

Study of the social significance of water and its treatment in La Reforma, Alto Lucero de Gutiérrez Barrios, Veracruz, Mexico: interests and opportunities

Irma Zitácuaro-Contreras ¹, Aarón López-Roldán ¹, Sergio Zamora-Castro ², José Luis Marín-Muñiz ^{3,*}, Juan Antonio Triana-Tello ⁴, Neira Sánchez-Zárate ³, Luis Manuel Álvarez-Hernández ¹, Karina Elizabeth Martínez-Aguilar ¹

¹ Posgrado Desarrollo Regional Sustentable. El colegio de Veracruz, Xalapa, Veracruz, México.

² Facultad de Ingeniería, Construcción y Hábitat. Universidad Veracruzana. Boca del Río, Veracruz, México.

³ Ingeniería Ambiental. Tecnológico Nacional de México/Instituto Tecnológico Superior de Misantla, Veracruz, México.

⁴ Facultad de Ingeniería Mecánica y Ciencias Navales. Universidad Veracruzana. Veracruz, México.

* Corresponding author: jmarinm@itsm.edu.mx; Tel.: (+52 2281624680)

Received: May 11, 2025

Accepted: June 4, 2025

Published: June 11, 2025

DOI: <https://doi.org/10.56845/rebs.v7i1.453>

Abstract: The treatment of wastewater in rural areas presents a multifaceted challenge that requires collaboration among government entities, academic institutions, and community members. In Mexico, over 184,000 rural communities lack adequate sanitation systems, leading to significant social and environmental issues. Non-conventional technologies, such as constructed wetlands (CWs) present favorable solutions for rural communities due to their environmental, economic, and social advantages. This study employed documentary research, participant observation, and structured interviews conducted door-to-door in the La Reforma community, located in Alto Lucero, Veracruz, Mexico. The aim was to assess residents' knowledge regarding environmental issues and the management of the community's wastewater, as well as their interest in adopting a non-conventional sanitation system, specifically a treatment wetland. The findings indicate that while the population is aware of water pollution, they lack in-depth knowledge regarding specific details. Although they are unfamiliar with sanitation infrastructure based on constructed wetlands, they expressed a desire for a treatment system when introduced to basic concepts and showed willingness to collaborate on the project. The initiative enjoys social acceptance, and the next phase will involve governmental coordination for implementation, with municipal authorities and academic participation identified as key stakeholders.

Keywords: Wastewater treatment, social participation, communal benefits, constructed wetlands.

Introduction

The development of rural communities through economic initiatives has focused on enhancing health services, food security, poverty alleviation, the delivery of essential services, and productivity, particularly within the agricultural, livestock, and forestry sectors (Government of Mexico, 2022). To support these goals, there are institutional public policies in place at both the international level, such as those from the United Nations (UN), and at the national level through programs implemented by Mexico's government secretariats. However, the challenges posed by limited economic resources and the widespread dispersion of rural communities in Mexico, which numbered 184,000 and accounted for 97.7% of the total as of 2020, complicate the delivery of sanitation services. These rural areas are home to 26.6 million individuals, representing 21% of the national population, with women making up 50.6% of this demographic. This is particularly significant, as they are often the most adversely affected by inadequate access to quality water for household needs.

Among the Mexican states with the highest percentage of rural areas, the order, from highest to lowest, is as follows: Chiapas at 50.8%, Oaxaca at 50.5%, Hidalgo at 42.7%, Tabasco at 41.5%, Guerrero at 40.3%, Veracruz at 38.3%, Zacatecas at 36.7%, and San Luis Potosí at 32.8% (Government of Mexico, 2022; INEGI, 2024). This situation has resulted in the identification of a significant issue in rural areas: the lack and poor quality of water, which accounted for 18.4% of the ten most prevalent problems in these regions (INEGI, 2020). The National Institute of Statistics, Geography and Informatics (INEGI) estimates that over 57,000 rural areas (31.0% of the total) are at risk due to the presence of polluting agents in the air, land, or bodies of water. Furthermore, sewage management presents a challenge, as open dumping aggravates public health issues through direct exposure to contamination sources. Currently, there are records of 22,600 rural localities (12.3%) with access to a public drainage system, where approximately 11.1 million people (41.7%) reside. This indicates that 77.5% of localities lack a sewage system, and there is no available data for the remaining 10.2%. Consequently, an estimated 15.5 million Mexicans do not have access to sewage services.

