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Investigating public awareness towards wastewater management in a small community

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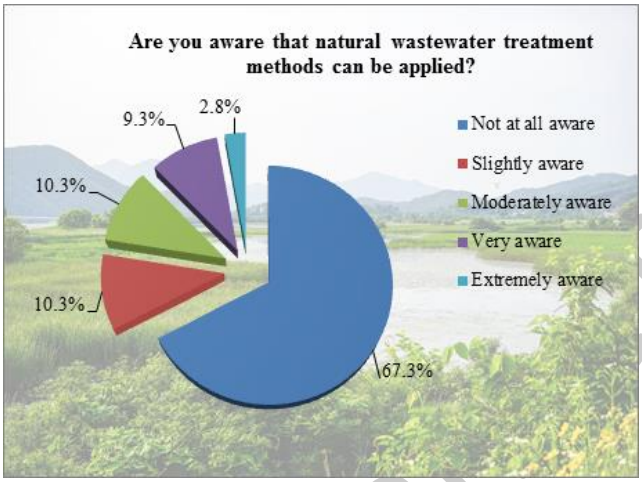
Graphical abstract



Abstract

A critical element for the successful management of wastewater in small communities is the active participation of its residents in all stages of treatment in order to ensure public acceptance. The primary purposes of this study are to identify and analyze the specific views and attitudes of the inhabitants of Leros Island, Greece, regarding (a) the performance of the wastewater treatment plant (WWTP) operating on Leros Island, (b) their level of awareness on natural wastewater treatment systems, and (c) their willingness to accept a natural wastewater treatment system. This study emphasizes the significance of a participatory approach to construct sustainable wastewater treatment systems in small communities. Findings of this study showed an apparent lack of information regarding natural wastewater treatment systems for all respondents. It is revealed that a high level of education is not directly related to high awareness of alternative wastewater treatment methods nor great acceptance of innovative wastewater treatment systems. Age showed a significant correlation with social acceptance of alternative ways of waste treatment, with people over the age of 56 shown to be most willing to apply a natural wastewater treatment system in remote areas of the Leros island. Therefore, it is evident that policies that strengthen environmental awareness contribute to a more sustainable wastewater management.

Keywords: Sustainable wastewater management, environmental awareness, wastewater reuse, water resources management, public acceptance, questionnaire survey.

1. Introduction

Public acceptance regarding the introduction of modern technologies for managing community waste is vital for both the successful operation of infrastructure and proper urban governance, although it is often overlooked as a critical factor in decision-making. Especially for alternative solutions such as natural wastewater treatment systems, which are continually gaining ground in many countries worldwide, especially in small settlements, it is necessary to investigate the level of awareness of community residents and their active participation in the systematic use of these systems. Natural treatment methods and specially constructed wetlands are accepted in European countries and the United States of America as reliable and suitable methods for primary and secondary residential wastewater treatment (Parisopoulos *et al.*, 2005; Lu *et al.*, 2016; Austin and Yu, 2016).

Europe is currently in a transitional phase in wastewater management. Due to modern know-how, there are unique opportunities to reuse water after additional treatment. Unfortunately, many countries lag in wastewater management, with significant shortcomings, even in the primary treatment stage. Every country's waste management policy frequently relies mainly on local communities, making it difficult to find direct answers to environmental challenges (Gavalakis *et al.*, 2017).

The Directive 91/271/EEC sets out the minimum necessary technical infrastructure for sewerage networks and

sewage treatment plants in the cities and towns of the European Union, distinguishing the wastewater recipients in three categories (Fotopoulou, 2005): (a) standard, (b) sensitive and (c) less sensitive. It also sets out the maximum permissible limits for the quality characteristics of treated wastewater obtained at the outflows of wastewater treatment plants. At the same time, it determines specific time limits within which settlements must complete the required infrastructure in each case, treatment and disposal of their municipal wastewater (Greek Ministry of Environment, 2012).

People living in communities with a population of under 2000 are estimated to be around 2.5 million in Greece (Greek Ministry of Environment, 2012). For these cases, the law stipulates the implementation of sewage management and treatment systems rather than the construction of sewerage networks. This adaptability enables extensive and disproportionately expensive sewerage networks while also increasing the demand for decentralized wastewater treatment and management systems. Under certain conditions, decentralized wastewater systems may become the best solution. These systems are characterized by low construction and operation costs and no specialized personnel is necessary. They can also replace the septic tank systems that may sometimes pollute the aquatic environment (Qing *et al.*, 2014).

