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Presentation of the Content

In the first article we present, *Technologies of savings systems that generate greater efficiency in the consumption of drinking water*, by FLORES-MEDINA, Eduardo, CASTRO-GUERRERO, Ana Cristina, VAZQUEZ-LUNA, Marisol and CARMONA VALENTE, Berenice, with adscription in the Universidad Politécnica de Juventino Rosas, as a second article we present, *Implementation of Community Wetlands for the sanitation of the Cajititlan Lake, Jalisco*, by CARO-BECERRA, Juan Luis, VIZCAÍNO-RODRÍGUEZ, Luz Adriana, LUJÁN-GODÍNEZ, Ramiro and MICHEL-PARRA, J. Guadalupe, with adscription in the Universidad Politécnica de la Zona Metropolitana de Guadalajara and Centro Universitario Sur de la Universidad de Guadalajara, as the following article we present, *Fertilizers in the yield of chile habanero (Capsicum chínense) in Úrsulo Galván, Veracruz*, by GARAY-PERALTA, Ignacio, DÍAZ-CRIOLLO, Alfredo, ESCUDERO-RAMÍREZ, Leira Carol and ELVIRA-RAMÍREZ, Dassael, with adscription in the Tecnológico Nacional de México Campus Úrsulo Galván, as the following article we present, *Develop an automated monitoring system that allows the creation of an efficient hydroponic ecosystem, which increases the production of lettuce per square meter*, by PEÑA-MONTES DE OCA, Adriana Isela, SALAZAR-MÁRQUEZ, Pablo Esteban, GONZÁLEZ-DEL CASTILLO, Edgardo Emanuel and LÓPEZ-LAGUNA, Ana Bertha, with adscription in the Universidad Tecnológica de Jalisco.

Content

Technologies of savings systems that generate greater efficiency in the consumption of drinking water

Tecnologías de sistemas de ahorro que generan una mejor eficiencia en el consumo de agua potable

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Abstract

This review article examines the main aspects of drinking water demand management from a technological and cultural perspective as a strategy for the efficient use of urban aqueducts. It is necessary to know the factors that affect the consumption of water in homes in order to generate management processes to solve the misuse of this resource. In the first room, a description of the demand is presented and some investigations are presented. Then some low water consumption devices are described, finally social mechanisms are mentioned to achieve a more efficient use of water.

Water conservation, Water management, Social participation

Resumen

Este artículo de revisión examina los principales aspectos acerca de la gestión de la demanda del agua potable desde una visión tecnológica y cultural como estrategia para el uso eficiente de acueductos urbanos. Es necesario conocer los factores que afectan el consumo de agua en viviendas con el fin de generar procesos de gestión para resolver el mal uso del este recurso. En primera estancia se presenta una descripción de la demanda y se exponen algunas investigaciones. Luego se describen algunos dispositivos de bajo consumo de agua, finalmente se mencionan mecanismos sociales para lograr un uso más eficiente del agua.

Conservación de agua, Gestión del agua, Participación social

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Introduction

Caring for the environment has been a very important issue to preserve the life of human beings and their environment. Over time, the use of natural resources is becoming scarcer and has brought risks. For this work the objective is drinking water, it is not only an indispensable resource for human life but also for socioeconomic development, energy production or adaptation to climate change; However, the mismanagement of this vital resource has caused pollution and shortages.

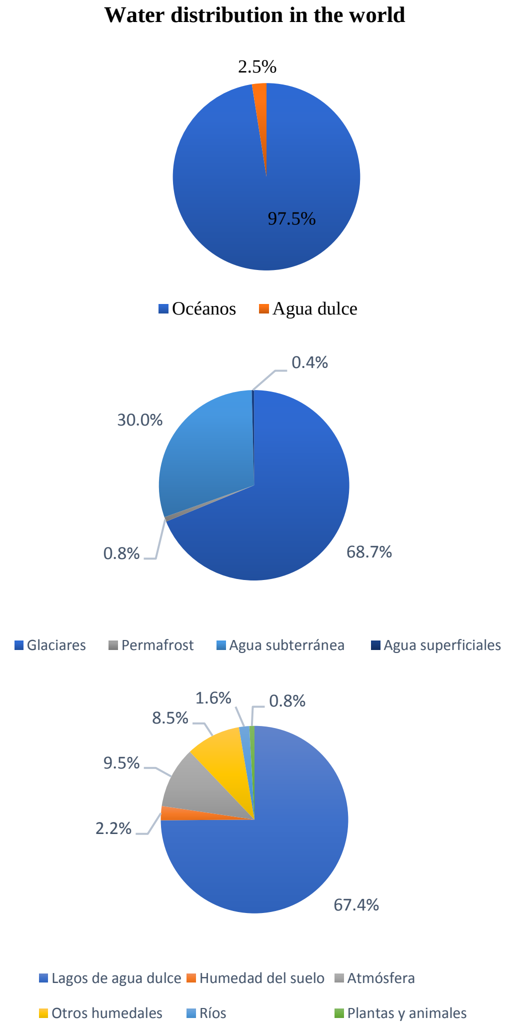
Water pollution exists in seas, lakes, rivers, and canals. The World Health Organization (WHO) defines contaminated water as that which undergoes changes in its composition until it is unusable. (IBERDROLA, s.f.) Therefore, contaminated water causes diseases and cannot be reused for irrigation of agricultural crops. The causes of pollution come from the roots of the use of fertilizers, pesticides, plastic waste, among others. Another cause for the deterioration of water comes from activities that we carry out. Deforestation, industrial, agricultural and livestock activities, garbage, maritime traffic and fuel spills. The problem of water pollution has produced negative effects on the environment and health.

The purpose of this work is to seek alternatives to reduce the inappropriate use of water and preserve this resource for future generations. The investigation allows to expand in knowledge to be able to act based on the results. That is why the investigation was carried out in the municipality of Santa Cruz de Juventino Rosas. In order to know through a sample, what tools and techniques of use, people use in their homes to make efficient use of drinking water.

1. Fresh water reserves in the world

There are around 1,400 million cubic kilometers of water on the planet, of which 2.5% correspond to fresh water, located mainly in rivers, lakes, glaciers, ice sheets and aquifers (UNEP-GEMS, 2007). Of the total fresh water, about three quarters are contained in glaciers and ice sheets, the majority (97%) in Antarctica, the Arctic and Greenland. Surface waters (lakes, reservoirs, rivers, streams and wetlands) very heterogeneously retain less than one percent of fresh, unfrozen water:

Only in the world's lakes are stored more than 40 times what is contained in rivers and streams (91,000 versus 2,120 km3) and approximately nine times that stored in swamps and wetlands (Graph 1). (Report on the Situation of the Environment in Mexico, n.d.)

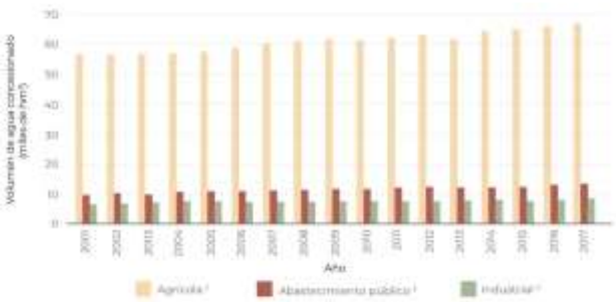


Graph 1 Distribution of water in the world (Report on the Situation of the Environment in Mexico, n.d.)

2. Consumptive uses of water

In Mexico, Conagua classifies water consumers into three sectors: agriculture, public supply and industrial.7 In 2017, the volume that was concessioned to these consumptive uses was 21% higher than that registered in 2001, going from 72.7 to 87.9 kilometers cubic; this last figure represents 19.2% of the total renewable water (451.6 km3). In 2017, in addition to the 87.9 cubic kilometers concessioned to the aforementioned sectors, an additional 183 cubic kilometers were concessioned for non-consumptive uses, in particular, for the generation of electricity in hydroelectric plants.

If the water concession in 2017 is detailed to the three main consumptive uses, it can be seen that 66.8 cubic kilometers corresponded to the agricultural sector (76.3% of the total concession), 12.6 km3 to public supply (14.4%) and 8.5 km3 to the industry: 4.3 to self-sufficient industry (4.9%) and 4.2 to electric power excluding hydroelectricity (4.7%). The sector that has grown the most in terms of the volume granted between 2001 and 2017 was public supply, which increased 32.8%, while the agricultural and industrial sectors increased 18.3 and 26.9% (Graph 2). (Report on the Situation of the Environment in Mexico, n.d.)



Graph 2 Volume of water concessioned by sector, 2001-2017. (Report on the Situation of the Environment in Mexico, n.d.)

3. Water conservation

Life on Earth exists thanks to the presence of water on the planet, especially that which is in a liquid state. The "blue gold" as this resource has already been called, receives this name for the importance it has for our existence and at the same time for its scarcity. Although three-quarters of the planet is water, only a very small percentage can be used by humans. Therefore, it is necessary to take care of the water we have because our present and future depend on it. In Green Ecology they talk about why it is important to take care of water, how to take care of it and about more related aspects.

4. Social participation

Doctors, scientists, nutritionists and other health specialists recommend drinking between a liter and a half and two liters of water a day, but why? The answer is that water is the most necessary element for our life. Our body is made up of 70% water, 95% of the weight of our brain is water, our blood contains 85% water and our lungs 90%. Each cell in our body contains around 70-80% water. But water also fulfills functions apart from hydrating our cells and organs.

Water is the medium where chemical reactions occur, such as in the manufacture of proteins, it is also the means of transporting ions and nutrients, it helps to cleanse our body of toxins by dragging our excretion products, it participates in digestion, regulates our temperature. body and performs other functions. As we see it, water is essential to our lives because we are partly water.

If water is important for human beings, it is also important for other living beings. Plants need water to photosynthesize and animals need to drink water just like we do to hydrate themselves and for their bodies to carry out the rest of its functions.

But not only that, water is the medium where many living beings such as animals, bacteria, plants, protozoa, fungi, etc. live. In addition, water helps regulate the temperature and climates that exist on the planet, it is a sink for CO_2 and a source of oxygen, it is also the means of transport that carries nutrients to all areas of the planet so that they are used by all organisms and of course it is a source of energy. Energy that can be harnessed to produce movement, electricity and heat.

5. Low water consumption devices

The installation of water saving systems in homes guarantees an efficient use of the resource on a continuous basis, a simple way to reduce the water bill, both environmentally and economically. Some of the savings systems that can be incorporated inside the houses to the hydraulic connections.

5.1 Thermostatic taps

The thermostatic faucet is an element of the water installation in the home that is based on a system that maintains the temperature of the water constant when it comes out of the tap.

5.1.1 Characteristics:

Flow control.
Temperature control.
With this tap we save a lot of water since it helps us to measure the temperature and thus we do not waste water since it is a priority to take care of it.

5.1.2 What is a thermostatic tap?

It is a method of installing water in a home that maintains the constant temperature of the water that comes out of the tap, it is also used for a shower in a bathroom so as not to waste cold water. As shown in Figure 1, 2 and 3

5.1.3 What is a thermostatic faucet for?

The function of thermostatic taps is, as the name suggests, to keep the water temperature fixed, and it does so automatically. Its operation is based on the fact that it lets through more or less cold water depending on the temperature we have selected. (Arch, 2019)

Figure 1 Roca thermostatic taps. (Topgrifo.com.es, s.f.)

Figure 2 ROCA Thermostatic Prada faucet. (Gerontological, s.f.)

Figure 3 ABC of reform. (FYCAL, s.f.)