In a different context, data from the Government of Mexico (2022) indicates that Veracruz ranks among the states with the highest number of rural communities. However, the region's diverse topography leads to a significant dispersion of

these communities, posing challenges in providing essential services, including sewage and wastewater treatment. Veracruz stands fifth in the nation in terms of community count, encompassing a total of 19,500, which represents 10.6% of the country's total. This area is home to 38% of Veracruz's population, amounting to approximately 8.1 million people (INEGI, 2020). To foster rural development concerning sanitation and enhance health management, particularly for children, it is crucial to reduce pollution from untreated wastewater discharges by establishing the necessary infrastructure to purify contaminants. In this regard, the National Water Commission (CONAGUA) (2023) reports that Veracruz operates 94 conventional treatment plants that handle a flow rate of 4,380.8 liters per second. These plants employ various processes, including biological discs, biological filters, stabilization lagoons, aerated lagoons, activated sludge, primary treatment, advanced primary treatment, upflow anaerobic reactors (U.A.S.B.), enzymatic reactors, Imhoff tanks, and septic tanks (CONAGUA, 2025). Treatment wetlands, also known as constructed wetlands, represent non-traditional wastewater management systems in Mexico. However, in Veracruz, the number of reported treatment wetlands is limited according to CONAGUA, primarily because most systems in various communities have been implemented through academic projects.

Notably, the 94 operational treatment plants in Veracruz serve only 0.5% of the total communities in the state. This statistic highlights the significant challenge posed by inadequate sanitation infrastructure, which results in water source contamination and a rise in waterborne diseases. Given the scarcity of financial resources and the dispersed nature of rural populations, treatment wetlands emerge as a viable alternative for wastewater treatment in these areas. These systems are included in the officially recognized sanitation systems documented by CONAGUA in its statistics. Consequently, these systems are regarded as a public policy, as the operational guidelines for allocating financial resources include the development of systems based on natural wetlands with pits (CONAGUA, 2025).

Sanitation wetlands are considered alternative systems; they represent ecotechnologies that operate similarly to natural wetlands. Both systems offer essential environmental services, notably the removal of contaminants through the cultivation of plants or phytoremediation processes. This involves the use of macrophytes and ornamental species that, through research, have demonstrated their adaptability to wetland ecosystems and their effectiveness in contaminant removal at pilot, household, and community scales. Additionally, these processes are enhanced by employing substrates that promote the proliferation of microorganisms or aerobic bacterial processes in the rhizosphere of plants, alongside the carbon cycling that occurs similarly to natural wetlands (Plaza de los Reyes *et al.*, 2011; Sandoval-Herazo *et al.*, 2019; Zamora-Castro *et al.*, 2025).

Sanitation wetlands offer several significant benefits, particularly in terms of sustainable management. Environmentally, they contribute to returning water of a higher quality to the ecosystem than what originally entered the system. Additionally, these wetlands utilize local materials and native plants, minimizing any adverse environmental impact. From a social standpoint, they foster community engagement by building social capital through outreach initiatives, which helps elevate the recognition of civic groups responsible for managing sanitation infrastructure. Evidence suggests that bioengineered wetlands are conducive to community involvement in their operation and maintenance. Economically, they stand out as a cost-effective alternative, as they do not necessitate substantial investments from government, academic, or community sources; their construction costs are significantly lower than those of traditional infrastructure (Hernández, 2016; Zitácuaro-Contreras *et al.*, 2021). These characteristics make sanitation wetlands particularly viable for implementation in rural areas where government funding may be limited.

In the State of Veracruz, the municipality of Alto Lucero de Gutiérrez Barrios faces significant wastewater challenges, particularly in the area of La Reforma, which is home to 1,335 residents. These inhabitants currently lack access to wastewater treatment services, leading to severe water and soil contamination issues. While alternative solutions could be introduced through effective governance strategies, it is crucial first to understand the principles of ecotechnology and to assess the interest, commitment, and potential for social participation within the La Reforma community. Accordingly, this study aims to explore the residents' awareness of environmental issues and the management of local wastewater, as well as their willingness to implement an unconventional sanitation system.

