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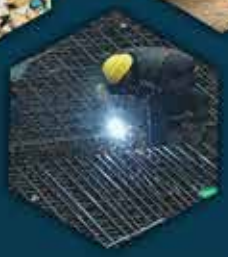



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EDITOR'S LETTER

Dear reading community, on this occasion we present the number 30 Volume 11 of the Journal of Scientific Dissemination of the UNACH: Espacio I+D Innovación más Desarrollo, with which we approach the celebration of the first ten years of uninterrupted publication of the digital magazine of the Universidad Autónoma de Chiapas, the result of joint, institutional and individual efforts that seek to bring knowledge from the academic world to our society, as part of the substantive commitments that we have as a leading institution in our region.

The editorial work in a university represents the establishment of a reliable and institutionalized communication channel, sometimes it goes unnoticed and is not given adequate importance, until, with pleasure, those of us who carry out the work with tenacity day by day see how our contributions are growing, like a network that is woven together with other entities of states and countries. The results of the editorial work within the Schools of Higher Education are long-lasting since they represent several minds working on its process; on top of that there is the enormous social responsibility of editing articles, a product of years of research and that even, sometimes, are used as works to support a thesis. On the other hand, public universities have responsibility with the messages, knowledge, and information they communicate, which makes the aforementioned process more complex, having ethical responsibilities to fulfill.

We mention all this to highlight the importance that these activities must have within the institution, with trained personnel, responsible practices, and commitment to the progress of society, through a constant and professional update, because only in this way can we reach the point where Espacio I+D is, after ten years of communicating knowledge, science, and culture in various parts of the world.

This issue contains articles such as Habitat improvement project for "El Encanto", Tapachula, Chiapas. Historical and regional context; Concrete mixed with cigarette butts as a proposal to minimize their waste in the

environment; Design, construction, and cost of a flexible rainwater collection system for excluded rural communities; Comparative evaluation of concrete beams reinforced with welded wired truss and GFRP rods; Access to women's justice through conflict management and mediation; Perception of the urban parks' ecosystem services in Tuxtla Gutiérrez, Chiapas, Mexico; 14-3-3 Proteins and neurodegenerative diseases: A computer simulation perspective, and Calculation of areas and static balance of barrel vaults with lunettes, from universities such as the Universidad Veracruzana, the Tecnológico Nacional de México - Zacatecas Occidente, the Universidad Autónoma de Baja California and Zacatecas or the CIMSUR-UNAM and, of course, the Universidad Autónoma of Chiapas.

It also includes an academic document on Viral diseases in Mexico; and the section A Space for Science incorporates the following materials: A brief approach to the performing arts in Chiapas and Science and Technology Workshops of the MCTP.

We thank all the actors involved in this issue and invite them to continue building with us this dissemination channel, following the magazine's social networks, and sharing the materials presented there.

Enjoy this Space of Innovation!

"*Por la conciencia de la necesidad de servir*"
Universidad Autonoma de Chiapas

The editors

ARTICLES

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Access to women's justice through conflict management and mediation

—

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— Abstract—

The qualities and benefits of public law and other areas of law have always been observed in promoting access to justice, not only for women but for all those who require it, however, it is appropriate to briefly analyze the effectiveness that mediation can have to manage conflicts produced in women, such as the social confinement that derives from the pandemic that is currently taking place and that can be understood as a source of conflicts and opportunities for women to end their disputes alone and obtain access to justice. It is for the above reasons that the objective of this research is to analyze the efficacy that mediation produces as a peace agent to provide women with the necessary empowerment to end conflicts through the management of these and, with it, have access to justice, seeing this access as a human right.

Keywords:

Conflict management; mediation; gender violence; positive discrimination.

The following thoughts about conflict management that results in women's free and full access to justice will be studied in the light of three approaches. The first will analyze Mediation as a Dispute Resolution Method (ADR), seen not only as a flat object that serves only as a method of conflict termination but also as an agent of positive peace. In the second approach, Mediation will be observed from an epistemological level of logic, that is, Mediation will be analyzed as a method that recognizes human rights in the Political Constitution of the United Mexican States (CPEUM), which it institutionalizes through the National Law on the Mechanisms for the Alternative Resolution of Disputes in Criminal Matters (LNMASCMP). While in the third approach, the study will focus on a reflection according to the existence of positive discrimination against women, a conceptual category that emerged within the decade of the seventies in the United Kingdom and that has an important boom in the current era.

CONTEXT OF GENDER-BASED VIOLENCE

One of the great manifestations of gender violence stems from the lack or little access that women must have to justice. In this regard, it is important to delimit this type of violence and clearly differentiate it from violence against women. First, it is necessary to define violence against women and girls, because, although this term is of great importance, it is also not the right one to understand the structural conflict of null access to justice by women. In this sense, the United Nations (UN) defines violence against women as "any act of gender-based violence that results in or is likely to result in, physical, sexual, or mental harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or private life" (UN, 2021).

As mentioned above, it is considered that the term violence against women and girls is not appropriate, since it seeks to define a structural conflict or, rather, try to analyze gender violence as part of a structural conflict that has not yet been fully mitigated. From this reasoning, it must be understood that gender violence manifests itself as the structural conflict that prevents women from having free and full access to justice.

To contextualize gender violence concerning mediation, it is mentioned that, throughout the history of legal science, there have been limitations in the termination of conflicts, where women who are involved in these conflicts fail to terminate them, therefore, their human right of access to justice is violated. To understand this term, the definition of gender violence proposed by the UN will be taken as a reference, which states that "gender violence refers to harmful acts directed against an individual or a group of

individuals based on their gender. It is rooted in gender inequality, the abuse of power and harmful norms." (UN, 2021).

Currently, access to justice for women has evolved since other types of extrajudicial methods began to be used or, failing that, judicial methods. However, if a comparison is made for the access to justice that women had in previous times, it is possible to notice that even the *patriarchal law*, stigmatizes the right as an exclusive issue for men. The above, allows us to consider the existence of an indirect form of gender violence against women, perhaps not explicitly, but tacitly. However, it should not be overlooked that, equally, many men could suffer from gender-based violence.

Recently, based on the provisions of the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW), UN Women, and the Inter-American Court of Human Rights, have issued recommendations to the Mexican State to demand the assurance of women's free and full access to justice, not only as victims of crime but also as possible participants in the commission of crimes. Likewise, some recommendations are aimed at alternative ways of ending conflicts, which are called extrajudicial methods, also known as Alternative Dispute Resolution Methods (ADRM), whose main function is to end disputes by the parties themselves.

In this regard, CEDAW issued General Recommendation No. 33 on Women's Access to Justice, which states, inter alia, that there should be free access for women to judicial systems and ADRMs, as well as a gender approach in judicial and extrajudicial processes involving women. Likewise, it established that both judicial and extrajudicial mechanisms "use a confidential and gender-sensitive approach to avoid stigmatization during all legal proceedings, including secondary victimization in cases of violence, during questioning, evidence collection and other procedures related to the investigation" (CEDAW, 2015).

THE OBJECT OF MEDIATION AS DRM

To begin with this section of the investigation, we will focus on mediation as the alternative method par excellence that procedural law provides, that is, of all the ADRM mediation has benefits that make it unique and, therefore, effective before the other ADRM. In that sense, it should be understood that "mediation is an alternative mechanism for dispute resolution. Some consider it as the most innovative technique that promises greater success in the field of conflict resolution, because it is up to the parties, assisted by an impartial third party, to resolve their own conflict situation" (Cornelio, 2014:92).

The above definition generates an environment that makes mediation easy to understand. It is interesting to study some elements that this defini-

tion provides, for example, mediation has a duality that tends to be considered a technique and a method to terminate conflicts. We can bring up the topic of justice citizenship by parties through mediation, that is, through mediation, the parties appropriate conflict management by themselves. In short, the parties that are involved in a dispute do not need an authority that directly ends it, it is enough for the parties to reach an agreement of their own will to conclude the dispute satisfactorily.

In this regard, "we can say that mediation is a process or management of conflict resolution, where the parties attend voluntarily and with the help of a professional third party, build agreements by making decisions naturally on the motivating issue of the conflict" (Cornelio, 2014: 92). For these reasons, it is considered important to analyze mediation, not as a flat object, but as a scientific construct, capable of ending conflicts, but with the condition of establishing an epistemology that allows us to see its valuative purpose (axiological plane), its normative regulation (logical-phenomenological plane) and its factual effectiveness (ontological plane).

Based on the above considerations, it is considered that mediation can generate even greater effectiveness than any other method, whether traditional (jurisdictional and administrative processes) or of any other nature, since mediation recognizes the human right of access to justice and, in addition, is institutionalized through a legal norm of a general nature. However, this point of view will be developed later. Therefore, to understand this condition, it is necessary to establish that, from the epistemological construct of mediation, women can empower themselves to end their own conflicts, which generates an aspect of justice citizenship and, therefore, free, and full access to it.

Based on the above, mediation is a novel way to end conflicts through a process called conflict management. Conflict management establishes conflict termination through the satisfaction of agreements between the parties, which leads us to the end pursued by this mediation, that is, positive peace or the culture of peace. As is known, mediation, being a booming scientific construct, has some problems with location within the general theory of the process, since it is complicated to locate it either within auto-composition or in hetero-composition. "As we can see, mediation then, is under a problem of the general theory of the process, since there is a slight confusion in knowing if it is a hetero-compositive or auto-positive method, however, with this deduction, we can infer that it is in a procedural limbo that has been called composition by conflict management" (Palacios, 2020: 31).

To have a greater precision of the context of positive peace and how it benefits women's access to justice, the absence of violence and conflicts must be understood as the purpose pursued by mediation since it seeks the non-existence of conflicts and lack of inequality. "For this reason, peace

culture or, rather, the construction of peace culture establishes the philosophical mechanisms that start from the structure of positive peace, which is understood as the absence of violence" (Palacios, 2020: 28).

THE LOGICAL PART OF MEDIATION, THE NORMATIVE PERSPECTIVE

In the previous sections of this work, it has been established that mediation is conceived as a process to end conflicts, which uses a type of composition by conflict management to achieve this objective. That said, mediation is known as a conflict management method that has positive efficacy concerning other ADR, which has caused this method to be constitutionalized, or, rather, to recognize the human right of access to justice through this method, which generates a way to institutionalize mediation within Mexican positive law.

One of the consequences of constitutionalizing the ADR is the LNMASCMP, which contains the necessary provisions to provide and legitimize the participants of a conflict, as well as the third parties who will serve as mediators or facilitators within these criminal conflicts. As a result of the above, and "given the impossibility and inconvenience of bringing all criminal proceedings to trial, the existence of mechanisms that promote the voluntary settlement between the parties has been foreseen... without the intervention of a judge, through the National Law on the Mechanisms for the Alternative Resolution of Disputes in Criminal Matters" (Fix-Fierro et. al., 2015: 121).

Given this condition, it is important to know the benefits that this legal norm has for women who want to have access to justice, as far as possible, in the face of other types of mechanisms, such as legal, jurisdictional, and administrative processes. Likewise, it is considered relevant to point out that women have an area of opportunity to achieve the management of their social conflicts alongside this law since it is a consequence of the incorporation of the ADR into the constitutional text from the criminal amendment of 2008.

For these reasons, mediation proposes a paradigm of fullness to the human right of access to justice, that is, even when the CPEUM enshrines such access, the monopoly of justice by the State means that there is even institutional resistance so that a person has the desired access to justice (more, if we have as that the null access to justice is considered gender violence), so that alternative justice through mediation, breaks with this paradigm and concretizes the prerogative mentioned above.

Another form of gender violence is that which is manifested by the inequality that people suffer when receiving unequal treatment within a judicial process, which, with mediation, this aspect is null; in this consideration, it is demonstrated how mediation has the advantage to mitigate this gender violence, or rather, it is observed how mediation provides access to justice,

reducing social inequalities, which can be the product of structural conflicts aimed at the normalization of such social inequality. However, regarding the global pandemic due to COVID-19, it is necessary to specify certain considerations that mediation currently has, that is, according to the paradigm of confinement where the courts are in recess given this circumstance, mediation can be carried out from private centers and at a distance.

This generates certainty when it comes to managing structural conflicts, which can trigger other types of conflicts and violence, because mediation, being a method that significantly reduces the time to terminate conflicts, produces an environment of well-being, not only personal but also, social welfare and satisfaction of the parties when it comes to finalizing the respective agreements. Mediation can then bring about the completion of present conflicts more quickly and easily and helps prevent future conflicts.

The above-mentioned finds support in the reports issued by the Judicial Power of Mexico City (PJCDMX, 2020), in which it is shown that in at least the last quarter of 2020, virtual sessions were of vital importance to end disputes, since out of the number of records (85), 35 of them, that is, 41.17% managed to enter a mediation process. This represents a positive step forward in understanding that mediation can give free and full access, not only to women but to anyone else who voluntarily carries out a mediation process to end their conflict.

On the other hand, there were other judicial institutions as well as private centers throughout Mexico that offered their services remotely (virtual) so that people could manage their conflicts without the risk of leaving their homes and getting the SARS-COV-2 virus. "In addition to the private mediators who offer this modality of service in several states of the republic, the judicial powers of Sonora and the State of Mexico have made remote mediation services available to citizens from their respective mediation centers" (Hernandez, 2020).

This condition makes the LNMASCMP look like a flexible vertex that allows the end of conflicts in times of emergencies, not only health-related, but social, economic, or even political emergencies. On the other hand, since we have reflected on mediation from two perspectives, it is time to see how positive discrimination due to gender violence influences mediation.

POSITIVE DISCRIMINATION AGAINST WOMEN

Many times, the question has arisen regarding the negative effects of discrimination against women; however, it is important to begin to question and reflect on when discrimination becomes positive. At present, the use of this term has not been common, or, if it has been used, it has not been fully understood. In this sense, it refers as an example that within our society, it

is only possible to perceive negative discrimination, which is understood as that discrimination that generates a detriment towards certain people because of their sex, gender, social status, etc.; or to a sector of the population.

In this regard, under the aforementioned conditions, it is possible to clearly observe the detriment of certain people or, rather, of people or social groups' dignity; however, the same does not happen when talking about positive discrimination since due to its characteristics it is a bit difficult to see and understand. For this reason, positive discrimination must be analyzed as a preamble to the study of two situations: gender equality and gender equity, since we cannot notice at first glance the complex difference between one and the other, that is, "the principle of equality has traditionally been configured as a principle of justice" (Alegret, 2006: 17).

Derived from this conception, it is necessary to remember that mediation aims to reduce structural conflicts, such as inequality, both social as well as gender, since one of the objectives of mediation is to provide equality to the parties involved in a conflict, which generates empowerment of women so that they themselves terminate conflicts. In this regard, "the promotion and defense of the concept of positive discrimination has been based, in part, on discussions on structural barriers to equal opportunities and the challenges to overcome the historical effects of sustained exclusions of some groups of people with active or equal participation in civic development, and the political life of the nation" (Jara-Labarthé, 2018: 333)

Under this paradigm of equality, it is necessary to remember that, in many constitutions, including the Mexican one, there is talk of equality between men and women, for having the same rights and obligations as citizens, which implies that, regardless of the condition of sex or gender, a man and a woman have equal rights and, therefore, obligations, however, this does not happen in the daily practice of the exercise of such a human right.

Under the assumption mentioned in the previous paragraph, two ideas prove what has been said. In the first place, there are still barriers between men and women, which have been coexisting for a long time with the culture in which contemporary society has developed, that is, there has been no ability to link the idea that a man and a woman are ultimately human beings and people who have unique abilities that make us balanced with each other.

Secondly, the lack of development for new ways of harmoniously living is due to the previously mentioned conditions of negative discrimination. Thus, it allows us to consider that women are inferior in any situation in life and to consider them capable of carrying out any activity aimed at the development of society. In this sense, it is evident that inequality and discrimination are linked very closely, by finding elements that make possible a difference between groups or sectors of the population, this is best described since "inequality is suffered by the whole group or collective (...),

inequality that has occurred due to various circumstances, fundamentally socio-cultural ones, that have led to certain groups not having access to certain rights, goods or services like the others" (Alegret, 2006: 20).

However, once this part of discrimination has been analyzed, it only remains to define positive discrimination, which is understood as that condition of distinctive treatment towards a person or social group, which is benefited before others by its condition of gender, sexuality, or social condition. Regarding the above, Jara-Labarthé (2018), takes up a definition that, from an objective perspective, is quite close to what has been expressed regarding this concept, that is, "in its simplest form, measures of positive discrimination – also referred to as affirmative action or positive action in some places – are intended to give special considerations to individuals based on their belonging to a social group that has been identified on some basis of disadvantage about other groups in society" (Wang, 1983).

The term positive discrimination tries to solve the problems of equality and gender equity, granting certain benefits to women because of their human condition, however, such a situation falls into positive discrimination by providing them with benefits that men cannot have, by their human nature, also being discriminated against negatively. However, to talk about positive discrimination, it is necessary to address an issue that identifies the equalization of minorities, that is, affirmative actions or positive actions must be understood, which come from court rulings as synonymous with positive discrimination.

Derived from the above, "affirmative actions – a concept that complements that of positive discrimination – aim to question and modify those factual situations that prevent and hinder excluded groups and individuals from achieving effective equality in the claim for their rights" (Durango, 2016: 141). This indicates that it is necessary to place the object of study in the place of people who need to have equality concerning others, or to a certain group of the population, to give them a balance that is projected to combat the inequality and discrimination they suffer day by day. Therefore, affirmative, or positive action is understood as any logical, political, social, legal, economic, or any other approach so that a person or social group is not segregated through inequality or is discriminated against as a result of this inequality.

This principle of positive discrimination is supposed to be a term, whose ideology proposes non-discrimination to another sector or person, against which it is being endowed with positive action. This is because constant social, economic, political, and other changes create new scenarios that do not allow the rights of a person or a group to be correctly assessed or weighed.

For the specific case, feminism is observed as a fully social and positive movement for contemporary dynamics, as an agent that seeks gender equality

and equity. However, the poor performance and radicalization that this movement has had breaks with the main philosophy by which it was started before the seventies, to generate spaces for women.

Similarly, some legal phenomena have given greater weight to the rights of women over those of men, such as the specific case of the presumption of innocence for the case of crimes that arise from gender violence, which, at least within Spanish legislation, protects a woman, while a man is disproportionate to the detriment of his rights guaranteed in the Constitution of that country. That is, there should not be a condition that limits the equality and equity of rights according to the issue of conduct typified as gender violence, at least when a woman is a victim, since the Spanish Substantive Criminal Law so determines, so the question arises: what happens when women are the active and not the passive? The answer refers to a clear example of positive discrimination against women since the presumption of innocence for a man in the crime of gender violence does not have the same conditions as if the active were a woman.

Derived from the above, negative discrimination against a man apparently arises, since, in the first place, there is a positive action to the female victim to the detriment of a man, when the logic of this positive discrimination is not to violate the rights of a person or a social group; second, a woman cannot commit the conduct of gender violence as a man but deploys the conduct of domestic violence within the Spanish substantive criminal coding, which also notes a benefit to a woman compared to a man.

If you continue with this type of example, you can continue to air this type of situation. However, the idea is not to criticize positive discrimination against negative discrimination, what matters is to raise awareness about the capacity of some traditional mechanisms to provide equality to the parties when ending the conflict.

Through this context, we observe what is happening in the European Union, especially in Spain, whose cases of positive discrimination have been aired by the European Court of Human Rights and, which, for our study, has a relevant interest in this regard, since it can be said that mediation is a method that provides the parties with equality, it gives a benefit to women when it comes to accessing justice. Therefore, there is a new way of seeing mediation, not only as an effective method that gives women access to justice but also mitigates gender violence and the new conflicts that society in general faces within this global pandemic.

CONCLUSIONS

The function of mediation has been objectively analyzed from substantive, adjective, normative, or logical perspectives and as a method of conflict termination management. It is concluded, therefore, that gender violence comes from a structural conflict, that permeates in a natural or normal way within the social structures themselves, which causes these behaviors to end up being a serious social conflict.

Similarly, it is observed that mediation provides a new paradigm of access to justice through the culture of peace and justice citizenship, which is a novel system to end any type of conflict effectively, including some of a structural nature.

On the other hand, mediation is very effective when it comes to ending conflicts and mitigating gender violence, especially derived from this confinement that we are going through at a global level since it provides procedural equality between the parties when it comes to ending conflicts.

Another conclusion derives from indicating that mediation recognizes human rights and, in addition, institutionalizes these human rights. This as a whole is called the normalization of mediation, since the recognition is found in the constitutional text of the Mexican fundamental law and, the institutionalization in the LNMASCMP.

Likewise, some traditional methods may have difficulties in terminating conflicts and increasing inequality between women, which can cause an increase in gender violence, translated into zero access to justice by women, an example of this, we observe the positive discrimination against women.

The foregoing leaves a reflection that no matter under what perspective discrimination is visualized, whether positive or negative, the idea here is based on not promoting under any circumstances any type of discrimination so as not to hinder the work of mediation to terminate disputes.

REFERENCES

Alegret Burgués, M. E. (2006). Presentación e introducción. En M. E. Alegret Burgués, *La discriminación positiva* (pp. 13-32). Madrid: Consejo General del Poder Judicial.

Convención sobre la Eliminación de Todas las Formas de Discriminación contra la Mujer. (2015). *Recomendación general núm. 33 sobre el acceso de las mujeres a la justicia*. Organización de las Naciones Unidas.

Cornelio Landero, E. (2014). Los mecanismos alternativos de solución de controversias como Derecho Humano. *barataria. Revista Castellano-Manchega de Ciencias sociales*(17), 81-95.

Durango Álvarez, G. (2016). Las acciones afirmativas como mecanismos reivindicadores de la paridad de género en la participación política inclusiva: Ecuador, Bolivia, Costa Rica y Colombia. *Revista de Derecho,* 137-168.

Fix- Fierro, H. F., Suárez Ávila, A. A., & Corzo Sosa, E. (2015). *Entre un buen arreglo y un mal pleito. Encuesta Nacional de Justicia*. Ciudad de México: unam.

Hernández Mergoldd, P. (2020). *El Economista*. Obtenido de El Economista: https://www.eleconomista.com.mx/opinion/La-Cultura-de-la-Paz-Mediacion-a-Distancia-en-tiempos-del-Covid-19-20200505-0050.html

Jara- Labarthé, V. (2018). Discursos y prácticas de la discriminación positiva para políticas indígenas en educación superior. *Cinta de moebio*, 331-342.

México, P. J. (2020). *Centro de Justicia Alternativa*. Obtenido de Poder judicial de la Ciudad de México: https://www.poderjudicialcdmx.gob.mx/cja/wp-content/uploads/F-Enero-Dic-Virtu-791x1024.jpg

Organización de las Naciones Unidas. (2021). *onu Mujeres*. Obtenido de onu Mujeres: https://www.unwomen.org/es/what-we-do/ending-violence-against-women/faqs/types-of-violence

Palacios Xochipa, J. (2020). La epistemología de la mediación y su impacto en la profesionalización de los masc en la cultura de paz. *Eirene, estudios de paz y de conflictos*, 25-36.

Wang, B. L. (1983). Positive Discrimination in Education: A Comparative Investigation of Its Bases, Forms, and Outcomes. *Comparative Education Review*, 191-203.

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14-3-3 Proteins and neurodegenerative diseases: A computer simulation perspective

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— Abstract—

Neurodegenerative diseases are defined as the set of ailments that affect the neurons of the nervous system. Examples of these neurodegenerative diseases are Parkinson's Disease, Alzheimer's, and Amyotrophic Lateral Sclerosis (ALS). These diseases cause mental functionality and movement problems, which are weakening and incurable.

You have heard about these ailments, which are commonly studied in a clinical-experimental way. The health sector is making several efforts to find a treatment for such diseases. These efforts are focused on both experimental and theoretical research. But neurodegenerative diseases can also be studied by using computational tools.

Nowadays, computers are an essential ally in searching for solutions to many of the issues affecting our society, specifically, problems related to public health. To take advantage of this tool, a vast range of computer algorithms have been developed. These algorithms are the way we want the computer to do the tasks to solve a problem.

To study neurodegenerative disease's molecular origin, tools, such as molecular dynamics simulation, have been developed from a computational perspective. Molecular dynamics simulation aims to mimic a system's behavior on a computer; in this case, the system would be biological, for instance, a protein in a lipidic brain membrane environment.

Keywords:

Neurodegenerative Diseases; Molecular Dynamics; Proteins.

Neurodegenerative disease is one in which there is cell death, which causes wear and tear of nerve tissue. Neuronal death can be caused by small lesions caused anywhere in the nervous system (Williams, 2002). Some examples of the most common neurodegenerative diseases are amyotrophic lateral sclerosis (ALS), Alzheimer's disease, Crutzfeld-Jakob disease, and Parkinson's disease.

Neurodegenerative diseases cause problems with movement and mental functioning; they are debilitating and incurable. In addition, they share characteristics such as unknown cause, multifactorial origin, non-specific initial symptoms with multiple forms of presentation, and different degrees of disability, affecting the person's quality of life (Amor, Puentes, Baker, & Van der Valk, 2010).