The method of constructed wetlands can be applied for secondary or tertiary wastewater treatment, in combination with other systems or separately (mainly in small settlements <5000 equivalent persons (EP). These settlements usually have the required space for building this infrastructure (Varkas, 2007; Rahman *et al.*, 2020; Fahd *et al.*, 2007).

When comparing the constructed wetland systems to wastewater treatment plants (WWTPs), some of the critical advantages of the former are (Gratziou, 2005; Kefalakakis, 2005): (a) low construction and operation costs and minimal maintenance cost, (b) not a requirement of pumping stations and low requirement of supply networks, (c) low production of solutes and low corrosion rates, (d) simplicity in operation and maintenance, (e) development of decentralized solutions to serve the most remote areas (Fotopoulou, 2005).

In Greece, many communities in islands and rural areas are not connected to a central wastewater collection; while applying the best solutions for wastewater treatment with the lowest environmental impact and the sustainable cost of the treatment method is still a question (Stathatou *et al.*, 2015).

Social acceptance at all stages of decision-making as well as the operation of wastewater treatment plants and environmental management projects is crucial as even if the barrier such as the cost of infrastructure requirements can be overcome, little can be achieved if there is no social consensus on this (Menegaki *et al.*, 2007). According to Ashley *et al.* (2008), publicity, including media advertising, education, and the involvement of all stakeholders (politicians, experts and the general public) in the decision-making process, are critical elements for the successful design and implementation of sewage systems (Saad *et al.*, 2017). Gibson and Apostolidis (2001) argue that the best way to engage the general public and gain their support and acceptance is through successful demonstration projects (Gibson and Apostolidis, 2001). In order to achieve the desired result in the implementation of a project, the varitery of factors controlling the level of acceptance of community members should be explored. Communities are made up of people of different genders, ages, and groups with varying levels of education and awareness of environmental issues. Thus, perceptual studies are a crucial component of any social analysis (Abu-Madi *et al.*, 2008; Saad *et al.*, 2017).

The main objectives of this research are to investigate the opinion of the inhabitants of the area studied: (a) on the implementation of WWTP that has been operating in recent years on the Leros island, (b) their level of knowledge on natural wastewater treatment systems, and (c) their willingness to embrace such a possible application in their community.

Both in Greece and Europe, although several studies have been conducted on the degree of acceptance of the reuse of recovered wastewater (Atsalinou, 2010; Hartley, 2006; Roditakis, 2018) or/and the level of satisfaction with the operation of a WWTP (Fouriki, 2009). No such research has been conducted in small settlements on the degree of information on community waste management issues, especially before construction or introduction a pioneering pilot wastewater treatment program (Wu *et al.*, 2015). Concerning the creation of natural wastewater treatment systems in small settlements, because it is still a method that is not widely applied, the possibility of exploring the opinion of the community before creating a plan is negligible (Smith *et al.*, 2018; Arden and Ma, 2018; Gikas and Tsihrintzis, 2012).

2. Methodology

2.1. Description of the state of art of wastewater treatment in Leros island

The Leros island is characterised by hilly relief consists of three peninsulas with a total area of 54 km^2 and 7,917 people (Greek Census, 2011). Agriculture and fishing are the main economic activities of the island, supported by shops and services. The fertile valleys in the centre of the island yield olives, figs, carots, fruit and grapes. Tourism development on Leros is a relatively recent phenomenon that adds to the local economy (Koutsi and Stratigea, 2019; Hughes and Platon, 2018).

Since 2009 there is a complete sewerage network of the settlements of the Municipality of Leros that ends into a WWTP located on the east side of a private settlement. The processing plant's construction capacity is 10833 EP, in order to meet the island's growing needs during the summer season. The Annual Average of total incoming load in WWTP (Kg BOD5/day) is 2,140, with a maximum of 4,650. This biological treatment plant accepts and treats no industrial wastewater. (Wastewater Treatment Plants Monitoring Database, 2022) Unfortunately, many Leros

settlements are located in areas where a connection with WWTP is impossible, resulting in separate sewers for wastewater treatment, which has a questionable environmental impact.