Materials and Methods

Study Area

The study was conducted in the rural locality of La Reforma, situated in the municipality of Alto Lucero de Gutiérrez Barrios, Veracruz, Mexico (see Figure 1). This area is located in the central part of the state of Veracruz at coordinates 19°35'46" N, 96°38'02" W, and is positioned at an altitude of 684 meters above sea level (PueblosAmerica, 2024). It lies approximately 11 km from the municipal seat of Alto Lucero.

As of 2020, the population of La Reforma was 1,330, with a slight male predominance at 50.7%, while females constituted just under 49.3%. The fertility rate in the area is 2.35, and recent census data indicates a population decline of 4.4% over the last 15 years. Notably, only 6.8% of the population is under 5 years old, whereas 23.3% are aged 60 and older. The community consists of 464 homes, which enjoy access to electricity (99.78%), water (99.57%), and sanitation services (99.14%). However, sewage coverage details are unspecified, and the area lacks sanitation infrastructure (PueblosAmerica, 2024).

There is no documented account of the indigenous population; however, education rates remain low (see Table 1), and primary education completion rates fall short of expectations, despite a decrease in illiteracy rates over the past decade. Access to higher education is restricted due to insufficient educational infrastructure. Economic activities in the region include agriculture, livestock farming, and commerce, particularly in the production of mangoes and passion fruit.



Figure 1. Location of the community La Reforma, Alto Lucero, Veracruz, Mexico.

Table 1. Schooling in La Reforma, Alto Lucero, Veracruz.

	2020	2010
Illiterate population (Total)	15.96%	18.72%
Illiterate population (hombres)	8.09%	19.25%
Illiterate population (mujeres)	7.87%	18.18%
level of schooling (Total)	5.96	5.14
level of schooling (man)	6.11	5.04
level of schooling (woman)	5.8	4.24

Source: PueblosAmerica (2024).

Methodology

The research employed a mixed-methods approach, combining documentary research with qualitative and quantitative data analysis (see Figure 2). This exploratory study utilized measurement instruments, including a structured interview format designed for house-to-house administration by a group of 11 graduate students. Statistical analysis was conducted to process the data, employing descriptive measures of the variables (Casado, 2007).

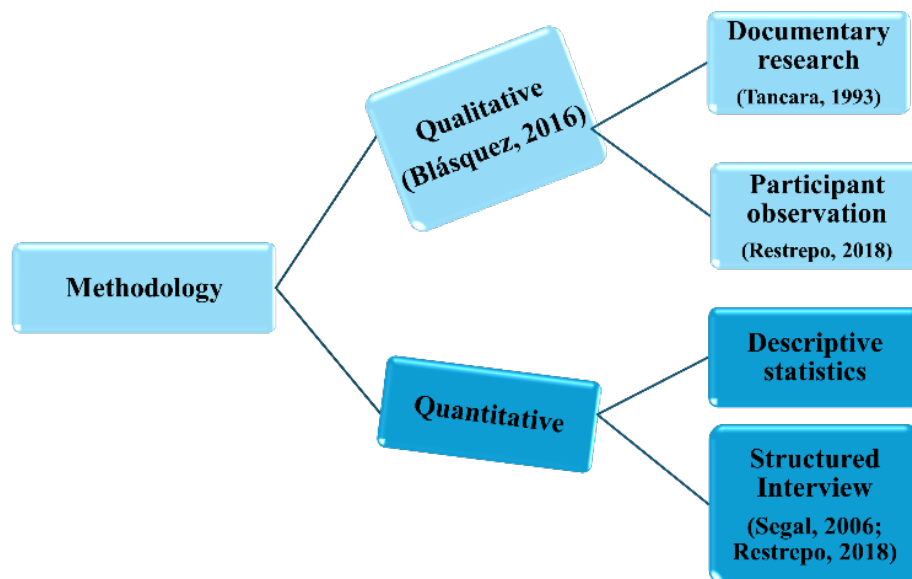


Figure 2. Methodological Process.

To determine the sample size for the interviews, the finite population equation was applied, taking into account the total number of homes in the community (464) (Rojas *et al.* 2014) (equation 1; $n \geq (Nz^{2_{1-a/2}}PQ / z^{2_{1-a/2}}PQ + d^2(N-1))$). Here, n represents the sample size, N denotes the population size, z is the value corresponding to the Gaussian distribution (1.96), p signifies the estimated population proportion, and d denotes the precision level (0.05), with a confidence level of 95%. This calculation resulted in a sample size of 107 subjects, which corresponds to the number of interviews conducted.