5.2 Automatic taps

Automatic faucets may seem a bit frivolous, but they are actually smart, hygienic, and energy- and water-efficient inventions in your home.

The taps that turn on without the need for you to touch them:

You put your hand underneath and the water comes out as if by magic. But its operation is based on technologies that have been used for decades, very intelligently adapted to taps. These automatic faucets have four key components: sensor, solenoid controlled valve, power source, and spout.

5.2.1 Sensor

The sensor of an automatic faucet is usually at the base of the faucet spout. It is not a motion sensor, but a presence sensor designed to detect the hands under the mouth and turn on the tap. When you remove your hands, the sensor commands the tap to turn off. Most faucet sensors use a small infrared light in conjunction with an infrared detector. When the hands get within a few inches of the base of the mouth, the remote infrared light on the skin towards the detector, which sends a signal that turns on the tap valve.

5.2.2 Solenoid valve

The faucet sensor typically controls a diaphragm solenoid valve. The solenoid is an electromagnet that you can pull or push, depending on the electrical polarity. Diaphragm valves use a kind of rubber disc to control the flow of water. The valve is usually kept closed, but, in response to a signal from the sensor indicating that the hands are present, the solenoid pulls to open the valve and that water can flow through the mouth; then push to close the valve when the sensor indicates that the hands are gone. Most automatic faucets flush only warm water, but some models can also flush hot or cold water. (Engines, 2017)

Figure 4 Solenoid valve. (NEUCON, s.f.)

5.2.3 Power source

All automatic faucets require a power source. Some models use dry batteries, while others draw low-voltage current from AC (alternating current) transformers. Electricity powers the sensor, controls the electronics and the water valve. Battery-operated faucets use solenoid valves that remain in the open position with no further electrical current until a stroke of power pushes them back to the closed position. Transformer-operated faucets use electrical current. (Engines, 2017)

5.2.4 Mouths

The automatic faucets, which hold all the parts, are made of zinc (the cheapest models) and brass (the highest quality). They can be coated with nickel or chrome, to ensure greater durability and better appearance. The mouths can be made by machine, with sand mold or pressure. There are different styles of faucet heads for the kitchen or bathroom, laboratory sinks, bars and restaurants. In addition, in the mouth of the tap is where aesthetics play a role. The shape and finish are the main factors that buyers take into account when choosing one tap or another.

The 3 most demanded automatic faucets with sensor:

5.2.5 Fy-Light Automatic Faucet with Infrared Sensor

Saving water and electricity: water flows when your hands get close to the induction zone and stops immediately once you remove your hands. This automatic faucet will greatly reduce your water use and save a ton of money on water bills. For DC (direct current) type, 4 AA batteries can be used for about 1 year.

Convenient and Hygienic: The faucet bath sensor is used without hand contact, preventing cross infection by germs. It is very convenient and easy to use. Comes with the temperature adjustment valve, you can adjust the water temperature with the hot and cold temperature mixer according to your preference.

High-quality and durable material: Made of high-quality solid brass, the automatic faucet is durable and not easy to rust. Its exquisite workmanship and classic and modern style blend perfectly in any sink. Filter built into the faucet that prevents sand and solid materials in the water from leaving the flow.

Easy Installation: Even if you are not a professional plumber or handyman, easy installation as long as you follow our instructions. The infrared automatic bathroom faucet comes with detailed instructions (diagram) included and all necessary accessories for installation. Satisfaction Guaranteed: Fy-light aims to offer 100% customer service satisfaction. (Engines, 2017)

5.2.6 Auralum - Electronic Automatic Sensor Faucets Mixer Sink Faucet with Sensor for Hot and Cold Water for Bathroom

– Faucets with automatic infrared sensor. You just have to put your hand under the tap to activate the water and it closes as soon as you remove your hand.
– Automatic basin faucet, water outlet automatically, no switch required, more convenient to use, the ideal choice for at home or public areas.
– Sink mixer with warm water, suitable for year-round use, the water flow can be adjusted by the button on the side of the faucet, very practical.

- Sensor tap with honeycomb aerator for the smoothest water jet, since without splashing, it allows to save water up to 30%, reduce water bills.
- Sink mixer mounts easily with provided installation instructions and accessories. (SuperVent, s.f.)

5.2.7 AZUNX Automatic Rubinetto Basin Faucets with Infrarossi Sensor Bathroom Mixer Tap for Cold and Hot Water

Adjustable temperature: you can adjust the temperature of the water with the hot cold temperature mixer according to your preference.

Cleaning and sanitation: the water will come out and stop automatically without touching the metal parts and it is convenient and hygienic. In case of cross-infection by germs, it should be effectively disinfected and rinsed once automatically after a 24-hour interval, if necessary.

Water saving function: the automatic function can prevent you from wasting water, and there is overtime of induction or the automatic function of induction due to its continuous deception by eye cobwebs, and the effect of saving water is obvious.

Faucet filter: The filter setting can prevent sand and solid materials in the water from coming out of the outlet. Easy installation: bathroom faucet with motion sensor. (SuperVent, s.f.)

Figure 5 Automatic faucet. (comprargrifos, s.f.)

5.3 Ecological toilet
5.3.1 What are ecological dry toilets?

When we talk about dry bathrooms or ecological toilets, we are referring to those in which we will not need water, saving this element so necessary and at the same time scarce.

These toilets are not attached or connected to the downspout of the house, so they will not be directed to the sewage network, and can be placed anywhere, both in a conventional house, as in a guest room or a shed. They are also called ecological because the waste that has accumulated can be used later for the cultivation of fruits and vegetables, saving both water and fertilizer.

5.3.2 How does a dry toilet work?

The operation of this type of toilet is very simple, as is its installation. The first thing we have to know is that these are two large cameras that will be located under the place where we will place the toilet. These cameras are dry, so you will continue to save water and will not produce pollutants. In addition to having this characteristic, we have to make sure that they are waterproofed, as well as that they will have to be completely hermetic, so that there are no leaks that could contaminate the environment of these toilets, nor does it leak into the ground.

The chamber that is located below the toilet is the first to be filled, taking approximately 6 months with conventional use, when this has occurred, the second will be filled, which will also have the same filling period. During this process, the residues and wastes that were in the first chamber will gradually become compost that will be very useful as compost. Once the two chambers have been filled, it must be emptied completely, so that the whole process can start again.

5.3.3 Advantages of the ecological dry bath

Having a toilet of these characteristics will bring you many benefits, among which we can highlight that you will not need a single drop of water to work. We are only going to use, of course, the water from the shower, the sink or the bidet, but that's it, saving a lot on the water bill.
Its installation is very simple and can be done in any home, whether or not it has a conventional toilet, although it is always recommended that it is supervised by an expert plumber so that there are no risks of leaks or floods. Thanks to this clean process you will not pollute, being able to use the waste or compost that is formed to fertilize the land.

5.3.4 What types of toilets are there?

Figure 6

In the current market you can find two types of dry toilets, which can be installed in a very short time by a plumber, giving you all the advice you need for their use.

5.3.4.1 Dry bath

The first of the models is known as a dehydration dry bath. And it consists, as its name indicates, in dehydrating all the waste that falls into the chambers. This is achieved by different methods, but none include chemicals, something very important for later use as compost. The chamber will be partially filled with drying material, which will absorb all the moisture and liquid from the waste, being also helped by the ventilation that exists in these chambers such as the heat itself. It is advisable in these cases that the urine is destined for a different deposit, to avoid adding more moisture to the mixture. For the drying to be effective, what we have to look for is that the process is carried out as quickly as possible, thus achieving that certain pathogens and odors are produced.

Although urine can become a perfect organic fertilizer for the plants and crops that you have in the garden, mixed with the feces will make the dehydration of the feces much slower and therefore, it will not be processed as it should, being able to get to smell. Once we see that the chamber has been filled, something that, as we have told you, will happen after a year, in double chamber toilets, the waste can be handled with peace of mind, being a perfect compost.

5.3.4.2 Composting toilets

This type of toilet is more common to be found in country houses that have large crops and that seek to produce organic fruits and vegetables, saving both water and compost. The structure of these ecological composting baths is exactly the same as those that we have described previously, although instead of finding drying materials, we will have a series of organic materials from the field that will help create a much richer compost. Among these materials we can include pieces of vegetables, fruits, peat, sawdust or straw. All this will be mixed with human feces, causing the microorganisms to treat all this waste material to get the compost to form. For this to happen, the ambient temperature must be taken into account, as well as ventilation and humidity.

To achieve this, these bacteria must be allowed to work, which will decompose all the matter, something that will happen after approximately 10 months.

For both the first and second cases, hiring a qualified plumber is essential, since a failure can cause our toilet to produce floods, leaks or contaminants, being a greater problem when it is inside an urban home. . This professional will advise you at all times, guide you through the installation and tell you the best tips for its correct operation. (B2B)

5.3.4.3 Importance

Water is synonymous with life, purity and well-being. For this reason, it is essential to know how to take care of it, since it is a non-renewable resource that we are depleting in an accelerated way. This reality puts our immediate future at risk, since its scarcity represents a danger for the permanence of the living beings that inhabit the planet.

The commitment is unavoidable and urgent for everyone: we must save water. The foregoing requires conscious consumption in which we are obliged to be attentive to the spending we make and the solutions we can adopt to reduce it.

Let's think, just to cite an example, in the water that is used with each flush of the toilet. It is estimated that the average annual water consumption each time a person pulls the water supply is almost 11 thousand liters.

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The figure rises when using old toilets, with a storage capacity of 10 to 12 liters. For this reason, it is of great importance to review the type of toilet we have at home, and if necessary change it for an ecological toilet capable of saving thousands of liters of water per year.

Some companies, concerned about this situation, have long invested in the development of toilets that work efficiently with less water, and that can well adapt to both the aesthetic demands of consumers and their budgets.

The new smart toilet claims to offer exceptional water efficiency, custom cleaning and drying functions, a heated seat and even high-quality built-in speakers. The toilet's signature colors have been enhanced for dynamic and interactive multi-color surround and ambient lighting.

Users can easily perform any task such as playing music, writing items on the shopping list, operating home automation (technologies that allow home automation) of the home, and even listening to the news.. (Interiorismo, 2020).

6. Methodology

6.1 Statement of the problem

This article was made to obtain information on water consumption in Santa Cruz de Juventio Rosas, Guanajuato. In some regions of the country there is a serious problem due to their scarcity of water. The hydraulic resource required in all human life must be supplied to all regions through efficient distribution.

6.2 General objectives

Create an awareness of the care of water, since it is an indispensable resource to survive; through saving technologies, which create an efficient use of drinking water and help to maintain this resource for future generations.

6.3 Specific objectives

Identify the main factors that intervene in the misuse of water and detect the problem that prevents the use of water-saving devices. To implement daily habits strategies that make the use of drinking water more efficient in addition to informing the benefits of drinking water saving devices.

6.4 Demand management

The constant growth of the population and the need to meet the demand for water required to meet their basic needs considers management strategies that promote efficient use of water, such as: legal regulations, rate measures, information and / or educational campaigns, implementation of new technologies and infrastructure control. Demand management implies changing the way in which it has traditionally been dealt with, based solely on predicting and supplying, for a strategic and comprehensive management that involves modifying the practices and behaviors of water users.

Water consumption is determined by different variables that are included in the following factors: climatic factor (temperature, rainfall, relative humidity), social factor (inhabitants per dwelling, family composition, level of education, social stratum), economic factor (family income, water price, historical consumption) and / or cultural factor (people's lifestyle, values, norms and social models, beliefs associated with environmental behavior), which, according to the context, will have different relevance.