2.2. Questionnaire design and application

The study population was collected randomly and consisted of people aged ≥18 years who were residents in various Leros island settlements, both located near the WWTP wastewater treatment plant and those in more remote areas. An anonymous questionnaire was shared door to door, to which respondents were asked to answer. The questionnaire assessed demographic characteristics of the residents (age, gender and level of education). Then the participants were asked the questions about wastewater treatment in Leros island that are shown in Table 1.

Table 1. List of questions and the type of scale selected

Questions	Type of scale	1	2	3	4	5
How certain are you that the island has a wastewater treatment plant? (Biological treatment plant)	Likert (5-point scale)	Not at all certain	Slightly certain	Moderately certain	Very certain	Extremely certain
Are you connected to the biological treatment plant system?	Dichotomous Scale	Yes	No			
If you answered YES, how satisfied are you with the operation of the biological treatment plant in Leros?	Likert (5-point scale)	Not at all satisfied	Slightly satisfied	Moderately satisfied	Very satisfied	Extremely satisfied
If you answered No, what is the reason for your Negative answers?	Multiple Choice Questions	Technical	Economic	Other		
Are you aware that natural wastewater treatment methods can be used?	Likert (5-point scale)	Not at all aware	Slightly aware	Moderately aware	Very aware	Extremely aware
Would you support the creation of constructed wetlands in distant island villages that cannot be connected to biological treatment?	Likert (5-point scale)	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Are you aware that wastewater treatment plant effluent contains nutrients? (eg N, P)	Likert (5-point scale)	Not at all aware	Slightly aware	Moderately aware	Very aware	Extremely aware
Would you agree to the use of adequately treated wastewater for irrigation purpose?	Likert (5-point scale)	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
What prevents you from accepting wastewaterreuse?	Multiple Choice Question	Presence of toxic compounds	Presence of germs	Odors	Other	
How much do you trust the Municipal Water Supply / Sewerage Service with the treatment and discharge of liquid waste to the water recipient?	Likert (5-point scale)	Not at all	Slightly	Moderately	Very	Extremely
How much do you think that the cost of treated irrigation wastewater instead of the water you currently use should be?	Multiple Choice Question	10-20%	20-25%	25-30%	30-40%	
Would you make further investments in your crops if there was a sufficient supply of water from reused waste?	Likert (5-point scale)	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Would you wish the quality of the reused water for irrigation to be checked?	Likert (5-point scale)	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

2.3. Data analysis

The IBM SPSS® Statistics (International Business Machines Corporation; Statistical Product and Service Solutions; Armonk, NY, USA) software package for Windows was selected for statistical processing of the results. Chi square test was used to compare the questions from Table 1 to the demographic questions (gender, age, level of education) in order to test for statistically significant differences. In addition, Chi square test was also used to determine the correlation of the questions from Table 1.

3. Results and discussion

One hundred eight citizens of Leros island completed hard copies of questionnaires during a five-day visit in the field. Of the 108 participants, 43.5% (n=47) were women and 56.5% (n=61) were men. The age profile of the sample was: 10.2% between 18-30 years, 25.9% between 31-45 years, 20.4% between 46-55 years and approximately 43.5% over 56 years.

Regarding the participants' level of education, 45.8% had primary education, 40.2% had a university diploma, 9.3%

had a postgraduate program diploma, and 4.7% had a doctorate degree.

Of the total participants in the questionnaire (n = 108), the higher percentage (60.2%) has not been connected to the existing WWTP, i.e. biological treatment, while 39.8% has been connected and has a reasonable satisfaction with the operation of the system (Table 2).

Table 2. The level of awareness on sewage treatment issues regarding the natural systems of Leros island

Valid	Frequency	Valid Percent	Cumulative Percent
Not at all aware	72	67.3	67.3
Slightly aware	11	10.3	77.6
Moderately aware	11	10.3	87.9
Very aware	10	9.3	97.2
Extremely aware	3	2.8	100.0
Total	**107**		

Regarding the question "How certain are you that the island has a wastewater treatment plant? (Biological treatment plant)?", it is interesting that only 69.3% of the participants know for sure the existence of the WWTP on the Leros island.

As observed in several other relevant surveys, gender did not have a statistical correlation with any questions (Wu *et al.*, 2019). The present study clearly shows little public information about alternatives to wastewater management. As shown in Table 1, the vast majority have never been informed about other options for wastewater treatment methods (Figure 1).