Results and Discussion

The absence of wastewater treatment in the La Reforma community has led to a widespread practice of reusing wastewater for agricultural irrigation. However, the absence of proper treatment has led to unsanitary conditions that compromise the quality of agricultural produce and pose significant public health risks for farmers, consumers, and the wider community. This study included an investigation into the awareness among La Reforma residents regarding the environmental conditions related to water and the disposal of the community's wastewater. Additionally, it aimed to gauge potential interest in collaborating with academic institutions and government authorities to establish a wastewater treatment system for urban public sources. Such an initiative is essential to mitigate the soil contamination in agriculture areas and to protect the groundwater tables of the Actopan Valley aquifer (Conagua, 2024). This contamination occurs by infiltrates the subsoil, either by gravity through unlined channels or through its reuse in agricultural irrigation.

To assess the population's knowledge, we began by identifying the sample group that provided the basis for our results. The interviews were conducted in the morning, leading to a predominance of female participants, although males were not excluded and represented just over a quarter of the sample (Figure 3a). The age of participants ranged from 15 to 95 years, with the majority—50%—falling within the 46 to 65 age brackets. Notably, among the 6% of adults aged 76

to 95, many live alone. Consequently, the issue of contaminated water discharge is not significant, as this demographic constitutes a very small percentage (Figure 3b).

The reported level of education among the population is primary education (PueblosAmerica, 2024), which aligns with the findings from the structured interview (Figure 3c), where 49% of participants indicated they have a primary education. This should not raise concerns, as the textbooks cover fundamental topics such as the responsible use of natural resources, particularly water, which is emphasized as essential for resource preservation (Zitácuaro-Contreras *et al.*, 2024). This is further supported by environmental education theory, which highlights its connection to formal education (Gaudiano, 2001). This theory suggests that environmental education has been enhanced through teacher training in environmental issues and the sustainable use of natural resources. Therefore, the educational level enables the application of more effective resource practices, which can also lead to sustainability (Fedulova *et al.*, 2019). Given these findings, the population possesses the knowledge to comprehend the origins of water pollution and the implications of discharging untreated water. The key lies in actively engaging them in the pursuit of solutions to address their pollution challenges.

One key factor influencing wastewater generation is the occupation of the population. In the sampled interviews, the predominant activity is homemaking, accounting for 50% (Figure 3d), which aligns with the observation that the majority of respondents are female (Figure 3a). This is followed by agricultural work, representing 17%, which is significant as many individuals are typically employed in the fields during the morning hours. However, interviews were conducted exclusively in the morning due to safety concerns on the roads in the area. Notably, there is no industrial activity present, which contributes to the relatively low severity of the pollution issue, as industry is the economic sector responsible for the highest levels of pollutants (CONAGUA, 2022). Additionally, given that this is a rural community with a population of fewer than 2,500 inhabitants, economic activities exert little influence on pollutant generation. Nevertheless, it is crucial to recognize that community wastewater discharges can pose infection risks for residents as well as for local crops, flora, and fauna.