For the analysis of the variables that intervene in the demand for water for residential use, the first works carried out on the forecast were based on a single variable: population growth. Based on the study and knowledge of the variables influencing the use of water, consumption patterns in residential users can be analyzed, which makes it possible to build an integrated model that describes water consumption, which translates into strategies to reduce water consumption. demand and contributes to the improvement of resource management policies aimed at its conservation and the promotion of efficiency in its use.

The shower and toilet consume approximately 30% to 40% of the water in a home. So replacing these appliances with low discharge ones would help save money since the consumption bill would lower and save up to 32% of water consumption. As can be seen in fig. 1.1.

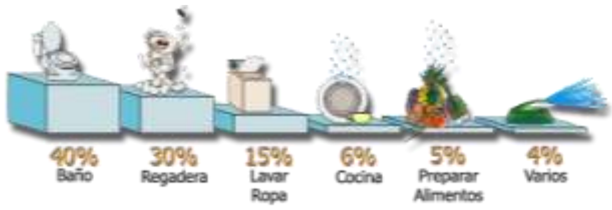

Figure 7 Approximate percentages of water use in the home. (CESPT, s.f.)

6. 5 Justification

The waste of water due to manual activities or the lack of awareness is a fundamental part to be able to maintain the levels of the vital liquid, for the supply of all the activities that take place in each region of the country.

By having the problem of the lack of water in certain regions, we could improve this condition through its correct distribution and use of the proposed technologies. It is considered to apply the system in houses-rooms to improve the sanitary system and to know the results to see if they are favorable both technically and economically.

Since the toilet consumes approximately 40% of the water in the home, replacing this appliance with a low-flush one or applying appliances that minimize the amount of water they consume would help save money in a family.

6. Geographical segmentation

(Country, area, region, municipality ...) our brand or product can be perceived or consumed differently in each geographic unit and the differences are usually so important that they force us to differentiate a marketing strategy or a communication campaign in two territories. (Moraño, 2010)

Figure 8 Santa Cruz de Juventino Rosas, Gto. (Google Maps, s.f.)

7.1 Demographic segmentation

Demographic (Age, sex, marital status, studies, occupation, income ...) we will segment the market taking into account all those demographic variables that influence the consumption of our product or brand. (Moraño, 2010).

Numerous studies have addressed the characteristics of environmentally conscious consumers, either as a primary point of research or as a secondary topic.

7.1.1 Years

Going back to the first studies of ecology and green marketing, several researchers have explored age, (eg, Aaker and Bagozzi, 1982). The general belief is that younger people are likely to be more sensitive to environmental problems. There are a number of theories offered in support of this belief, but the most common argument is that those who have grown up in a period where environmental concerns have been a prominent issue at some level are more likely to be sensitive to this questions. (D. Straughan & A. Roberts, 1999)

7.1.2 Income

In general, income is thought to be positively related to environmental sensitivity. The most common justification for this belief is that people can, at higher income levels, bear the marginal increase in costs associated with supporting green causes and favoring the supply of green products. (D. Straughan & A. Roberts, 1999).

7.1.3 Education

Education level is another demographic variable that has been related to environmental attitudes and behavior (eg, Aaker and Bagozzi, 1982). Specifically, education is expected to have a positive correlation with environmental concerns and behavior. (D. Straughan & A. Roberts, 1999)

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7.1.4 Place of residence

Place of residence has been another variable of interest since the beginnings of green research, Hounshell and Liggett (1973) have found that those who live in urban areas are likely to show more favorable attitudes towards environmental problems. Hounshell and Liggett did not find a significant relationship between the two variables. (D. Straughan & A. Roberts, 1999)

7.2 Pictographic segmentation

Pictographic (Personality, lifestyle, values, social class ...) is a widely used criterion that analysts value highly, since it allows us to know the reaction of a certain profile towards its environment, reaching a greater level of depth, in the one that we come into contact with the emotional part of the consumer. (Moraño, 2010) Several studies have attempted to identify pictographic correlates of ecological attitudes and behaviors.

7.2.1 Political orientation

Hine and Gifford (1991) investigated the effect of a fear appeal related to the anti-pollution movement on several different pro-environmental behaviors. Among the significant findings, the researchers found that political orientation was significantly correlated with one of the lower-order responses, verbal engagement. Specifically, their findings suggest that those with more liberal political beliefs are more likely to show strong verbal commitment than those with more conservative political views. (D. Straughan & A. Roberts, 1999).

7.2.2 Altruism

Based on the norm activation theory of Schwartz, Stern et al. (1993) examined the role of social altruism and selfishness in influencing ecological behavior. Specifically, their discussion focuses on whether social altruism, a concern for the well-being of others, is the sole driver of environmentally friendly market behavior, or whether the positive effect of social altruism is countered by the negative influence of social altruism. selfishness, which inhibits the will to incur. (D. Straughan & A. Roberts, 1999).

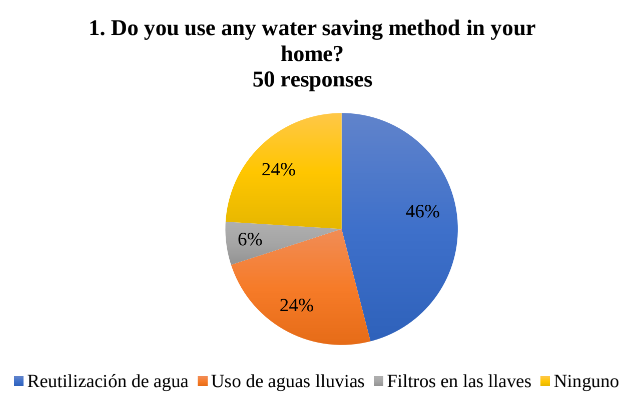
7.2.3 Efficacy perceived by the consumer

Several studies (eg, Antil, 1978; Berger and Corbin, 1992; Kinnear et al., 1974) have addressed the premise that consumers, Attitudes and responses to environmental appeals are a function of their belief that individuals can positively influence the outcome of such problems. This attitude or belief is known as perceived consumer effectiveness (PCE).. (D. Straughan & A. Roberts, 1999).

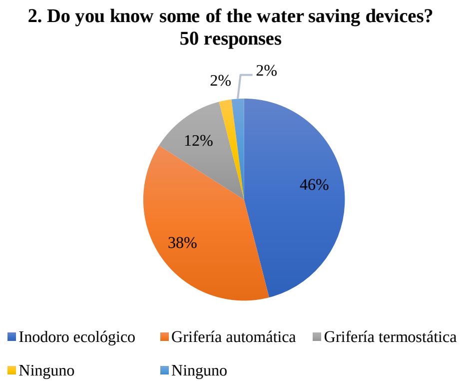
7.2.4 Environmental concern

The relationship between attitudes and behavior is one that has been explored in a variety of contexts. In the environmental literature, the question has been approached by exploring the relationship between the attitudinal construct, environmental concern and various measures of behavior and / or observations. Those studies (eg, Antil, 1984; Kinnear et al., 1974) examining concern for the environment as a correlate of ecological behavior have found a positive correlation between the two. (D. Straughan & A. Roberts, 1999).

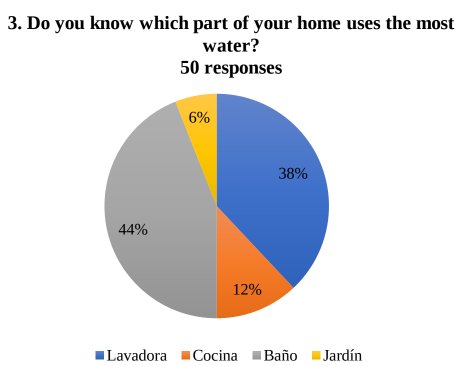
7. Graphs and conclusions of the results obtained



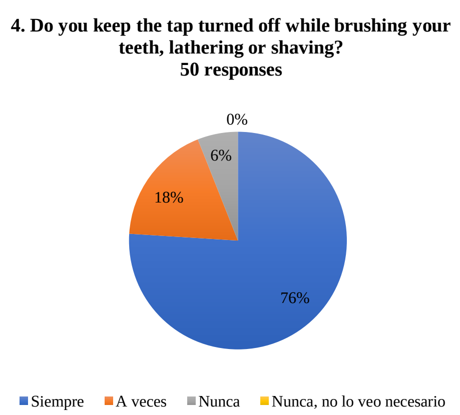
The graph indicates that 23 people who represent 46% of the 50 people who reuse drinking water, the behavior of the data allows us to infer that in Juventino Rosas the majority of people reuse water, although 12 people who represent 24% also do use of rainwater like another 24% of people use filters in their faucets and in a lower percentage of 6% do not use any method to reuse water.



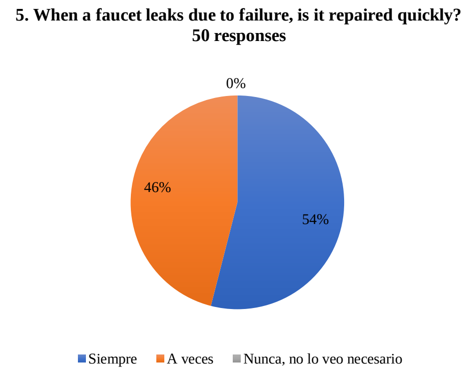
This graph indicates that 23 people, representing 46% of 50 people, know about ecological toilets, 38% know about thermostatic taps and 12% about thermostatic taps, it can be seen that most know some device that improves the efficiency of drinking water.



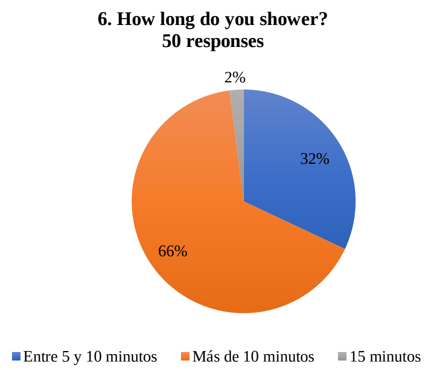
It can be seen in the graph that 44% of the people affirm that most of the water is used in the bathroom.



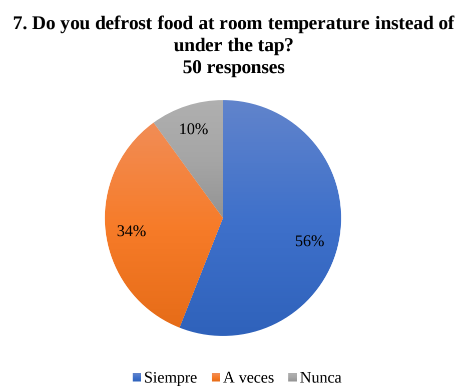
In some way, the majority of the people surveyed, 76%, are aware of the care of drinking water by keeping the tap closed while brushing their teeth, lathering or shaving.



It can be seen in this graph that 54% of people pay attention to immediate repair when a tap in their home leaks, but also 46% sometimes pay attention to a tap repair.



Most people shower for 5 to 15 minutes overall.



Thawing food with water is for most, still a habit that could affect the efficient use of water.