Currently, there is no cure for neurodegenerative diseases, but there are pharmacological treatments that help stop the progression of the disease and control symptoms. In addition, another key point is rehabilitation with physical and occupational therapy. In this way, a better quality of life for the patient can be ensured (Research, 2019). In these diseases, many times certain proteins are involved. You may have heard about proteins since high school, which are macromolecules formed by linear chains of amino acids and are particularly important in different biological processes (Figure 1, representation of an amino acid chain).

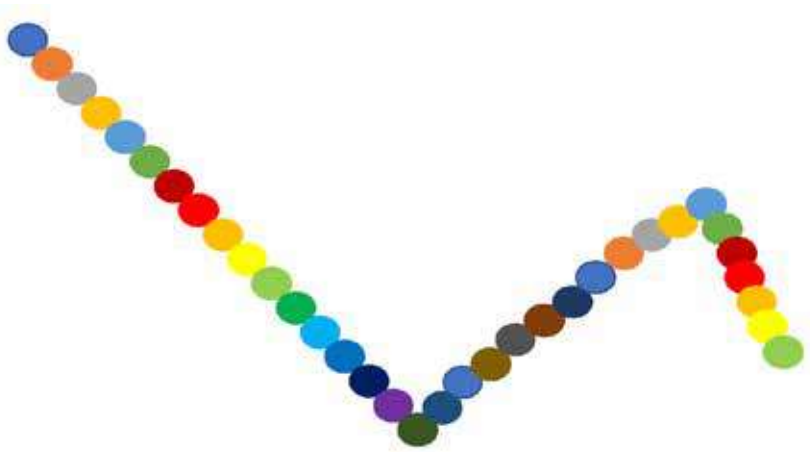

Figure 1. Representation of an amino acid chain. Source: Own elaboration

Efforts have been made in *postmortem* studies to improve diagnoses and detect biochemical markers related to these diseases. A biochemical marker can be defined as any protein, hormone, or substance that is detected in body fluids or tissues. Inside the biochemical markers, 14-3-3 proteins and the amyloid-beta protein were found, to name a few (Foote & Zhou, 2012).

So, some of the proteins mostly related to neurodegenerative diseases are 14-3-3 proteins, which are a family that is mostly expressed in the brain and have seven isoforms (this word refers to different forms of a protein) which are: β, γ, ε, η, ζ, σ and τ/θ. 14-3-3 proteins are involved in biological processes such as signal transduction, apoptosis, neuronal development, and the cell cycle, and have been linked to some neurodegenerative diseases (Foote & Zhou, 2012).

A COMPUTATIONAL APPROACH TO THE STUDY OF NEURODEGENERATIVE DISEASES

As we have mentioned before, there are several ways to study neurodegenerative diseases. One of them is from the experimental point of view and another can be from the computational point of view, for example, through the computational simulation method known as molecular dynamics. The computational simulation aims to reproduce on a computer the behavior of a system, in this case, the biological system. For example, the behavior of a certain protein related to neurodegenerative disease. Figure 2 illustrates that computational simulation occupies an intermediate place between theory and experiment and, therefore, is very often also known as a computational experiment with which conditions can be achieved easily that, in the experiment, would be exceedingly difficult or expensive.

Figure 2. Computational simulation lies between experiment and theory. Source: Own elaboration

Molecular dynamics is a technique in which molecules are described as linked point objects that can have electric charge, and magnetic dipole moment, among other physical properties. This technique describes the temporal evaluation of bonds, bond angles, torsions, and interactions modeled by a force field, which is represented by equations that characterize an interaction potential (Maldonado Arce, *et al.*, 2016).

Although there are computational tools for the study of neurodegenerative diseases and corresponding biological systems, such as a model brain membrane, a computational simulation study has not yet been carried

out using the method of molecular dynamics of a model brain membrane and its interaction with a 14-3-3 protein.

Now we will briefly describe some of the best-known neurodegenerative diseases, some studies using molecular dynamics of these diseases, and the potential role of 14-3-3 proteins in the pathogenesis of these diseases.

Alzheimer's disease accounts for one of the most common neurodegenerative diseases (WHO, 2020). Alzheimer's disease is the most usual form of senile dementia. As reported in the United States, 5 million people were affected by this disease, and globally, the figure was 25 million people (WHO, 2020). While, for the specific case of Mexico, according to data from Gutiérrez Robledo *et al*., 800,000 people suffered from Alzheimer's in 2014 (Government of Mexico, 2017).

The affected areas of the brain observed in Alzheimer's disease can be the hippocampus and areas related to olfactory and visual pathways. The main symptoms of this disease include memory loss, poor learning in general, and dementia (Cummings & Cole, 2002). This disease is characterized by two important pathological aspects: amyloid plaques, which are those formations between the interneuron spaces of the brain's gray matter that serve as a deposit of l peptide amyloid-beta, and neurofibrillary tangles, composed of fibrils intertwined in neurons, which in the case of Alzheimer's are proteins formed of small fibers between neurons. It has been reported that 14-3-3 proteins are related to Alzheimer's disease, based on their location near the neurofibrillary tangles, and thus the interaction of proteins related to the development of the disease occurs (Foote & Zhou, 2012).

However, the causes of Alzheimer's disease are not yet known, but there are several hypotheses such as metabolic disorders, acetylcholine deficiency, and the accumulation of amyloid β-proteins, 14-3-3 proteins, and neurofibrillary tangles (Foote & Zhou, 2012). The first hypothesis relates the development of the disease to metabolic disorders such as hyperglycemia (high blood sugar) and insulin resistance (Gualdrón & Ávila, 2007). The second hypothesis, the deficit of acetylcholine, is the oldest in the development of Alzheimer's disease; many of the current treatments are based on this hypothesis. This hypothesis suggests that Alzheimer's is caused by the reduction of acetylcholine, a neurotransmitter (Ferreira-Vieira, Guimaraes, Silva, & Ribeiro, 2016). Finally, hypotheses arose linking the accumulation of amyloid β-proteins, 14-3-3 proteins, and neurofibrillary tangles in the brain.

To study the composition of the brain, how it is related to neurodegenerative diseases, and the proteins related to these diseases, there are both experimental and computational methods.

The molecular dynamics can be accompanied by different models depending on the spatial or temporal scale that interests us. To study bio-

logically relevant systems without losing structural details, coarse-grained models represent a suitable alternative. These models reduce the number of atoms and, therefore, the computational cost of the system. What is done in a coarse-grained model is to represent a certain number of atoms with a pseudo-particle.

Thus, for example, we can cite the study conducted in 2017 by Ingólfsson *et al.*, where they used the coarse-grained model known as Martini, to develop and examine a model of a lipid brain membrane such as the one illustrated in Figure 3, and this was compared with a mammalian plasma membrane. Compositional differences between the membranes showed complementary influence on many of the bilayer's properties.

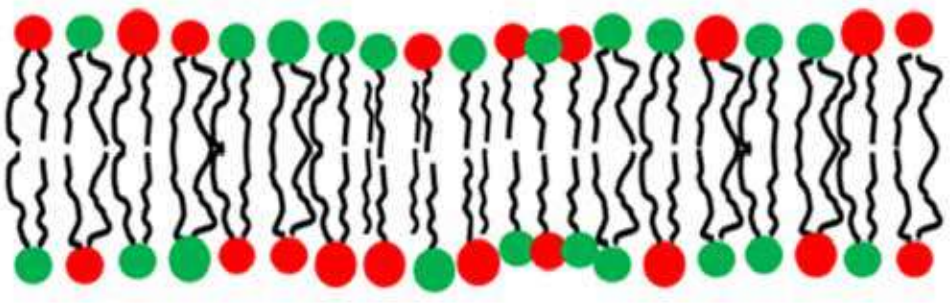

Figure 3. Representation of a biological membrane. The hydrophilic heads are red and green, while the hydrophobic tails are black. Source: Own elaboration

Now, continuing with the most common neurodegenerative disease is Parkinson's disease, which is progressive and one of its symptoms is tremors, which begin imperceptibly, but later cause damage such as:

- Stiffness
- Balance Problems
- Impairments in speech and writing
- Decrease in the movement of the affected person

This disease is characterized by dementia caused by Lewy bodies, which are abnormal aggregations of proteins that contribute to the development of the disease and the loss of the neurotransmitter dopamine. 14-3-3 proteins are related to the disease due to their localization concerning other proteins that also are related to their development and the binding with these proteins. It has been observed that this disease is caused by the gradual death of neurons that produce dopamine. The latter is a chemical messenger, which when decreased causes an abnormality in the activity of the brain, which leads to the development of Parkinson's disease (Foote & Zhou, 2012).

It has also been reported that amyloid β- and α-synuclein, both of which are intrinsically disordered proteins, are closely related to Alzheimer's and Parkinson's diseases. For the study of these proteins and diseases, both experimental and computational techniques have been used; for example, Coskuner-Weber & Uversky (2018) reported that nonsense mutations can be used in computer simulations to better study the relationship between Parkinson's disease and the amyloid β and α-synuclein proteins.

In another study, Herrera (2008) reported by computer simulation, the relationship between the interaction of α-synuclein and dopamine. Which, as mentioned above, are related to Parkinson's disease. In this work, we used the technique of molecular dynamics with the force field known as Amber99. Within the results of the study, it is suggested that dopamine ligands bind at a c-terminal end of the protein α-synuclein.

Another of the most common neurodegenerative diseases is Crutzfeldt-Jakob disease, which causes decreased movement and loss of mental function. The types of this disease are 3 and are mentioned below:

- Sporadic type that occurs in unknown situations
- Familiar type
- And finally, the acquired form

Crutzfeldt-Jakob disease may be related to other diseases such as rare human hereditary diseases (such as fatal familial insomnia). In an article, reported by Shamsir & Darby (2005), it is mentioned that these diseases are related to a mutation in codon 178 (sequence of 3 nucleotides of DNA or RNA), but that they differentiate from each other by a polymorphism in codon 129. Using molecular dynamics, these authors investigated the effect of mutation on codon 178 and polymorphism on codon 129.

Regarding the same disease, it may be related to other exceedingly rare human hereditary diseases, such as kuru and fatal familial insomnia. Finally, it has been observed that there is a variant of Crutzfeldt-Jakob disease that triggers mad cow disease (Will *et al*., 1996).

CONCLUSION

Among the different studies that have been carried out on neurodegenerative diseases, some have been through experimental techniques and some others with computational techniques, such as the simulation of molecular dynamics or Monte Carlo. For example, through computational simulations, proteins and ligands related to neurodegenerative diseases have been studied.

Despite the aforementioned studies, a computational simulation study has not yet been carried out using the molecular dynamics method of a model brain membrane and its interaction, for example, with 14-3-3 proteins related to neurodegenerative diseases. The current availability of both theoretical and computational resources allows us to carry out studies of, for example, the interaction of the isoform 14-3-3 tau with a model brain membrane. We are currently developing this type of study.

REFERENCES

Amor, S., Puentes, F., Baker, D., & Van der Valk, P. (2010). Inflammation in neurodegenerative diseases. *Immunology, 129*(2), 154–169. doi:10.1111/j.1365-2567.2009.03225.x

Coskuner- Weber, O., & Uversky, V. N. (2018). Insights into the Molecular Mechanisms of Alzheimer's and Parkinson's Diseases with Molecular Simulations: Understanding the Roles of Artificial and Pathological Missense Mutations in Intrinsically Disordered Proteins Related to Pathology. *International Journal of Molecular Sciences, 19*(2). doi:10.3390/ijms19020336

Cummings, J. L., & Cole, G. (2002). Alzheimer disease. *The Journal of the American Medical Association, 287*(18), 2335–2338. doi:10.1001/jama.287.18.2335

Ferreira- Vieira, T. H., Guimaraes, I. M., Silva, F. R., & Ribeiro, F. M. (2016). Alzheimer's disease: Targeting the Cholinergic System. *Current Neuropharmacology, 14*(1), 101–115. doi:10.2174/1570159x13666150716165726

Foote, M., & Zhou, Y. (2012). 14-3-3 proteins in neurological disorders. *International Journal of Biochemistry and Molecular Biology, 3*(2), 152–164.

Gobierno de México. (2017). Género y Salud en Cifras, Vol. 15 Num. 1. Enero - Abril 2017 | *Centro Nacional de Equidad de Género y Salud Reproductiva* | Gobierno | gob.mx. Retrieved January 12, 2021, from https://www.gob.mx/salud/cnegsr/documentos/genero-y-salud-en-cifras-vol-15-num-1-enero-abril-2017?state=published

Gualdrón, A. J., & Ávila, V. Á. (2007). Insulin and Alzheimer disease: type 3 diabetes? *Revista de La Facultad de Medicina*.

Herrera, F. E. (2008). Computational approaches to the investigation of proteins involved in Parkinson's Disease. PhD thesis

Ingólfsson, H. I., Carpenter, T. S., Bhatia, H., Bremer, P.-T., Marrink, S. J., & Lightstone, F. C. (2017). Computational lipidomics of the neuronal plasma membrane. *Biophysical Journal, 113*(10), 2271–2280. doi:10.1016/j.bpj.2017.10.017

Maldonado Arce, A. D., Contreras Aburto, C., Favela Rosales, F., Arvayo Zatarain, J. A., & Urrutia Bañuelos, E. (2016). MÉTODOS DE SIMULACIÓN COMPUTACIONAL EN BIOLOGÍA. *Epistemus. Revista de Estudios En Música, Cognición y Cultura, 10*(21), 84–92. doi:10.36790/epistemus.v10i21.38

Research, J. (2019). ¿Qué es una enfermedad neurodegenerativa? | *JPND*. Retrieved January 11, 2021, from https://www.neurodegenerationresearch.eu/es/que-es-una-enfermedad-neurodegenerativa/

Shamsir, M. S., & Dalby, A. R. (2005). One gene, two diseases and three conformations: molecular dynamics simulations of mutants of human

prion protein at room temperature and elevated temperatures. *Proteins: Structure, Function, and Bioinformatics, 59*(2), 275–290.

WHO. (2020, September 21). Dementia. *Who*. Retrieved January 10, 2021, from https://www.who.int/news-room/fact-sheets/detail/dementia

Will, R. G., Ironside, J. W., Zeidler, M., Cousens, S. N., Estibeiro, K., Alperovitch, A., ... Smith, P. G. (1996). A new variant of Creutzfeldt-Jakob disease in the UK. *The Lancet, 347*(9006), 921–925. doi:10.1016/s0140-6736(96)91412-9

Williams, A. (2002). Defining neurodegenerative diseases. *BMJ (Clinical Research Ed.)*, 324(7352), 1465–1466.

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Habitat improvement project for “El Encanto”, Tapachula, Chiapas. Historical and regional context

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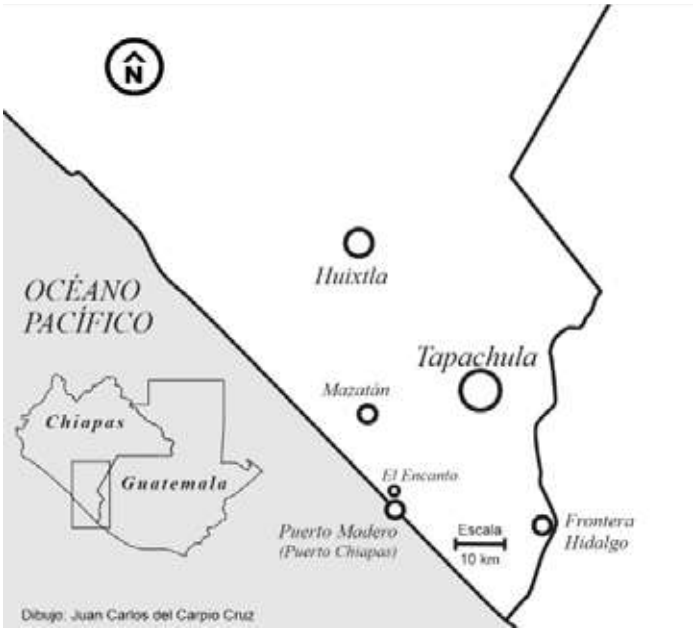
— Abstract—

In 2019, we carried out a diagnosis of the town "El Encanto" in Puerto Madero, Chiapas, to obtain field data on socioeconomic aspects, the population's health conditions, housing, habitat, and natural physical environment. The objective of the diagnosis was to provide empirical support for various proposals for intervention to improve the living conditions of the inhabitants of the town. The team was formed by four professors (an architect, a civil engineer, an anthropologist, and a doctor), 49 students in the seventh semester of bachelor's degree in architecture, two students of social service of the same career, and a graduate of master's degree in architecture and urbanism of the School of Architecture of the Universidad Autónoma de Chiapas. We will not offer the diagnosis' results or analyze the quantitative data obtained from the survey in this document; these results are presented, analyzed, and discussed in another document. What we do in this article is to draw attention to the need to contextualize the quantitative data obtained in the survey, providing a perspective of local and regional history, so that the numerical data used by the designers to make their intervention proposal, have an explanatory framework. Why is the town located in such an inappropriate place topographically? Why are the people there so poor and lacking in urban infrastructure? Who are these people? We maintain that the universe that architects, urban planners, and doctors intend to intervene and transform is the locality, and therefore the diagnosis is reduced to that scale, thus the data collected must be interpreted concerning processes of regional scale and long duration, so we focus our gaze on the economic, sociocultural and environmental changes of the Soconusco from the late nineteenth century to the present to understand the context in which the studied locality arises and develops and its problems.

Keywords:

Southern Frontier; Soconusco; Central America; Long-duration processes.

Towns like "El Encanto" inhabited by people without wealth and power are generally born as appendages of an economic process of a regional, national, or international character. The town under study is located on the southern border of Mexico, just 25 kilometers from the international demarcation line that divides Mexico with Central America, in the region known as Soconusco, which has been key in the emergence and development of various economic, political and even civilizational processes, as this place is one of the points where civilization emerged in Mesoamerica (Clark & Blake, 1993). The objective of this document is to provide a historical and regional framework for the interpretation of the economic, sociocultural, and environmental processes of the town "El Encanto", the municipality of Tapachula, Chiapas (see map 1). The users of the information generated will be the designers of the housing and equipment projects for the locality so that the interventions that are proposed at the habitat scale consider the general context in which the mentioned site is located.



Map 1. "El Encanto" and its surrounding area. Source: Own elaboration

2. MATERIALS AND METHODS

As a first step, in cabinet and using *Google Earth* a cartographic and statistical review of the region was made, locating, and hierarchizing the network of roads, towns, and cities, the pattern of settlements, land uses and bodies of water. Subsequently, fieldwork was carried out in the area and in the

locality, which included interviews with key informants, focus groups, and boat tours of the coastal channels to observe and photograph the fishing sites and the areas of final disposal and treatment of solid and liquid waste, as well as a tour of the port facilities.[1] As a final step, before the drafting of the diagnosis presented to the Instituto de Ciencia, Tecnología e Innovación del Estado de Chiapas (ICTI), a bibliographic review was carried out to frame historically and geographically the data obtained in the field, which is what is presented in this document.

3. RESULTS

The Soconusco and regional dynamics from the delimitation of the Mexico-Guatemala border

In 1882 the Boundary Treaty between Mexico and Guatemala was signed, beginning in the region a period of economic bonanza, since the treaty gave legal certainty to foreign and national investors interested in the cultivation, benefit, and trade of coffee, which in Guatemala had been produced commercially for more than 50 years, since the time of the founder of that nation, Rafael Carrera, who ruled the country from 1844 to 1865, a period during which coffee generated 50% of GDP, being the origin of the main transformations of the country (Del Carpio Penagos, 2017; 2018).

The Boundary Treaty sign was a consequence of the demand for land to expand this crop and the fertile mountain slopes of Soconusco and the Guatemalan Boca Costa offered these in large and unbeatable virgin extensions. But there were no legal conditions guaranteeing ownership of the land, as it was an undefined international border. However, since the signing of the treaty, many foreign and national entrepreneurs invested in Soconusco in the development of coffee plantations. One of them was the Spaniard Bruno García Mijares, who, in addition to owning several properties in the coffee area as well as in the coastal plain, including "La Alianza", took on the task of rebuilding the port of San Benito, opened in 1861, to give way to the agricultural and extractive production of the region. Bruno García was a businessman with broad interests, also dedicating himself to the transport

1 The project: "Habitat improvement project for "El Encanto", the town of Puerto Madero, Tapachula, Chiapas", Key: ID-1033 (2019), was funded by the Instituto de Ciencia, Tecnología e Innovación del Estado de Chiapas (ICTI). The statistical results, as well as the different proposals for housing improvement and introduction of infrastructure and urban equipment can be consulted in Escamirosa *et al.*, 2020, "Reconstrucción del hábitat en comunidades rurales de Chiapas: caso de estudio Ocuilapa y El Encanto" (Online): www.AcademiaJournals.com and the Technical Report of the project (Escamirosa *et al.*, 2020), in Red Investiga ICTI (Online): https://RedInvestiga.chiapas.gob.mx

and trade of goods, as well as the production of electrical energy, a fluid from which he supplied the city of Tapachula until 1937 when the government of Lázaro Cárdenas created the Federal Electricity Commission.

In the final years of the nineteenth century and the first decades of the twentieth century, the coffee production of the plantations located in the upper parts of the Soconusco region was brought to Tapachula by mules. This city was the center of the collection of all the production and there were established numerous companies that benefited from the grain: they shelled it, dried it, removed the shell, weighed it, and bagged it. Don Bruno had interests in all phases of the process.

Once transformed into a profitable commercial product, as it was desired by a growing market in Europe and the United States, coffee was transported in hundreds of ox-drawn carts through the plain that separates Tapachula from the Pacific beaches, passing through the town of Mazatán, which was a relay station of the teams, where the animals that dragged the carts from Tapachula were replaced by others that completed the journey to the beach of San Benito, where Don Bruno rebuilt and enlarged the cabotage port that served the trade of the region since the times of Juarez. Each wagon carried a ton of weight in goods, mainly coffee, although coal, salt, wood, and bananas were also exported.[2]

The port consisted of a wooden pier that went into the sea as far as a large "shepherd" could anchor; each of these boats was handled by six rowers and loaded with up to 10 tons. Through them, the coffee was carried on the boats that anchored 3 kilometers offshore to avoid running aground. It was these ships that took coffee to New York, Hamburg, London, and other large urban centers of the world, where the grain, originating from the Ethiopian plateaus, generated new habits of consumption, relationships, and use of time, at the end of the nineteenth century. Each ship was loaded with up to 5,000 tons, says Don Tito Rivera, an elderly inhabitant of El Encanto, a descendant of one of the founders of the Puerto Madero ejido.

The arrival of the railroad to Tapachula in 1908, connected Soconusco with the rest of the country and began the decline of the emporium of Don Bruno, who tried to stay in the business of transporting goods by building a port like San Benito in the region of the Guatemalan Bocacosta, a place he

2 Karl Helbig, a German geographer who made his classical studies on the geography of Chiapas in the 60s, reports, in a book called *El Soconusco y su zona cafetalera en Chiapas* (1964: 114), that San Benito was significantly enlarged from 1895, in the middle of Porfirismo. It was these works that Don Bruno García carried out, that allowed him to operate the port terminal as his property. He probably enjoyed a concession given by the government of Porfirio Díaz, as in those years it was customary to do, to promote the capitalist development of the country.

would call Puerto Miniso. For that, he ordered to bring everything necessary from Europe with the ship *Sisoste*, which had the misfortune of running aground, thus losing the investment and accelerating the final ruin of Don Bruno. Its workers meanwhile survived by working the properties of San José, Santa Rita, and Juan Grande, which Don Bruno had granted them to keep them cohesive, thus giving rise to the population and ejido of Puerto Madero, founded in 1942. There were 42 families who founded the town, among them, the brothers Ernesto, Rafael, Ricardo and Humberto Estrada Vázquez, as well as Francisco Sánchez Baños.

The economy of Soconusco has always been of an extractive type, of the enclave, which consists of producing wealth that is exported to other regions of the country and the world, remaining the local population and the region practically without significant changes or being these very slow dynamics, thus guaranteeing its role as producer of wealth for the benefit of foreign elites.

However, during the 40s some transformations began to take place in the regional landscape. By then the original ejidos had increased their population and received extensions of their territories. Gradually, the productive infrastructure was also expanded with the construction of irrigation systems and roads in the coastal plain, which stimulated agricultural diversification, soil fertility, and work and investment efficiency.

