Article

Participatory diagnosis for the transfer of ecotechnology in a rural community of Oaxaca

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Abstract

The objective of this work was to diagnose in a participatory way the rural community of San Miguel Tlanichico, Oaxaca, Mexico in 2020, to determine the feasibility of implementing an appropriate technology, as a proposed solution to the problem of wastewater sanitation (SAR). The methodology was carried out in two phases; In the first phase, a bibliographical review of the natural and built environment of the San Miguel Tlanichico community was carried out and in the second phase, field trips were carried out where a survey with 27 items was applied in four thematic axes: 1) perception of the problem; 2) culture of water; 3) sewage treatment; and 4) willingness to train in technologies for wastewater treatment. This was applied in a census to 137 people from the community. Based on the diagnosis made, it was identified that 94.89% recognized that there are environmental problems in their community, 57.69% perceive water contamination as a priority problem, 30.3% indicated that they do not carry out the SAR generated and 73.72% indicated that if they attended any course to train in the construction of sanitation technologies. The previous results reflect that it is essential to know the problem and the availability of people to be able to adopt a technology, for this it is necessary to carry out participatory diagnoses and ethnography, in order to identify the culture of people and communities.

Keywords: appropriate technology, diagnosis, sanitation, wastewater.

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Introduction

Water sanitation is one of the central axes of sustainability and universal right for humanity, since it affects the three axes of sustainable development, environmental, social and economic. In the social aspect, it has a direct impact on public health because the lack of WWS manifests itself with an increase in gastrointestinal diseases of people due to direct or indirect contact with polluted water (Saavedra *et al*., 2012; Ríos, 2017). In the environmental aspect, a loss of environmental resilience caused by the discharge of wastewater (WW) without any treatment is identified (Perevochtchikova, 2013; De la Torre and Moreno, 2019) and in the economic aspect, it is reflected in excessive expenses due to investments to achieve environmental compensation (Sosa, 2012; Jaramillo *et al*., 2013).

In Mexico in 2017, 215.2 $m^3 s^{-1}$ of municipal wastewater was collected and only 135.6 $m^3 s^{-1}$ of this water was sanitized (CONAGUA, 2018). In the state of Oaxaca in 2016, 3.75 $m^3 s^{-1}$ of municipal WW was collected and only 1.071 $m^3 s^{-1}$ was sanitized, so a total expenditure of 2.679 $m^3 s^{-1}$ of untreated water had to be discharged directly into bodies of water or national assets in breach of current federal regulations on water sanitation (CONAGUA, 2016).

It should be noted that, in Oaxaca and as established by the government of the state of Oaxaca (2016), it defined for this year that its population distribution was 77% urban and 23% rural, of which 70% of rural localities do not have infrastructure to sanitize their polluted water. It is important to note that more than 80% of WW in developing countries does not receive any treatment, 40% due to high costs of conventional technologies (UNESCO, 2017). This has led to the search for technologies that comply with current regulations on WWS; however, the participation of the people who will use it is also required to achieve its acceptance and subsequent appropriation (Morales *et al*., 2015; Buendía *et al*., 2019).

When planning a project of technology transfer in the communities, it is first necessary to make a diagnosis, which can be carried out with different methods, such as that proposed by Mori (2008), who considers a qualitative and participatory method with the use of ethnographic techniques. Maya and Holgado (2017) suggest a diagnostic methodology, through the NETMAP technique, through discussion groups with the application of sociograms, in order to analyze key actors to achieve an effective community intervention. Sandoval *et al*. (2021) carried out a community diagnosis using the learning-service (ApS) strategy methodology, under a participatory-action-research (PAR) design.

In the case of Ramírez and Camacho (2019) they developed a participatory diagnosis through a rural evaluation in Álamos, in Sonora, Mexico, participatory workshops were aplied, which were given to the community and government organizations with the purpose of identifying problems related to water scarcity and pollution, to later plan actions to solve them. The objective of this work was to diagnose the community of San Miguel Tlanichico in Oaxaca (SMTO), Mexico, which has environmental problems due to the lack of sanitation of its wastewater.

The methodology used for the diagnosis of the community was participatory to know the context of the problems caused by the lack of WWS and assess the possibility of implementing an innovative wastewater sanitation technology through a single-family anaerobic reactor composed of two phases. 1) upflow anaerobic sludge blanket (UASB); and 2) upflow anaerobic filter (UFAF), using materials of low cost and easily accessible in the region, this prototype is intended to be implemented in the SMTO community with a technology transfer process, which involves awareness, training, building and dissemination in order to generate these steps in a technology transfer.