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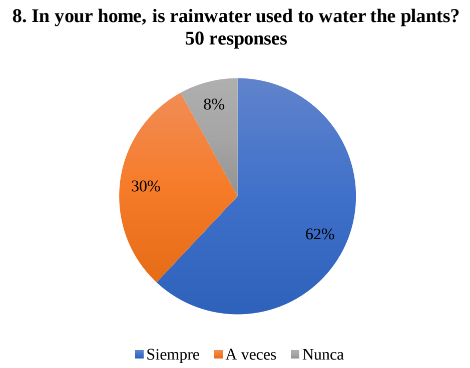
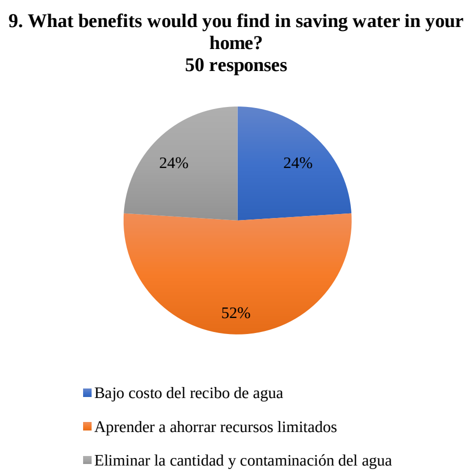
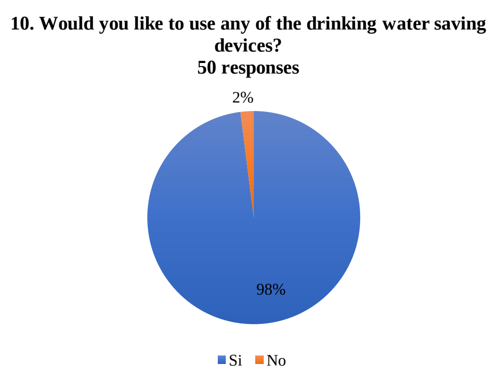


It is observed that 62% of people take advantage of rainwater. Although in recent years the rains have decreased in some places.



There are many benefits that we can obtain by taking care of water. In this graph, 52% of the people believe that the benefit is the low cost of the water bill, and 24% learn to save water and another 24% eliminate the quantity and contamination of the water.



98% of people would like to use a device that improves efficient water use.

8. Conclusion

According to the data obtained, we can see that most of the people who responded to the survey know of a drinking water saving device and also in some way seek to improve the efficiency of water consumption to contribute to the environment. Although there are actually currently many technologies that efficient the use of drinking water.

Life on Earth exists thanks to the presence of water on the planet. The "blue gold" this resource receives this name because of the importance it has for our existence and at the same time because of its scarcity, human consumption is increasing in progression, Driven by population growth and a rapidly growing economy, environmental sustainability is then about conservation efforts to maintain the traditional sense and measurement of income in an age when the natural capital is water. sweet, it is no longer a free good but, with increasing frequency, a limited factor in development. Our objective of the project is to implement our ideas such as thermostatic faucets, automatic faucets, dry toilets and composting toilets. The efficient use of water brings benefits, both to the companies that provide drinking water and sewerage services; in savings, in development and construction of new infrastructure, reduction of commercial losses, reduction of operating costs, drought management and supply cut.

9. Annexes

Development of a research questionnaire

Technologies that help us save drinking water.
1. Do you use any water saving method in your home?
☐ Water reuse
☐ Use of rainwater
☐ Filters on the keys
☐ None

2. Do you know some of the water saving devices?
☐ Saver toilet
☐ Low consumption tanks
☐ Pearlizers

3. Do you know which part of your home uses the most water?
☐ Washing machine
☐ Kitchen
☐ Bathroom

 Garden

4. Do you keep the tap turned off while brushing your teeth, lathering or shaving?
 Always
 Sometimes
 Never, I don't see it necessary

5. When a faucet leaks due to failure, is it repaired quickly? (the dripping of a tap uses 30 liters a day and 10,000 liters a year)
 Always
 Sometimes
 Never, I don't see it necessary

6. How long do you shower?
 Between 5 and 10 minutes
 More than 10 minutes
 Other

7. Do you defrost food at room temperature instead of under the tap?
 Always
 Sometimes
 never

8. In your home, is rainwater used to water the plants?
 Always
 Sometimes
 never

9. What benefits would you find in saving water in your home?
 Low cost water bill
 Learn to save limited resources
 Eliminate the amount and contamination of the water

10. Would you like to use any of the drinking water saving devices?
 Yes
 No

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Implementation of Community Wetlands for the sanitation of the Cajititlan Lake, Jalisco

Implementación de Humedales Comunitarios para el saneamiento de la Laguna de Cajititlán, Jalisco

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Abstract

Wetlands are systems that promote the sustainability and development of a society. The goal of this research was the implementation of a prototype aquatic garden to assess the quality of water in Cajititlán Lake, using sewage treatment plants with the purpose of removing nutrients, phosphates and nitrates among others parameters. This was made possible by floating structures containing aquatic vegetation species like.: *Typha latifolia*, *Lemna minor*, *Canna indica*, *Iris pseudacorus*, *Equisetum arvense*, *etc.* whose basic function is to retain nutrients through phytoremediation processes. The results indicate that the implementation of community wetlands made possible to reduce BOD levels from 220 mg/lt to 12 mg/lt across a surface of 120 m², treating a flow rate of approximately 5.30 gal/min to obtain an effluent in accordance with norm NMX-AA-012-SCFI. It is concluded that community wetlands are suitable ecological alternatives for the treatment of the wastewater discharged directly into the lake.

Community wetlands, Phytoremediation, Sustainability

Resumen

Los humedales son sistemas que favorecen a la sostenibilidad y el desarrollo de una sociedad. El objetivo de esta investigación fue la implementación de jardines acuáticos prototipo en la laguna de Cajititlán con el propósito de evaluar la calidad de agua, utilizando a su vez plantas de tratamiento de aguas residuales removiendo nutrientes, fosfatos y nitratos entre otros. Esto fue posible gracias a estructuras flotantes: *Typha latifolia*, *Lemna minor*, *Canna indica*, *Iris pseudacorus*, *Equisetum arvense*, etc. cuya función es retener los nutrientes mediante procesos de fitorremediación. Los resultados indican que con la implementación de humedales comunitarios fue posible reducir la DBO de 220 mg/lt a 12 mg/lt en una superficie de 120 m², tratando así un caudal de 5.30 gal/min y obtener un efluente que cumple la norma NMX-AA-012-SCFI. Se concluye que los humedales comunitarios son alternativas ecológicas que tratan las aguas residuales vertidas directamente al lago.

Humedales comunitarios, Fitorremediación, Sostenibilidad

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1. Introduction

Wetlands are systems designed to treat wastewater by means of phytoremediation processes aimed to avoid as much as possible the altering of the local natural environment. This is achieved due to the fact wetlands are ecological techniques with innovative filtration technologies that make use of floating macrophyte plants, with the additional benefit of a relative small investment for an effective purification of water entering the wetland.

These water purification system requires little maintenance tasks (at least once a year) such as: dead plants replacement and excessive plant biomass elimination, generated by the biofilter.

Achieving a sustainable development for the Cajititlan Lake will foster a tourism, handicraft and recreational fishing development for the inhabitants of the region, which in recent times have experience great cultural and ecological wealth losses.

Design, development and knowledge of the community wetlands are directly related to the understanding of the site in which they are to be implemented, that is, the more knowledge about the regional ecosystems, the better the wetland performance, allowing to obtain different final results as a consequence rain, sun, humidity, land and vegetation fluctuations (Justice Center for Women, 2016).

That is the reason why community wetlands by the use of aquatic plants are becoming more relevant in Cajititlan Lake, to compensate the existing low coverage of sanitary sewage, which mostly included in situ treatments options such as septic tanks, absorption wells and filtration ditches (Juarez, 2010).

A clear example of the high rates of contamination caused by discharges of heavy metals into local rivers and streams are the numerous cardboard and mescal manufacturing facilities located in the municipality of El Salto, Jalisco (McCulligh, 2020), where 1 in 2 people lack adequate sanitation conditions, which is equivalent to two and half times the clean water deficit supply (United Nations Development Program, 2015).

There are many definitions of wetlands, however, among the most important ones is that one that states that wetlands are water purification systems that help to reintegrate wastewater into its natural hydrological cycle, with an optimal quality without causing pollution in the process.

Wetlands are classified into two types: subsurface flow type and surface flow type. Surface flow wetlands are usually supported by environmental restoration programs, which are designed to capture effluents that have already been processed, so our aquatic plant wetland system aims to additionally improve water quality (Reed, Crites & Middlebrooks, 1995).

Subsurface flow systems are key process for wastewater treatment, as they are usually used in small populations. Their advantages are greater treatment capacities, low risk of contact with water, low presence of insects, being the effluent of a subsurface type; the water circulation is underground in contact with the roots and rhizomes of the plants (García and Corzo, 2009).

Figure 1 Cross section of the aquatic plant garden where the connection with the Cajititlan Lake can see in the background
Source: Our Preparation, 2018

Talking about community wetlands in Cajititlan Lake, implies that this research work performs a hydrological balance of the surface water, identifying what is the minimum percentage of wastewater treatment in our country.

In Mexico only 23% of wastewater receive some treatment (CONAGUA, 2015), of this latter percentage 42% receives treatment using activated sludge systems which require a very high energy investment compared to natural and sustainable non-conventional alternatives such as Artificial Natural Ecological Systems (ANES).

NESS type systems allow wastewater treatment by using the same kinds of microorganism living in the root receptacles of aquatic plants, such as: *Typha latifolia, Lemna minor, Canna indicates, Iris pseudacorus, Equisetum arvense*, to name a few. These microorganisms are benefited by the presence of sunlight and nutrients in water; as a payback, they satisfy their needs through their own microbiological processes. As a result of this natural treatment by means of wetlands, clean and good quality water is obtained; this wastewater treatment system is a 100% natural process which yields no products like, fecal coliforms, pathogens and bad odors.

2. Backgroung

Cajititlan Lake is located in the municipality of Tlajomulco of Zuñiga forming part of the Guadalajara Metropolitan Area (GMA). It is located in the central region of the state of Jalisco between coordinates 20° 28´ north latitude and 103° 27´ west longitude at an average altitude of 1575 meters above sea level (Chávez Hernández, 2009).

Figure 2 Satellite image of the Cajititlan Lake basin
Source: Google Earth

From a hydrological point of view, Cajititlan Lake constitutes the second most important natural reservoir in the state of Jalisco, with a storage capacity of approximately 54 million cubic meters (CONAGUA, 2015) and a surface of 4225 acres, as show in figure 2.

2.1 Historical background

The *chinampas* origin goes back to almost 2000 years before Christ. According to some experts they originated between 200 and 800 A. D. and their years of splendor were between 1400 and 1600 A. D. With the passage of time its origin has been lost, since no archaeological data have been found on the existence of the *chinampas* before the Aztec era.

The *chinampas* are agroecosystems of pre-Hispanic origin built artificially in areas of the Xochimilco-Mixquic Lake. Originally, they were squares in shape combined with features like terraces and channels, as a main feature they do not require irrigation owing to the fact that the needed water is obtained by infiltration (Molina, 1974). Generally, the *chinampas* are surrounded by rows of *Salix bonplandiana*, which is planted on the edge of the wetland to retain soil and prevent erosion.

3. Theoretical Framework

Dimensions of the wetland are dependent on the amount of water to be treated. They can be large or small, so the installation of biogardens, which are easy to maintain, is recommended.

Wetlands are closely linked to Artificial Natural Ecological Systems (ANES) and their treatment techniques can be singly applied. It is very important to keep in mind that water pollution in the environment has a cyclical character (Domínguez, 2015); therefore, the goal is to make a responsible use of water resources in order to maintain that cycle.

The ANES type technology can be considered as a highly stable ecosystem that can withstand fluctuations and unforeseen events without collapsing, sustaining the safety of users and water quality, in addition to functioning as a complete ecosystem that is integrated into its environment, achieving a fully sustainable treatment system in the process, as can be seen in figure 3.