Per the creation and expansion of ejidos in the area, which was largely a way of breaking the power that German farmers had come to have in Soconusco, a potentially dangerous situation for the country and the United States in the context of World War II; the Mexican state embarked on the creation of new productive infrastructure in the region and the improvement of the existing one. Between 1947 and 1952, irrigation systems were built in Suchiate and Cacahoatán for cocoa production on almost 6 thousand hectares. Until 1958, seven thousand hectares of alluvial soils had been irrigated on the Suchiate River in 1658, and similar works were planned on the other rivers in the region. The irrigation systems required the construction of bridges, embankments, and canals that affected the tributaries by the generation of sediments. On the other hand, deforestation always accompanies agricultural and extractive activities, which are increased with open communication routes and with the construction of irrigation systems, thus accelerating the erosive process of the watersheds, modifying the physical, chemical, and mechanical parameters of the water currents, which affects, of course, other levels of associated ecosystems, such as lagoon systems and pampas and estuaries.

In the 60s, the already by then old railway road began to become obsolete with the paving of the coastal highway of Chiapas, which in 1964 linked more expeditiously Tapachula and the other cities of the coast, such

as Huixtla and Tonalá, with Tuxtla Gutiérrez and the rest of Chiapas and the country, increasing the traffic of private vehicles and cargo and passenger transport, all activities that allowed the emergence of a thriving tertiary sector, the tasks of the government grew and diversified, trade multiplied.

In the 70s, when the construction of Puerto Madero (today Puerto Chiapas) began and "El Encanto" emerged, a policy of drainage of swamps and other wetlands on the coast of Chiapas began, through drains, the rectification of channels, boards, and drains collectors. The project sought to intensify the use of land for agricultural purposes, meaning another very strong blow to lagoon ecosystems by the extraction of water from rivers for irrigation, modifying the topography of the region.[3]

The 70s, the welfare state

The former workers of Don Bruno, who became ejidatarios in the town that they decided to call Puerto Madero, in honor of the hero of the Mexican revolution Francisco I. Madero turned to shrimp fishing, whose wealth was discovered by 3 Japanese ships that sailed the Soconuscan coast in 1945, at the beginning of the Second World War, with the mission of installing a radio station in La Palma, municipality of Acapetahua[4], as well as exploring the marine waters and the coast, highlighting the great abundance of shrimp, sharks, and flake species, which fed on the organic wealth provided by the numerous rivers that descend from the highlands of the Soconuscan mountain range. Subsequently, in Salina Cruz, in the isthmus of Tehuantepec, Oaxaca, shipyards were built and fishing companies were established that operated with boats.

In Chiapas, it was until 1970 that the shrimp, shark, and fishing extraction of Puerto Madero was organized, with the creation of a fishing cooperative, the establishment of a technical fishing school, and the construction of a fleet composed of seven vessels of 72 feet in length, which could be loaded with 30,000 liters of diesel and 20,000 liters of water. The boats had an autonomy of 20 days and were equipped with 5 crew members and a team of 60 feet on each side of the boat, in addition, they were provided with a cooling system in their warehouses to freeze the captured species. These ships were the *Puerto Madero*, built in Salina Cruz; the *Tapachula*, built in Veracruz shipyards; the *Chiapa de Corzo*, the *Tuxtla Gutiérrez* and the *San*

3 Field information indicates that flooding problems in the urban area of "El Encanto" worsened when the Tapachula-Puerto Madero highway was paved and widened, as the natural slopes and runoff channels were modified.

4 The Japanese settled in El Soconusco in 1897, when a group of 36 settlers founded Escuintla, the Enomoto colony (Kerber Palma, 2017).

Cristóbal, built in Topolobampo, Sinaloa and the *Bonampak* and the *Chamula*, armed in Mazatlan, also in Sinaloa.

Among the first fishermen of the port were Tereso Ramos and his sons Tereso, Natalio, and Daniel Ramos López, originally from Tapanatepec, Oaxaca, who fished with cayuco in the Cabildos Lagoon various species of scales such as bream, sea bass, and snapper; they were also those who years later introduced the use of trammel with sleeves of different sizes made of cotton yarns of nine and twelve and with three and four fingertips mesh. Others fished from the beach with berths and others used harpoons to catch large steals. The first fish buyers in Puerto Madero were Manuel Chacón and Gonzalo Matías. However, the dredging works of the port changed the physical parameters of the lagoons and their waters, since seawater was introduced to them, while the freshwater that came from the mountains decreased and degraded through an extraordinary influx of rivers that formed during the rainy mountain range, favoring the appearance and predominance of new species and the decrease and loss of others.

The early 1970s were a boom for fishermen, who went so far as to export 60,000 pounds of shrimp to San Francisco and San Diego, California, making huge profits. The business was going so well, that the company had in addition to its fleet, four more boats in a joint lease with a private company called Toyloca, with which it was in a partnership 45-55 (45% for the cooperative and 55% for Toyloca). The private company bore the expenses of fuel, maintenance, and equipment, in addition to paying the salary of the employer and the motorist. The cooperative paid the salary of the crane driver, who was responsible for keeping the product in optimal condition for the United States market, the sailor, who oversaw the nets and other fishing gear, and the cook.

Shark fishing was also a very important economic activity. It was a man from Tapachula named Leoncio Molet Coutiño, whose parents were furniture merchants in that city, who formed the first offshore fishing cooperative. Leoncio bought two boats equipped with stationary Lister engines, which made them slow. They fished with a hoof, with inappropriate hooks 20 centimeters long, which prevented catching the largest specimens, they managed to escape after straightening the harpoons with their strong jaws. Leoncio brought Justo Criollo from Alvarado, Veracruz, the first to start catching sharks using nets, which he carried by boats up to about 50 kilometers offshore. More than 600 25-foot-long boats equipped with 75-horsepower outboard engines, each making three trips a week to the high seas, and returning loaded with up to two tons of product, came into operation. Puerto Madero was in those years the first national place in shark capture. Today the overexploitation has ended with the activity, being

necessary to go up to 300 kilometers inside the sea to catch some specimens, making their capture unaffordable.

In 1975 gill nets were introduced, and the brothers Hilario, Conrado, and Héctor Hernández Villatoro were the first ones to use them. Meanwhile, Yiyo, from Veracruz, was the first to use echo sounders to locate fishing sites, specializing in catching huachinango, grouper, goat, chicken, and grouper.

In addition to the local fleet, called "Sociedad Cooperativa de Producción Pesquera Puerto Madero", boats from the "Progresista Istmeña" cooperative, which had 35 boats, and "La Suriana", with 26 boats, arrived in the coastal waters of Chiapas, both based in Salina Cruz. Also arriving were boats from Mazatlan and Topolobampo, Sinaloa.

According to the bonanza, in 1972 the state decided to promote the creation of an industrial development hub in the area, where companies processing marine products, fishmeal factories, and others were to be installed. For this, the federal government expropriated the lands near the coast, dispossessing the inhabitants of Puerto Madero and the ranchers of the area of their ejido plots and agricultural properties, who returned to the nation so that a high seas port could be built there, which should, according to the project, be the exit door for the agricultural production and raw materials of Chiapas and the entry of goods from various countries of the Pacific basin. However, none of this happened, or at least not on the scale on which it was imagined.

The port has not been operational because, despite so many works to avoid its mud, the strong waves that burst from the sea drag large amounts of sand towards the beach, decreasing its depth constantly, preventing large boats, such as cruise ships and ocean liners, from docking on its docks, limiting its operation to shallow vessels, such as fishing boats and private yachts.

The emergence of the colony "El Encanto"

The works to erect the port required large quantities of building materials, including brick of baked clay. This is how the "El Encanto" colony originated in the early 1970s, with construction workers who came in search of employment in the port works and who stayed to live in marginal and higher-risk areas, such as the floodplains near the port, where bricks emerged next to the access road to the town of Puerto Madero. People arrived from all over Chiapas and other states of the country, attracted by the supply of labor, among them some who knew the trade of making bricks and quickly identified the optimal quality of the alluvial soils of the area, thus starting the elaboration of this material to supply the demand not only of the works of Puerto Madero but also in Tapachula, which in those years of abundance

also expanded towards its peripheries, with the opening of new roads and the improvement of others, as well as new infrastructure and housing areas.

The first bricklayers were people who came from the Morelos colony, four kilometers away. Among the first were the Estradas, the Espinosas, the Molinas, the Matías Urreas (Adulfo Matías and his sons Eleazar and Cesar Matías), Juan Carlos Flores Cabrera and Juan Cortés. From Tabasco came an individual named Román Soto Balmaceda, who made a contract with the port administration to supply him with bricks. Don Román hired several people from Tehuantepec to do the bricks and so Isaías Pérez, Enedino López Castañón and Jorge López arrived. Don Román was a capitalist who financed production, and this contract considerably increased his fortune by becoming a builder. Nowadays their children run a construction company and have contracts to build roads, "they are very rich," says a resident of "El Encanto."

The activity also attracted non-regular laborers who roamed the ranches engaging in various unskilled activities. Several of these walking pawns settled in the colony as they found stable jobs in the brickworks. In those years, the landscape of the place was composed of several brick ovens scattered in the land full of weeds. The first houses of the village were the huts of the owners and pawns of the bricks, next to the ovens and drying areas of the raw bricks.

By 1989 there were already eleven houses occupied by Juan Cortés and his family, Isaías Pérez, Horacio Martín Urrea, Jesús Lastres, Vicente Zavala Vilchis, Isaías Zebadúa de León, Cecilio Cortés López, Agustín Cortés López, Elena Matías Urrea (Horacio's daughter), Oscar Tercero, Juan García Soriano, and that year Edi Chacón Flores, originally from Frontera Hidalgo, was added. The Cortés López, on the other hand, are native to Huixtla.

The roof of the houses of the place was of real palm, the same that has been maintained until the present day despite the increasing use of galvanized sheets, so it has a lot of demand in construction. It is a material produced by private ranchers in the area. As of today, November 2019, the price of a thousand sheets is 3,000.00 pesos put in place, so the transfer must be paid by the user. To cover a square meter of surface, 30 leaves are needed, so that with a thousand, a little more than 30 square meters are covered. The walls and structure of the houses are made of weeping bamboo rods, which are purchased at 30.00 pesos per piece. The thickest and most resistant, which perform structural functions, have a value of 60.00 pesos per piece. The beams and tie rods of the houses are made of coconut wood, which is sold sawn at 20.00 pesos per linear meter or 200.00 pesos per 7-meter tree, from which four 8 x 8 cm poles can be obtained. It is a very hard wood that does not sting. Bamboo is also used. To prevent it from being

chopped, the bamboo must be cut at dawn on the fourth day after the full moon, a period that the coast people call "the seasoning moon."

All these families lived from making bricks, thousands daily, but during the government of Manuel Velasco Coello (2012-2018), the administration of the port built the fence to enclose the lands of the industrial park, the lands where they extracted the land were protected by the fence, so the main source of income of the villagers of El Encanto became extinct, subjecting them to new conditions to achieve their reproduction. Today there are still two or three people who are still engaged in its elaboration but buy the raw material with the private owners of the neighborhood, who sell them trucks of land, as well as the fuel to burn it, mango firewood.

The cost of six cubic meters of land is 1000.00 pesos, mango wood is 700.00 pesos a load, and to burn a batch of eight thousand bricks two loads are used, while the cost of labor for making a thousand bricks is 400.00 pesos. A thousand bricks are sold in advance, at 1000 pesos per thousand, so the real beneficiaries of this industry are the owners of the Tapachula material stores, which sell the product at $2300.00 per thousand.[5]

Officially the colony is an ejido, an agrarian nucleus that, by decree, received land for its subsistence and housing. The territory of the ejido is divided into three separate fractions. In other words, their territory does not form a continuous geographical unit, but they are three fractions:

1. Agua Prieta, formerly known as Juan Grande, is a fraction of 50 hectares of flat and floodable land, which previously was a ranch belonging to an individual named Nibardo Betanzos, yielded by the government to the settlers in 1992. In the dry season, the swamp becomes a pasture where some heads of cattle grazing, and also some African palm plants subsist, but as the land is salty these almost do not produce fruits, so they do not constitute a source of income for the peasants or if they do it is very marginal. In addition, the land is in dispute with a group of people from Puerto Madero, who through deception and collusion managed to write it in their favor, thus generating a legal conflict for the possession of the property. A local inhabitant, originally from an island town, reports the existence of a Asociación Civil Encanto Moctezuma A. C., founded in 2006 to manage the regularization of land tenure.

   Lemon, mango, tamarind, guanabana, cherimoya, chicozapotes, mamey, papaya, and cashew trees thrive very well in the non-salty

5 September 2019 prices.

areas of the property, and it is even possible to make plantations with these products, which are in great demand in urban markets.

2. La Esperanza, a fraction of 19 hectares, was originally owned by Elodia Pérez and awarded to the settlers in 2004. This property was expropriated by the government to be incorporated into the Puerto Chiapas Industrial Park.[6]
3. The Mansion, a land of 21 hectares, whose original owner was Manuela Barceló Cigarroa, was awarded to the colony also in 2004, but like the previous one, expropriated by the government to incorporate into the surface of the industrial park.

During the few years that the land was theirs, each settler had twelve ropes of surface, in addition to an urban lot to build their home. But as usually happens, most of them, forced by necessity, sold their rights to the luckiest comrades. So nowadays, of all the families that inhabit the colony, only ten of them own land in the Agua Prieta fraction, for an area that goes from three to five hectares per family.

In 2007, they parceled the land where the village is located, dividing it into grids of 20 x 20 meters (400 square meters), although some obtained smaller lots.

As a result of the recent construction of the industrial park, the already floodable lands in which the colony is located were further damaged because the floods during the rainy season worsened, causing at that time of year the inhabitants of the village to have to take refuge in the shelters of the city of Tapachula, so they have sold the land and houses when they find a buyer, although most commonly they leave them, emigrating to other places and leaving the properties in the hands of those who decide to stay.

Brief Life Stories

Eva is originally from Tuxtla Chico, she arrived at El Encanto already married in 1985. She and her husband are originally from Frontera Hidalgo, where they worked as temporary laborers on the ranches. They settled in "El Encanto" because they found permanent work in brickworks. They got the house where they currently live from a family who migrated, leaving them the land and the hut in exchange for a promise of payment that was never fulfilled.

6 The town of Puerto Madero, which has gradually acquired the character of a city, retains this name, and the name of Puerto Chiapas has been invented, for the federal area where the military and the port's civil government operate the facilities are located so that they dock the boats, the yacht club or Marina Chiapas and the polygons destined for industrial and commercial use.

Tito. He was born in Puerto Madero on October 4, 1938, so he is more than 80 years old and knows by heart specific data about the history of Puerto Madero and "El Encanto". He is the son of a founder of Puerto Madero, a former worker of Don Bruno García. He has been a political leader and representative of Mexico in forums on the fishing activity at the international level. In 1973, Don Tito brought from Ecuador the knowledge of commercial fish breeding in fish farms. He was a representative of his organization, the Sociedad Cooperativa Pesquera de Puerto Madero, at an event in the Andean country, which in those years also had a buoyant fishing industry, as did Peru. Tito was the founder of the Centro de Estudios Tecnológicos del Mar (CESMAR) number 24, located in Puerto Madero. In the colony, its house is spacious, built with coconut wood, bamboo, bagpipes, and galvanized sheet. In a spacious covered area, it sells beans, corn, and other grains and grocery products. Tito and his daughter serve their customers and also have, in their yard, a facility for the breeding of bream, which has come to produce them in thousands, supplying the local demand, since, even though the inhabitants of this place have access to the estuaries of the Lagoon of Cabildos, fishing gear, and fish are needed to catch, and both are lacking, because years ago the estuaries stopped producing because its structure was altered by the dredging works of the port and by the overexploitation of resources. There Tito has found an opportunity for his product.

Edi. He was born in Rancho San Joaquín Cosalapa, in the municipality of Frontera Hidalgo, Chiapas. He's a boarder man. He came to live in El Encanto in 1989.

Idolina. She is 60 years old and is originally from Revolución Mexicana, in the municipality of Villa Corzo, in the center of Chiapas. Idolina's father was a bricklayer in the Mexican Revolution and came to work on the elaboration of this material at El Encanto, Idolina was 14 years old when they arrived in 1974. In the brickwork she met her husband, who took her to live in Tuxtla Chico for a few years, returning to El Encanto, where they currently live.

Elena. She is the daughter of one of the two bricklayers in the town who are still engaged in this activity. It is a large family that has a large plot in a corner of the village, where there is the brick kiln, the house of walls and wooden structure and galvanized sheet roof, as well as several fruit trees and a vegetable garden. She is a great manager of equipment and infrastructure for the town. She oversees a company that produces bottled water that covers the demand of the town and Puerto Madero. The company was funded by a major league baseball player through an American religious

organization. Annually, the company is supervised by members of the organization, who verify that the production complies with the rules of hygiene and administrative management. Elena is also the manager of the domestic water distribution system that in November 2019 began to give tap water to the inhabitants of the town. The water of the company as well as that of the system comes from deep wells, so both the infrastructure required for extraction, storage, and distribution, as well as the operation of the network, is very expensive. So water management demands a high commitment from Elena. It is through it that institutions external to the town, such as the municipal water system of Tapachula or the Universidad Autónoma de Chiapas, are related to the town. Her role as a manager makes her an intermediary between external institutions and local society.

Soconusco today

The Soconusco is the natural bridge between Mexico and Central America since it connects both the Pacific coast and the mountainous area of the Cuchumatanes mountain range and the Sierra Madre, the Highlands, and the Central Depression of Chiapas. Food products, beers, alcohol, household appliances, migrants from all over the world seeking to reach the United States, prostitution, drugs, and weapons are introduced through the roads that cross this region. Some of these goods go from north to south and others in the opposite direction. Weapons, for example, go from north to south, as well as appliances, beers, alcohol, and agricultural products, goods that are cheaper in Mexico than in Guatemala, so merchants and smugglers enter Mexico to sell with a considerable profit margin in the markets of the Highlands and in El Quiché, where they come from. Almost all other commodities, such as drugs, migrants, prostitution, and people, go from south to north, seeking the "American dream."

Although the region was integrated into the world market and attracted a large and diverse population of the world, from the end of the 19th century, Tapachula took until the end of the 30s and early 40s to become a city (Camas Reyes; 1995: 36), connected in those years mainly with the center of the country through the railroad and with cities abroad through Puerto San Benito (later Puerto Madero and today Puerto Chiapas). Communication with the center of Chiapas was weak since the roads that connected it to the center of Chiapas were barely covered with dirt in 1932, that of the coast and 1934 that of the mountain range, which passes through Motozintla, both following a trace that dates from colonial times and even further back.

To the extent that the road network was expanded and the productive infrastructure increased, the urban area was also expanded with the emer-

gence of new colonies, a situation that gained greater relevance from the 1970s, a period in which, as we have said lines back, the region had its good times. In the service sector, the sale of improved seeds, fumigation companies, sale of agrochemicals, warehouses, and transport companies flourished. Many of those who were attracted by the job offer stayed to live in Tapachula or its surroundings, as we have seen with "El Encanto", a colony founded by migrants from other parts of Chiapas and the Isthmus of Tehuantepec.

The coffee industry also attracted to the region numerous Chinese, brought as workers for agricultural enterprises but quickly became independent to engage in their activities, services, and commerce. The Japanese also arrived and founded a colony in Escuintla. Germans, Swiss, Spaniards, Americans, Lebanese, and Syrians, among others, also arrived as entrepreneurs, skilled workers, or merchants and settled in the city and the farms and villages of the region, so that it is a region and localities whose population is culturally, economically, and ideologically very diverse.

Today, Tapachula is a city of between 350,000 and 400,000 inhabitants. In the 2010 census, it officially had 320,451 inhabitants, making it the second largest city in Chiapas, after Tuxtla Gutierrez, the state capital. At the same time, urban, environmental, social, and political problems of all kinds have also been growing and multiplying: the collapse of infrastructure and collective equipment, high demand for housing and low production, depletion, pollution and loss of agricultural soils, the emergence of pests, floods; degradation and depletion of water sources, organized crime, gangs, migrant caravans; a pandemonium both in its meaning of confusion, noise, and screams and in what it means "gathering of demons".

The neoliberal policies and wars unleashed by the United States in the Middle East have destroyed the societies of the third world, leaving large contingents of its inhabitants as the only alternative for survival emigration to Western Europe and the United States.

Just as North Africa, Turkey, and the eastern borders of Europe have become the main points of containment for migrants seeking to reach the cities of advanced capitalism in Western Europe, Soconusco, and particularly the city of Tapachula, has become the strategic point for applying the policy of containment to migration seeking to reach the United States. Mexico has to play the role of filter and receiver of migrants that the United States refuses to receive. Let us remember that these caravans are the product of an economic policy imposed on weak nations by the United States.

The National Institute of Migration estimates that, only from January to June 2019, 460,000 undocumented migrants entered Mexico through the border with Guatemala, most of them through Tapachula. The contingents, while

still predominantly Central American, are also now made up of many people of African, Arab, and Asian origin, adding to the missing ingredients, the potential danger of terrorists hiding among them, as well as health threats.[7]

Dr. René Estrada Arévalo, a prominent member of the university community, is concerned that a global pandemic will reach the country through Soconusco, and the Mexican state lacks the necessary infrastructure, personnel, and protocols to deal with it. The thesis of this professor of the UNACH refers to the conjunction of the great richness of the biodiversity of the Soconusco, which, together with the intense migratory flow in all its modalities -legal, temporary, of passage, etc.-, produce extreme conditions of risk in health. In a framework that considers health as a public and universal good and in the context of the national security of the country, he proposes that to protect the migrant and resident population of the region, a health shield be established to strengthen health security in Soconusco.

There are so many aspects that go beyond the government's capacity to respond. Everything is urgent, the sanitation of rivers, estuaries, and lagoons; ensure the supply of drinking water, mitigate, or reverse the negative impact of waste solid, liquid, and gaseous discharges to ecosystems; reduce the degradation of agricultural soils; equip the localities with sanitary, health, education, culture and training services. Migration, criminal violence, diseases...

7 During the days when the fieldwork that gave rise to this article was done, the worldwide news with which TV news and news agencies saturated us daily was the threat of the Wuhan coronavirus, which by then had already caused the death of hundreds of people for a few weeks. A year later, the coronavirus had claimed the lives of more than 2 million people around the world, also causing the collapse of global tourism and other branches of the economy associated with it, generating changes in working conditions and education and health systems. The coronavirus pandemic did indeed prove that no one was prepared to face a threat of such magnitude.

REFERENCES

Camas, F. J. (1995). "El crecimiento de la ciudad de Tapachula durante el siglo XX. Algunas reflexiones y resultados preliminares", en Villers Aispuro, Roberto (Coordinador), *Desarrollo Urbano y Ordenamiento del Territorio en Chiapas: Realidades, Prospectiva, Estudios y Acción*, Facultad de Arquitectura, UNACH, pp. 35-43

Clark, J. E. y Blake, M. (1993). "Los Mokayas", en Esponda Jimeno, Víctor Manuel (Compilador), *La población indígena de Chiapas*, Instituto Chiapaneco de Cultura, Gobierno del Estado de Chiapas, pp. 25-45.

Del Carpio, C. U. (2017). Soconusco, Chiapas. Transformaciones ambientales de origen antrópico. *Decumanus*, No. 2, Vol. 2, Octubre 2016-Otubre 2017, Instituto de Arquitectura, Diseño y Arte, Universidad Autónoma de Ciudad Juárez, Chihuahua, México.

Del Carpio, C.U. (2018). Los mames y la formación de la frontera Cuchumatanes-Soconusco en el siglo XIX. *Mundo Amazónico,* 9(2): e65195. DOI:http://dx.doi.org/10.15446/ma.v9n2.65195

Escamirosa, L. F., Del Carpio, C., Ocampo, M., Estrada, R., *et al*. (2020). Informe Técnico: Propuesta de mejoramiento del hábitat de El Encanto, Tapachula, Chiapas. Instituto de Ciencias, Tecnología e Innovación del Estado de Chiapas (ID-1033). (Online): https://RedInvestiga.chiapas.gob.mx

Escamirosa, L. F., Del Carpio, C., Ocampo, M. y Estrada, R. (2020). Reconstrucción del hábitat en comunidades rurales de Chiapas: Caso de estudio Ocuilapa y El Encanto. *Investigación en la Educación Superior, Academia Journals*. Puebla, México, pp. 1061-1066. Online: www.AcademiaJournals.com.Tomo+09+-+Investigación+en+la+Educación+Superior+-+AJ+Puebla+2020.pdf (squarespace.com)

Helbig, C. (1964). *El Soconusco y su zona cafetalera en Chiapas*. Instituto de Ciencias y Artes de Chiapas, Tuxtla Gutiérrez, Chiapas.

Kerber, V. (2017). La primera comunidad japonesa en Chiapas, una utopía social a finales del siglo XIX. En *Relatos e Historias en México* No. 105, México (Online):www.relatosehistorias.mx

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Concrete mixed with cigarette butts as a proposal to minimize their waste in the environment

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— Abstract—

Cigarette butts take from two to ten years to degrade; they have substances harmful to the environment because a single cigarette butt can contaminate eight liters of seawater and up to 50 liters of drinking water. They are not biodegradable waste so throwing them away along with organic waste is not an alternative. It is a tiny waste difficult to recycle; for these reasons, innovative alternatives must be sought for their disposal and final destination.