Materials and methods

The municipality of Trinidad de Zaachila is located in the region of central valleys of the state of Oaxaca, Mexico, at coordinates 16° 55' north latitude and 96° 48’ west longitude, at an altitude of 1 490 m. It borders to the north with Villa de Zaachila, to the west with Santa María Róalo, to the south with Ciénaga Zimatlán, to the east with Rancho de la Estancia (INEGI, 2015b). The municipality has a total area of 21 km^2, representing 0.01% of the total of the state. It has four localities, one is urban (Trinidad de Zaachila) and three are rural (San Miguel Tlanichico, Barrio la Guadalupe and Santa María Roaló). The study where the research was carried out corresponds to the locality of San Miguel Tlanichico, located 1.37 km from the municipal seat (Figure 1).

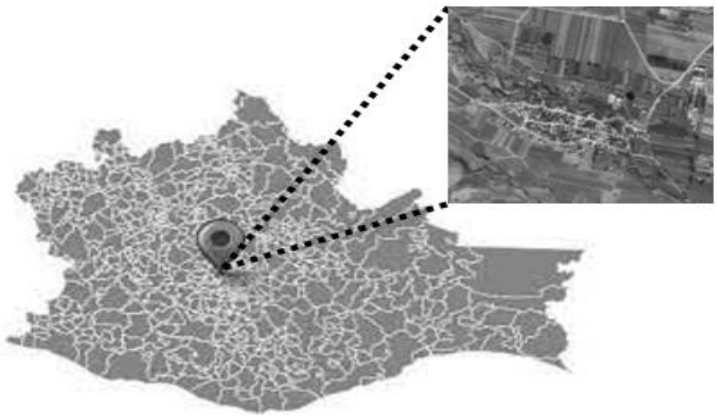

Figure 1. Location of San Miguel Tlanichico, Trinidad de Zaachila, Oaxaca.

For the development of the work, a delimitation of the study area was carried out based on the following criteria: 1) be located within the territorial limits of the community; 2) that it be located within the urban area of the population; and 3) homes with problems of lack of water sanitation. For the delimitation of the area, the SIGEIA (SEMARNAT, 2017) was used, with which the coordinates of the area of work and subsequent intervention in SMTO were obtained (Table 1).

Table 1. Location coordinates of the locality of San Miguel Tlanichico, municipality of Trinidad de Zaachila, in the state of Oaxaca.

Point	X	Y
1	735386	1873624
2	736458	1873029
3	737219	1873026
4	737383	1873994
5	736619	1874133
6	735830	1874191
Datum: NAD27	Zone: 14	Band: Q

Based on SIGEIA.

The methodology applied to carry out the diagnosis of the community was made up of two phases, as established by Pedroza *et al*. (2010); Ramírez *et al*. (2015). The first phase corresponded to a bibliographic review of the population to be studied, focused on the search for information on the natural and artificial environment and the identification of critical areas with homes that do not treat their wastewater. In the second phase, ethnographic methods were applied (Bolio and Bolio, 2013; Romero and Hernández, 2015), whose techniques were field tours and informal talks with residents and municipal authorities of the community to know their perception of the problem of lack of WW sanitation.

At this stage, a survey was designed and applied, which consisted of 27 questions grouped into four thematic axes. a) perception of the problems; b) water culture; c) WW sanitation; and d) willingness to train in technologies for WW treatment. The instrument considered six questions to identify the perception of the problems, two to inquire about the culture of water, ten questioned about WW sanitation practices and three questions to identify the willingness of people to train in the building of water sanitation technologies in their homes.

For the application of the survey, a community census was carried out in the homes of SMTO according to the research carried out by Aular *et al*. (2010). It is important to note that, when carrying out the first field tour in the community in May 2020, it was identified that, of the 146 houses built, only 137 are inhabited. This census was carried out through home visits, where the survey was applied to the owners of the houses or a member of the family over 18 years of age. Descriptive statistics were used to report the data obtained from the survey. The answers were grouped into tables, which indicate the frequency with the coincidence of the answers (F); likewise, the percentage according to the total of respondents (%) is indicated.

Results and discussion

First phase of the diagnosis

According to the search for bibliographic information, the locality of SMTO has a population of 830 inhabitants: 44.59% men and 55.41% women in a total of 147 inhabited homes (INEGI, 2015). According to the Secretaría de Bienestar (2020), this locality is classified as highly marginalized,

high social backwardness and rural area of priority attention in the state of Oaxaca, in which there is a deficiency in basic services such as electricity, drinking water and drainage. It should be noted that 100% of homes do not have access to drainage, generating an estimated 1.44 L s^{-1} of WW without any treatment and discharged mainly to the soil.