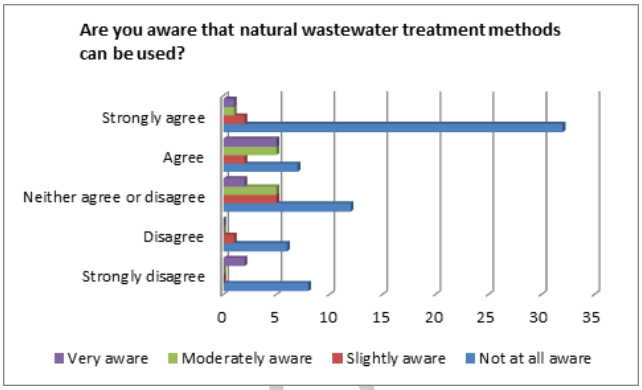


Figure 1. The level of awareness on sewage treatment issues with natural systems concerning the age of the sample.

Table 3. The distribution of answers according to age in the question «Would you support the creation of constructed wetlands in distant island villages that cannot be connected to biological treatment?

Age	Completely disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	Total
18–30	2	0	2	4	3	11
31–45	4	4	5	6	9	28
46–55	3	2	1	5	8	19
56–	5	0	2	5	35	47
Total	14	6	10	20	55	105

Despite the lack of awareness on alternative natural wastewater treatment methods, the sample seemed quite receptive to the possible construction of a constructed wetland for wastewater treatment in a remote area of the island, with 52.4% being positive in such a project, 19.0% «Agree», 9.5% «Neither agree or disagree», 5.7% «Disagree» and 13.3% «Completely disagree». Figure 2 shows the degree of acceptance of a possible wastewater treatment project with natural systems concerning the sample's age.

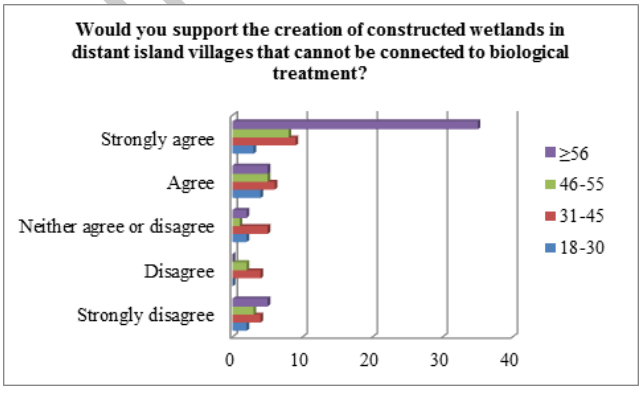


Figure 2. Public acceptance of a potential constructed wetland creation, in relation to age.

The sample also looked quite positive concerning the use of effluents from wastewater treatment systems for irrigation of crops on the island. Table 3 shows that 55.9% answered that they would «Strongly agree» with the reuse, 11.8% responded that they would «Agree», 13.7% choose «Neither agree or disagree», while 4.9% answered that they did «Disagree» and 13.7% choose «Strongly Disagree» (Table 4).

Table 4. The distribution of answers to the question «Would you agree to the use of adequately treated liquid waste for irrigation purpose?»

	Frequency	Valid Percent	Cumulative Percent
Strongly disagree	14	13.7	13.7
Disagree	5	4.9	18.6
Neither agree or disagree	14	13.7	32.4
Agree	12	11.8	44.1
Stronlgy agree	57	55.9	100.0
Total	102	100.0	

Although often the lack of a high level of education is to blame for the suspicion of residents regarding the acceptance and participation in new, more environmentally friendly methods, the following diagram shows that the low level of education does not necessarily

mean a lack of willingness to accept such a system (Figure 3).

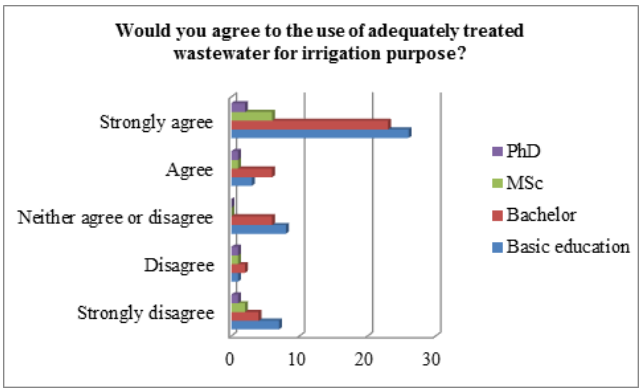


Figure 3. The receptivity to reuse of wastewater concerning the level of education.