In the construction industry, concrete is one of the most used materials in the world due to its physical and mechanical characteristics before various demands and its vast local availability. The objective of this work is to use cigarette butts in concrete as an alternative for their waste disposal, thus reducing the percentage of waste in the environment.

Mixtures with compressive strengths of 24.5 and 29 MPa were designed to which the cigarette butt was added in different percentages. Concrete tests were performed in a hardened state of cylindrical compression and indirect traction. In the cool state, the workability of the concrete, temperature, density, and air content were measured; favorable results were obtained, demonstrating that the addition of cigarette butts to concrete as an alternative for the final disposal of such waste is viable.

Keywords:

Concrete; Butts; Cigarette.

Environmental pollution has been increasing in recent years, which is why there was a need to educate society on proper management, control, and recycling of waste; through great efforts on the part of governments, institutions, and private enterprises. Today, there is a gradual awareness of responsible waste management (Lizano, 2010).

Within the long list of waste, there is paper, plastic, and even technological waste, but in this list, little has been done for cigarette filters. For many, it is a small role that does not need to be discarded or treated, but the reality is different, and there is no awareness of it.

Currently, according to numerous studies, it has been determined that cigarette butts are considered the most common solid waste worldwide. There are indications that in the world there are 6 million smokers who consume an average of three cigarettes a day generating a total of 18 million cigarettes per day (Cai and others, 2019). It is estimated that 767 million kilograms of cigarette butts are discarded each year (Novotny, 2009). In another study made in 2011 by Ocean Conservancy, it was determined that a single cigarette butt can contaminate eight liters of seawater and up to 50 liters of drinking water. Throwing them away along with organic waste is not an alternative because they pollute them and do not degrade, thus nullifying the possibility of transforming them into compost; the same happens when they are mixed with recyclable waste because they prevent them from being used. They are a waste difficult to recycle due to the number of materials that compose them; therefore, innovative, and non-polluting alternatives have to be sought for their disposal and final destination.

The general objective of the research is to evaluate the technical feasibility of adding cigarette butts in the elaboration of concrete, to minimize the high environmental impact that they generate to guarantee that all their contaminants and toxic agents are "encapsulated" in concrete.

It is intended that concrete mixed with cigarette butts can be used without losing its original resistant characteristics, but that the materials that make up the cigarette butts add other characteristics such as lightness, thermal insulation, and, above all, it is a viable alternative for the final disposal of this type of waste. It is also sustainable, feasible to be introduced and transformed into a common practice in the reinforced concrete elaboration process.

BACKGROUND

A cigarette butt can take anywhere from 18 months to 10 years to decompose (they are not biodegradable). Many smokers have a bad habit of throwing cigarette butts on the floor when they finish smoking. The rains usually drag this waste to the water sources, where they give off their chemicals, which contain toxic contaminants such as tar, benzene, ammonia, and cadmium,

among others (UNE, 2015); which can contaminate up to 50 liters of water. There are also mercury, lead, arsenic, uranium, torino and cadmium, which together are substances that can infiltrate soil and groundwater (Novotny, 2009). It is considered that more than fifty percent of the forest fires on the planet are caused by lit cigarette butts (Novotny, 2009).

Cigarette filter composition: cigarette filters are designed to absorb the accumulation of vapors and smoke particles, to retain tar and other harmful products, both those carried by tobacco and those produced in the combustion of the cigarette, before they reach the lungs of smokers (Guevara Lizano, 2010).

Filters, in general, have the following components:

- A cellulose acetate filter "plug": 95% of cigarette filters are made of cellulose acetate (plastic), and the rest are made from paper and rayon.
- Cellulose acetate is a relatively hard, shiny, colorless, transparent, and amorphous thermoplastic material with good clarity, UV stability, and moderate chemical resistance; in Figure 1, you can see a graph of a conventional cigarette (Lincango & Mancero, 2020)

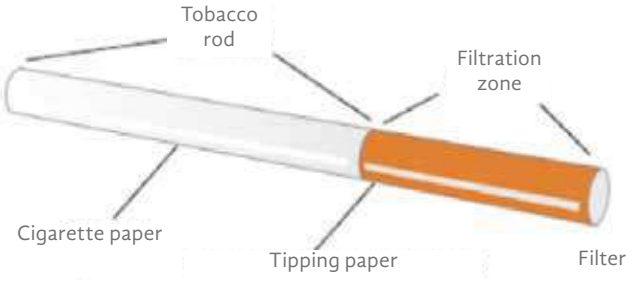

Figure 1. Parts of a conventional cigarette. Source: Lincango, J., & Mancero, E. (2020)

Cigarette wrapping and butt: The paper used to wrap tobacco is made from flax fiber. Manufacturers add various chemicals to the paper, including salts to speed up or control the rate of combustion. The rate of combustion has an important effect on the number of inhalations that can be obtained by the smoker, the smoke, and the performance.

Use of cigarette butts in building materials: As mentioned above, cigarette butts are harmful waste to both health and the environment. There are various initiatives to mitigate the environmental impact they cause. Dealing with cigarette residues is one of the world's most difficult environmental dilemmas due to the high content of toxic resources they contain, metals such as arsenic, chromium, nickel, and cadmium (Cortez Camacho & Ponce Muñoz, 2019).

According to (Mohajerani, 2016) "one man's garbage is another man's building material", so the idea was to turn cigarette butts into raw material to produce ecological bricks. In this regard, Mohajerani points out that: "Incorporating cigarette butts into bricks can effectively solve a global garbage problem. Recycled cigarette butts can be placed on bricks, without fear of leaching or contamination. They are also cheaper to produce, in terms of energy needs since the energy cost decreases as more cigarette butts are introduced into production." We can see in Figure 2 that the physical appearance of these bricks with cigarette butts is very similar to that of normal bricks.

Figure 2. Bricks made from cigarette butts. Source: http://www.archdaily.co/co/791421/investigadores-de-rmit

Concrete: Concrete is a building material composed of large particles formed by a continuous cementitious matrix that binds to an aggregate of fine particles (aggregate or fine aggregate or sand, and aggregate or coarse aggregate) (Sánchez de Guzman, 1993).

Materials made from mortars and Portland cement concrete are attractive to use as a building material; because they offer a good cost/benefit ratio, are durable, and have strength and rigidity suitable for structural uses. Additionally, in a fresh state, they are easily moldable, so they can adopt shapes as capricious and complex as you want (Lopez Roman & Mendoza Escobedo, 2016).

Incorporating fibers into a concrete blend is efficient in improving the mechanical performance and durability of hardened Portland cement concrete, by reducing and controlling the spread of microcracks generated by retraction and allowing the redistribution of internal stresses that tend to crack the cementitious matrix (Robayo, Mattey, & Delvasto, 2013).

METHODOLOGY

A cigarette butt collection campaign was carried out with the support of the Universidad Autónoma de Guerrero through the department of UAGro Verde in restaurants, bars, schools, and parks in the cities of Chilpancingo and Acapulco, Guerrero, Mexico. The experimentation process was carried out in the soil and materials laboratories of the School of Engineering of the UAGro.

Several aspects were analyzed: The workability or manageability of the concrete mixture using the water-cement ratio (W/C), the compressive strength acquired on days 7, 14, and 28 days of normal concrete and concrete with the same characteristics as the normal one was compared but added with cigarette butts. The flexural strength of the concrete was also evaluated at 28 days, observing in all cases the stress to rupture, the types of failures of the samples under study, and the different eventualities.

To achieve the objectives of the experimental development, two designs of 28-days compressive strength mixtures were carried out, 24.5 MPa (250 kg/cm^2) and 29.4 MPa (300 kg/cm^2). Once the designs of the mixtures were obtained, 0.5%, 1%, and 2% of cigarette butts were added, and a control mixture without the addition of cigarette butts was also made.

The compressive strength of concrete was obtained from cylindrical specimens made, cured, and tested per ASTM C31 (ASTM C31 / C31M-21a, 2021), ASTM C192 (ASTM C192 / C192M-19, 2019), and ASTM C39 (ASTM C39 / C39M-21, 2021) standards, respectively, to obtain the control mixtures that would be used throughout the experimental work.

The experimental work consisted of several stages; in the first instance, we took into account the physical properties of materials to determine parameters for mixture designs.

PROCESSING OF CIGARETTE BUTTS

Collection of cigarette butts. A survey was conducted to determine the most frequent smoking sites in the city of Chilpancingo, Guerrero; with the help of the Department of Ecology of the Universidad Autónoma de Guerrero (UAGro) and following an adequate biosecurity protocol, plastic containers were distributed in various bars and restaurants in the city. An awareness and collection campaign was also carried out on the university's social networks (Facebook and Instagram) to collect cigarette butts individually from smokers.

Cleaning of cigarette butts. The paper and adhesive were removed from the cigarette butts; then, the cigarette butts that were complete were selected and those that were very dirty or burned were eliminated. Figure 3 shows the state in which the cigarette butts were obtained.

Figure 3. Different cigarette butts with a wrapper. Source: Image taken in the laboratory

Shredded cigarette butts. Cigarette butts were shredded into thinner strands of, approximately, 0.5 to 1 mm thick. From each shredded butt, an average of 16 portions of the mentioned diameter was obtained. Thinner strands like those on the left side of Figure 4 were not considered a viable option for this project.

Figure 4. Strands obtained after shredding the butts. Source: Image taken in the laboratory

Characterization of cigarette butts. For the characterization of the cigarette butts, the following parameters were considered:

a) Length and weight: Different butts were measured and weighed at random, from which an average length and weight were obtained (Table 1).

Table 1
Physical characteristics of cigarette butts

Average Measure of Cigarette Butts	
Complete	**Shredded**
25.6 mm	20.7 mm
Cigarette Butts Width	
8.51 mm	
Average Wight of Cigarette Butts	
0.178g	

Source: Own elaboration

b) Absorption and density: To determine the absorption and density of the cigarette butts, since there is no standardized procedure, the tests carried out in soil mechanics were adapted to determine these parameters (Figures 5 and 6).

Figure 5. Absorption and density tests in cigarette butts. Source: Image taken in the laboratory

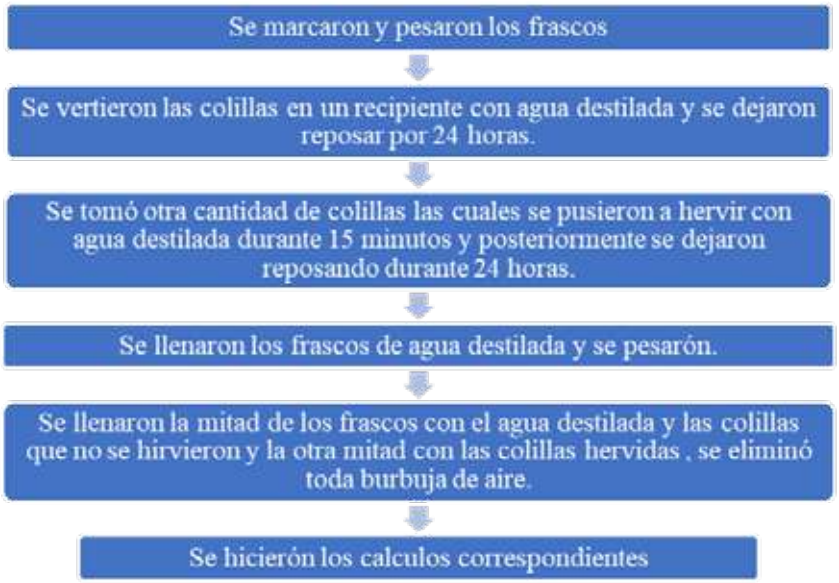

Figure 6. Procedure to obtain the absorption and density of cigarette butts. Source: Own elaboration

Design and elaboration of mixtures. Concrete mixtures were made with an f'c at 28 days of 29.4 and 24.5 MPa (250 kg/cm² and 300 kg/cm²) to compare the mechanical properties of normal concrete with concrete mixed with cigarette butts in percentages of 0.5%, 1%, and 2% (Tables 2 and 3). Several aspects were analyzed: The workability or manageability of the concrete mixture using the water-cement ratio (W/C); the compressive strength acquired in 7, 14, and 28 days; and the concrete flexural strength at 28 days. We observed the stress to rupture in all cases, the types of failures of the samples under study, and the different eventualities.

Table 2

Mixing design for f´c = 24.5 MPa (250 kg/cm²) and 29.4 MPa (300 kg/cm²) by the ACI method

Resistance	29.4 MPa (300 kg/cm2)		24,5 MPa (250 kg/cm2)	
REV=10				
Material	1 M^3	0.01445 M^3	1 M^3	0.01445 M^3
Cement	260	3.757344814	330	4.768937648
Gravel	950	13.7287599	980	14.16229968
Sand	925	13.36747674	810	11.70557423
Water	200	2.890265241	205	2.962521872
Cigarette Butts				
0.5%	11.675	0.168719233	11.625	0.167996667
1%	23.35	0.337438467	23.25	0.335993334
2%	46.7	0.674876934	46.5	0.671986669

Source: Own elaboration

During the mixing process, some parameters were determined for concrete in the fresh state, per ASTM standards, such as slump, unit mass, and air content by the pressure measurement (See Figure 10).

Figure 7. Density test and concrete slump. Source: Image taken in the laboratory

The compressive strength of concrete, was obtained from cylindrical specimens made, cured and tested at different ages, in accordance with standards ASTM C31 (ASTM C31 / C31M-21a, 2021), ASTM C192 (ASTM C192 / C192M-19, 2019) and ASTM C39 (ASTM C39 / C39M-21, 2021) (Figure 8).

Figure 8. Cylinders with compressive strength of 24.5 MPa (250 kg/cm^2).
Source: Image taken in the laboratory

For each mixture design, twelve cylindrical specimens of 10 x 20 cm were tested at compression at 7, 14 and 28 days (ASTM C39 / C39M-21, 2021); at flexural, three cylindrical specimens of 15 x 30 cm were tested at 28 days (ASTM C496 / C496M - 17, 2017).

RESULTS AND DISCUSSION

To determine whether the concrete mixed with cigarette butts proposed in this work reaches the mechanical conditions to be used in practice, several tests were performed to determine the optimal quantities in each specified design. A design of added mixtures with percentages of 0.5%, 1%, and 2% of cigarette butts and a control mixture for each compressive strength proposed, and the properties in the fresh state of all the elaborated mixtures were evaluated; below are the results obtained in the applied trials (Table 3).

Table 3
Test results for fresh concrete

f'_c = 24.5 MPa (250 kg/cm²)				
Characteristics / Mixture	Shrinkage (10 ± 2)	Air %	Unit mass kg/m³	Temperature
f'_c = 29.4 MPa 0.5%	9	2.8	2789.21	29 °C
f'_c = 29.4 MPa 1%	8	3	2576.47	27 °C
f'_c = 29.4 MPa 2%	7	2.9	2657.65	28 °C
f'_c = 29.4 MPa control	9.5	2.6	2697.96	34 °C
f'_c = 29.4 MPa (300 kg/cm²)				
f'_c = 24.5 MPa 0.5%	8	2.9	2700.21	28 °C
f'_c = 24.5 MPa 1%	7.5	3.1	2467.37	26 °C
f'_c = 24.5 MPa 2%	7	3	2595.59	28 °C
f'_c = 24.5 MPa control	11	2.7	2689.96	33 °C

Source: Own elaboration

Compressive strength. The compressive strength is the most important characteristic to evaluate in concrete. It is one of the parameters that will determine if it is viable to use the cigarette butts in the concrete without affecting its resistance; thus, cylindrical specimens of concrete in a hardened state were tested at 7, 14, and 28 days (table 4 and figures 9 and 10).

Table 4
Compression test results

Compressive test results				
f'_c = 24,5 MPa (250 kg/cm²)				
	Control mixture	M1= 0.5%	M2 = 1 %	M3= 2%
Days	0	0	0	0
7	14.04	14.99	15.52	14.65
14	22.26	19.95	19.01	21.57
28	24.03	20.78	19.00	20.01
f'_c = 29.4 MPa (300 kg/cm²)				
7	12.30	19.19	19.26	19.91
14	25.67	22.23	22.29	22.96
28	29.39	18.03	18.84	18.81

Source: Own elaboration

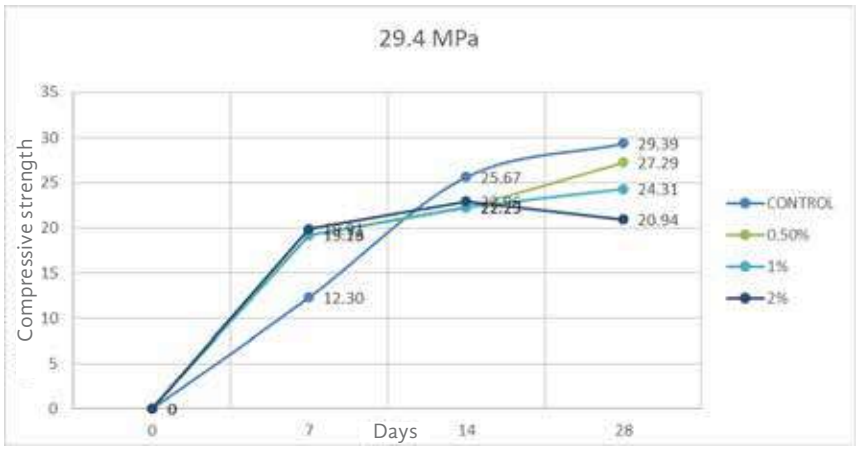

Figure 9. Comparative graph of the compression results for the design f´c = 29.4 MPa with different percentages of cigarette butts. Source: Own elaboration

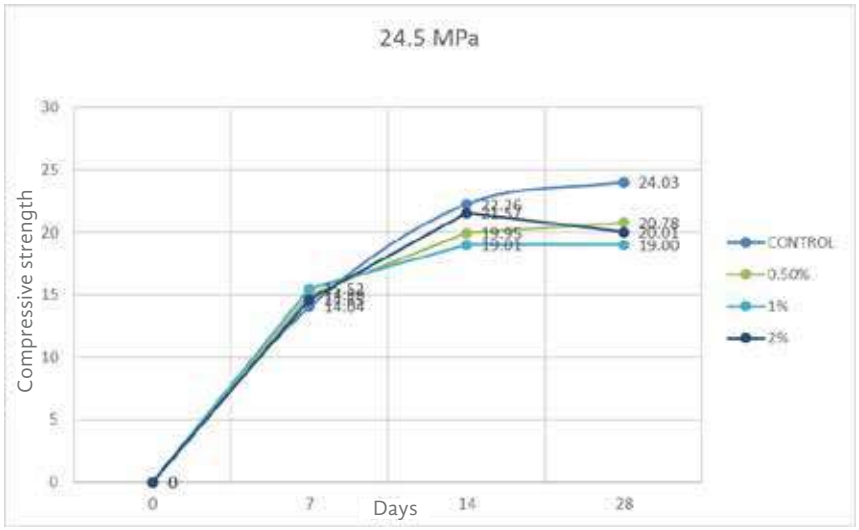

Figure 10. Comparative graph of the compression results for the design f´c = 24.5 MPa with different percentages of cigarette butts. Source: Own elaboration

The experimental results of the tested specimens show that the mixture with the addition of 2% of cigarette butts had an increase in its resistance up to 14 days and decreased considerably at 28 days, this is because the presence of butts in the concrete inhibited the hydration heat process in the concrete since at the time of testing these cylinders we observed there was humidity inside.

With the comparison of the results obtained in the different mixtures for the strength of the concrete, the best results were obtained with the 5% cigarette butt mixtures.

Photographs of the experimental process are shown in Figure 11. On the left, the cone is shown in the press after completion of the compression loading of the specimen. On the right, the photograph shows the appearance of

a fractured cylinder sample where the structure of the concrete containing the filaments of the material that constitutes the cigarette butts is observed.

Figure 11. Cylinder subjected to compression. Source: Image taken in the laboratory

Indirect tensile strength. Also known as the Brazilian test, is a test used to determine the tensile strength of concrete, which consists of applying an external compressive load on one side of the sample, while the opposite end to the load remains supported. In this way, two diametrically opposite forces are generated that produce a uniform distribution of transverse tractions along the load axis, causing the tensile rupture of the sample (ASTM C31 / C31M-21a, 2021). The results are shown in Table 5.

Table 5
Stress test results

Resistance to indirect traction		
Stress MPa test results		
Mixture	Resistance to stress MPa	Percentage concerning compressive
29.4 MPa 0.5%	2.63	8.93
29.4 MPa 1%	2.69	9.16
29.4 MPa 2%	2.61	8.89
29.4 MPa	2.75	8.88
24.5 MPa 0.5%	2.75	11.23
24.5 MPa 1%	2.72	11.12
24.5 MPa 2%	2.71	11.06
24.5 MPa	2.72	11.11

Source: Table obtained from the results of the stress tests of the concrete

A photograph of the stress test process of the specimen is shown in Figure 12. The failure is shown practically horizontal, which exhibits adequate experimental behavior without local faults due to cylinder heterogeneities. The foregoing shows that there is no interference of the cigarette butts material added to the concrete, creating a final product viable for the construction sector.

Figure 12. Tensile test failure. Source: Image taken in the laboratory

CONCLUSIONS

The fresh state characteristics of the concrete mixed with cigarette butts are very similar to those of concrete under normal conditions; a slight decrease in temperature is observed, which generates a longer setting time and, in turn, a more manageable mixture (Claros, 2020).

The incorporation of cigarette butts in percentages of 2% decreases the compressive strength after 14 days, the highest compressive strength was obtained with the concrete mixed with 0.5% of butts, in all mixtures a small increase in compressive strength was observed at early ages.

It should be noted that the incorporation of cigarette butts into the concrete does not alter the tensile strength, since the percentages are within the normal parameters.

The fresh and hardened characteristics of the concrete added with butts indicate the possibility of being used in non-structural concrete and open up a new alternative for other fields of application of this material in the construction sector.

REFERENCES

astm C192 / C192M-19. (2019). *Práctica estándar para fabricar y curar muestras de ensayo de concreto en el laboratorio*. West Conshohocken, PA: astm Internacional. doi:10.1520 / C0192_C0192M-19

astm C31 / C31M-21a. (2021). *Práctica estándar para fabricar y curar probetas de ensayo de hormigón en el campo*. West Conshohocken, PA: astm Internacional. doi:10.1520 / C0031_C0031M-21A

astm C39 / C39M-21. (2021). *Método de prueba estándar para resistencia a la compresión de probetas cilíndricas de hormigón*. West Conshohocken, PA: astm International. doi:10.1520 / C0039_C0039M-21

astm C496 / C496M - 17. (2017). *Método de prueba estándar para Determinación de la resistencia a la tracción por compresión diametral de especímenes cilíndricos de hormigón*. West Conshohocken, PA. doi:10.1520 / C0496_C0496M-17

Cai , K., Gao, W., Yuan, Y., Gao, C., Zhao , H., Lin , Y., . . . Lei , B. (2019). An improved in situ acetylation with dispersive liquid-liquid microextraction followed by gas chromatography-mass spectrometry for the sensitive determination of phenols in mainstream tobacco smoke. *Journal of chromatography,* A;1603, 401-406. Obtenido de https://doi.org/10.1016/j.chroma.2019.05.007

Claros, E. (2020). *360 en concreto*. Obtenido de 360 en concreto: https://www.360enconcreto.com/blog/detalle/categoria/normatividad/191cual-debe-ser-la-temperatura-maxima-del-concreto-fresco

Coke, A. (19 de Mayo de 2017). *Obtenido de Alquitrán de hulla crudo Ficha de datos de seguridad (fds)*. Obtenido de http://www.drummondco.com/wp-content/uploads/ABC-SDSCrude-Coal-Tar_es.pdf

Cortez Camacho, L. F., & Ponce Muñoz, D. E. (2019). Impacto generado por colillas de cigarrillo en el medio ambiente a nivel mundial. *Boletín Informativo cei*, 131-132. Obtenido de http://editorial.umariana.edu.co/revistas/index.php/BoletinInformativoCEI/article/view/2140

Lincango, J., & Mancero , E. (Junio de 2020). Cromatografía de gases en filtros ecológicos para cigarrillos y su biodegradabilidad. *Revista Ibérica de Sistemas e Tecnologias de Informacion*, 30, 287 - 298. Obtenido de https://www.proquest.com/openview/702bb032dbf1a264c7802fc586496c8d/1?pq-origsite=gscholar&cbl=1006393

Lizano, A. G. (2010). *Sistema para el adecuado desecho de colillas de cigarrillo*. Escuela de Ingenieria en Diseño Industrial. Costa Rica: Instituto Tecnologico de Costa Rica. Obtenido de https://repositoriotec.tec.ac.cr/bitstream/handle/2238/2921/Informe_Final.pdf?sequence=1&isAllowed=y

López Roman, J., & Mendoza Escobedo, J. (2016). análisis de las propiedades del concreto reforzado con fibras cortas de acero y

macrofibras de polipropileno: influencia del tipo y consumo de fibra adicionado. *Sociedad Mexicana de Ingenieria Estructural*.