Figura 3 Wastewater treatment by means of an ANES Type system
Source: Our Preparation, 2018

ANES systems can treat a wide variety of pollutants through physical, chemical and biological processes, including heavy metals, pathogenic microorganisms and of course BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), TSS (Total Suspended Solids) and other parameters for measuring wastewater quality such as salinity, hydraulic conductivity, suspended sediment accumulation, as well as biomass accumulation.

On the other hand, macrophyte vegetation contributes to the oxygenation of the substrate, nutrient removal in the subway part where the microbial community develops (Rabat, 2016). The pollutant scavenging processes with macrophytes occur through primary mechanisms such as:

– Filtration and sedimentation of solids in suspension.

– Incorporation of nutrients in plants.

– Degradation of organic matter by a group of facultative microorganisms associated with plant roots.

These aquatic systems are based on the maintenance of a vegetation cover of floating macrophytes on a sheet of water through ponds in series linked to each other where the effluent flows (Martelo, 2012). It is worth mentioning that the wetland constructed as a prototype in Cajititlan Lake contemplates the periodic removal of aquatic plants, as show in Figure 4.

Figure 4 Platanillo (Canna coccinea) is one of the best aquatic plants, as it has some medicinal properties; however, it is highly toxic in large quantities
Source: Our Preparation, 2019

4. Methodology

The first step in the construction of the aquatic plant garden was to locate the site, then, the sizing od the needed area; the next step was the implement the placement of *Schoenoplectus acutus* o *Salix bonplandiana* (typical wetland plant species) whose main characteristic is its ability to withstand excess water.

The following step is to bond cattails branches to form a fence, which is placed at the bottom of the aquatic plant substrate to form a base that will be left to dry during 15 days, then the mud is extracted to fill the fence that forming the *chinampa.*

The aquatic plant garden has an area of approximately 145 yd² and consisting of the following layers: the first layer is the pond which the effluent enters both by infiltration and pumping, in this layer are placed the solid sediments, as well as those also dragged by the water, the second layer consist of masonry stone; and the third layer consist of a special kind of soil named *tezontle* that will cover the ¾ parts of the wetland just where the aquatic plants do their ecosystemic function responsible for the absorption of heavy metals, used use as food through their roots.

4.1 Size of the wetland

The minimum width (B min) and minimum length (L min) were calculated for sizing the wetland. The calculation of the minimum length serves as a basis to propose an ideal distance and a program of wetland construction.

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It should note that the width of the wetland is a function of depth, slope and hydraulic conductivity of the filtering material.

The size of the constructed wetland depends on the incoming effluent flow and the Biochemical Oxygen Demand (BOD) loads that need to be reduced, based on the obtained results (Jenkins, 2015) and the climatic and soil permeability conditions of Cajititlan Lake.

To determine a more precise size of the wetland (Crites & Tchobanoglous, 1998) proposes the following examples calculations to clarify $900\ gal/fam/week,$ required for a single living unit, a depth of 2 ft, width 1.5 ft and length of 6 ft is required and for a community of 400 families discharging 850 gal/min a depth of 2.5 ft, width of 16.50 ft and length of 69 ft is needed *(ibid).*

In order to calculate the size of the local wetland, climatological information from the La Huerta station in the municipality of Ixtlahuacan de los Membrillos was used; thus the reaction rate constant Kr (day^{-1}) was used as a reference, according to the following equation:

$$kr = k20 * 1.06^{(T-20)} \quad (1)$$

The reaction rate constant at 68 °F or 20 °C (k_{20}) varies depending on the system to be implemented, for example, (Crites & Tchobanoglous, 1998) estimated 1.1 day^{-1}, and (Burton, 1991) estimates a (k_{20}) of 1.35 day^{-1} for blackwater wetlands, while (Olson *et al*, 1967) showed that the reaction rate for greywater is 2.5 times bigger due to the large amount of untreated organic matter.

Obviously, these values depend on the performance of the wetland and cannot be accurately calculated until it could be constructed and monitored, so it is recommended to use a low conservative value, since most of the wastewater treatment depends on the activity of micrㅤorganisms in the wetland, which cannot be determined before the construction phase, so a (k_{20}) of 1.35 day^{-1} is recommended for blackwater treating wetlands such as the effluent from Cajititlan Lake.

$$Kr = K20 * 1.06^{(T-20)} = 1.35 * 1.06^{(27-20)}$$

$$Kr = 1.91\ day^{-1}$$

The calculation of retention time, will depend on the time the water must remain in the wetland, its equation is a follows:

$$t = \frac{-\ln\left(\frac{C}{Co}\right)}{kr} \quad (2)$$

It is worth mentioning that the aquatic plant wetland to implement as prototype in Cajititlan Lake can decrease BOD levels but cannot eliminate them.

To determine the organic loading rate *Lorg* (gr BDO_5/m^2-day), the following equation was used:

$$Lorg = \frac{(C)(dw)(\eta)}{t} \quad (3)$$

Where *C* is the BOD level in the effluent (mg/l), *dw* is the depth in the substrate ranging from1.30 ft to 2.80 ft, obviously the deeper the wetland the more anaerobic conditions can be found, which means a lesser reduction of BOD and nutrients.

In our case, a substrate depth of 2 ft was chosen taken and to be constructed with sand and gravel material, as shown in figure 5.

Figura 5 Prototype of the aquatic plant wetland in Cajititlan Lake
Fuente: Our Preparation, 2019

Using the retention time previously calculated in equation (2), the effective porosity η can be determined, which is defined as the ratio between non-solid volume and total volume of the material according to the gravel size as shown in the table 1.

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Substrate	Effective size d10 mm	Effective size η
Sand (medium)	1	0.30
Sand (coarse)	2	0.32
Sand with gravel	8	0.35
Gravel (medium)	32	0.40
Gravel (coarse)	128	0.45

Table 1 Typical values for artificially constructed wetland substrates d10 is the diameter of a particle in a weight distribution that is smaller than all particles in the 10%
Fuente: Crites and Tchobanoglous

Land area factor required for the subsurface flow wetland bed is determined as follows:

$$As = \frac{Qave*t}{\eta*dw} = \frac{28.8*1.522}{0.35*0.60} = 208.73\ m^2 \qquad (4)$$

Where *Qave* is the average effluent flow rate (m^3/day), *t* is hydraulic retention time calculated from equation (2), with a substrate depth of 0.60 m and an effective $\eta = 35$ for gravelly sands, taken from table 1.

The following equation was used to determine the wetland dimensions:

$$w = \left(\frac{As}{Ra}\right)^{1/2} = \left(\frac{208.73}{2}\right)^{1/2} = 10.20\ m \qquad (5)$$

Where *w* is the width of the wetland, *As* is the surface area of the wetland and *Ra* is the length to width ratio. For artificially constructed subsurface flow wetlands (Crites y Tchobanoglous, 1998) recommend a ratio 2:1 to 4:1. Finally, the length *l* of the artificially constructed wetland was calculated with the following equation:

$$l = \frac{As}{w} = \frac{208.73}{10.20} = 20.46\ m \qquad (6)$$

5. Results

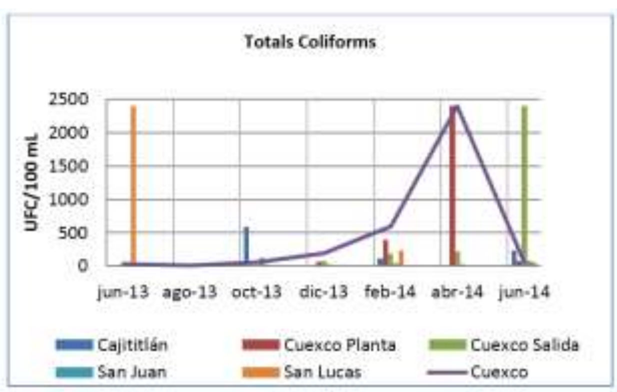
Deterioration of Cajititlan Lake has prompted various sectors of the local society to take actions aimed to rehabilitate and protect the reservoir by means forums, assemblies and agreements, carried out at a watershed council level. Researchers from the Polytechnic University of the Metropolitan Zone of Guadalajara and the University of Guadalajara have presented numerous studies on water quality, limnology, watershed hydrology, bathymetric, and an inventory of local flora and fauna.

Water quality studies indicate temperature levels ranging from 20 to 30 °C, and dissolved oxygen ranging from 0.0392 to 17.35 mg/L, records of Fecal Coliform organism varied from 7 to 2400 UFC/100mL and the count for Total Coliform organism varied from 5 to 2400 mg/L. These indicators clearly show that the lake is a highly polluted water body with low oxygen levels, so its recovery is of utmost importance for future generations, since good conservation, preservation and management practices will help to clean up and recover the Cajititlan Lake.

5.1 Diagnosis of Cajititlan Lake

According to the limnological studies of Cajititlan Lake presented by (Vizcaíno Rodríguez *et al*, 2018) and analyzing physical and biological factors such as temperature, dissolved oxygen, alkalinity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and pH, the final results are:

1. Temperature: from 20 to 30 °C
2. Dissolved oxygen: 0.392 to 17.38 mg/L. Observed variations depend of the time, light intensity and sampling site
3. pH: 8.84 - 9.52
4. High concentration of disolved phosphate and ammonium
5. Biochemical Oxygen Demand at 5 days (27.6 – 9.6 mg/L)
6. Chemical Oxygen Demand COD (394 – 14.76 mg/L)
7. Total solids: 0.405 – 0.454 mg/L
8. Total coliforms 5 – 2400 CFU/100mL, as show in graphic 1
9. Mercury: 0.005 mg/L in water; 0.0250 – 0.0517 mg/K in sediments; 0.0250 – 0.0478 mg/kg in plants and 0.0250 – 0.0478 mg/kg in fish



Graphic 1 Total Coliform graph
Source: Vizcaíno Rodríguez, 2018

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6. Prospective analysis

The current state of Cajititlan Lake does not allow to reverse the effects and consequences of the ecological deterioration in which it is found, but it is of great value to recover the watershed.

One of the most important actions is the appropriation of federal zones that belong to the riparian communities of San Juan and San Lucas Evangelista, an action which will only be achieved if there is political will on both sides of government and society, reconstructing the historical memory of the territory as well as the uses and customs of the first settlers. This goal will be achieved by carrying out Land and Ecological Management plans at both municipal and watershed levels.

To achieve the proposed objectives, it is necessary to modify the current conditions, such as high levels of pollution, insecurity, accumulation of solid waste due to tourism, to name a few.

Additionally, it is necessary to work based on the principles of sustainable development in order to establish conservation strategies in the community wetlands and their problems to solve. On the other hand, it is urgent to reduce or totally eliminate direct untreated discharges into the lake, which generate bad odors, skin and gastrointestinal diseases, and as a final consequence, a public health problem centered on the most vulnerable sectors.

7. Conclusions and recommendations

Some artificial wetlands are susceptible to clogging due to sediment entrainment; this can have avoided with a number 40 fine mesh, this will allow the effluent to remain at an optimal water level. On the other hand, it is important not to introduce species that are not from the region because some plants are more aggressive that others, as happened with the migratory plant named *Crysopogon zizanoides*.

These limitations should not be a factor to avoid the conclusion the project titled "Implementation of community wetlands in Cajititlan Lake", since the provided benefits will be greater for the community, thus generating environmental awareness and achieving a paradigm shift.

The community wetlands in Cajititlan Lake will effectively contribute to achieve the objectives of this project, additionally, it will make possible the reuse of treated wastewater is to give it reuse for agriculture purposes.