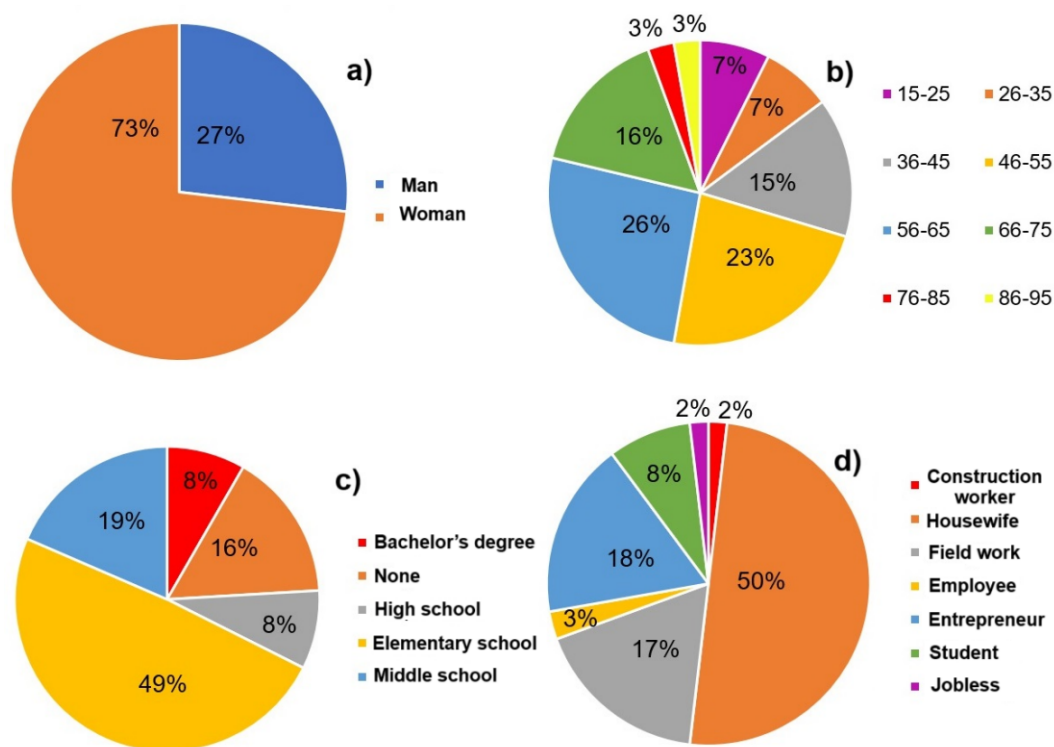


Figure 3. The figure presents the following variables: a) Sex, b) age, c) educational level, and d) occupation.

The second section involved analyzing the data to assess whether the interviewed participants were aware of the destination of the wastewater generated in homes in La Reforma. Due to the absence of drainage coverage data, the findings from the measurement instrument indicated that a significant majority (93%) of homes are connected to the

drainage network (see Figure 4a). Additionally, 72% of respondents were able to identify the discharge points (Figure 4b). These discharge points are located on the outskirts of the town and function through gravity runoff. One of the points involves collecting the water in a well, from which it is subsequently reused for certain agricultural irrigation activities via pumping.

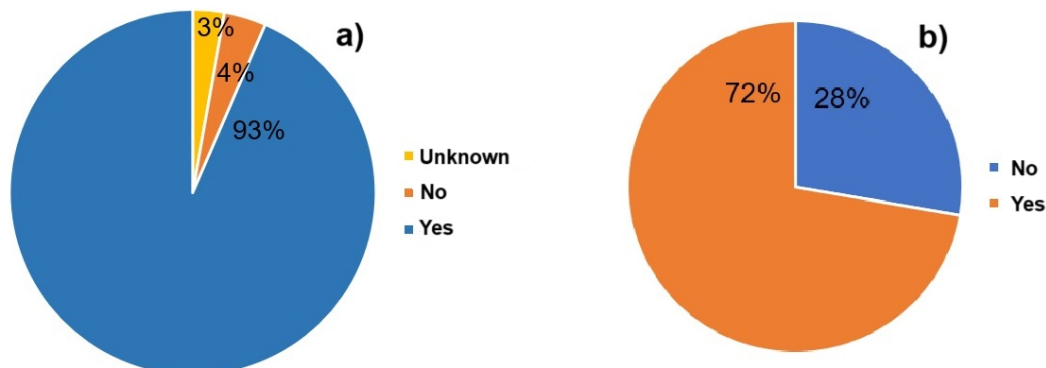


Figure 4. a) House connected to the sewer, and b) destination of the water discharge.

Once it has been established that the homes are connected to a sewer service, the implementation of a wastewater treatment system can proceed. However, this implementation must be supported by community involvement to ensure the project's sustainability in both operation and maintenance. Furthermore, when asked if measures are being taken to prevent water pollution, 60% of respondents indicated that they do not engage in any such activities. This suggests that while awareness of environmental issues may exist, practical application has not been realized. This situation is not directly related to education; at the primary level, environmental topics concerning the conservation of natural resources are indeed taught. According to Piaget (1991), children at this stage exhibit characteristics that foster an understanding of environmental responsibility and the ability to conceptualize problems and translate them into solutions through practical action in their social environments. Additionally, it is evident that treated water can have a secondary use. As illustrated in Figure 5b, opinions expressed indicate that treated water can be reused at home for various purposes, such as washing sidewalks, watering plants, cleaning cars, and maintaining domestic and animal areas.