Mohajerani, A. (2016). *Estudio del comportamiento del ladrillo artesanal con la incorporación de filtro de cigarrillo en su composición*. Australia: Royal Melbourne Institute of Technology (rmit) de Australia.

Novotny, T. (Noviembre de 2009). *Ocean Sentry*. Obtenido de https://www.oceansentry.org/es/

Robayo, R., Mattey, P., & Delvasto, S. (2013). Comportamiento mecánico de un concreto fluido adicionado con ceniza de cascarilla de arroz (cca) y reforzado con fibras de acero. *Revista de la Construcción*, 139-151.

Sánchez de Guzman, D. (1993). *Tecnologia del Concreto y del mortero*. Bogota: Bhandar Editores.

une (2015). Determinación de mentol en la corriente principal del. Madrid, España: aenor. Obtenido de https://www.une.org/encuentra-tu-norma/busca-tunorma/norma/?c=N0053405

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Comparative Evaluation of Concrete Beams Reinforced with Welded Wired Truss and GFRP Rods

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— Abstract—

This study analyzes and compares the behavior of concrete beams reinforced by welded wire truss and the alternative use of reinforcements made with glass fiber reinforced polymers (GFRP). The purpose of the research is to determine the level of safety using GFRP compared to that provided by high-resistance steel reinforcement with the reinforcement ratio acceptable in terms of the Complementary Technical Standard for Masonry (NTC M, 2004) of the Mexican code.

The results show that the use of GFRP is feasible in terms of resistance, as an alternative for application in housing construction, replacing welded wire trusses. The experimental data used in the study come from tests carried out at the Benemérita Universidad Autónoma de Puebla (BUAP) (Sánchez Hernández, 2019). (Sánchez Hernández, 2019).

Keywords:

Reinforced polymers; glass fibers; reinforced concrete; welded wire truss.

In North America, the use of polymer composite rods such as GFRP has taken great demand as a substitute for the traditional steel reinforcement of structural concrete. Its use spreads to larger structures, as the update of the Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings (AASHTO (GFRP), 2017) seems to indicate, which is added to the already existing Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer (FRP) Bars (ACI 440 1R, 2015). This is due to the low maintenance cost obtained due to its durability and absence of corrosion before the agents that commonly damage the steel, as reported by various investigations carried out by GangaRao, Taly, and Vijay (2007); (R., Cousin, & Benmokrane, 2009); Nanni, Luca, and Jawahery (2014); (Gooranorimi, Gremel, Myers, & Antonio, 2015) and other authors cited by Sánchez Hernández J. A. (2019).

Mexico, with its wide coastline exposed to corrosive agents for traditional steel reinforcement, especially in the Gulf area, due to its low seismicity, could represent an area of opportunity to take advantage of the potential of this type of reinforcement.

Welded wire trusses made of drawn steel took great boom in self-construction due to their low cost and that, together with their high resistance, requires low reinforcement rates, which were allowed by the 2004 (NTC M, 2004) standard. At present, despite its low use, the main problem when using these trusses in homes is the rapid deterioration due to corrosion.

For this reason, the reinforcement based on GFRP rods results in a useful alternative that could surpass in benefits of resistance and durability to the current technology, based on steel, used for these housing developments.

In the present analysis, it was observed that there is an acceptable performance of this material, especially with reinforcement amounts close to the minimum requested by the current regulation (NTC M, 2017).

2. SPECIMENS AND DATA

The specimens used in the comparison were rectangular beams of 15x20 cm in section, whose dimensions are per those established in the Technical Standards of Masonry (NTC M, 2017) for the confinement slabs of the walls and that usually extend between the clearings of windows and doors.

The concrete used has an ultimate compressive strength f'c>150 kg/cm², which complies with the aforementioned masonry regulations in Mexico and whose variations between specimens are detailed in Table 1.

The value of the ultimate stress at a tension of the GFRP rod was fixed with ffu = ff*u = 8000 kg/cm² similar stress ultimate voltage limit set by the manufacturer; ffv = 1500 kg/cm² as the shearing limit effort set by the manufacturer; and Ef = 500000 kg/cm² as the elastic modulus established by

the manufacturer, for the evaluation of resistant nominal elements. While steel was taken as a reference with the values of fy = 5000 kg/cm², Ey= 2.1E6 kg/cm² and fyv=1600 kg/cm² according to the supplier's specifications.

The tests were carried out in a reaction frame with a 100t hydraulic jack to transmit the load in each element tested, the load was separated into two punctual loads through a load distribution beam rigid enough not to deform. The beam was placed in a system of isostatic supports, 2.0m in distance.

The specimens tested are described below, in Table 1, defining those assembled in the upper bed (LS) and lower bed (LI) as follows: 2D4 that should be read as two bars of 4mm in diameter because the material used, of European origin, is millimeter. While the uniform stirrups of 4mm only their spatial distribution expressed in cm of separation (E@15) was enunciated. The armed ones that were composed with hooks at the ends were designated by a letter "G".

These reinforcements were set based on a competition strategy, with traditional welded wire trusses, seeking cost-capacity optimization.

Table 1

Specimens Description

BEAM	TRUSS		f'c kg/cm²	Af / As Total cm²	Af cm²	AMOUNT		
						ρ_b	ρ_{MIN}	ρ_{REAL}
1 (V)	LS	2D4						
	LI	2D4 E@15	250.00	0.50	0.25	0.0054	0.0037	0.0009
2 (V1)	LS	2D4						
	LI	2D4 E@15	218.50	0.50	0.25	0.0054	0.0037	0.0009
3 (V2)	LS	2D4						
	LI	2D4 + G E@15	279.80	0.50	0.25	0.0060	0.0037	0.0009
4 (V3)	LS	2D4						
	LI	2D4+1D6+G E@15	279.80	1.63	0.53	0.0060	0.0031	0.0020
5 (V4)	LS	2D6						
	LI	3D8 +G E@10	218.50	2.07	1.51	0.0047	0.0031	0.0057
6 (STEEL)	LS	2D6						
	LI	2D6 E@15	321.00	1.27	0.63	0.0245	0.0023	0.0023

Source: Own elaboration

The reinforcement areas for steel (As) and fibers (Af) were obtained geometrically considering the area a circle of similar diameter to that of the rod. While the amount of actual reinforcement was calculated as $\rho = A/(b\,d)$, with "A" being the area of reinforcement in the lower bed calculated as

indicated and "b" the base of the cross-section, and "d" being the effective cant with a free coating of 2.0 cm.

According to NTC M (2017), considering the fy of welded wire trusses (fy=5000 kg/cm²) and the minimum acceptable strength for concrete (f'c=150 kg/cm² in slabs), the minimum total longitudinal reinforcement corresponds to:

$$As\ min = 0.2\ (f'c/fy)\ b\ h$$

Thus, for the steel reinforced trusses, the minimum will be:

$$As\ min = 0.2\ (150/5000)\ (15)(20) = 1.80\ cm^2 \ldots (Q1)$$

Meanwhile, for GFRP, and applying the same criteria, the minimum reinforcement is:

$$ffd = CE\ ff^*u \qquad (ACI\ 440\ 1R\ ,\ 2015)(6.2\ a)$$

Where: $ff^*u = 8{,}000\ kg/cm^2$ y $ffd = CE\ ff^*u = 6{,}000\ kg/cm^2$

$$Af\ mín = 0.2\ (150/6000)\ (15)(20) = 1.50\ cm^2 \ldots (Q2)$$

CE corresponds to the Environmental Quotient, established by the ACI 440.1R for different exposure levels, which was given the value of 0.75.

Based on these calculations, the GFRP reinforced beams, listed in Table 1, from 1 to 3 have armed (Af) lower than the minimum calculated in Q2, while beams 4 and 5 would be acceptable to confine according to the NTC M (2017). However, the present work focuses on comparing the behavior to bending and cutting through its resistant mechanical elements, between the slabs (confinement beams) armed with the materials described above. Therefore, all these elements will be compared with beam 6 reinforced with metal elements and with an assembly area (As) described in the same table less than the normative minimum (Q2).

The actual, balanced, and minimum amounts reflected in Table 1, for steel reinforcement, were calculated using the following expressions represented in the NTC CR (2017) (5.1.5).

$$\rho = As\ /\ (b\ d)$$
$$\rho\ mín = 0.7\ (f'c)^{1/2}/fy$$
$$\rho b = (f''c/fy)\ [(6000\ \beta 1)/(fy+6000)]$$

Where "As", is the reinforcement to bending; "d", is the effective cant and b=15 cm, the cross-section base; being β1=0.85 and f''c=0.85f'c.

While the assessment of the amounts for GFRP was carried out according to the ACI design code (ACI 440 1R , 2015) using units of kg and cm.

$$\rho = Af / (b\ d)$$
$$\rho fb = 0.85\beta 1\ (\ f'c\ /\ ffd\ )\ [\ 0.003*Ef\ /\ (\ 0.003*Ef+ffd)\ ]$$
$$\rho mín = 1.31\ (f'c^{1/2})\ /\ ffd \geq 23.43\ /ffu$$

The load history and deflections were obtained by electronic and digital sensors, from the reports generated from the tests carried out, except in beam 1, whose measurement was made with a micrometer with the equipment and procedure of application of the load described by Sánchez Hernández (2019).

3. ANALYSIS OF MECHANICAL ELEMENTS

The determination of the resistant nominal moments was made for the reinforcement with steel, per the provisions of the NTC Mexico City (2017) for concrete beams reinforced with steel rods in its section (5.1.3) relating to Flexural strength, as well as section (5.3.3) corresponding to Shear strength resistance. While for those relating to GFRP reinforced beams, what is stated in ACI 440 1R (2015), chapter 7.2 on Flexural strength and chapter 8 on Shear stregnth were used. The doubts of interpretation on the design with GFRP were resolved supported by the work of Wainshtok Rivas, Hernández Caneiro, and Díaz Pérez (2015).

4. COMPARISON AND ANALYSIS OF RESULTS

Bending moment

Figure 1 shows the comparative graph of moments between the tests corresponding to the beams armed with GFRP (beams 1 to 3) and the welded wire truss beam (beam 6), all of them with a reinforcement amount (ρ) lower than those which Mexican regulations (NTC 2017 M) allow as reinforcement of these elements (see Table 1).

In graph 1, the progress of the load could be observed that both the GFRP beams and the metal reinforcement beams presented slippage by adhesion and load redistribution, until failure. Beam 3, among those that were armed with GFRP, showed a better behavior by developing its resistance with greater uniformity and lower deflections, this is possibly due to the existence of hooks at the ends of its assembly in the lower bed, which shows the importance of its use. Likewise, in this graph, the resistant moment calculated by the expressions of each regulation was represented with horizontal lines, as cited in title 3 of this work.

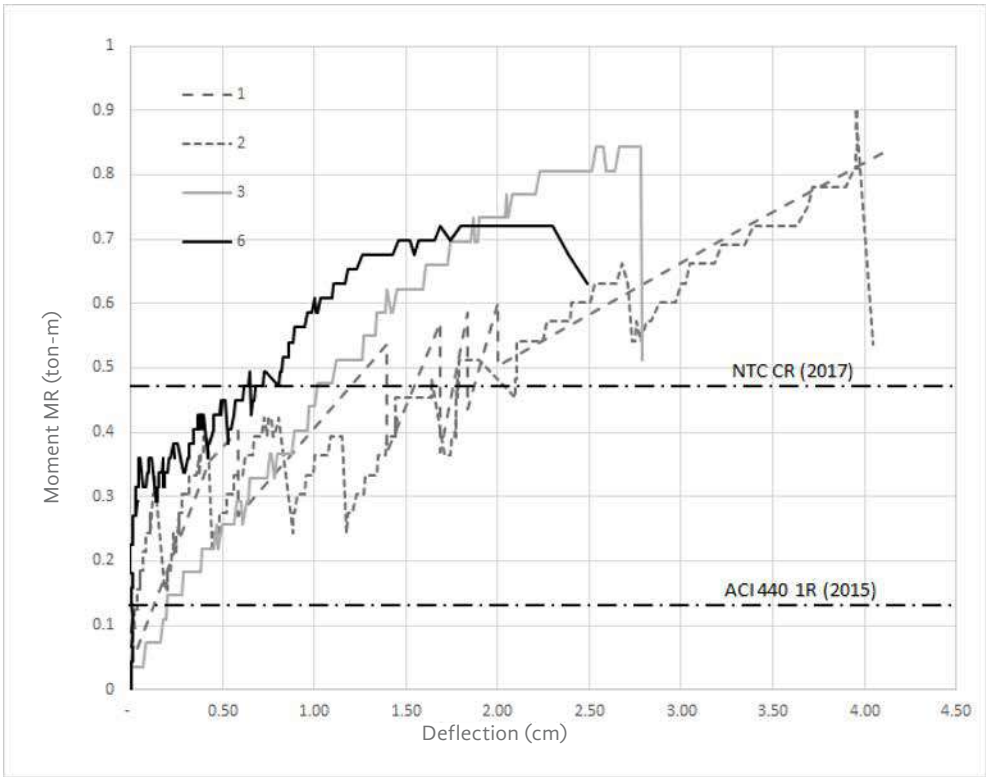

Figure 1. Comparison Chart of the Moments between GRP beams 1 to 3 and steel beam 6.
Source: Own elaboration

Graph 2 shows GFRP beams whose reinforcements are more attached to those calculated at a minimum (Q1 and Q2) according to the NTC M (2017) for the confinement of masonry walls. These beams (4 and 5) showed a better performance in terms of the development of bending resistance, being even greater than the resistance achieved by the beam reinforced with drawn steel. Specifically, beam 4 is very close in real amount (from Table 1, $\rho = 0.0020$) to that used in the bending reinforcement of beam 6 ($\rho = 0.0023$), however, its resistance with GFRP at the moment reaches almost twice the moment achieved by the steel reinforcement. Even with this, both reinforcements reached failure values higher than those evaluated according to their applicable standards.

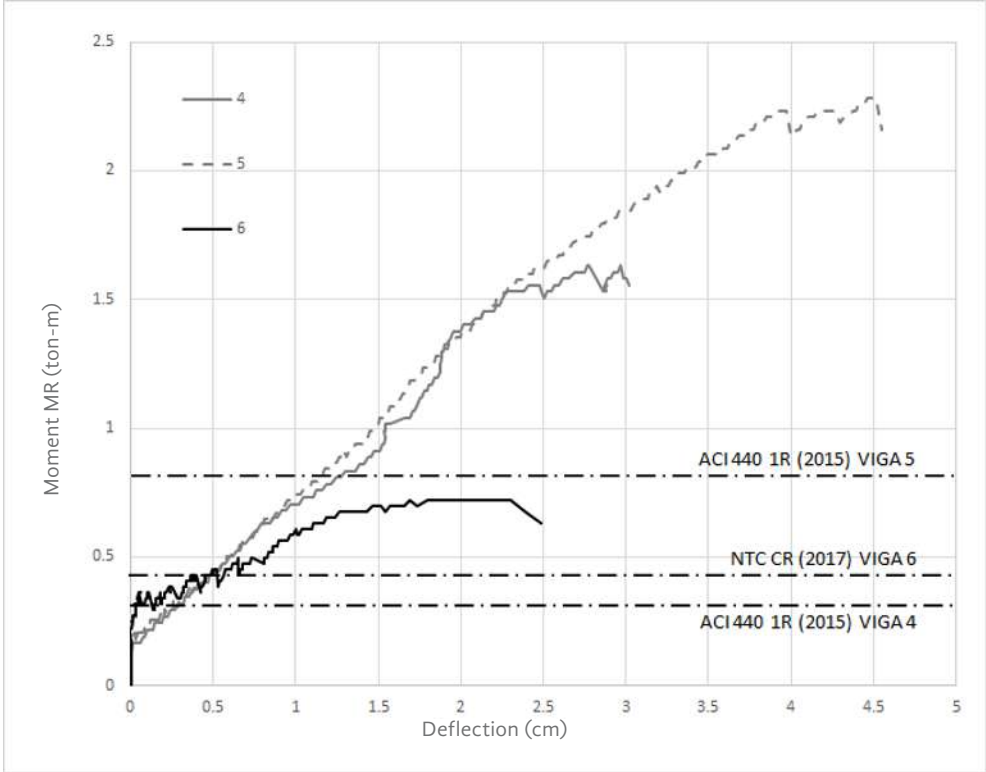

Figure 2. Comparison Chart of the Moments between GRP Beams 4 and 5 and Steel Beam 6.
Source: Own elaboration

In Table 2, it can be seen that the nominal resistant moment (MR), calculated according to ACI 440 1R (2015) for beams armed with GRP, results overall in more conservative values than those referred to by the NTC CR (2017).

However, to make an adequate comparison between the values reached by the design against the experimental values, we ended up using a safety factor defined as FS=Mmax/MR, in which the wide margin of safety in the bending design for these elements under-forced with GFRP can be appreciated. Similar conclusion on safety in GFRP design is made by Joaquím L. and Diaz Pérez (2017) in the reception work called "Estructuras de hormigón armado con barras de Polímero Reforzado con Fibras de Vidrio (PRFV). Estado del arte.", in which he mentions that "The formulas proposed by the ACI 440 ... were considered too conservative because they are based on the controlled compression domain (concrete crush failure)."

Table 2
Safety Factor Design per Bending Moment

BEAM	BENDING		
	MR_{CALC} Kg-m	MR_{REAL} Kg-m	FS
1 (V)	146.39	836.00	5.71
2 (V1)	146.39	806.67	5.51
3 (V2)	146.39	863.33	5.90
4 (V3)	302.44	1,596.67	5.28
5 (V4)	833.91	2,246.67	2.69
6 (STEEL)	487.79	836.00	1.71

Source: Own elaboration

Shear strength

The comparative evaluation of the shear strength also shows the same behavior in terms of the safety factors (FS=Vmax/VR) obtained from the experimental values and those obtained by the conventional analysis methodology according to the applicable design code according to the reinforcement material. GFRP designs represent higher safety indexes against the evaluation of steel assemblies (see Table 3).

It is worth observing that beam 4 reinforced with GFRP and beam 6 reinforced with steel have a very similar reinforcement amount, as far as we notice. However, the shear strength of the steel-reinforced beam, contrary to the result seen in bending, was higher than that of GFRP (Figure 3). That is, the beam with welded wire truss when compared with those of GFRP of a similar amount (beam 6 with 4) presented a better performance in resistance to cutting and displacement, as well as an FS very similar to that obtained with that of GFRP.

It can be observed that the development of the failure to cut in the beams reinforced with GFRP stirrups was linear to the limit. This behavior observed in these beams reinforced with GFRP stirrups suggests paying

attention to the adequate design of the shear reinforcement due to the fragility of the failure and the lower margin of clearance obtained in the FS, when compared to that obtained by bending of the same beams.

Table 3
Safety Factor Design per Shear Strength

BEAM	SHEAR		
	VR_{CALC} Kg	VR_{REAL} Kg	FS
1 (V)	596.58	1,200.00	2.01
2 (V1)	664.48	1,210.00	1.82
3 (V2)	604.16	1,295.00	2.14
4 (V3)	704.88	2,395.00	3.40
5 (V4)	1,230.31	3,370.00	2.74
6 (ACERO) 6 (STEEL)	1,491.31	2,660.00	1.78

Source: Own elaboration

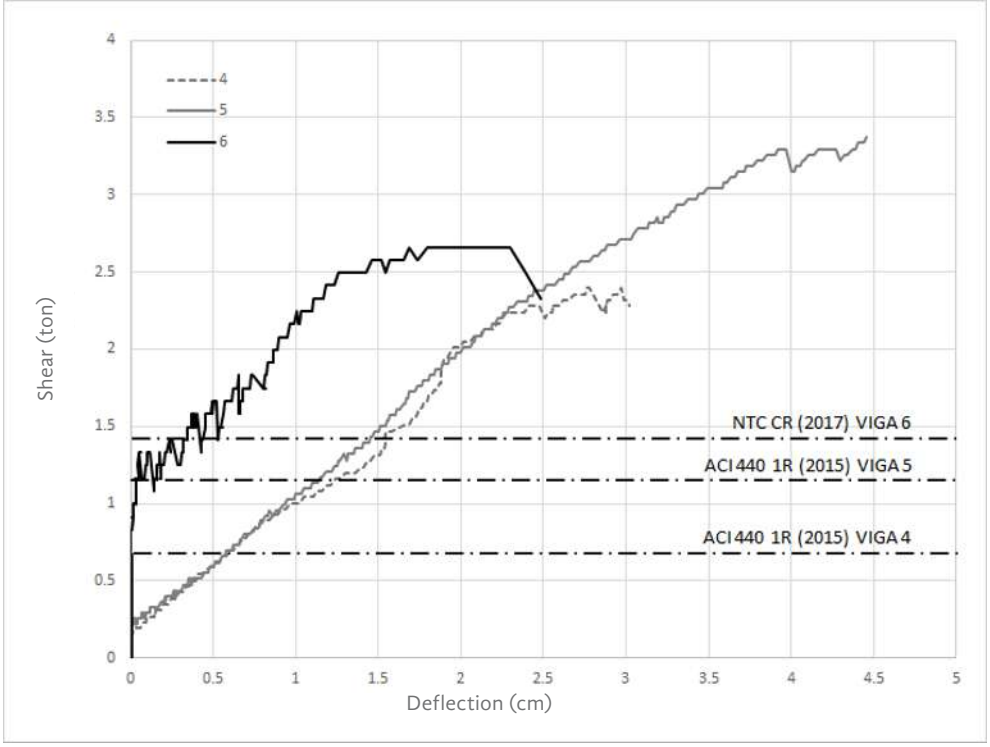

Figure 3. Shear Comparative Chart between GRP beams 4 and 5 and steel beam 6. Source: Own elaboration

Figure 4. Failure in beams, collapse by shear: beam 4. Source: Own elaboration

The FS obtained, which relates the resistance empirically obtained in the tests with that evaluated by the normative theoretical models, seems to be very promising. However, it will have to take into account that most of the GFRPs available on the market do not yet have standardized capacities, so

these are subject to the manufacturer's formulas and standardization of their quality processes, which must normatively guarantee 2.5 times the Coefficient of Variation (2.5Cv) or three standard deviations of the sample (3 σ), for each of the resistance values they provide us, as mentioned by Sánchez (2020).

The problem of adhesion that was appreciated in the load variations remains pending, although they were comparable to those of the welded wire truss and did not affect the comparative of the test, for beams of higher load and/or clear index could be meaningful.

5. CONCLUSION

The comparative study between GFRP-based composite materials shows an acceptable behavior for use in residential buildings based on confined masonry and to some extent safe in self-construction, within the same parameters with which high-strength welded wire truss have been used as reinforcement against gravitational loads and relatively short clearings.

Bending strength results in better performance than steel within the limits of this test with high safety margins against design conditions. However, the shear strength could be noticed at a disadvantage when compared with that obtained from the drawn steel of the welded wire truss, particularly in the first beams (1, 2, and 3), whose capacity was exceeded especially because its reinforcement index was much lower than that of the steel beam (6). Likewise, it was observed that improving the amount of longitudinal reinforcement in GFRP beams also improves their shear response (beam 4).

The above suggests the shear design could be critical for use in clearings greater than 2.0m, so it requires an adequate revision and structural design, with robust transverse reinforcements, to save even clear bridges such as those mentioned in the AASHTO manual (AASHTO (GFRP), 2017).

Thanks

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REFERENCES

AASHTO (GFRP). (2017). *LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings*. Washington D.C.

ACI 440 1R. (2015). *American Concrete Institute, Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer (FRP) Bars*. Michigan: ACI.

GangaRao, H. V., Taly, N., & Vijay, P. V. (2007). Reinforced Concrete Design with FRP Composites. M. Florida, U.S.: CRC Press.

Gooranorimi, O., Gremel, D., Myers, J. J., & Antonio, N. (2015). Durabilidad a largo plazo del refuerzo interno de GFRP (PRFV) en estructuras de concreto. *ACI Journal*.

Nanni, A., Luca, A. d., & Jawahery, H. (2014). *Reinforced Concrete with FRP Bars, Mechanics and Design*. New York: CRC Press.

NTC CR. (2017). *Normas Técnicas Complementarias de Concreto*. Cd., de México, México.

NTC M. (2004). Normas Técnicas Complementarias para Mampostería 2004. *Gaceta oficial del Distrito Federal*. Distrito Federal, México.

NTC M. (2017). Normas Técnicas Complementarias para Mampostería 2017. *Gaceta Oficial de Cd., de México*. México.

R., M., Cousin, P., & Benmokrane, B. (2009). Durability of GFRP Reinforcing Bars Embedded in Moist Concrete. *Journal of Composites for Construction*. doi:10.1061/ASCE1090-0268(2009)13:2(66)

Sánchez Hernández, J. A. (2019). Estructuras de Concreto en Zonas Costera usando Barras de Polímero Reforzados con Fibra de Vidrio. *Revista PAKBAL*(45), 26-32.