The results of this research have shown that the quality of life conditions have improved, since the living place have become self-sustainable units, in order to minimize pollution problems related to wastewater.

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Anexes

Graphic 2 Daily rainfall and mean temperature by month, La Huerta Station
Source: CONAGUA

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Fertilizers in the yield of chile habanero (*Capsicum chínense*) in Úrsulo Galván, Veracruz

Fertilizantes en el rendimiento de chile habanero (*Capsicum chínense* Jacq) En Úrsulo Galván, Veracruz

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Abstract

Mexico is the country in the world with the greatest genetic variety of Capsicum: its richness is largely due to the diversity of climates and soils, which is why the commonly called “habanero” pepper is found throughout the peninsula. The objective of this project is to evaluate their adaptation to edaphoclimatic conditions different from those prevailing in their area of origin. As well as different mineral and organic fertilizers, which meet the nutritional needs in the cultivation of habanero pepper to obtain better yields and better profits for the producer. The experiment was carried out at the Tecnológico Nacional de Mexico Campus Úrsulo Galván. The experiment was carried out in a shade mesh cover, the experimental design was completely randomized with 5 treatments and 7 repetitions with a total of 35 experimental units. Therefore, it is expected that fertilizers and fertilizers have a greater significant response in the increase of the habanero pepper (Capsicum chínense Jacq) in Úrsulo Galván, Ver.

Fertilizers, Mineral fertilizers, Increase

Resumen

México es el país en el mundo con mayor variedad genética de *Capsicum*: su riqueza se debe en gran parte a la diversidad de climas y suelos por lo que el comúnmente llamado chile “habanero” se encuentra distribuido en toda la península. El objetivo de este proyecto es evaluar su adaptación a condiciones edafoclimáticas diferentes a las prevalentes en su zona de origen. Así como diferentes fertilizantes minerales y orgánicos, que cumplan con las necesidades nutricionales en el cultivo de chile habanero para la obtención de mejores rendimientos y mejores ganancias para el productor. El experimento se realizó en el Tecnológico Nacional de Mexico Campus Úrsulo Galván. el experimento se realizó en cubierta de malla sombra, el diseño experimental fue completamente al azar con 5 tratamientos y 7 repeticiones con un total de 35 unidades experimentales. Por lo que se espera que los fertilizantes y abonos tengan una mayor respuesta significativa en el incremento del chile habanero (*Capsicum chínense Jacq*) en Úrsulo Galván, Ver.

Abonos, Fertilizantes minerales, Incremento

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Introduction

North America is where the genus *Capsicum* is considered native, which consists of 27 species, of which five of them are used as fresh vegetables, or as they are also called "species", among which we have: *Capsicum annuumm L., Capsicum chinense*, Jacq, *Capsicum frutescens* L., *Capsicum baccatum* L., *Capsicum pubescens* L. (Ibiza *et al.*, 2012).

Habanero chilli (*Capsicum chinense* Jacq.), is a vegetable of economic importance, due to its fresh consumption and as raw material for the elaboration of industrial products. Traditionally, agronomic management is based on the application of chemical inputs to complete its vegetative cycle, (Castillo-Aguilar *et al.*, 2015).

The irrational or inadequate use of fertilisers is a factor of environmental degradation, hence the importance of NORMA MEXICANA NMX-AA-91-1987. On the one hand, an insufficient dose from a nutritional point of view generates low yields, while an excessive dose generates high economic and environmental costs. For this reason, a balanced fertilisation approach has been promoted in recent decades, which consists of supplying nutrients in the amount and at the time required by the crop (Ryan, 2008). Under this view, knowledge is needed on crop nutrient requirements as well as on nutrient supply, based on chemical analysis of soil and plants, (Alejo-Santiago *et al.*, 2015).

Nowadays it is important to think about crop management with less environmental impact, which could be achieved with the use of rhizospheric micro-organisms, which are beneficial to plants; for example, several *Bacillus* species are plant growth promoting rhizobacteria (PGR). (Sosa-Pech *et al.*, 2019).

Another activity to be carried out in agricultural production is the continuous improvement of irrigation practices and fundamental changes in the application of irrigation water saving methods. Drip irrigation in horticultural crops is the simplest and most efficient method of delivering water and fertilisers to the root zone of plants, (López-López *et al.*, 2018).

Something that is very important to mention is that despite the fact that the habanero chilli (*Capsicum chinense* Jacq.), is not native to Mexico, it has taken over the Mexican palate because of its extraordinary spiciness: national culinary activity is inconceivable without this exclusive condiment for certain dishes and sauces. Its origin is in South America in the Orinoco basin from where it spread to the Caribbean islands in pre-Columbian times (González et al. 2006). While in the Mexican region, specifically in the Yucatan peninsula, variants of great regional importance are found; sweet, spicy, etc., (Cázares-Sánchez *et al*., 2005).

Regarding the production of chilli in greenhouses, it is mainly carried out to provide a better environment for the growth and development of the plant, due to the fact that wind, radiation and temperature lower than 15 ºC, can affect the yield and quality of the fruit (Flores, 2013). However, under these conditions, according to Uribe, (2008) yields are low due to the lack of adequate production technology in relation to varieties, nutrition, disease prevention, etc.

Greenhouse habanero chili increases fruit yield (Cauich *et al*., 2006), but there are limiting factors such as pollination (Quezada-Euán, 2009), which can be promoted by abiotic means such as the use of hormones and biotic means such as the use of pollinating insects (Dávila, 2011). The use of hormones has advantages, such as higher quality of commercial product, lower risk of pollinating insect bites and greater crop vigour, but it can interact with other foliar chemicals and cause stress to the crop (Tapia-Vargas, 2016). Hence the importance of carrying out this research to generate information that serves as a basis and reference to know how habanero chilli behaves in the region and its production.

Objectives

To identify the fertiliser and/or manure that increases habanero pepper (*Capsicum chínense* Jacq) yield in Úrsulo Galván, Veracruz.

Methodology

The experimental research will be carried out in the municipality of Úrsulo Galván, Ver, Mexico.

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Location of the experimental area

The experiment will be carried out in the experimental area of the Technological Institute of Úrsulo Galván, Ver. The experimental plot will be located in the parallels 96° 22' north longitude and 19° 24' west latitude, with an elevation of 20 meters above sea level (masl).

Climatic characteristics

The climatic conditions are of an AW_2 climate (warm sub-humid climate with rainfall in summer) with an annual rainfall of 1350 mm per year distributed in the months of June to September and the dry period from January to May with an average temperature of 24 and 25 °C with a maximum of 35 °C in the hottest months and a minimum of 16 °C in the winter months, the relative humidity is 80 %).

Vegetative characteristics

This zone is dominated by vegetation consisting of induced grassland, low subcaducifolia forest and rainfed agriculture. Subsequently, the vegetation in lesser presence consists of scrubland dominated by leguminous plants to boiling acahuales.

Soil

The soil is predominantly clayey loam with an acidic pH of 5.5 to 5.9.

Description of the experimental area

The place where the experimental research was carried out is in semi-protected conditions (greenhouse) because it has a shade net cover where the plants are located. Temperature and pest control is not possible due to the conditions of the area, but irrigation control is possible because it is manual. Therefore, conditions are like those found outdoors.

Determination of design and treatments

According to the conditions of the crop, mainly the uniformity of the soil (sandy) and the fact that there is a shade net cover on the site, a completely randomised experimental design with 5 treatments was established; based on different fertilisation mixtures, each treatment will have 7 replications, making a total of 35 experimental units.

Description of the treatments

Treatments	Description
T1	Dap (9.6 grams) Urea (6.4 grams)
T2	Dap (14.4 grams) Urea (9.6 grams)
T3	Cow dung 40 grams/plant
T4	Vermicompost (200 grams/plant)
T5	Witness

Table 1 Representation of the different mixtures applied to each treatment
Source: Own Elaboration

Distribution of the treatments in the field.

T1R4	T4R1	T1R5	T3R6	T5R6
T5R1	T1R1	T3R2	T4R5	T2R1
T4R3	T4R2	T1R2	T3R3	T3R1
T5R2	T2R7	T1R7	T4R7	T3R4
T5R7	T4R6	T1R6	T3R6	T5R3
T5R4	T4R4	T2R6	T5R5	T2R3
T2R5	T1R1	T3R7	T2R4	T2R2

Table 2 Shows the distribution of the different treatments in the experimental area located within the Instituto Tecnológico Nacional de México Campus Úrsulo Galván
Source: Own Elaboration

Variables to evaluate:

Plant height: this variable was collected every week, measuring with a metre from the soil surface to the largest leaf of the sub apical meristem.

Plant diameter: The measurement of this variable was collected, leaving 5 cm from the soil once a week after transplanting until harvest with a vernier.

Number of leaves: a count was taken once a week after transplanting until the appearance of fruit visually.

Number of fruits: measured once a week after the first appearance of fruits. This was done visually.

Weight of fruits: all fruits were cut per plant and each one was weighed on an analytical scale.

Statistical analysis

The results obtained will be captured and analysed in the SAS programme (Stadistic Analysis System), then a mean comparison test will be carried out to identify the best treatments statistically speaking according to the Tukey 0.05 % mean comparison test.

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Results

Plant height

In relation to the plant height variable, it can be observed in table 3. After carrying out the ANOVA with the comparison of Tukey's method (0.05%), since these are field conditions and not laboratory conditions, this level of significance is used. In the different dates in which this variable was sampled (12 October, 19 October, 26 October, 2 November, 9 November, 16 November, 23 November and 30 November 2018), that in treatment 2 which consists of the application of DAP (14.4 g) UREA(9.6 g) was better and statistically speaking, superior with respect to the other treatments, that is to say that if this mixture of fertilizers is applied with respect to one of fertilizers a greater response will be observed, but we must remember that fertilizers maintain soil dynamics and macro and microbial life, the above agrees with what was published by Medina, (2015). Where he carried out chemical fertilisations based on nitrogen fertilisers.

Treatment	Fertilisation rates	Height of plant in cm (height/plant)							
		12 Oct.	19 Oct.	26 Oct.	2 Nov.	9 Nov.	16 Nov.	23 Nov.	30 Nov.
1	Dap (9.6g) urea (6.4 g)	5 A	9.7 A	14.2 B	22.5 BA	32 B	36.4 B	48.8 B	59.1 B
2	Dap (14.4g) urea (9.6 g)	7.1 A	12.4 A	21.1 A	27.4 A	50 A	61.7 A	74.2 A	89.4 A
3	Cow dung (40 g /plant)	6.8 A	10.8 A	15.4 BA	20.8 BA	38.4 BA	50.0 BA	59.4 BA	70.1 BA
4	Vermicompost (200 g/plant)	6.8 A	10.4 A	15.2 BA	21.2 BA	36.1 BA	48.1 BA	54.1 BA	66.2 BA
5	Witness	6.4 A	12.1 A	14.5 B	19.7 B	34.1 BA	46 BA	53.8 BA	64.2 BA

Table 3 Comparison of means of the variable plant height
Source: Own Elaboration

Plant diameter

Regarding the plant diameter variable, it can be observed in table 4. After performing the ANOVA with Tukey's method comparison (0.05%). On the different dates on which this variable was sampled (12 October, 19 October, 26 October, 2 November, 9 November, 16 November, 23 November and 30 November 2018), no statistical difference was obtained in any of the samples, that is to say that if an organic fertilizer or mineral fertilization is applied as well as if nothing is applied in soils with high content of organic matter, no statistical difference will be obtained in terms of this variable,

But it must be taken into account that if organic matter is not incorporated into the soil, this will impoverish until it is no longer able to supply the nutrients that the crop requires, the above agrees with what is published by Medina, (2015). Who carried out the analysis of variance where they indicate (α= 0.05) that there is no significance on the stem diameter of habanero chili plants, due to the combined effect of fifteen fertilisation treatments of nitrogen, phosphorus and potassium.