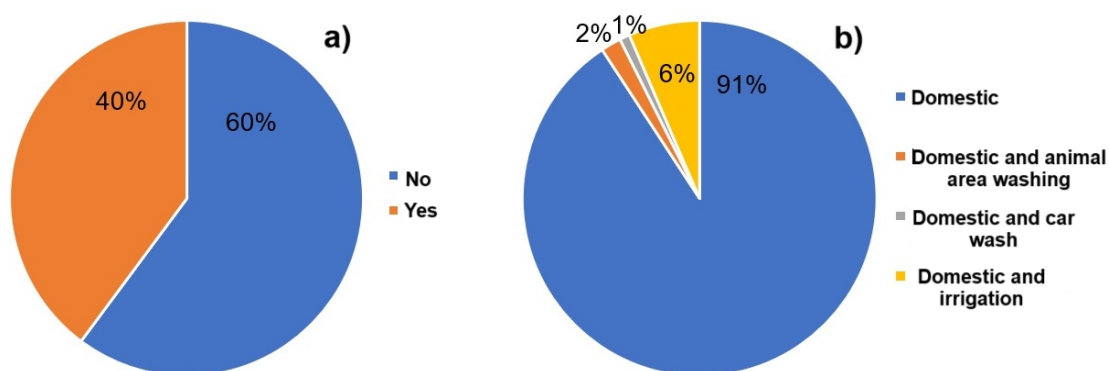


Figure 5. The questions posed included: a) Are you taking any measures to prevent water pollution? and b) What potential uses could treated wastewater have?

Another analytical approach involved creating opinion clouds to capture what certain environmental issues signify. Water quality is associated with the positive aspects of water use essential for sustaining life and ensuring that it is safe for consumption (see Figure 6a). Interviewees expressed that caring for water represents life itself; it is viewed as a necessity and an act of stewardship. However, opinions vary widely, with some demonstrating a lack of engagement and highlighting an insufficient understanding of how to protect this vital resource. This underscores the need for awareness-raising initiatives focused on water culture (refer to Figure 6b).

The next mandatory question followed a brief explanation of constructed wetlands, including images and highlighting their benefits for wastewater sanitation. Participants were then asked if they would be willing to assist in the construction of a treatment wetland, either through active participation or by providing materials. It was encouraging to discover that 95% of the sample expressed their willingness to contribute to the project. While community and academic involvement is assured, government participation is still in the planning stages.

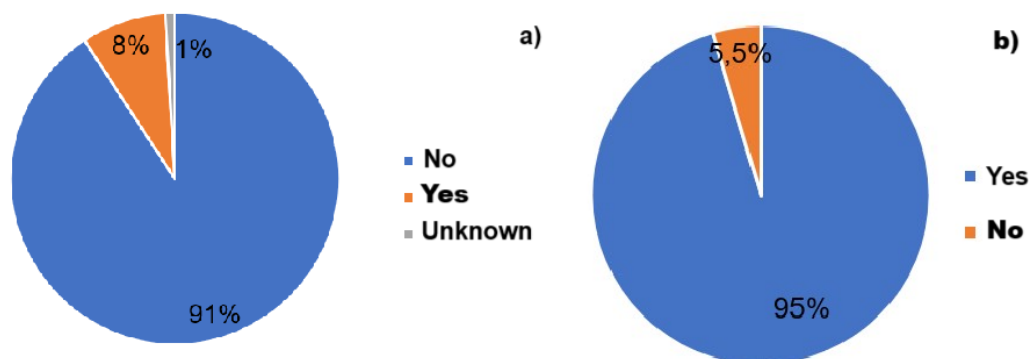


Figure 8. a) Are you familiar with the concept of a wetland? b) Would you be willing to take part in the construction of a treatment wetland?

The evidence presented indicates a general understanding of topics related to water, including its quality, distribution, and conventional conservation practices. However, this knowledge is not widespread; technical concepts, the environmental benefits these systems provide, and their social advantages remain largely unknown. Additionally, the motivations for social participation and the development of social capital are not well understood. Similarly, the collaborative efforts required for the construction, operation, and maintenance of these systems are unfamiliar to many. Consequently, the successful implementation of a sanitation project necessitates the engagement of the community and the cultivation of the essential capital for effective system management. In the initial phase of the sanitation project in the La Reforma community, social interest in the initiative has been documented.