To the question «What prevents you from accepting wastewater reuse?» participants were allowed to choose between the four possible answers as well as to select a combination of them. Participants had to choose between germs, toxic compounds, the presence of odours and their variety._29.7% chose the «combination of the above options», 33.3% put the fear of the «presence of toxic compounds» as the only factor of distrust, 29.6% set the fear of the «presence of germs» as the sole factor of distrust, while 7.4% replied that it is challenging to accept reuse due to «odours».

In a corresponding survey conducted in Athens to investigate what prevents citizens from accepting a green centre for solid waste management, citizens (63.4%) answered that the main obstacle is the concern about the presence of odours (Drimili *et al.*, 2020).

Also, an interesting result is the high bonding ratio (x^2 = 0.005), the degree of satisfaction with the operation of the WWTP on the Leros island, with the acceptance of a possible alternative project in remote residential areas.

As shown in Figure 4, Although the majority of respondents said they had no information about natural systems, at the same time, the sample proved to be highly willing to invest further in its crops if irrigation water costs were lower due to reuse.

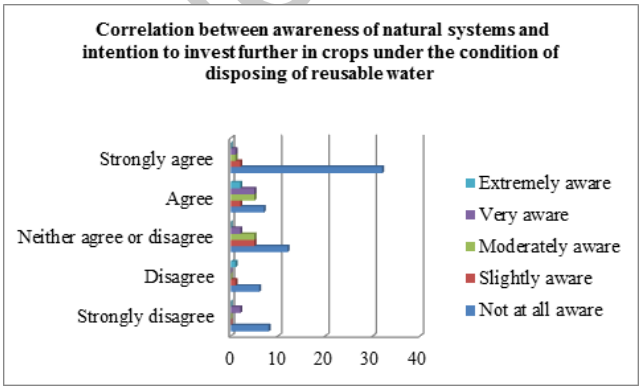


Figure 4. Awareness of natural systems regarding to the intention to invest further in crops under the condition of disposing of reusable water.

The age group over 56, is by far the most enthusiastic group to invest in its crops as long as it could use reusable water benefits (Figure 5). This might be because elderly adults are more familiar with environmental issues and nature and all it entails than younger generations who are exposed to advanced technology and its uses from a young age over a broad spectrum of their everyday life (Wiernik *et al.*, 2012).

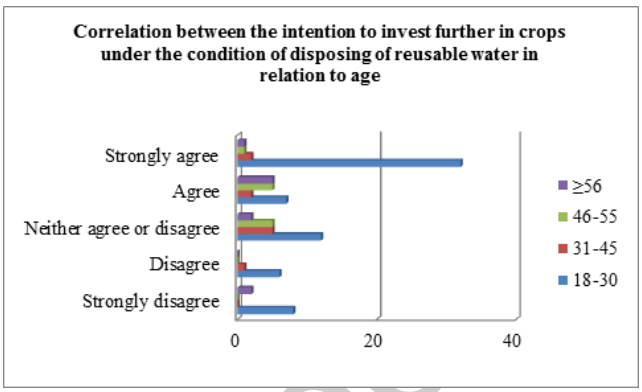


Figure 5. Answers received to the question «Would you make further investments in your crops if there was a sufficient supply of water from reused wastewater in relation to the respondents' age.

Several research projects related to wastewater reuse have taken place in Greece. A preliminary study has been carried out on the need to set criteria for wastewater reuse in the country (Tsagarakis *et al.*, 2004). The results from a study in Crete show that high environmental awareness is the factor that contributes towards the willingness of citizens to consume products irrigated with recycled water. The study also showed that lower-income citizens were more likely to consume products irrigated with reused water (Menegaki, Hanley, and Tsagarakis, 2007). In a similar study in Iran, the vast majority of farmers participants (92%) were willing to use the treated water for irrigation, while more than half of the farmers (56%) were willing to pay for the recovered water at a price equal to a freshwater irrigation fee, since they have trust in its quality (Deh-Haghi *et al.*, 2020).