Treatment	Fertilisation rates	Height of plant in cm (height/plant)							
		12 Oct.	19 Oct.	26 Oct.	2 Nov.	9 Nov.	16 Nov.	23 Nov.	30 Nov.
1	Dap (9.6g) urea (6.4 g)	1.7 A	2.8 A	3.7 A	5 A	5.1 A	6 A	7 A	7.8 A
2	Dap (14.4g) urea (9.6 g)	2.2 A	2.8 A	4 A	6.2 A	6.5 A	7.8 A	9.2 A	10.2 A
3	Cow dung (40 g /plant)	2 A	2.1 A	3.4 A	4.8 A	5.7 A	6.7 A	8.1 A	8.8 A
4	Vermicompost (200 g/plant)	2.4 A	2.5 A	3.7 A	5.1 A	5.8 A	7.2 A	8.1 A	9.2 A
5	Witness	1.8 A	2.5 A	3.8 A	5.8 A	7.4 A	6.5 A	7.7 A	8.4 A

Table 4 Comparison of means for the variable plant diameter
Source: Own Elaboration

Number of leaves

In relation to the variable number of fruits, it can be observed in table 5. In the different dates in which this variable was sampled (12 October, 19 October, 26 October, 2 November, 9 November, 16 November, 23 November and 30 November 2018), that in none of the samplings statistical difference was obtained, that is to say that if you apply an organic fertilizer or mineral fertilization as well as if nothing is applied in soils with high content of organic matter no statistical difference will be obtained in terms of this variable.

But we must also take into account that it is very important to incorporate organic matter in soils so that they have the capacity to supply the elements that plants require, which is in agreement with what was published by Campos, (2016), who carried out the analysis of variance where they indicate that there is no significance on the number of leaves of habanero peppers.

Treatment	Fertilisation rates	Height of plant in cm (height/plant)							
		12 Oct.	19 Oct.	26 Oct.	2 Nov.	9 Nov.	16 Nov.	23 Nov.	30 Nov.
1	Dap (9.6g) urea (6.4 g)	7.2 A	12.1 A	14 A	16.2 A	16.8 A	19.4 A	25.7 A	33.2 A
2	Dap (14.4g) urea (9.6 g)	8.4 A	12.5 A	14.4 A	18.1 A	19 A	23 A	28.7 A	38.4 A
3	Cow dung (40 g /plant)	8.1 A	11.5 A	13.1 A	13.2 A	16.1 A	21.4 A	28.4 A	36.1 A
4	Vermicompost (200 g/plant)	8.7 A	11.8 A	13.4 A	16.2 A	17.2 A	22 A	27.5 A	33.4 A
5	Witness	8 A	10.7 A	12.5 A	14.1 A	18.1 A	21.5 A	30.2 A	37 A

Table 5 Comparison of means for the variable number of leaves
Source: Own Elaboration

Number of fruits per plant

In relation to the variable number of fruits, it can be observed in table 6. After performing the ANOVA with the comparison of Tukey's method (0.05%). In the different dates in which this variable was sampled (28 December 2018, 4 January, 25 January and 8 February 2019), that in the first and third week with respect to treatment 2. Dap (14.4 g) Urea (9. 6 g) was better and statistically superior with respect to the other treatments, statistical difference was obtained in the sampling, that is to say that if you apply a mineral fertilization will have a greater number of fruits compared to an organic application, but we must remember the relationship between number of flowers and a nitrogen fertilization can be affected because factors involved, the above agrees with the published by Salvador, (2016) where he mentions that in relation to the variable number of flowers coincides with the increase in number of fruits where he found statistical difference.

Treatment	Fertilisation rates	Number of fruits production (fruit/plant)			
		28 Dec.	4 Jan.	25 Jan.	8 Feb.
1	Dap (9.6 g) Urea (6.4 g)	6.4 B	14.5 A	17.5 BA	8.4 A
2	Dap (14.4 g) Urea (9.6 g)	17.1 A	24.1 A	20.8 A	11.4 A
3	Cow dung (40 g /plant)	12.7 BA	16 A	14.5 BA	7.1 A
4	Vermicompost (200 g/plant)	9 BA	15 A	10.5 BA	8 A
5	Witness	8.5 BA	11.5 A	9.1 B	3.8 A

Table 6 Comparison of means of the variable number of fruits/plant
Source: Own Elaboration

Fruit weight

In relation to the fruit weight variable, it can be observed in table 7. After carrying out the ANOVA with the comparison of Tukey's method (0.05%).

In the different dates in which this variable was sampled (28 December 2018, 4 January, 25 January and 8 February 2019), that in none of the samplings was statistical difference obtained, that is to say that if you apply an organic fertilizer or mineral fertilization as well as if nothing is applied in soils with high organic matter content no statistical difference will be obtained in terms of this variable, but it must be taken into account that if organic matter is not incorporated into the soil, it will become poorer until it is no longer able to supply the nutrients that the crop requires, which is in agreement with what is published by Campos, (2016). Where he mentions that in relation to the polar diameter variable, no statistical differences were observed.

Treatment	Fertilisation rates	Number of fruits production (fruit/plant)			
		28 Dec.	4 Jan.	25 Jan.	8 Feb.
1	Dap (9.6 g) Urea (6.4 g)	8.0 A	5.8 A	17.5 A	7.0 A
2	Dap (14.4 g) Urea (9.6 g)	9.0 A	8.5 A	20.8 A	7.6 A
3	Cow dung (40 g /plant)	6.4 A	7.2 A	14.5 A	6.3 A
4	Vermicompost (200 g/plant)	6.9 A	5.8 A	10.5 A	5.8 A
5	Witness	7.4 A	6.5 A	9.1 A	6.7 A

Table 7 Comparison of means of the fruit weight variable
Source: Own Elaboration

Conclusions

Based on the results obtained, we could say at first that the results we found are very interesting as we realise that the plant height and number of fruits benefit from treatment 2 (14.4 g of Dap and 9.6 of Urea).

However, this does not influence the yields because, according to the ANOVA carried out, there are no statistical differences.

This information obtained will be very important because it is a spearhead in the production of habanero pepper in the Úrsulo Galván region, because although it is a sugar cane area, this crop can be an option for the diversification of crops in this area.

In spite of the adversities, the plants finished their productive cycle and the phenological or vegetative development was optimal, as it coincides with what has been investigated by other authors for habanero pepper producing regions.

Finally, we can say that the habanero chilli has economic and productive potential for the region according to the data obtained in this experimental work.

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Develop an automated monitoring system that allows the creation of an efficient hydroponic ecosystem, which increases the production of lettuce per square meter

Desarrollar un sistema de monitoreo automatizado que permita la creación de un ecosistema hidropónico eficiente, que eleve la producción de lechugas por metro cuadrado

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Abstract

The agricultural production methods of the last decades, have stood out for the use of the spaces, leaving aside even the land, mediating the greenhouses; in order to protect crops from climate variations, pests, raising their quality through better physicochemical characteristics and longer shelf life. The purpose of this work is to develop an automated system by means of materials such as sensors and microcontrollers capable of controlling physicochemical variables in a greenhouse, in order to provide the concentrations of nutrients, for the creation of an efficient hydroponic ecosystem, and standardized for an increase to production, in the cultivation of Romain variety lettuce. It is important to point out that within the hydroponic system, the Romain lettuce variety is harvested, obtaining larger products with an approximate weight of 1200 to 1500 g per piece, compared to those grown by the traditional method whose weights range between 1100 to 1300 g per piece, with a shelf life of 8 days in refrigeration.

Automated system, Microcontrollers, Hydroponic ecosystem

Resumen

Los métodos de producción agrícola de las últimas décadas, se han destacado por el aprovechamiento de los espacios, dejando de lado incluso la tierra, mediando los invernaderos; a fin de proteger los cultivos de las variaciones del clima, las plagas, elevando su calidad a través de mejores características fisicoquímicas y mayor vida de anaquel. El propósito del presente trabajo es desarrollar un sistema automatizado por medio de materiales como sensores y microcontroladores capaces de controlar variables fisicoquímicas en un invernadero, a fin de proporcionar las concentraciones de nutrientes, para la creación un ecosistema hidropónico eficiente, y estandarizado para un incremento a la producción, en el cultivo de lechuga variedad Romain. Los resultados obtenidos incluyen el diseño y las mejoras, hasta la optimización del invernadero para una producción máxima de 36 lechugas por metro cuadrado .Importante es demarcar que dentro del sistema hidropónico, se cosecha la variedad de lechuga Romain , obteniéndose productos más grandes con un peso aproximado 1200 a 1500 g por pieza, en comparación con aquellas cultivadas por método tradicional cuyos pesos oscilan entre 1100 y 1300g por pieza, con una vida de anaquel de 8 días en refrigeración.

Sistema automatizado, Microcontroladores, Ecosistema hidropónico

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Introduction

In recent decades, studies have shown a trend towards the development of new techniques, methodologies and technologies to optimise production processes, without neglecting the important interrelation between human beings and machines. The word hydroponics is derived from two Greek words, hydro, which means water and ponos which means labour, hence "work in water".

Hydroponic cultivation was used as far back as ancient Babylon, in the famous Hanging Gardens. The Aztecs with the so-called Chinampas, amazing islands of vegetables. (Tlacaelel, 2017)

Nicolas de Sausssure (1804) published that plants are composed of minerals and chemical elements obtained from water, earth and air. In 1842, he published a list of nine elements considered essential for plant growth (Mexicana, 2018).

Research on plant nutrition showed that normal growth can be achieved through a water solution containing salts of nitrogen (N), phosphorus (P), sulphur (S), potassium (K), calcium (Ca) and magnesium (Mg), which are now defined as macronutrients. Subsequently, seven elements required in relatively small amounts were discovered and are known as micronutrients, including iron (Fe), chlorine (Cl), manganese (Mn), boron (B), zinc (Zn), copper (Cu) and molybdenum (Mo). (Canovas, 1993; Benitez, 2011).

According to Díaz, García and Espinosa (2011), the inputs to be distributed in the greenhouses should be standardised recipes that allow for simple dosage.

The system developed was capable of producing, although there were problems in the fluctuation of growth proportions, presence of mould and fungi, so it was decided to address the environmental variables, controlling temperature, humidity and oxygenation.

The aim of the present work is to develop a new proposal for an automated hydroponic system, which by means of inert materials such as sensors and microcontrollers allows the generation of an efficient hydroponic ecosystem, focused on the creation of value and innovation.

The importance of this research is based on the fact that raising productivity, by requiring less space and resources; mediating automated systems, which evaluate the features and interactions that overcome environmental changes, awakens through literature and its significance a boost to the economic development of the country; in order to achieve the correct adjustment between environment and capabilities to promote entrepreneurial behaviour, so as to promote business innovation, through the generation of competitive advantages in MySMEs.

The second section of the paper presents the conceptual framework, as well as a review of the literature and empirical studies related to automated hydroponic crops. The third section describes the methodology employed, while the analysis and results are presented in the fourth section, to finally present and discuss the conclusions, limitations and implications for future research.

Theoretical Framework

There are many antecedents that are identified in the literature as ideas and determining factors that in conditions of opportunity, use automated systems, as well as their interactions and generate better productive processes, better products or services, better forms of organisation.