It is important to highlight that studies of this nature are essential for advancing proposals aimed at addressing local issues. In the State of Veracruz, the Ministry of the Environment (SEDEMA) has been actively promoting financial support for environmental development over the past several years. One promising option for such support projects is the installation of sustainable water purification systems. These initiatives aim to tackle community challenges through collaboration with both society and academia. Consequently, having access to this information facilitates the development of preliminary projects for participation in relevant funding opportunities. Furthermore, it underscores the collaborative efforts that can be undertaken by all stakeholders for the greater good: a healthy environment and a responsible society.

Future studies could explore the areas suitable for intervention in treatment systems, as well as the establishment of leadership groups to support the various activities involved in the process. These activities may include system design, determining the strategic implementation point where the water to be treated arrives via gravity, training operators, monitoring resources, and conducting awareness-raising initiatives, among others.

Conclusions

The implementation of sanitation systems utilizing environmentally friendly ecotechnologies, such as constructed wetlands, is particularly well-suited for rural areas. The lack of awareness regarding ecotechnology hinders the generation of interest necessary to promote the use of government resources for the implementation of systems that adhere to the guidelines outlined in this public policy. The study revealed that while there is a general understanding of issues related to water resource preservation, this knowledge does not translate into a demand for sanitation infrastructure, nor does it foster community-driven construction efforts. Wastewater treatment solutions in rural areas present a viable option, provided that the population is informed about the requirements, as these systems are relatively straightforward to implement from environmental, economic, and social perspectives. Management should

be integrated to enable municipal authorities to implement these systems in alignment with the powers granted to them by the Mexican Constitution. In the state of Veracruz, there are various projects funded by the Ministry of the Environment of the state government, operated and maintained by organized civil society and academia. These initiatives adhere to a governance framework that has proven effective and contributes to a healthy environment, a fundamental human right established in the Constitution. The research conducted in this study highlights the necessity for awareness-raising actions focused on water culture, the implementation of eco-technologies for water treatment, and understanding the impacts of using wastewater for agriculture. The public's interest in the development of eco-technologies serves as an important first step in shaping these initiatives.

Acknowledgments and Funding: We extend our heartfelt gratitude to SECIHTI in Mexico for their generous funding of scholarships for graduate studies. Additionally, we would like to acknowledge the contributions of the graduate students in Sustainable Regional Development who supported us during the interview phase: Nelson Andrés Losada Rodríguez, Yennis Ramos Pérez, Damaris González Rivadeneyra, Claudia Muñoz Aguilar, and David Mejía Escobar.

Author contributions: I.Z-C, and A.L-R: writing, design, data collection, editing. L.M.A-H and K.E.M-A: data collection and capture, and analysis of data. J.L.M-M conceptualization, design, supervision. S.A.Z-C., N.Z-S, and J.A.T-T: Provide materials and edition of the methodology.

