Own elaboration, 2021

The electrical conductivity (EC) is considered a medium to high risk (figure 3) for use as irrigation water, due to the risk of salinity in soils and affecting crops with low or no tolerance to salinity. The use of wastewater in crop irrigation can induce salinisation processes in soils in the long term, especially because of the ion values and EC (Flores Avalos, 2015).

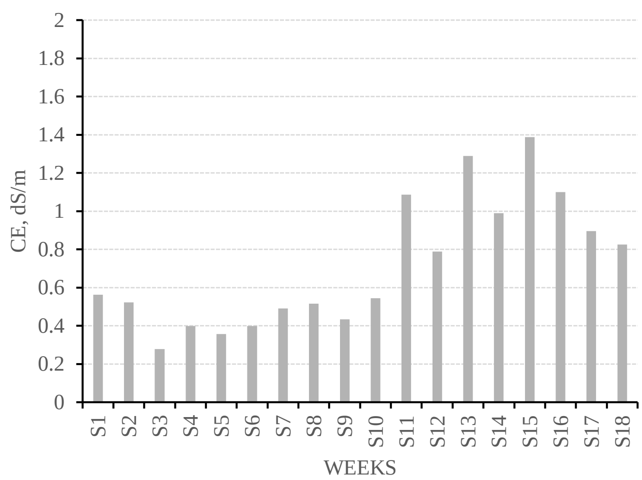

Figure 3 Average electrical conductivity in wastewater
Source: Own elaboration, 2021

It has been found that the wastewater analysed presents representative quantities of nutrients such as nitrates, phosphate, potassium, calcium and magnesium. For calcium and magnesium, the amounts in mg/L are double that of potassium as shown in figure 4, which is why the EC values are medium to high, while potassium is at the values reported by Perez-Diaz (2019).

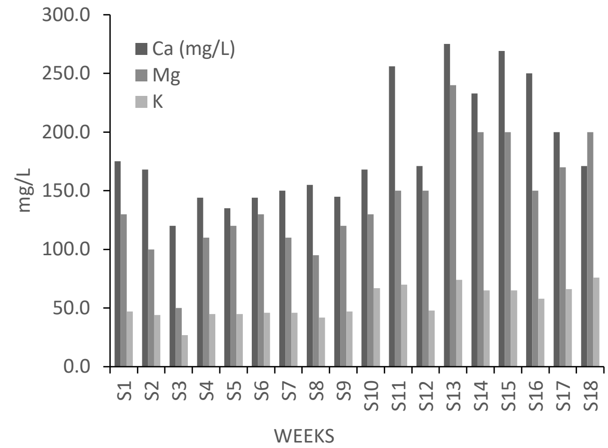

Figure 4 Calcium, magnesium and potassium values in wastewater
Source: Own elaboration, 2021

The presence of Ca^{2+} added to the soil through irrigation water can counteract the effect of the Na+ ion in the soil, which, although not determined in the study, reduces the risk of sodicity in soils and improves the structure. Wastewater (RA) has a high variation in its ionic composition.

Figures 5 and 6 show the results for phosphorus and nitrogen present in the wastewater. Nitrogen-nitrogen presents a risk due to the contamination that can be generated, as it is easily washed out and can be lost and cause contamination towards groundwater, something very similar happens with phosphorus, both ions also represent a risk for aquatic organisms when RA are not used for irrigation and are discharged into water bodies causing severe problems of eutrophication.

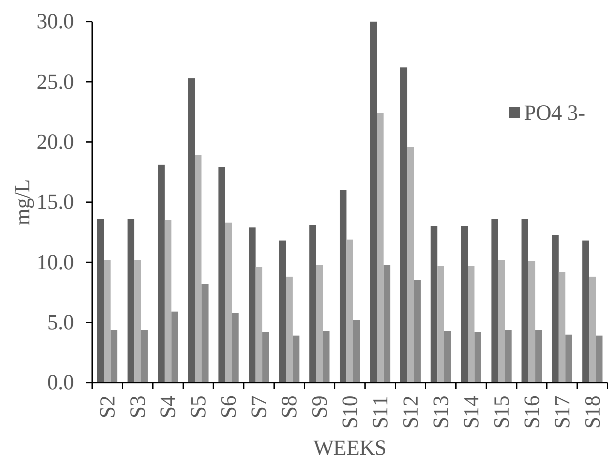

Figure 5 Phosphorus values in the form of phosphate in wastewater
Source: Own elaboration, 2021

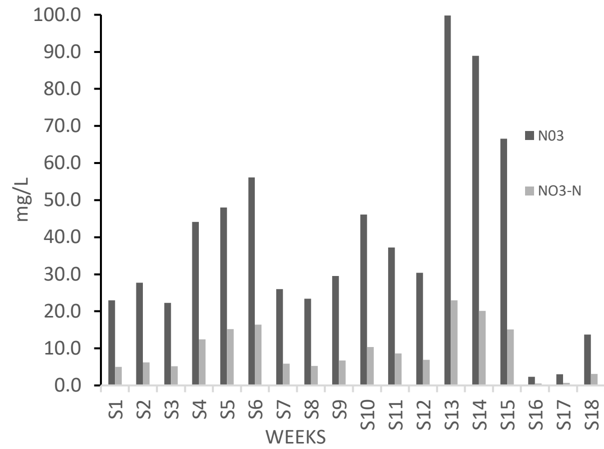

Figure 6 Nitrogen values in the form of nitrate and nitrate nitrogen in wastewater
Source: Own elaboration, 2021

Conclusions

The AR presents a high variation in its ionic composition. However, the pH is suitable for use as irrigation water.

The electrical conductivity is considered medium to high risk for use as irrigation water, as it can cause salinity in soils and affect crops with low or no tolerance to salinity.

The presence of Ca^{2+} and Mg^{2+} added through irrigation water can counteract the effect of the Na+ ion in the soil, which, although not determined in the study, reduces the risk of sodicity in soils.

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