In Mexico, the Mexican industry has not been studied in depth, so it is interesting to start from automated systems and knowledge; associate it with the existing knowledge in the environment and consider those products generated in the interaction.

Hydroponics _Soil-less agriculture

Cultivation in an artificial medium consisting of a nutrient solution containing the essential elements needed by the plant for its growth and development.

Internal factors.

Extensive and growing literature has examined the importance of photosynthesis, cellular respiration and phytohormones.

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External factors

Climatic, biotic, abiotic, social and economic factors are known.

Advantages

Fewer and lighter working hours, no need for crop rotation, several harvests per year, no competition for nutrients, better root development, greater uniformity of crop pieces, minimal water loss, minimal or no weeds, reduced use of agrochemicals.

Disadvantages

High initial cost, knowledge of plant nutrition and physiology, good water quality, temperature and pH control required. In the last decade, innovative activities are displacing aspects of strategic behaviour of companies, innovative activities should be understood as those that lead to the development or introduction of technological innovations, which can be classified into:

– Research and technological development (R&D)
– Industrial design
– Industrial equipment and engineering
– New products
– Commercialisation of new products
– Technology acquisition
– Services with technological content

In previous works Peña (2017), found that the variable Adoption of new Product Processes for their Company but existing in the Sector accompanied by New forms of organisation, have the greatest discriminating potential to boost innovation in SMEs.

In recent decades, indoor crop research has been widely accepted in countries such as Mexico and Chile, where there are experts in the field, manipulating physico-chemical variables of particular species (Carrillo and Vásquez, 2008).

Methodology

The research refers to the theoretical support, it is of transversal type, in which the main factors of the processes were identified, as well as the relationships, and controlled experimentation & observation was chosen as the working method.

The scope of the research is of an exploratory nature, as it makes an approach to the problem of relatively unknown studies and at the same time suggests verifiable statements in order to generate knowledge that will contribute to research on the subject. The greenhouse is 5 m wide by 13 m long and 4.5 m high, it includes a double access customs to avoid the entrance of external agents to the greenhouse, built with galvanised profiles and greenhouse plastics. (See figure 1 and 2)

Electrical components

– Submersible water pump with 2 nozzles of 13 and 16 mm 400 GPH without noise.
– pH sensor
– Water quality sensor
– Electrical conductivity sensor
– Digital submersible temperature sensor DS18B20
– Atmospheric humidity sensor DHT 22
– BabyGroot Card V1.1
– Hydrometer
– 12 V 2nd power supply
– Arduino CCTV applications

Design

In the design phase, Autodesk Inventor 2017 software was used to create a top view, in order to understand the idea before building it. (Serrano, 2005).

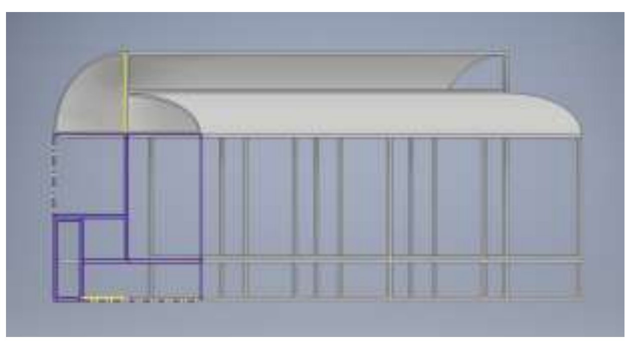

Figure 1 Greenhouse design side view Autodesk Inventor 2017

A DHT 22 environmental humidity sensor was installed, which sends a data packet to activate a relay that in turn activates a solenoid valve, which opens a water inlet directed to the anti-afrous mesh walls to control the humidity of the environment. The appropriate temperature should not exceed 40 degrees and should not drop below 40% humidity in the environment (Muñoz and Nuñez, 2012).

Figure 2 Customs-type double access door

Process

The first step is germination, by means of embryo until it becomes a plant; long-eared lettuce, Romain variety, was used.

Figure 3 Dry ice seedbed with seedling lettuce variety

To fill the cavities with substrate, a combination of 70 per cent Peat-moss and 30 per cent Perlite was used, three quarters of the cavity was filled, a hole was made 1 cm deep in the central part to place the lettuce seed and the remaining quarter was filled with substrate. (Anzorena, 1994; Guerrero et al., 2014; Flórez, 2012).

Second step, hydration of the seedbed, which was carried out in an ascending way, the seedbed was submerged in a tub until the water reached 50 per cent of the seedbed.

Third step, a wet napkin was placed on top of the seedbed and it was kept in a space where it had no contact with sunlight and its temperature was warm. It is left for 3 days until the sprout appears, after which it will be exposed to the sun for 21 days or until it reaches 10 cm of true leaf growth.

Fourth step, transplant the seedling, for which the root is cleaned using water to remove the substrate in which it was germinated.

Fifth step, the seedling is placed in a glass with indentations so that the root can support itself and obtain nourishment from the new substrate.

Figure 4 Slit vase plant

Sixth step, install the vessel in the pond to follow its growth. Holes were placed in a PVC pipe every 20 cm and with a perimeter of 10 cm.

Figure 5 Front view of hydroponic system

This alternative system can achieve up to 36 lettuces per square metre.

Figure 6 Hydraulic proportioning system with nutrient

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Seventh step, feeding the seedlings, through an irrigation system that includes a pump placed inside a 100-litre tank of nutrient solution, conductivity and pH sensors, which are calibrated and checked daily.

Figure 7 Assembled hydroponic system

Indicators

The BabyGroot development board with analogue outputs, connected to the environmental humidity, pH, electrical conductivity and temperature sensors, was used for digital monitoring purposes, for hourly, daily monitoring or to check for any extra changes and can be interpreted via LCD or Bluetooth communication to a mobile application.

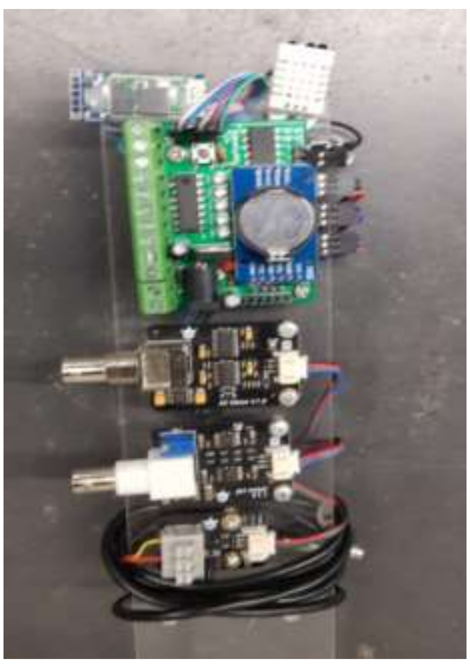

Figure 8 Automated system board

Results

According to what was expected after 3 days of germination, 21 days of seedling growth and 28 days of ripening in the hydroponic system, the Romain lettuce variety was harvested, obtaining larger products with an approximate weight of 1200 to 1500 g per piece, in comparison with those cultivated by traditional methods.

The lettuce obtained has a longer shelf life, reaching 8 days in a refrigerator, without losing its firmness, colour or flavour.

The yield per hectare in the traditional way is 70 to 80 days, for Romain lettuce with a large head, dark green colour and weights between 1100 to 1300 grams approximately, placing 3 plants per linear metre, with a planting density between 50 and 80 thousand plants per hectare, in comparison with the hydroponic system, which takes 56 days for dark green Romain lettuce with a weight between 1200 and 1500 g, without taking into account that the vegetable has less water and more fibre per lettuce, reaching 250,000 to 330,000 plants per hectare, in addition to the benefit of using 80% less water for irrigation during its growth.

Figure 9 Hydroponic lettuce for human consumption

Below is a sample of the code as an example, code that was used for the automation of the hydroponic automated system.

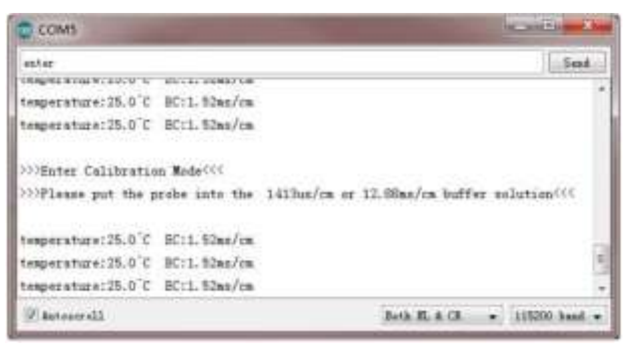

Figure 10 Arduino IDE terminal calibration of buffer solution

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Calibration of the pH sensor within 25 °C to pH 7.0.

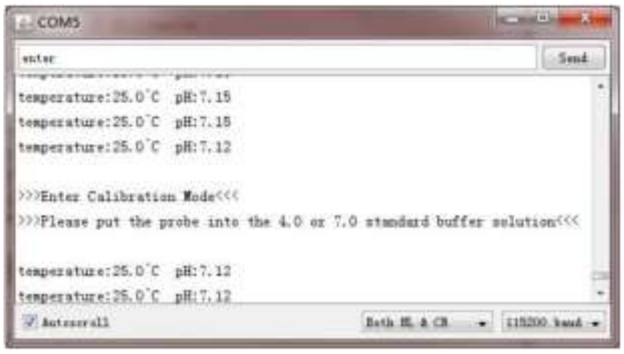

Figure 11 Arduino IDE terminal pH calibration

Conclusions

The study shows that automation in food procedures always results in benefits in terms of quality, precision, optimisation of the use of resources, including time, hygiene and productivity. In this case, it was possible to obtain up to 400 lettuces per week using 65 square metres.

Staff training is considered essential to control the variables, allowing the stability of the process.

Recognising that innovation projects are composed of more than one source of knowledge, type of organisation, geographical location, sector and market niche; thus, in the dynamics of innovation, organisation, technologies, sector dynamics and societal response are interwoven (Rip, 2012).

The optimisation of organisational performance is explained through the company's ability to constantly renew itself by identifying and exploiting new opportunities in response to customer demands and continuous improvement.

The present study is not without limitations, the complete coverage of all articles dealing with the topic of automated hydroponic system could not have been achieved, given the search procedure chosen. Therefore, there could have been papers that were addressed to automated hydroponic systems but used a different language. Consequently, the factors derived from the analysis need to be treated with caution.

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General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

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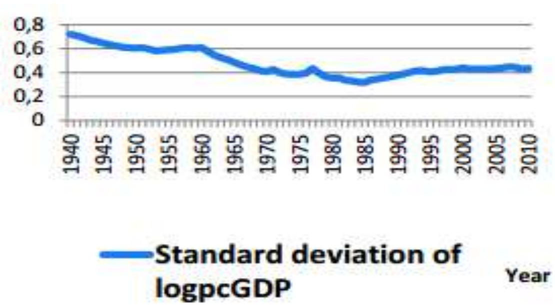

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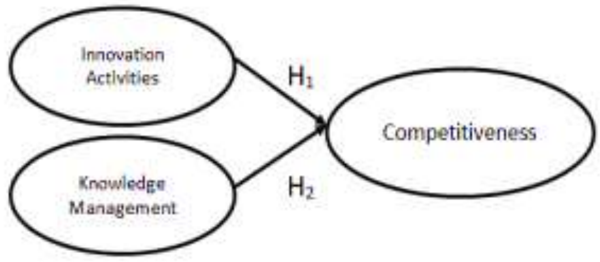

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$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \quad (1)$$

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Thanks

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Explain clearly the results and possibilities of improvement.

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