References

- Blásquez, M. L. I. (2016). La etnografía: una aproximación metodológica para la comprensión de los procesos sociales. En M. Guereca, T. (Ed), *Guía para la investigación cualitativa: etnografía, estudio de caso e historia de vida*. Universidad Autónoma Metropolitana.
- Comisión Nacional del Agua (CONAGUA). (2022). *Numeragua*. Gobierno de México.
- Comisión Nacional del Agua (CONAGUA). (2023). *Inventario de Plantas Municipales de Potabilización y de Tratamiento de Aguas Residuales en Operación*. México. Gobierno de México.
- Comisión Nacional del Agua (CONAGUA). (2025). *REGLAS de Operación del Programa de Agua Potable, Drenaje y Tratamiento (PROAGUA), a cargo de la Comisión Nacional del Agua, aplicables a partir de 2025*. Gobierno de México,
- Comisión Nacional del Agua (CONAGUA). (2024). *Actualización de la disponibilidad media anual de agua en el acuífero Valle de Actopan (3005), Estado de Veracruz*. Gobierno de México.
- Fedulova, I., Ivanova, V., Atyukova, O., y Nosov, V. (2019). Inclusive education as a basis for sustainable development of society. *Journal of social studies education research*, 10(3), 118-135.
- Gaudiano, E. G. (2001). Otra lectura a la historia de la educación ambiental en América Latina y el Caribe. *Desenvolvimento e Meio ambiente*, 3, 141-158.
- Gobierno de México (2022). ¿Qué nos dice el Censo de Población sobre la juventud rural de nuestro país?, Consultado el 25 de febrero de 2025 <https://www.gob.mx/siap/articulos/que-nos-dice-el-censo-de-poblacion-sobre-la-juventud-rural-de-nuestro-pais?idiom=es#:~:text=M%C3%A9xico%20cuenta%20con%20189%2C432%20localidades%20a%20lo,del%20total%20de%20las%20localidades%20del%20pa%C3%ADs.&text=Asimismo%2C%20la%20poblaci%C3%B3n%20joven%20en%20las%20localidades,del%2017%20de%20la%20poblaci%C3%B3n%20rural%20total>
- Hernández, A. M. E. (2016). Humedales ornamentales con participación comunitaria para el saneamiento de aguas municipales en México. *RINDERESU*, 1(2): 01-12.
- Instituto Nacional de Estadística y Geografía (INEGI) (2024). *¿Qué hay en las localidades rurales de México?* Consultado el 20 de enero de 2025. https://www.inegi.org.mx/contenidos/productos/prod_serv/contenidos/espanol/bvinegi/productos/nueva_estruc/889463915119.pdf
- Instituto Nacional de Estadística y Geografía (INEGI) (2024). *Información por entidad Veracruz*. Consultado el 28 de enero de 2025 <https://cuentame.inegi.org.mx/monografias/informacion/ver/poblacion/default.aspx?tema=me&e=30>
- Martínez-Aguilar, K.E., Marín-Muñiz, J.L., Álvarez-Hernández, L.M., Defín, E., Zamora-Castro, S. (2024). Current status of wastewater treatment through large-scale treatment wetlands in the state of Veracruz, Mexico. *Renewable Energy, Biomass & Sustainability (REB&S)*, 6(2), 32-42. <https://doi.org/10.56845/rebs.v6i2.105>
- Piaget, Jean (1991). *Seis estudios de psicología*. España. Labor. 199 p.
- Plaza de los Reyes, C. Vera, L., Salvato, M., Borin, M., & Vidal, G. (2011). Consideraciones para la eliminación del nitrógeno en humedales artificiales. *Tecnología del agua*, 31(330), 40-49.
- Rojas, O., Sáez, K., Martínez, C., Jaque, E. (2014). Post-catastrophe social-environmental effects in vulnerable coastal areas affected by the tsunami of 02/27/2010 in Chile. *Interciencia*, 39, 383–390.
- Segal, D. L., Coolidge, F. L., O'Riley, A., y Heinz, B. A. (2006). Structured and semistructured interviews. *Clinician's handbook of adult behavioral assessment*. 121-144.
- Restrepo, E. (2018). *Etnografía: alcances, técnicas y éticas*. Universidad Nacional Mayor de San Marcos.
- Sandoval, L., Zamora-Castro, S. A., Vidal-Álvarez, M., & Marín-Muñiz, J. L. (2019). Role of wetland plants and use of ornamental flowering plants in constructed wetlands for wastewater treatment: A review. *Applied Sciences*, 9(4), 685.
- Tancara, C. (1993). La investigación documental. *Temas sociales*, (17), 91-106.
- Zamora-Castro, S. A., González-Moreno, H. R., Hernández-Orduña, M. G., Zitácuaro-Contreras, I., & Marín-Muñiz, J. L. (2025). Environmental Assessment of a Constructed Wetland with Ornamental Vegetation for Wastewater Treatment: A Sustainable Option for Neighborhoods (The Case of Veracruz, Mexico). *World*, 6(2), 50.

-
- Zitácuaro-Contreras, I., Vidal-Álvarez, M., Hernández y Orduña, M. G., Zamora-Castro, S. A., Betanzo-Torres, E. A., Marín-Muñiz, J. L., & Sandoval-Herazo, L. C. (2021). Environmental, Economic, and Social Potentialities of Ornamental Vegetation Cultivated in Constructed Wetlands of Mexico. *Sustainability*, 13(11), 6267.
- Zitácuaro-Contreras, I., Marín-Muñiz, J. I., Zamora-Castro, S. A. (2024). La educación en México hacia la sustentabilidad: un área de oportunidad para el bienestar socio-ambiental. En Ortega, P. G., Ronquillo, B. N. R. Edit. *La educación, un camino seguro para el futuro*. 114-134. IVES.
- Zurita F., Castellanos-Hernández O.A., y Rodríguez-Sahagún A. (2011). El tratamiento de las aguas residuales municipales en las comunidades rurales de México. *Revista Mexicana de Ciencias Agrícolas*, 1(1), 139-150.