Sánchez Hernández, J. A. (2019). Evaluación de los Criterios de Diseño de Vigas de Concreto Subreforzadas con Varillas de PRFV. *Revista PAKBAL*(46), 5-11.

Sanchez Hernández, J. A. (2020). Resistencia Real, Última Garantizada y Resistencia de Diseño del Polímero Reforzado con Fibra de Vidrio (PRFV). *PAKBAL*(47).

Wainshtok Rivas, H., Hernández Caneiro, J. A., & Díaz Pérez, I. d. (2015). *Empleo de Barras y Telas de Mallas de PRF como refuerzo del hormigón y el ferrocemento*. (978-84-17098-39-1, Ed.) Habana, Cuba: Edita.me.

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Perception of the urban parks' ecosystem services in Tuxtla Gutiérrez, Chiapas, Mexico

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— Abstract—

Urban parks provide ecosystem services to people who live near these spaces and those who frequent them to carry out a specific activity. The services offered by urban parks are of vital importance for the development of society since they make it possible to reduce the stress of the population, improve air quality and climate control, as well as carry out recreational activities. This work aims to contrast the perception of users about the ecosystem services of two parks that are in the same eastern area of the city. We used the participant observation technique, were we obtained a comparative description of the characteristics of gray and green infrastructures of the parks of Tuxtla Gutiérrez, Chiapas, Mexico (Parque del Oriente and Parque Fundamat). Likewise, surveys were carried out to know the perception that users have about the previously mentioned parks with respect to some ecosystem services. Results show that the size, variety of activities, and the state of the infrastructure offered by Parque del Oriente influence the fact that there are users from distant neighborhoods, unlike what happens with Parque Fundamat, where users live close to that location. It should be noted that the people going to both parks recognize the cultural and regulatory ecosystem services.

Keywords:

Environment; urban environment; quality of life.

The world's population has increased fivefold since the last century (United Nations Human Settlements Programme, 2011). Currently, 55% of the population lives in cities and this percentage is estimated to increase by 13% by the year 2050 (Debnath *et al*., 2014; United Nations, 2018). This population increase brings, on the one hand, the acceleration of the use of natural resources, while, on the other, the greater requirement for green areas that provide Ecosystem Services (ES) to the population (Balvanera and Cotler, 2007; Vásquez, 2016; Seto *et al*., 2017). In the urban context, the concept of Ecosystem Services (ES) is relevant because it allows the assessment of the relationship between ecosystems and the well-being of the population, as well as the integration of green areas and natural resources for decision-making in the urban policies (Balvanera & Cotler, 2007; Frutos & Esteban, 2009; Camacho & Ruiz, 2012; Laterra *et al*., 2017).

The term ES is defined by the international group of Millennium Ecosystem Assessment (Balvanera and Cotler, 2007), as: "The benefits that the population obtains from ecosystems" (MEA, 2003). Although ES emerge as a seemingly concrete and simple concept, some authors point out more specific aspects that address their complexity. In this sense, De Groot *et al*. (2002) link ES with the ability of natural processes and components to provide goods and services that meet human needs, directly or indirectly; while the U.S. Environmental Protection Agency or in the United States (2004) defines ES as those environmental functions or processes that, directly or indirectly, contribute to human well-being or have a potential to do so in the future. On the other hand, Camacho and Ruiz (2012) and Guevara *et al*. (2003) explain that ES can be divided into a) goods and b) services, the former are tangible and refer to physical objects such as food, wood, plants, water, and soil; while services are considered intangible since they are processes that cannot be touched physically, where the benefit to the population is obtained indirectly, as in carbon capture, climate regulation, landscape, or erosion control.

A classification of the ES that ecosystems offer to society is given by the MEA in 2005, which divides these benefits into four different types of services (Table 1):

Table 1
Table of classification of ecosystem services according to the MEA (2005)

Types of ecosystem services	Operation
SUPPORT	
Soil formation and conservation	Aid for non-desertification of the place
Nutrient cycle	It enriches the soil with organic matter and the regeneration of the plants' mineral nutrients.
REGULATION	
Water regulation	Vegetation cover can decrease surface runoff and aid in absorption to feed the groundwater, i.e., the cover serves as a moderator in flash floods and other problems such as erosion.
Climate regulation	The vegetation cover helps in carbon sequestration (CO2 atmospheric) and prevents irradiation and heat islands.
Pollination and seed dispersal	It helps in the processes of floral gametes dispersion with the help of pollinators, animals, wind, and water.
SUPPLY	
Food	It provides food and the development of a plant, animal, or microbiological species that can be consumed directly or indirectly by humans
Non-eatable products	Fiber (cotton), wood, biochemical (medicinal plants, cosmetics, etc.), and firewood.
From water	The vegetation cover needs the availability of water, but in turn serves as its provider, generating and maintaining the available water quality.
CULTURAL	
Identity and diversity	La identificación de las personas hacia los ecosistemas crea un vínculo entre ellos.
Landscape, Values, and Heritage	Most ecosystems represent a landscape value to the community that is often protected by UNESCO as cultural heritage sites.
Spiritual	Many communities link the presence of trees to certain ancient beliefs and belonging to that place.
Aesthetics	They provide an ornamental element to the place.
Recreation and tourism	The ecosystems represent characteristics that make other people who are not precisely from that community want to visit them.
Generation of knowledge	They serve as places where scientific and traditional knowledge can be produced.

Source: MEA, 2005

ES serves as a connection between the population and the ecosystem, the latter being represented in this study through urban parks, which are outlined, open, publicly accessible areas, where their use is predominantly recreational, and ecosystems with vegetation and trees that dominate the landscape constitute the main green spaces within an urban settlement

(Chiesura, 2004; Gómez-Baggethun & Barton, 2004; taken from Vargas & Roldán, 2018). Culturally these places allow the interaction of the person with himself, with others, and with the natural environment, which favors the construction of identity (Ballinas, 2014) and the coexistence of users of different social strata (Martínez-Valdez *et al*., 2020). There are some authors (Reyes-Paecke & Figueroa, 2010; Leandro-Rojas, 2014; Cuevas, 2015; Merayo *et al*., 2016; Stainbrook, 1973 cited by Martínez-Soto *et al*., 2016; Martínez-Soto *et al*. 2020) who mention that parks help improve the mental state of the community because people express the health benefits of doing physical activities in contact with nature. The reduction of some mental conditions is reflected in the work of Song *et al*. (2014), which was carried out in Japan, where a group of young men found a low in anxiety and stress in 14.3% of the population studied when young people had access to a frequent walk through a park with trees (cited by Merayo *et al*., 2016).

ES studies in urban areas include those that refer to hedonic prices (Loret de Mola, 2018) and environmental indicators (Morales- Cerdas *et al*., 2018), as well as studies that emphasize the zoning of ES (Guauque, 2019). The implementation of urban policies and citizen participation in the improvement of green areas have been studied concerning the increase in ES (Cervantes & Martínez, 2021), while planning is analyzed and linked to the distribution of urban areas that allow access to ES (Ojeda, 2020).

Within the various types of urban green spaces, the park has a special appreciation for its architectural, aesthetic, and historical characteristics; as well as for the construction of a better image and habitability of the city (Castro *et al*., 2003; Montañez, 2017; Martínez-Valdez *et al*., 2020).

In the urban park, vegetation is a fundamental characteristic since it constitutes a quality factor for the lives of people in cities (Rapoport *et al*, 1983; cited by Meza & Moncada, 2010). However, the attraction to these spaces is related to the present vegetation, the quality of maintenance, social security, free access (Duygu, 2015), and the distance from the users' place of residence to the park. In this context, Katz (2011) states that the optimal distance to make use of urban parks is approximately 5 minutes from the users' place of residence (Katz, 2011); however, the UN considers a distance traveled up to 30 minutes (Sepúlveda, 2017).

Another important feature in the study of parks is the presence of green and gray infrastructure (Castro *et al*., 2003). Green infrastructure is the presence and interconnection of trees that preserve ecosystem functions and provides benefits to the population, while gray infrastructure is represented by civil works that are built within parks (Benedict and McMahon, 2002; Tzoulas *et al*., 2007; Eisenman, 2013; cited by Vasquez, 2016). For Vásquez (2016) the green infrastructure arises as an alternative to the grey one since the latter is created only to satisfy a specific need; instead, the

green infrastructure allows to solve naturally several problems at the same time, for example, flood containment, water scarcity, thermal changes and lack of green space for the population. Zuñiga-Terán *et al*. (2020) indicate that these two types of infrastructure can work in a complementary way, coexisting in urban parks, spaces where ES is perceived. However, urban green areas can be perceived as a policy object, through the agreement of conservation and maintenance plans (Rivas-Torres, 2001; Fischesser, 2009; cited by Velasco *et al*., 2013).

For the present research, an assessment is proposed that includes both user perceptions and technical aspects. The methodology of this study is based on the perception that people have with respect to ES at a cultural level, without this implying the exclusion of other ecosystem services perceived by the community as relevant. This is ultimately linked to the data obtained in the participant observation.

MATERIALS AND METHODS

The municipality of Tuxtla Gutiérrez is in the Socioeconomic Region 1 of the State of Chiapas, Mexico. The city is bordered on the north by the municipalities of San Fernando and Usumacinta; on the south by Suchiapa; on the west by Ocozocoautla de Espinoza and Berriozábal; and on the east by Chiapa de Corzo (INEGI, 2010; cited by SEDESOL, 2013). Tuxtla Gutiérrez has 159 spaces for recreation and sport within the city's 480 neighborhoods, within these are 107 parks (Pérez, 2014) of which only two will be studied for the present work.

Figure 1. Location of Parque del Oriente and Parque Fundamat in the city of Tuxtla Gutiérrez, Chiapas. Source: Perla Paniagua for this project, 2020

Table 2
Geographic location of the two evaluated parks

PLACE	COORDINATES	HEIGHT (msnm)	EXTENSION (m^2)
PARQUE DEL ORIENTE	93° 5' 25.4" W 16° 45' 37.47" N	505	107.19
PARQUE FUNDAMAT	93° 5' 0.63" W 16° 45' 7.23" N	517	72.44

Source: Own elaboration with INEGI data, 2020

The two parks that make up this study are located in the northeast of the city of Tuxtla Gutiérrez, Chiapas at a distance of approximately 1.5 km (see Table 2). Parque Fundamat has a smaller extension, approximately 33% less than Parque del Oriente. The latter adjoins the northern area of the city, which serves as a fast-track link between the east and west, and is also opposite a public secondary school, as well as nearby houses. While Parque Fundamat is located inside the El Retiro neighborhood, around it, there are houses and within a radius of approximately 500 m, there is a high school, an administrative unit, and a shopping mall (see Figure 1).

Participant observation

For the participant observation, it is allowed to describe the gray infrastructure of both parks and the activities carried out by users in those spaces. We observe the influence of people, infrastructure for sports, rest and recreation areas, and the presence of containers, public lighting, and parking. For the green infrastructure, we observe the differences in the woodland, the characteristics of the density, and the care of each space. Finally, we observe the use of space in urban parks, that is, the interaction of visitors with the green and grey infrastructure.

We also used participant observation to describe the infrastructure of the two areas (Díaz, 2010), in which we made a preliminary observation and record. In the end, data from this observation are organized and analyzed, according to the aspects considered in this study.

Survey

The surveys were based on cultural ES classified by MEA (2005). Random sampling was performed by quotas, a procedure that is part of the non-probability samples (Ochoa, 2015). For this case users over 18 years are chosen, since some questions are dating back to past years.

96 surveys are carried out in total, which is divided between the two parks (48 for each park), applying six daily surveys in eight days, the application schedule is staggered to cover different groups of people who come to the park, either in the morning, noon, afternoon or evening. The aspects considered for sampling are gender (men and women) and age (18-35, 36-50, and 51 years and older).

The topics covered in the survey are the neighborhood of origin, frequency of attendance, knowledge of administration, use and knowledge of infrastructure, assistance to other parks, knowledge of biodiversity, park changes over time, and future prospecting.

Figure 2. Conducting surveys. Source: Own elaboration

RESULTS

The results of the participant observation are exemplified by the characteristics of the infrastructure, as well as the conditions in which these spaces are (Table 3).

Table 3
Comparison table of the grey and green infrastructure observation

CHARACTERISTICS	PARQUE DEL ORIENTE	PARQUE "FUNDAMAT"
	GREY INFRASTRUCTURE	
Courts	One basketball court that is in good condition.	A small football field.
Gym	Open to the public at the established schedules.	Not applicable.
Running and walking tracks	In good condition, one for each activity.	It has only one track for both activities.
Pool	In good condition, semi-Olympic.	It does not have one.
Exercise machines	They are located in two areas of the park.	It does not have one.
Bathrooms	Two bathrooms that are supervised by one person.	Closed and in poor condition.
Trash cans	There are eight containers in poor condition.	There are six containers with no space to deposit garbage.
Parking	It has one inside and two outside.	It has one on the outside.
Benches	There are fifteen benches	There are eight benches
Palapas	There are two that are used for dance classes	It does not have one.
Administrative unit	You can ask for information and enroll in different activities	Not applicable.
	GREEN INFRASTRUCTURE	
Forestry status	The trees' appearance is better visualized	There are dry trees and uncut branches.
Density	In comparison with Parque Fundamat, it has a lower tree population density.	In comparison with Parque del Oriente, there is a greater tree density per unit of area.
Signaling	There are signs at the entrance doors encouraging people to take care of the green areas.	It does not have signs.

Source: Own elaboration

As seen (in Table 3) both parks have things in common, such as courts or fields (although for different activities); they also have running or walking tracks, garbage cans, and some benches to sit on. Parque del Oriente has more gray infrastructure, such as a gym area, a pool, exercise equipment, and a palapa where some activities are performed such as Latin or Arab dances; unlike Parque Fundamat which contains less diversity of grey infrastructure, which is in deteriorating conditions.

Attendance Frequency

The results of the survey regarding the frequency of attendance to parks are represented in how many times users come to these during a month, the

response is divided into three categories: 0 to 4 times, 5 to 10 times, and 11 to more times in the month. We can see (Figure 3 and Figure 4) the answers divided between men and women.

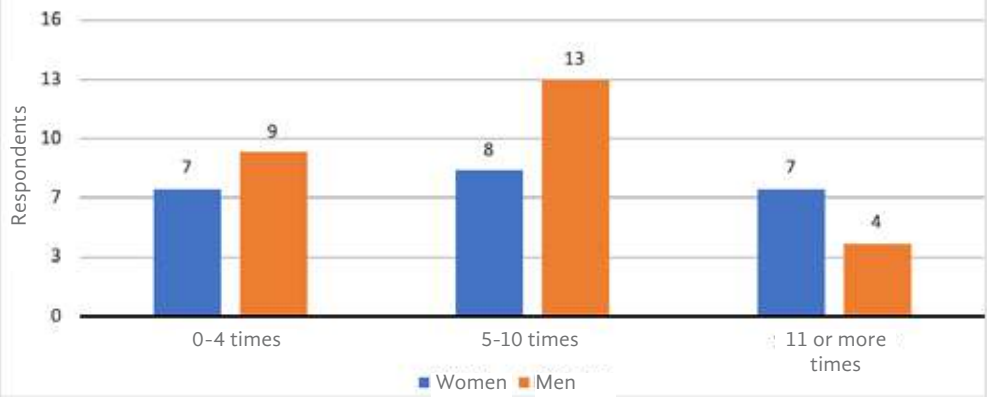

Figure 3. Frequency of attendance at Parque del Oriente for one month. Source: Own elaboration

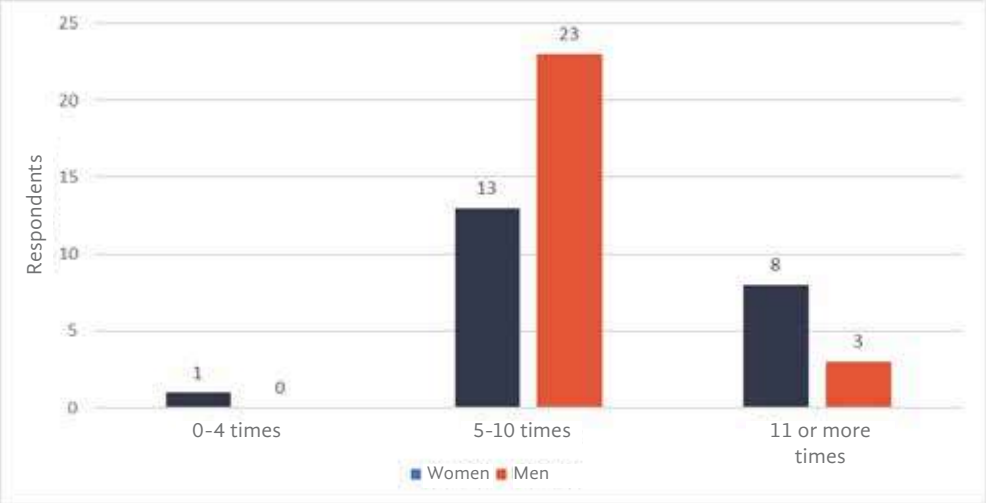

Figure 4. Frequency of attendance at Parque Fundamat for one month. Source: Own elaboration

As can be seen, both in Parque del Oriente (Figure 3) and in Parque Fundamat (Figure 4), there is a higher frequency of attendance in the range of 5 to 10 times a month. In Parque del Oriente, the only frequency range in which women's participation is higher than men's is the range of 11 to more times per month. In the case of Parque Fundamat, there is a greater presence of men than women in the range of 5 to 10 times per month. The frequency range of attendance at the park from 0 to 4 times a month is higher in Parque del Oriente (16) than in Parque Fundamat (1); while the frequency range of attendance at the park from 5 to 10 times a month is higher in Parque

Fundamat (36) than in Parque del Oriente. In the last range of 11 to more times per month, the same number of people is observed for both parks (11).

Age

The ages of the respondents, as well as the frequency of visits, are divided into three categories as mentioned in the methodology, these being: 18 to 39, 40 to 59, and 60 years and older. It should be noted that the lower limit is 18 years. The answers are represented in percentages for each park (Figure 5 and Figure 6).

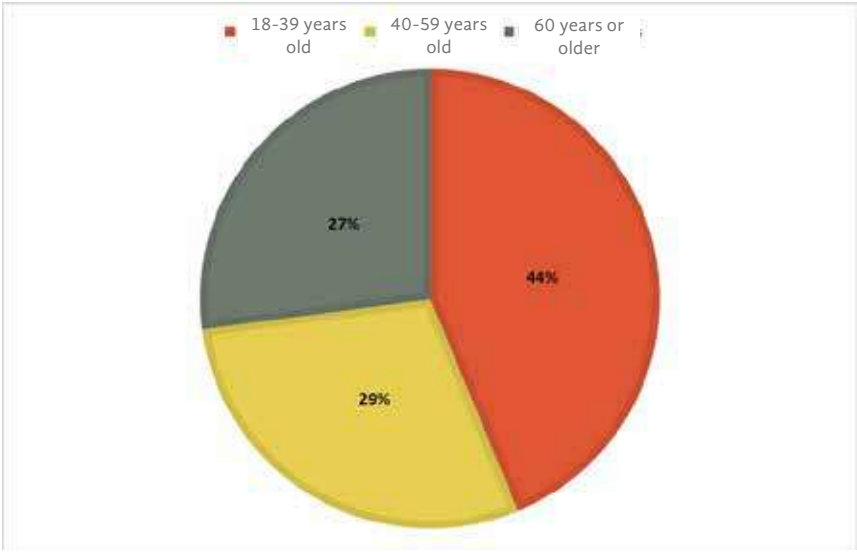

Figure 5. Respondents' ages in Parque del Oriente. Source: Own elaboration

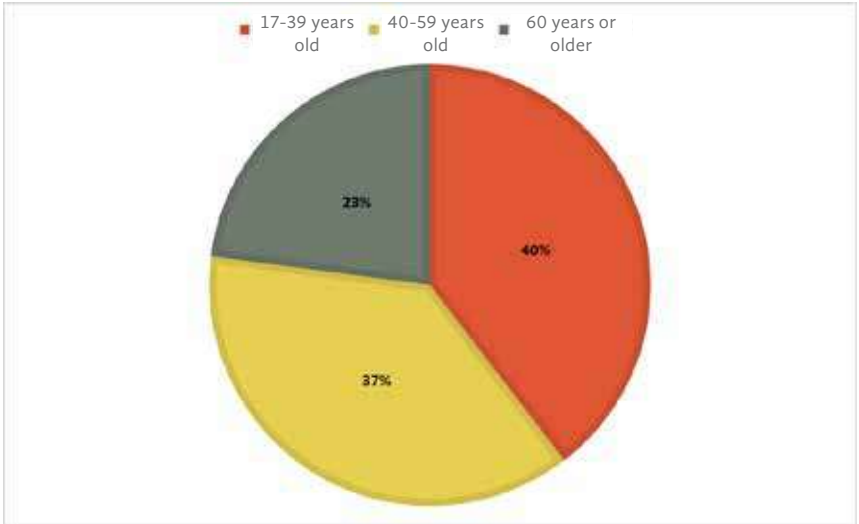

Figure 6. Respondents' ages in Parque Fundamat. Source: Own elaboration

The age group with the highest percentage of visits to both parks was the youngest, that is, those under 40 years of age, with 44% for Parque del Oriente and 40% for Parque Fundamat. The second group with the highest attendance is the 40 to 59 years old, with 29% for Parque del Oriente and 37% for Parque Fundamat. Finally, there is the group of attendees over the age of 60, with an attendance of 27% and 23% respectively. It is noted that Parque Fundamat has 8% more visits than Parque del Oriente in the age range of 40 to 59 years.

Origin

In the survey, in the population data, we wanted to know the users' origin, thus obtaining a map with the neighborhood from which the people who attend Parque del Oriente (Figure 7) and Parque Fundamat (Figure 8) come.

Figure 7. Map of the neighborhoods where the users surveyed in the Parque del Oriente reside.
Source: Own elaboration

The previous map (Figure 7) shows the spatial distribution of the neighborhoods of the visitors to Parque del Oriente. There were six neighborhoods found within a radius of less than 1 km for 37% of the respondents, while 63% of the visitors come from 18 neighborhoods located within a radius greater than 1 km from the park. It should be noted that, among the latter group of neighborhoods, one of them is located approximately 10 km from the park.

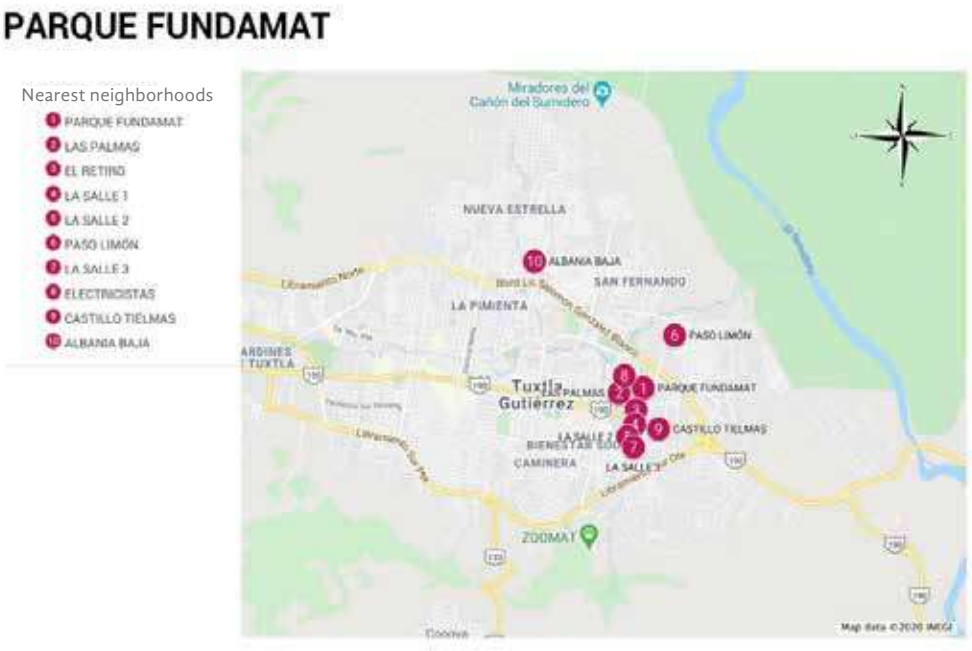

Figure 8. Map of the neighborhoods where the users surveyed in Parque Fundamat reside.
Source: Own elaboration

In Parque Fundamant (Figure 8) there are seven neighborhoods in a range of less than 1 km from where 88% of the respondents come, while 12% of visitors from two neighborhoods are within a radius of more than 1 km, within the latter group, one of them is located at a distance from the park of approximately 4 km. Parque del Oriente has vistors that come from more than double the number of neighborhoods than Parque Fundamat, and it is also visited by users from more distant neighborhoods.