As shown in the present survey in Leros, where most survey participants want a lower price for treated water, the cost is an important variable that affects their receptivity because they believe that this type of water is of lower quality. Therefore it must be cheaper than freshwater (Menegaki, Hanley, and Tsagarakis, 2007). Relevant research in Thessaly on the reuse of recycled water concluded that the treated waste could serve as an alternative water resource, especially in regions with water scarcity (Bakopoulou, Polyzos, and Kungolos, 2010). In Thessaly plain (Greece), an agricultural area, the reuse of treated wastewater in the cultivated areas could be a viable solution in times of drought (Bakopoulou, Emmanouil, and Kungolos, 2011; Bakopoulou, Polyzos, and Kungolos, 2010; Menegaki, Hanley, and Tsagarakis, 2007; Oron *et al.*, 2014; Tsagarakis and Georgantzís, 2003). In the present study, and since no process of reuse of treated wastewater has ever been carried out, it was deemed appropriate to ask whether a policy of cheaper recycled water would encourage possible investments in the crops of Leros, with the results being positive. Farmers

in Thessaly showed a strong willingness to use recycled water in times of drought in the survey mentioned above (Bakopoulou, Polyzos, and Kungolos, 2010), regardless of the fact that high-income farmers are generally unwilling to pay for recycled water when freshwater is available.

Interestingly, the same farmers say they are eager to pay even more for recycled water than fresh water if there is a drought. As mentioned above, there is no research investigating the degree of public awareness of wastewater treatment issues with natural systems such as constructed wetlands. This demonstrates how little the global scientific community has been concerned with the widespread application of natural processing systems in small communities in conjunction with public decision-making._Mainly, research to investigate the degree of acceptance of environmental management projects exists only in the broader scientific field of the environment and primarily on energy issues (Kajenthira *et al.*, 2012).

However, this does not mean that conclusions cannot be drawn to assess sustainability concerning public awareness for wastewater treatment systems. Each community should be adequately informed of any potentially applicable technology's environmental, economic, social and technical dimensions. Most of the studies focus only on financial and/or environmental aspects of wastewater treatment, with moderate concern for the social dimension. Often the relevant studies do not fully cover the concept of sustainability in all its aspects (Sawaf and Karaca, 2018). Of significant correlation and interest are surveys conducted in the Greek capital, Athens, which concern public opinion and citizens' attitudes regarding solid waste management and green growth issues (Drimili *et al.*, 2020). In an extended development of the present study, it is appropriate to emphasize the participants who appeared negative, both in the creation of a constructed wetland system for wastewater treatment in remote settlements of Leros and in the participants who seemed wary of reuse issues, to clarify whether this opinion would change if the newly introduced system were fully subsidized.

A successful public awareness campaign requires a clear understanding of current public perceptions, activities and lack of knowledge of sustainable environmental management (Naughton and Hynds, 2014). However, it should be noted that communication is not a one-sided process as the public will evaluate the benefits and risks of a given technology and will be invited to take an active part in its operation (Lienert, Sütterlin, and Siegrist, 2018). In Greece and especially in the small island settlements, although the problem of water shortage is severe and is expected to increase with climate change, both treated wastewater and sludge reuse are still being experimented with in order to create a scientifically sound and safe basis for reuse (Pedrero *et al.*, 2010).

4. Conclusions

The current study demonstrates a lack of public awareness of wastewater management issues. On the other hand, the sample appeared to be relatively positive to the possibility of creating a constructed wetland for wastewater treatment in a remote section of the island. The sample also seemed to be reasonably favourable in using wastewater from wastewater treatment systems to irrigate crops on the island. Often, people's scepticism about embracing and participating in new, more ecologically friendly ways for wastewater treatment is frequently blamed on a lack of advanced knowledge. It is shown that a low level of education does not always imply a lack of willingness to accept alternative wastewater technologies.

The need for more awareness and accessible data has emerged regarding potential alternatives in isolated regions and the operation of the existing WWTP that many people are unaware of. A significant part of the sample was willing to participate in alternative management methods such as reuse, which would motivate more crop investment when combined with a discount policy.

It is concluded that community information campaigns, both before and during the design of any project, are critical for fostering trust between authorities and citizens, dispelling misunderstandings about environmental issues, ensuring the efficient operation of facilities, and ensuring adequate environmental protection.

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