Regarding the diagnosis of the natural environment, it was identified that the type of climate present in the locality corresponds to the semiarid (Bsh1w) and semi-warm subhumid (A)C(wo) types based on the Köppen system (CONABIO, 2022). For its part, INEGI (2015) considers it as a type of climate that corresponds to the group B semi-dry temperate with rains in summer and low precipitation during the winter. An important fact for the purposes of the project corresponds to the estimated average consumption of drinking water in the community, which, according to CONAGUA (2015), is 203 L $inhabitant^{-1}$ day^{-1}.

In relation to its hydrology, the locality is immersed in the basin of the Atoyac River, sub-basin of Coyotepec belonging to the hydrological region no. 20 (RH-20), the above according to the analysis carried out by SIATL (INEGI, 2022), coinciding with what was established by INEGI (2015); SEMARNAT (2017); CONABIO (2022). This hydrological region has an area of 3 727 km^2 and is located southeast of the Mexican Republic in the central region of the state of Oaxaca (SEMARNAT, 2017). Based on the above data, it was possible to determine that the discharges of wastewater without any treatment directly or indirectly affect the Atoyac basin, either superficially or underground.

The locality under study is characterized by the prevalence of shrubs and steppes, INEGI (2015) establishes that, in SMTO, grasslands and induced vegetation predominate due to anthropic activities. For its part, CONABIO (2022) defines that this type of climate is characterized by the presence of induced vegetation. This information suggests that the water treated with the single-family hybrid reactor (SHR) can be reused for irrigation of green areas or discharge to soils.

During the field tours carried out on the dates from March 10 to March 13, 2020, it was identified that, in the central area of SMTO, there is little vegetation due to the action of anthropic activities. Likewise, changes in land use were observed, which are due to the building of houses, mainly in the central and northeastern parts of the population where there is a greater concentration of these, so in this area a technological proposal is urgent to give solution to the problems of lack of wastewater treatment, because this site is where there is a higher concentration of water without any treatment and discharges occur directly to the soil (Figure 2).

The diagnosis of the artificial environment was carried out through field tours during the period from March 1, 2020, to March 29, 2021, where it was identified that the houses are built mostly with masonry walls, concrete structural elements and metal sheet roofs, to a lesser extent with adobe and metal sheet walls. As for the land where the homes are located, they usually do not occupy all the space, allowing them to have a progressive growth or have other areas for gardens, cultivation and rearing of domestic animals.

Figure 2. Natural environment of the central area of the SMTO.

It was learned that the infrastructure and services in the community are minimal, the streets lack paving and there is a health center to give attention to the population. According to information obtained from interviews with officials of this clinic, there is an increase in cases of diseases, mainly gastrointestinal, due to the lack of infrastructure for wastewater sanitation (Gobierno del Estado de Oaxaca, 2013).

The field tours and informal talks in the locality were carried out in conjunction with municipal agents and community residents, in order to identify felt problems of the lack of water sanitation. The participant observation allowed knowing the context of the community, the places where people dump their polluted water, and the technologies used by the residents to treat WW. Table 2 reports data from homes in San Miguel Tlanichico, Trinidad de Zaachila, Oaxaca on the type of sanitary service they use, according to field tours.

Table 2. Indicators of the locality with problems of lack of water sanitation.

Indicator	(%)
Homes with latrine	95%
Homes with septic tank	5%
Homes with drainage connection	0%

Field tours.

Survey results

From the informal talks with the residents and the municipal authorities, it was identified that adults show interest in the sanitation of wastewater, as expressed by the municipal agent ‘the truth is that the homes do not have any way to treat their wastewater, some even throw it to the street, a solution according to the economic situation of the locality is urgent, since building a water treatment plant is very expensive, it is not enough, because we do not even have drainage’ (Cuevas, Per. Commun., April 01, 2020).

The above coincides with opinions expressed by residents of the locality 'dirty water is very serious, one cannot, sometimes the smell in the streets is too strong, neighbors have already been told not to throw it but they do not listen and we cannot stand because sometimes in the meetings of the assembly of the community we only get angry because they do not listen, we would like someone to support us or tell us what we can do with our dirty water' (Gutiérrez, Per. Commun., April 05, 2020). Another inhabitant expressed 'we cannot stand the dirt of the water, some neighbors we have tried to solve with pits, but they are already very expensive' (Avendaño, Per. Comnun., May 15, 2020).