Visiting other parks

As seen in Figure 9, almost half of the users of Parque del Oriente visit another park apart from this one; while in Parque Fundamant there is less diversification of visits to other parks (see Figure 10).

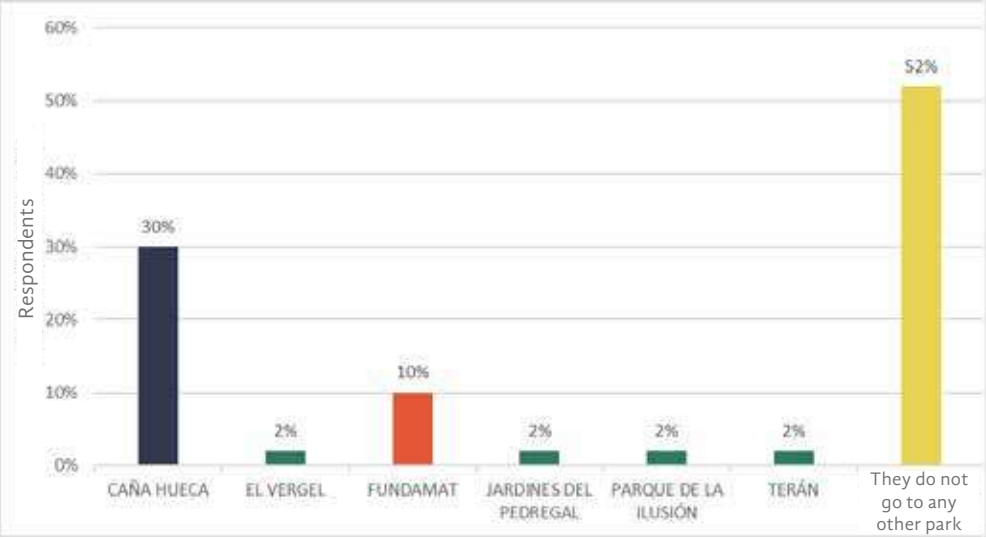

Figure 9. Other parks visited by users of Parque del Oriente. Source: Own elaboration

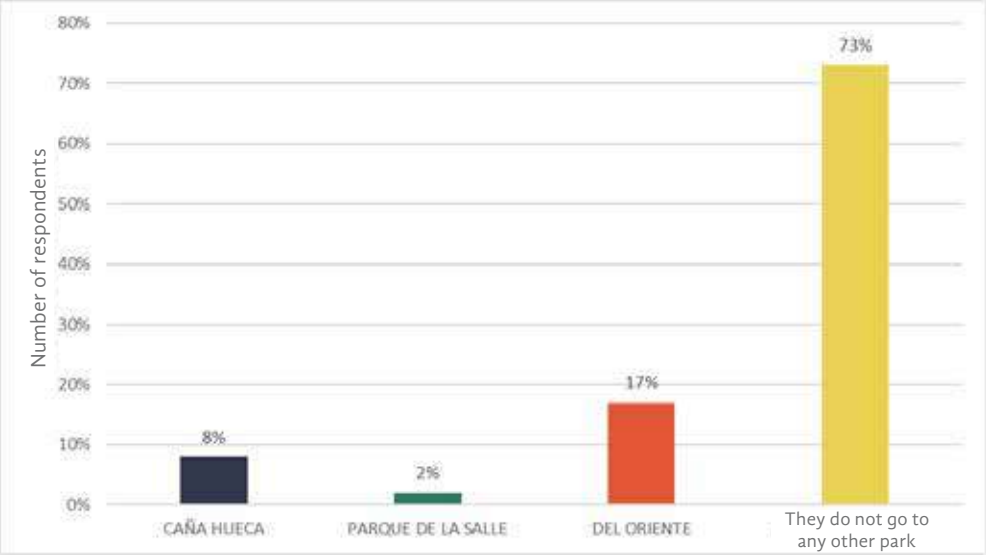

Figure 10. Other parks visited by users of Parque Fundamat. Source: Own elaboration

In Parque del Oriente, 48% of the total users also attend another park, while in Fundamat, 27% of respondents usually visit a second park to perform their daily activities.

The second park to which users of Parque del Oriente go more often is Parque Caña Hueca (30%), while 10% of the people come to Parque Fundamat. On the other hand, the survey carried out in Parque Fundamat shows that 8% of visitors go to Parque Caña Hueca, and 17% of respondents go to Parque del Oriente.

Infrastructure

The grey or green infrastructure, which users use more when they go to parks, is different in the cases mentioned in this study since in Parque Fundamat there is greater tree density while in the Parque del Oriente there is more diversity of gray infrastructure and a larger built space.

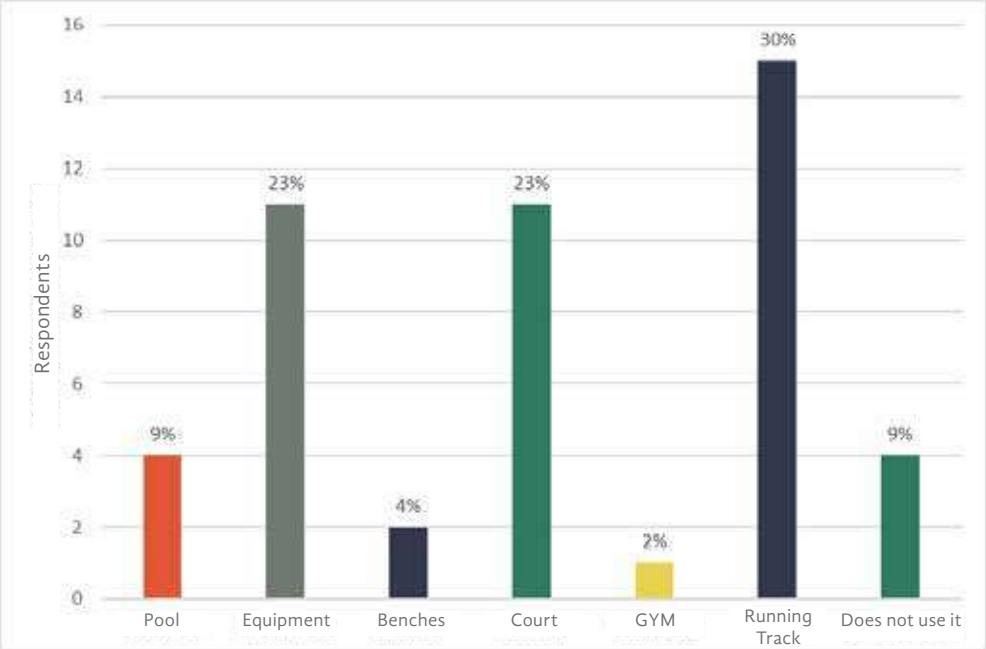

Figure 11. The infrastructure used in Parque del Oriente. Source: Own elaboration

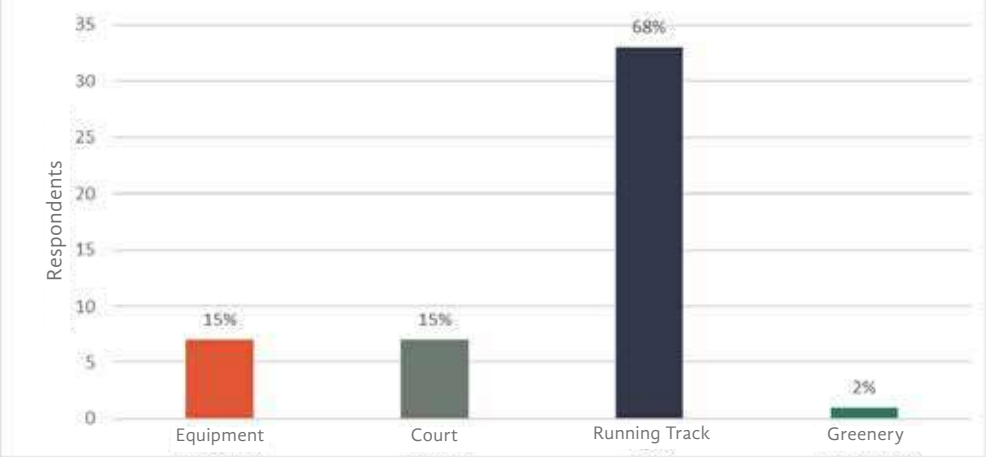

Figure 12. The infrastructure used in Parque Fundamat. Source: Own elaboration

The infrastructure most used in both parks was the running track, with 30% of those surveyed in Parque del Oriente and 68% of those surveyed in Parque Fundamat, slightly more than twice as many as the first park. In terms of the equipment for exercises and the use of the courts both answers had the same amount in each park (23% in Parque del Oriente and 15% in Parque Fundamat). It should be noted that the use of courts or fields in Parque Fundamat is for football, and in Parque del Oriente is for basketball.

Other answers found in Parque del Oriente are the use of the pool, benches, and the gym with 9%, 4%, and 2% of users respectively, and 9% of visitors do not use any infrastructure. For Parque Fundamat only one user commented that for him, the vegetation is the infrastructure that he uses the most, representing 2%.

Ecosystem services

One of the most important features to evaluate was the perception of the benefits that users feel they receive from the park they attend, this was an open question in which visitors mentioned only one answer. In both results, it can be observed that the benefits that most matter to users are related to the ES supplies, with 89% for Parque del Oriente (Figure 13) and 87% for Parque Fundamat (Figure 14), for cultural ES the results, were 11% and 13% respectively.

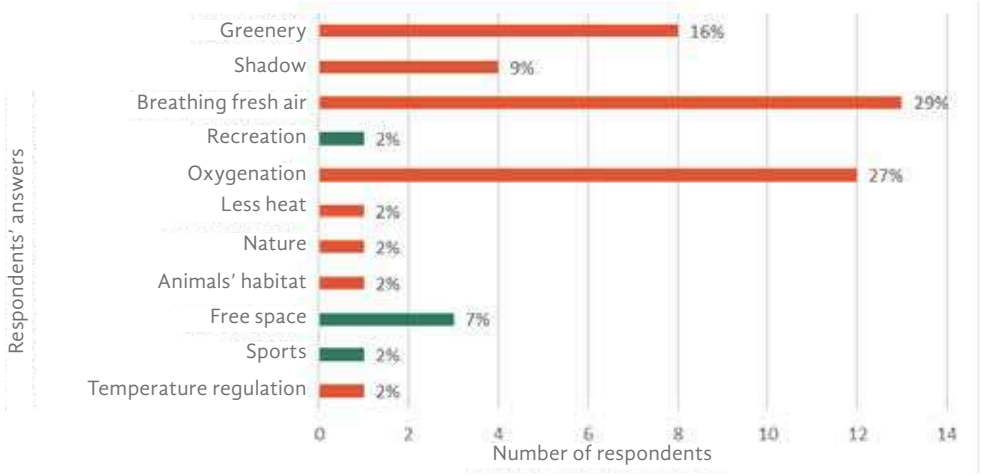

Figure 13. What ecosystem services are perceived in Parque del Oriente?. Source: Own elaboration

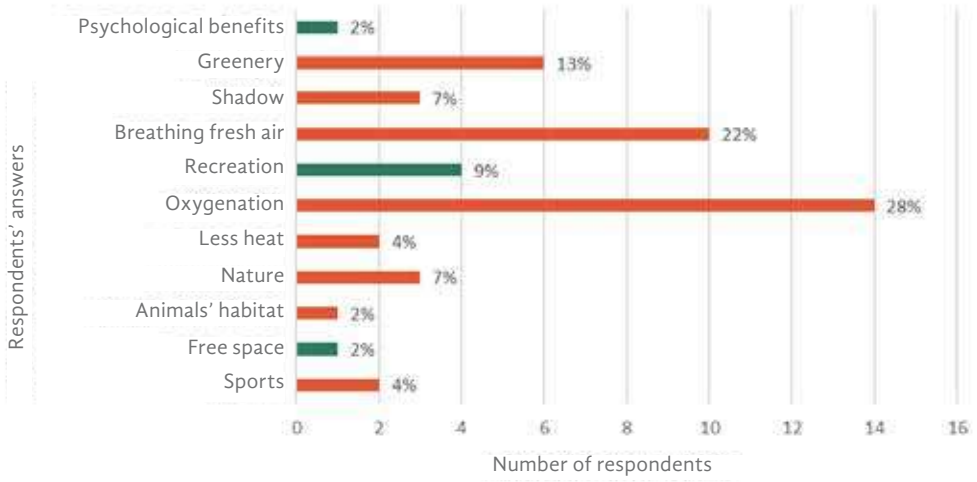

Figure 14. What ecosystem services are perceived in Parque Fundamat?. Source: Own elaboration

For the users of both parks, "Oxygenation" and "Breathing clean air" ecosystem services were the most mentioned results with 29% and 27% respectively for Parque del Oriente, and 28% and 22% for Parque Fundamat. These are related to the good air quality that people feel when they are in such places, although it should be noted that sport, relationships with animals, psychological benefits, or having recreational spaces had a low presence in the perception of users, even though it is previously stated that users do perform some sport or recreational activity in the designated infrastructures. This means that users attach more importance to the environmental benefit of air quality than to sports activities. Another data to consider is the perception of vegetation that had more relevance in Parque del Oriente.

Prospecting

Survey responses favored the Parque del Oriente, where 89% of users believe it can improve, while 9% believe the park could remain the same and 2% believe it can have a worse condition than the current one. Figure 15 shows how they believe the park can be improved.

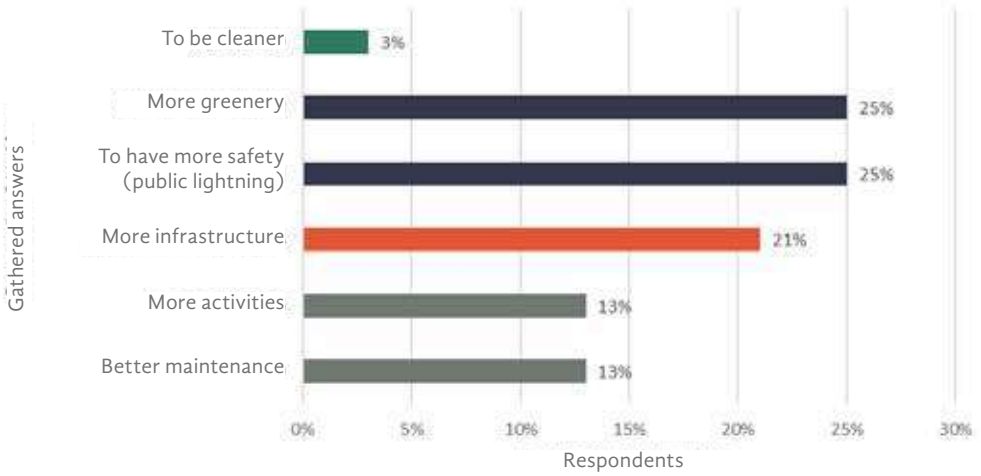

Figure 15. Prospecting for Parque del Oriente in the future. Source: Own elaboration

For Parque Fundamat, 63% mentioned that the park could be in better condition, 24% believe it could stay the same, and 13% think it could be worse than its current condition. The "better condition" response breaks down the following options shown in Figure 16.

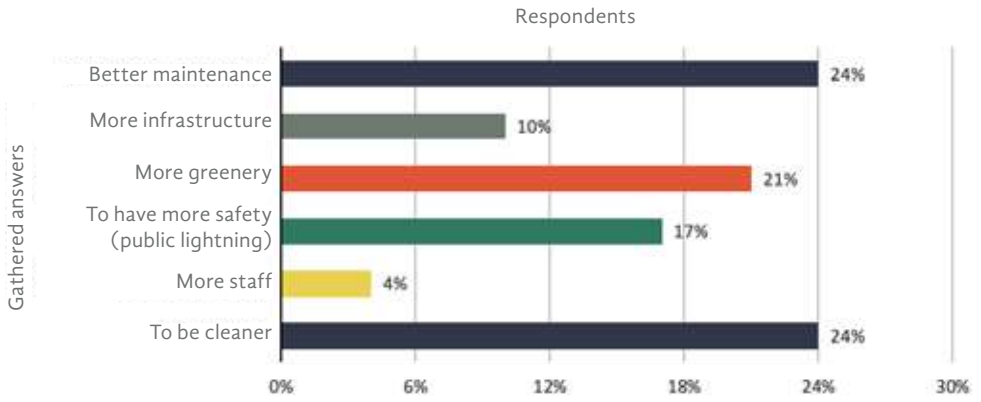

Figure 16. Prospecting for Fundamat Park. Source: Own elaboration

23% of the users of Parque del Oriente (Figure 15) mentioned that it could be in a better state, 16% mentioned that it could have more vegetation and another 16% expect the park to have more lighting to improve the security of the park at night. This means that approximately 90% of users expect some aspects to be improved, such as infrastructure and maintenance, 2% expect the park to be in worse condition in the future, and 9% expect no change.

Contrary to the previous results, 24% of users of Parque Fundamat (Figure 16) believe that the park will remain the same in the future, while 15% of users believe that the park can have better maintenance and be

cleaner, 13% expect more vegetation, and 13% of respondents think the situation of the park could get worse.

DISCUSSION

As for the age of the users surveyed, this research agrees with the work of Flores-Xolocotzi (2012), since in the present study, it was found that the age block of 60 and over is the one with the lowest percentage of visitors to the parks, also agreeing with the work of Pérez and Fargher (2016) who found that teenagers and young adults were the ones who came to the parks the most. On the other hand, the study of Gómez (2013) differs from these authors and the present work, since, in the parks of Salamanca, Spain the visitors who come the most are elderly, This factor may be because older adults form part of 24% of the population in Spain (López, 2019), while in Mexico the elderly sector represents 12.8% of the total population (National Demographic Dynamics Survey, 2018 taken from Monroy, 2020).

The frequency of visits to the parks of this study and the work of Pérez and Fargher (2016) agrees since for both places more than 50% of visitors come to the parks in a range of 5 to 10 times a month. Another study carried out by the National Association of Parks and Recreation of Mexico (ANPR, 2018), reported that more than 50% of the respondents visit them from 8 to more than 12 times a month. In the case of this work the percentages favored Parque Fundamat with 97% compared to Parque del Oriente with 66% in the range of 5 to more visits per month, this figure differs from Reyes-Paecke and Figueroa (2010), which describe that visitors go more times to larger parks, considering that Parque del Oriente has 35 m2 more than Fundamat, so this preference in this work is not met.

As for the origin of neighborhoods, the study of Reyes-Paecke and Figueroa (2010) found that a park, having more length, attracted people from more distant neighborhoods. This aspect is like what was observed in this study since Parque del Oriente attracts visitors from more than twice as many neighborhoods as Parque Fundamat, as well as users from more distant neighborhoods. In addition to the size of the park, some other features are also related to the attraction of users such as the presence of more and better infrastructure, as obtained in the participant observation, the proximity of mobility routes, diversity of users, visibility (public lighting), and the sense of accessibility (Múñoz, 2014; Videla, 2016; Katz, 2017) help Parque del Oriente to attract people from more distant neighborhoods.

The resulting comparison of the participant observation (Figure 2) showed that the infrastructure Parque del Oriente has is predominantly gray: the courts, the walking tracks, parking, garbage dumps, and benches. It should be emphasized that the observation showed that the Parque del

Oriente's infrastructure is in better condition than that of Fundamat, so perhaps the location and larger size of the first one influence the desire to maintain a cleaner and more careful image for the citizens who travel the northern highway of the city.

Figure 17. Entrance to Parque del Oriente. Source: Own elaboration

Figure 18. Entrance to Parque Fundamat. Source: Own elaboration

As for the ES perceived by users of both parks the most perceived benefit was that of oxygenation as opposed to Flores-Xolocotzi (2012) who stresses the importance of recreation and sport, while in their work, the ANPR (2018) showed that 44% believe parks help provide conservation and environmental services (cultural ES). It is important to consider that compared to the ANPR, in this comparative work the greatest result was the perception

of provisioning and regulation ES, which gives implicit importance to the green infrastructure; although the reference to activities favored by grey infrastructure appears more often than not.

Like this study, the ANPR's work (2018) also questions the exploration of the park by users, since 25% were inclined to think that the maintenance of the park could be an area to improve in the future while for this work the results were 14% for Parque Fundamat and 8% for Parque del Oriente. As for public lighting improvement, the ANPR's result was 15%, agreeing with the results of the present work. The improvement of toilette facilities (16%) and accessibility to disabled persons (12%) were considered in the responses provided by the ANPR, which were not subjects mentioned by the people in this study, who focused on issues such as cleanliness and increased vegetation.

CONCLUSION

Although both parks are located on the east side - north of Tuxtla Gutiérrez, Chiapas and are characterized by being spaces of public and free access, the infrastructure that each one has means that different activities will be carried out, attracting different types of users. Sports and recreational activities are better valued in the present work and in that of Pérez (2014), this shows that the attraction of people to urban parks is directed to the use of gray infrastructure. On the other hand, it is noted that this infrastructure may be linked to the more evident presence of administrative and maintenance personnel, as is the case in Parque del Oriente.

Although for this work the number of users arriving at each park was not counted, in the participant observation and the application of surveys it was observed that more people came to Parque del Oriente, since it was easier to find more visitors to survey in a shorter period than in Parque Fundamat where the questionnaire time was longer due to the waiting of people to survey.

As for the extension, the larger a park is, the greater diversification of activities and care from public actors can be found in them, thus attracting people even from distant neighborhoods. Although the green infrastructure of Parque del Oriente is in better condition due to greater intervention, the trees in Parque Fundamat are in a more "natural" condition giving it a different appearance that can attract other types of users.

The relevance of this comparative study is based on the objective of investigating the perception that park users have about cultural and recreational ES as attraction factors to visit a park within the city. However, the result shows that visitors to both urban parks are more attracted by regulatory ES,

which is related to the presence of green infrastructure, even though their activities are carried out in gray infrastructure.

The data obtained can reinforce the idea of other authors who emphasize the importance of services provided by urban parks (Flores-Xolocotzi, 2012; Costanza *et al*., 1997) opening lines of research that resume the social importance of urban parks' impact (Egea and Salamanca, 2020). Some researchers (Merayo *et al*., 2016; Reyes-Paecke & Figueroa, 2010; Leandro-Rojas, 2014; Cuevas, 2015; Merayo *et al*., 2016; Stainbrook, 1973 cited by Martínez-Soto *et al*., 2016; Martínez- Soto *et al*. 2020) claim that, unlike the population living in rural areas, the urban community that has contact with nature, presents more social and health pathologies. In this sense, it would be relevant to investigate the relationship between urban parks and health, from the perspective of Ecosystem Services in the case studies. Finally, the urban parks analyzed from the perspective of Ecosystem Services are presented as spaces of opportunity to promote the cities' quality of life.

REFERENCES

Asociación Nacional de Parques y Recreación. (2018). *Viviendo los parques*. Recuperado de anpr.org.mx/wp-content/uploads/2018/08/VIVIENDO-LOS-PARQUES-Usos-y-Costumbres-de-los-Mexicanos-2018.pdf

Ballinas, M. (2014). Áreas verdes en el diseño de viviendas sustentables: una mirada desde la calidad de vida urbana. En González, R(Ed.), *Estudios ambientales y riesgos naturales* (pp. 53-90). Jaguar.

Balvanera, P. y Cotler, H. (2007). Acercamientos al estudio de los servicios ecosistémicos. *Gaceta Ecológica*, 84-85 (2),8-15. https://www.redalyc.org/articulo.oa?id=53908502

Barranquilla, Colombia. *Lecturas de Economía, 88* (1)183-205. https://dx.doi.org/10.17533/udea.le.n88a06

Benedict, M. y McMahon, E. (2002). Green infrastructure: smart conservation for the 21st century. *Renewable Resources Journal, 20*(3), 12-17.

Camacho, V. y Ruiz, A. (2012). Marco conceptual y clasificación de los servicios ecosistémicos. *Revista Bio ciencias, 1*(4), 3-15.

Castro, P., Escoriza, T., Oltra, J, Otero, M. y Sanahuja, E. (2003), ¿Qué es una ciudad? Aportaciones para su definición desde la prehistoria. *Scripta Nova. Revista electrónica de geografía y ciencias sociales, 7*(146) http://www.ub.edu/geocrit/sn/sn-146(010).htm

Cervantes A. y Martínez, M. (2021). *Relación de las áreas verdes urbanas con las mejores ciudades del mundo. Una revisión histórica. Teoría y educación ambiental. Reflexiones en tiempo de pandemia* (96-112). Universidad Autónoma de Chapingo.

Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Suttonkk. P. y van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Ecological Economics, 25* (1), 3-15. https://doi.org/10.1016/S0921-8009(98)00020-2

Cuevas, S. (2015). Análisis comparativo de los beneficios sociales, psicológicos y de seguridad de las zonas verdes en Malmö (Suecia) y Querétaro (México). *La pantalla insomne*. http://www.revistalatinacs.org/15SLCS/libro-colectivo-2015-2-edicion.html

De Groot, R., M. A. Wilson y R. M. J. Bowmans. 2002. A typology for the classification, description, and valuation of ecosystem functions, goods and services. *Ecological Economics* 41: 393-408.