Below, and in accordance with the methodology designed and in particular of the second phase of the diagnosis, the results found from the previously validated survey applied to the residents of SMTO are shown, it was applied in 137 homes, in a population of 93 women and 44 men, of which 16.05% were between 18 and 25 years old, 30.66% from 26 to 35 years, 48.9% from 35 to 45 years and 4.39% from 45 to 63 years old. It should be noted that the residents of the locality perceive the present problems of the lack of sanitation of WW; likewise, they recognize technologies in single-family homes to contribute to the sanitation of polluted water, and there is a good willingness to train in the implementation of appropriate technologies. Table 3 shows the perception of environmental problems by the inhabitants of SMTO.

Table 3. Do you think there are problems related to environmental pollution in your community?

Answer	Frequency	(%)
Yes	130	94.89
No	7	5.11
Total	137	100

In relation to the perception of environmental problems by the residents of the community, it was identified that a high percentage recognizes that there are problems in this aspect in the locality, which coincides with what was found by several researchers (Gädicke, 2017; López *et al*., 2021), who argue that there are different priorities to environmental problems in communities, however, these types of problems are highly perceptible by residents in rural communities due to the link between the appreciation of natural resources and anthropic activities. Table 4 shows the results of the perception of the residents in relation to the environmental problems existing in their locality.

Table 4. If the previous answer was yes, mention which ones according to the following table.

Answer	Frequency	(%)
Street pollution by garbage	37	28.46
Water pollution	75	57.69
Air pollution	2	1.54
Bad odors caused by WW	16	12.31
Total	130	100

Fifty-seven point six nine percent of the surveyed residents perceive water pollution in their locality as a priority, 28.46% recognize the pollution of the streets by urban solid waste (USW) as the preeminent environmental problem, it should be noted that, currently, these are highly perceptible problems, not only locally but globally (Iturrat, 2020; Ruiz, 2020). Table 5 describes the knowledge of technologies for water sanitation by SMTO residents.

Table 5. Which of the following technologies for WW treatment that can be implemented in your home do you know?

Answer	Frequency	(%)
Biofilter	5	16.13
Dry toilet	12	38.71
Artificial wetlands	2	6.45
Septic tank	12	38.71
Total	31	100

From the question to know to what extend people surveyed had knowledge of alternative technologies for the treatment of WW in single-family homes, 38.71% mentioned the septic tank as the best known, as well as the dry toilet; while the biofilter had a mention of the order of 16% and, as established by Ortiz *et al*. (2014), the appropriation of technologies is a fundamental step, since otherwise the technologies are abandoned, so special emphasis must be placed on social participation so that the appropriation is carried out.

Likewise, Ortega (2021) argue that the participation of users is necessary when implementing or transferring technologies for water sanitation. Rivera (2018) states that a solution proposal for the lack of compensation for the wastewater generated must promote the participation of the inhabitants in order to identify key elements for an adequate management and intervention model. Table 6 shows the results of the question related to respondents' willingness to train or receive courses in technologies for water sanitation.

Table 6. Would you attend a course and workshop to train in the building of technologies for water sanitation?

Answers	Frequency	(%)
Yes	101	73.72
No	36	26.28
Total	137	100

Seventy-three point seven two percent of the total respondents indicated that they would attend a course or workshop and, according to Ortiz *et al*. (2014), they suggest that it is of utmost importance to establish strategies for the inclusion of alternative technologies for their appropriation and empowerment. Rivera (2018) points out that, when community intervention projects are carried out to transfer technologies for wastewater sanitation, it is required that they be carried out through participatory workshops in which technical experts are not protagonists of the activities to be carried out, but rather the knowledge of people in the community is also recognized.

Conclusions

Based on the participatory diagnosis carried out in the rural locality of San Miguel Tlanichico, municipality of Trinidad de Zaachila in the state of Oaxaca, Mexico, the perception of the problem of lack of wastewater sanitation by the inhabitants of the community was identified, and the need to address this problem through a sustainable, viable and feasible proposal was recognized.

The identification of the characteristics of the natural environment and the artificial environment allowed recognizing in the first instance the feasibility of the implementation of the project either at the municipal level or at the single-family level, the above avoids that there is inadequate dimensioning for the area where it is intended to intervene and build the prototype of the proposed alternative technology, integrated by an upflow anaerobic sludge blanket (UASB) and the upflow anaerobic filter, through the use in their construction of materials that are economical and accessible to the population.

It should be noted that there is a good willingness to train in technologies for water sanitation by the inhabitants of the community, as long as there is a group of experts to guide them to a solution to their current problems, so it is necessary to define a strategic planning for the transfer of an alternative technology (SHR) that contributes to water sanitation in the community under study, this through a line of action that includes training through courses and workshops, together with a program of sensitization and awareness for proper water management.

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