Debnath, A. K.; Chin, H. C.; Haque, M. M. and Yuen, B. 2014. A methodological framework for benchmarking smart transport cities. *Cities*. 37(2):47-56

Díaz, L. (2010). *La observación*. http://www.psicologia.unam.mx/documentos/pdf/publicaciones/La_observacion_Lidia_Diaz_Sanjuan_Texto_Apoyo_Didactico_Metodo_Clinico_3_Sem.pdf

Directorate-General Enviroment. (2014). Pasando de la infraestructura gris a la verde. https://ec.europa.eu/environment/efe/themes/moving-grey-green-infrastructure_es

Duygu, R. (2015). Environment and Ecology at the Beginning of 21st Century, Publisher: St. Kliment Ohridski University Press, Editors. En Efe,R., Bızzarrı,C., Cürebal, I. y Nyusupova, G (eds.), *Recreation and Urban Park Management*. pp.302-312. St. Kliment Ohridski University Press

Egea, C. y Salamanca, E. (2020). Sociabilidades en las plazas de Buenos Aires. Usos, usuarios y diseño urbano. *Estudios Demográficos y Urbanos. 35* (2), 517-556. http://dx.doi.org/10.24201/edu.v35i2.1880

Flores- Xolocotzi, R. (2012). Análisis de los gustos recreativos en el Parque Ambiental Bicentenario de Metepec, Estado de México. *Pasos. 10* (3), 315-329. https://doi.org/10.25145/j.pasos.2012.10.038

Frutos, P., y Esteban, S. (2009). Estimación de los beneficios generados por los parques y jardines urbanos a través del método de valoración contingente. *Urban Public Economics Review*, (10), 13-51.

Galindo-Bianconi, A. y Victoria-Uribe,R. (2012). La vegetación como parte de la sustentabilidad urbana: beneficios, problemáticas y soluciones para el Valle de Toluca. *Quivera, 14* (1): 98-108. https://www.redalyc.org/articulo.oa?id=401/40123894006

Gómez, A. (2013). *El verde urbano de las ciudades de Salamanca, Valladolid y Zamora: Delimitación, ubicación y percepción* (tesis doctoral). Universidad de Salamanca, España.

Guauque, D. (2019). *Zonificación de importancia de servicios ecosistémicos aportados por áreas verdes de la ciudad de Bogotá*. (Tesis para especialización). Universidad Militar Nueva Granada, Colombia.

Guevara, A., Pérez-Duarte, M., Varela J., Porrúa M., Manson, R., Muñoz-Piña, C., Montiel, E., Zamora, C. (2003). *Introducción a los servicios ambientales*. SEMARNAT.

Instituto Ciudadano de Planeación Municipal (IMPLAM) (2015). Valoración de los parques urbanos la ruta hacia una Tuxtla sustentable. https://tuxtla.gob.mx/iciplam/descargas/VALORACION-DE-LOS-PARQUES-URBANOS-2015.pdf

Katz, P. (2017). *What makes a good urban park*. https://www.cnu.org/publicsquare/2017/03/01/what-makes-good-public-park

Laterra, P., Martín-López, B., Mastrangelo, M. y Garibaldi, L. (2017). Servicios Ecosistémicos en Latinoamérica. De la investigación a la acción. *Ecologia Austral, 27*(1), 094-098. 10.25260/EA.17.27.1.1.611

Leandro-Rojas, M. (2014). Potencial del espacio público como facilitador de bienestar y salud mental. *Revista Costarricense de Psicología, 33*(1),31-45. https://www.redalyc.org/pdf/4767/476747237002.pdf

López, L. (2019). *Bilbao prueba dos parques pioneros en Europa con juegos de memoria para los mayores*. https://ortotecsa.com/wp-content/uploads/2019/08/Bilbao.pdf

Loret de Mola, U. (2018). *Sobre el Uso de Índices de Precios Hedónicos para Comprender la Provisión de Servicios Ecosistémicos de las Áreas Verdes Urbanas en Cinco Megaciudades de América Latina.* (Tesis de licenciatura). Universidad Científica del Sur, Perú.

Loures, L.,Santos, R., y Panagopoulos, Thomas. (2007). Urban Parks and Sustainable City Planning-The Case of Portimão, Portugal. *WSEAS Transactions on Environment and Development, 10* (3), 171-180. https://www.researchgate.net/publication/228860531_Urban_Parks_and_Sustainable_City_Planning-The_Case_of_Portimao_Portugal

Martínez-Soto, J., López-Lena, María, y de la Roca Chiapas, J. (2016). Efectos psicoambientales de las áreas verdes en la salud mental. *Interamerican Journal of Psychology, 50*(2), 204-2014. https://www.redalyc.org/articulo.oa?id=28447010004

Martínez-Valdés, V., Silva Rivera, E, y González, E. (2020). Parques urbanos: un enfoque para su estudio como espacio público. *Intersticios sociales, 19* (1), 67-86. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-49642020000100067

Merayo, J., Serrano, N. y Marqués, P. (2016). Influencia de los espacios verdes urbanos en la salud mental. *Metas Enfermería, 19* (9), 20-26. https://www.enfermeria21.com/revistas/metas/articulo/80987/influencia-de-los-espacios-verdes-urbanos-en-la-salud-mental/

Meza, M. y Moncada, J. (2010). Las áreas verdes de la ciudad de México. Un reto actual. *Scrip Nova, 14* (1), https://revistes.ub.edu/index.php/ScriptaNova/article/view/1707

Millennium Ecosystem Assessment. (2003). *Ecosystems and Human Well-Being: A Framework for Assessment*. *Washington, DC: Island Press*, 2003. 49-70

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-being: Biodiversity Synthesis. Washington, DC: *World Resources Institute*, 82

Monroy, J. (2020, 26 de marzo). En México, 15.4 millones de personas de 60 años o más. *El economista*. https://www.eleconomista.com.mx/politica/En-Mexico-15.4-millones-de-personas-de-60-anos-o-mas-20200326-0008.html

Montañez, D. (2017). *Hacia un modelo de parque urbano sostenible.* https://m50.com.mx/2017/07/13/hacia-un-modelo-de-parque-urbano-sostenible-por-david-montanez-rufino/

Morales-Cerdas, V., Piedra, L., Romero, M. y Bermúdez, T. (2018). Indicadores ambientales de áreas verdes urbanas para la gestión en dos ciudades de Costa Rica. *Rev. Biol. Trop. 66* (4): 1421-1435.

Múñoz, M. (2014). *Accesibilidad a las áreas verdes urbanas como espacios públicos. El caso de Ciudad Juárez, Chihuahua* (tesis de maestría). El Colegio de la Frontera Norte, México.

Ochoa, C. (2015). *Muestreo no probabilístico: muestreo por cuotas*. https://www.netquest.com/blog/es/blog/es/muestreo-por-cuotas

Ojeda, L. (2020). Equidad en el acceso a las áreas verdes urbanas en México: revisión de literatura. *Sociedad y ambiente*. https://revistas.ecosur.mx/sociedadyambiente/index.php/sya/article/view/2341

Organización de las Naciones Unidas (2018). *Las ciudades seguirán creciendo, sobre todo en los países en desarrollo.* https://www.un.org/development/desa/es/news/population/2018-world-urbanization-prospects.html.

Pérez S., y Fargher, L. F. (2016). Uso de los parques recreativos en Mérida, Yucatán. *Estudios demográficos y urbanos, 31*(3), 775-810. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0186-

Pérez, A. (2014). *Estudio socioambiental de los parques y áreas verdes de la ciudad de Tuxtla Gutiérrez, Chiapas.* (Tesis de licenciatura). Universidad de Ciencias y Artes de Chiapas, México.

Reyes- Paecke, S. y Figueroa, I. (2010). Distribución, superficie y accesibilidad de las áreas verdes en Santiago de Chile. *EURE, 36*(109), 89-110. https://dx.doi.org/10.4067/S0250-71612010000300004

SEDESOL. (2013). *Unidad de Microregiones, cédulas de información municipal.* http://www.microrregiones.gob.mx/zap/datGenerales.aspx?entra=nacion&ent=07&mun=101

Sepúlveda, A. (2017). *Parques urbanos.* https://parquesalegres.org/biblioteca/blog/parques-urbanos/#:~:text=CARACTER%C3%8DSTICAS,verdes%20a%20trav%C3%A9s%20de%20andadores.

U.S. Environmental Protection Agency. (2004). *Ecological benefits assessment strategic plan*. Washington. DC: SAB Review Draft.

United Nations Human Settlements Programme (2011). *Cities and climate change: Global report on human settlements*. http://www.unhabitat.org/downloads/docs/GRHS2011_Full.pdf

Vásquez, A. (2016). Infraestructura verde, servicios ecosistémicos y sus aportes para enfrentar el cambio climático en ciudades: el caso del corredor ribereño del río Mapocho en Santiago de Chile. *Revista de geografía Norte Grande*, (63), 63-86. http://dx.doi.org/10.4067/S0718-34022016000100005

Vásquez, A. (2016). Infraestructura verde, servicios ecosistémicos y sus aportes para enfrentar el cambio climático en ciudades: el caso del

corredor ribereño del río Mapocho en Santiago de Chile. *Revista de Geografía Norte Grande,* vol. (63). 63-86

Velasco, E., Cortés, González, A., Moreno, F. y Benavides, H. (2013). Diagnóstico y caracterización del arbolado del bosque de San Juan de Aragón. *Revista mexicana de ciencias forestales, 4*(19), 102-111. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-11322013000500009

Vélez, L. (2009). Del parque urbano al parque sostenible. Bases conceptuales y analíticas para la evaluación de la sustentabilidad de parques urbanos. *Revista de Geografía Norte Grande*, (43), 31-49. http://dx.doi.org/10.4067/S0718-34022009000200002

Videla, J. (2016). *Parques urbanos y sustentabilidad.* http://www.arquitecturaenacero.org/proyectos/sustentable/parques-urbanos-y-sustentabilidad

Zuniga-Teran, A., Staddon, C., de Vito, L., Gerlak, A., Ward, S., Schoeman, Y., Hart, A. & Booth, G. (2020) Challenges of mainstreaming green infrastructure in built environment professions, *Journal of Environmental Planning and Management, 63*(4), 710-732. https://doi.org/10.1080/09640568.2019.1605890 .

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Calculation of areas and static balance of barrel vaults with lunettes

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— Abstract—

Masonry structures were conceived from robust elements whose essential function is to support compressive forces. The dimensions of these constructions arose from principles of statics and geometry. Therefore, in this work a purely geometric and balanced approach is proposed to determine the forces that a vault with lunettes must support. To avoid the use of sophisticated programs, new equations are developed to calculate the surface that is generated and, from it, calculate the respective volume and weight.

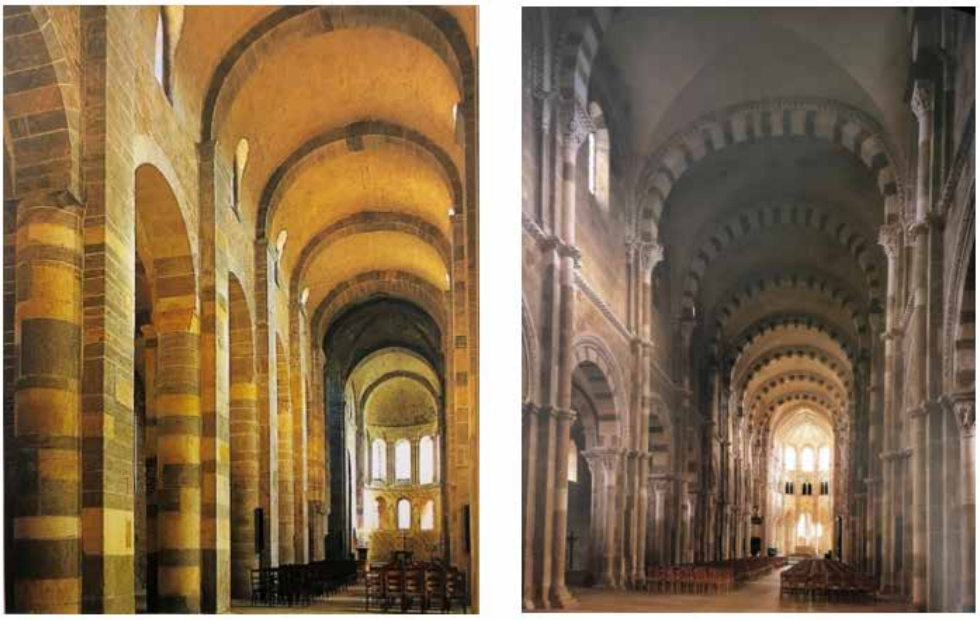
The proposed equations are checked for the case of a groin vault and compared with a particular applied mathematics solution. After that, they are used in a reconstruction project in a small temple where materials from the region are used. The capacity of the material and the structural element as a whole is checked through balance conditions.

Keywords:

Vault with lunettes; groin vault; static equilibrium.

BACKGROUND

In old constructions, the use of the arch represents one of the most used structural elements to cover small to large spaces. From the tenth-century straight barrel vaults were built without any opening, and later windows were added, as in figure 1a) and groin vaults as in figure 1b). Arch ribs represent the transverse support and allow the vault to be divided into short segments. The symbiosis of the barrel vault with ports and the groin vault can be accepted as the basis for the construction of the barrel vault with lunettes, where the ports extend perpendicularly as an intersection of two-barrel vaults.



a) Barrel vault with ports **b)** Groin vaults

Figure 1. Example of two types of vaults (Laule & Geese, 2003)

The structural design of these massive structures was based on principles of statics and geometry, and among the firm defenders of this approach is Santiago Huerta (2004). In addition, finite element models require the adoption of physical hypotheses of a little-known material (Meli, 1998), which motivates the development of this analysis.

INTRODUCTION

Barrel vaults with lunettes, usually with semicircular arches, are formed by the perpendicular intersection of two of them (Figure 2). To correspond to a vault with lunettes, the diameters between one and the other vault are

different, or at least, they must be at different heights. When the diameters are equal and start from the same level you can get a groin vault.

Figure 2 shows a model with two vaults of different diameters starting from the same level. Figure 3 shows the most common case, where the lunettes have a small length that extends to the cloth of the walls as in figure 4, which corresponds to the temple of San Pedro and San Pablo in Ecatzingo, State of Mexico. These are lunettes similar to those in Figure 3. Note that the extreme arch of the lunettes has a string of dimensions less than its diameter, a case that will be studied in this work. In that temple, the thin vault next to the dome collapsed. Much of the side wall, façade, and bell tower were also lost.

Figure 2. Model barrel vault with lunettes. Source: Own elaboration

Figure 3. Model barrel vault with cropped lunettes. Source: Own elaboration

Figure 4. Vault with lunettes. Source: Elaboration INAH (2018)

OBJECTIVE

This paper presents equations to calculate the volume of these two types of vaults: lunettes and groin. The equations are analytically checked for the second case because it is a direct comparison. After that, they are applied in a particular way to a current restoration project.

MATERIALS AND METHODS

Calculation of areas

To develop the equations, some geometric considerations are required, such as those given in Figures 5 and 6. The first one is a lunette with its beginning from the diameter but at a different height h, while in 5, in addition to the previous condition, the beginning of the lunette can be even higher h". The vertical area differential dA allows to obtain the area of the lunette, and the horizontal differential dA' allows to obtain the area that is eliminated from the barrel vault.

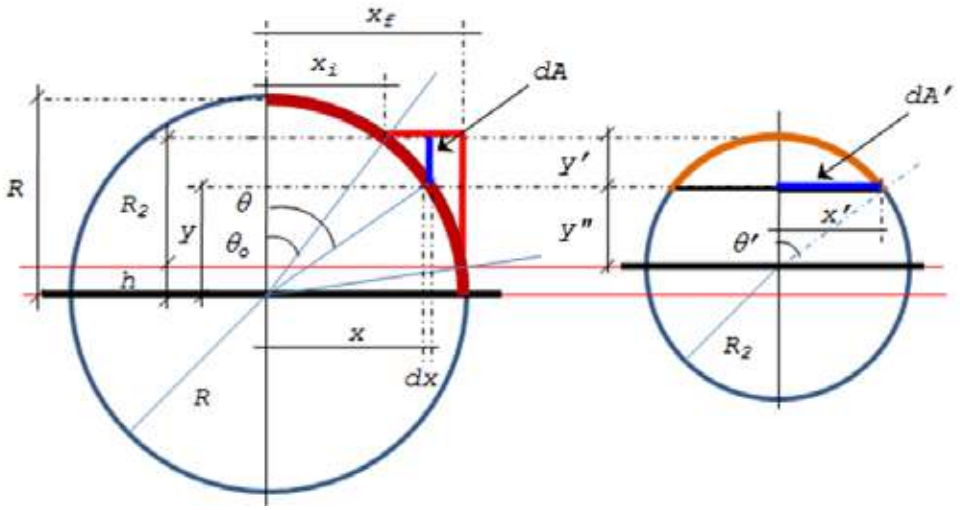


Figure 5. Diameters at different heights *h*. Source: Own elaboration

The base geometry usually includes the rope and arrow of the barrel vault and lunette. This string does not coincide, on many occasions, with the diameter as seen in Figure 4, so it is necessary to calculate the radius for both cases, this is R and R2 with the general equation (1).

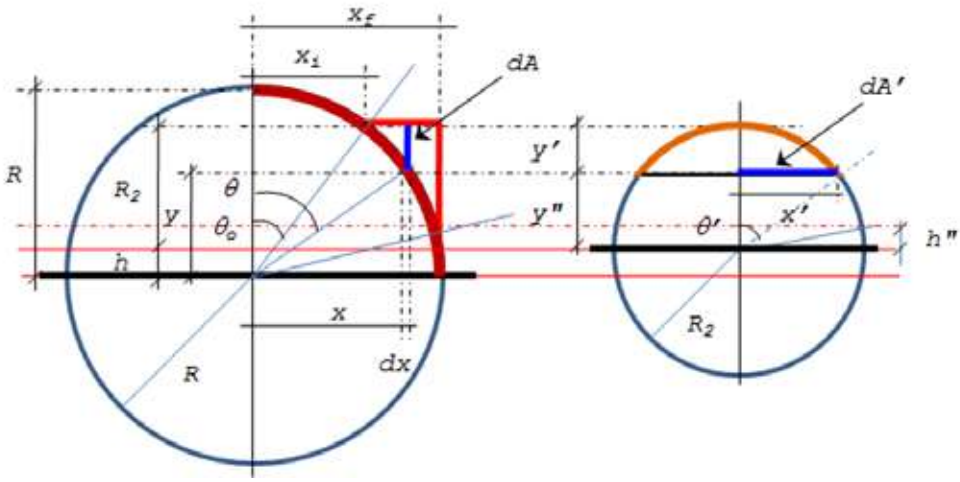


Figure 6. Lunette beginning on its diameter *h*". Source: Own elaboration

$$R = \frac{x^2 + z^2}{2z} \tag{1}$$

where *x* is half rope and *z* the arrow. According to Figure 4, *x*' and *y*' would be *x* and *z* in equation (1) respectively. In figures 5 and 6, the circles on the left correspond to the barrel vault and those on the right to the lunette. In

the case of the edge vault, in both directions, they are vaults or lunettes, whatever the name preference could be.

To calculate the surface of the lunette, the area differential $dA = l' \cdot dx$ will be integrated, while to obtain the area that is extracted from the vault the differential $dA' = x' \cdot dy$ will be integrated. Note that different differentials are used for each case. dA is made dependent on x, and dA' is made dependent on y.

To calculate the arc l' of the lunette that is formed at the distance x (left circle) you will get x' (right circle) and thus obtain the angle θ'. Since we know the radius, whether by data or calculated with the equation (1), the length depends on the angle θ'.

$$l' = R_2 \cdot \frac{\pi \cdot \theta'}{90} \tag{2}$$

From previous figures,

$$y = \sqrt{R^2 - x^2} \tag{3}$$

$$x' = \sqrt{R_2^2 - y''^2} \tag{4}$$

$$y'' = R_2 - y' \tag{5}$$

$$y' = (R_2 + h) - y \tag{6}$$

$$x' = \sqrt{R_2^2 - \left(\sqrt{R^2 - x^2} - h\right)^2} \tag{7}$$

So we can express l' in terms of x as,

$$l' = \frac{\pi \cdot R_2}{90} \cdot sen^{-1}\left[\frac{\sqrt{R_2^2 - \left(\sqrt{R^2 - x^2} - h\right)^2}}{R_2}\right] \tag{8}$$

Using equations (6) and (1), we can rewrite x' as,

$$x' = \sqrt{2R_2(y') - y'^2} = \sqrt{R_2^2 - h^2 + y(2h - y)} \tag{9}$$

Due to the above, we have:

$$A_L = \frac{\pi \cdot R_2}{90} \int_{x_i}^{x_f} sen^{-1}\left[\frac{\sqrt{R_2^2 - \left(\sqrt{R^2 - x^2} - h\right)^2}}{R_2}\right] dx \tag{10}$$

$$A_h = \frac{\pi \cdot R_2}{90} \int_{y_i}^{y_f} sen^{-1}\left[\frac{\sqrt{R_2^2 - h^2 + y(2h - y)}}{R_2}\right] dy \tag{11}$$

For the correct use of the integrals, it is necessary to define the limits x_i and x_f so that for the first x_i'= 0 and for the second x_f'= rope at height h" from where the lunette starts. If the axes of the diameters are at the same height and in addition, the lunette starts from those axes, h=h"=0 and x_i'=0, x_f'=R_2. For this,

$$x_i = \sqrt{R^2 - (R_2 + h)^2} \tag{12}$$

$$x_f = \sqrt{R^2 - (h + h")^2} \tag{13}$$

For limits y_i and y_f we have:

$$y_i = h" \tag{14}$$

$$y_f = R_2 \tag{15}$$

FIRST VALIDATION

To verify the results of equations (10) and (11), take a groin vault as shown in Figure 7. A_L is the area of the lunette to be calculated, A_h is the area to be eliminated by the intersection of the vaults and A_B is the complete area of the vault in a direction without lunettes. For this case R=R_2 =5.25m and h=h" =0m.

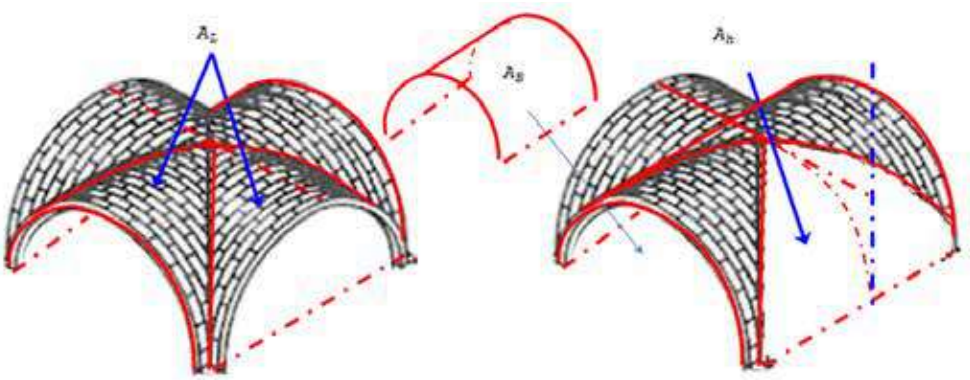


Figure 7. Groin vault. Source: Mixed elaboration with Google (2021)

From equations (12) and (13), x_i=0.0m, x_f=5.25m and from equations (14) and (15) y_i=0, y_f=5.25m. As proof, from equation (7), it should be verified that x_i'=0 y x_f'=R_2. Now from equations (10) and (11):

$$A_L = \frac{\pi \cdot R_2}{90} \int_0^{5.25} sen^{-1}\left[\frac{\sqrt{27.5625 - \left(\sqrt{27.5625 - x^2}\right)^2}}{5.25}\right] dx$$

$$A_h = \frac{\pi \cdot R_2}{90} \int_0^{5.25} sen^{-1}\left[\frac{\sqrt{27.5625 - y^2}}{5.25}\right] dy$$

That is, A_L=31.46514751456868m², A_h=55.125m².

Verification

To test the above results, the area of the vault A_B will be calculated until the end of the lunette (figure 7), that is, halfway through the vault, that is:

$$A_B = \pi \cdot R \cdot (l) = \pi \cdot R^2 = 86.59014751456868m^2$$

If we subtract the area A_h to A_B, the lunette area A_L must result, thus:

$$A_L = A_B - A_h \tag{16}$$

$$A_L = 86.59014751 - 55.125 = 31.46514751456868m^2$$

The remarkable thing about equations (10) and (11) is that they show no difference in the calculation of A_L with equation (16). Another check of the calculation of A_L can be found in Salinas and Costa (2017), where ½·A_L for λ=5.25 is obtained by:

$$A_L = 2 \cdot \lambda^2 \left(\frac{\pi}{2} - 1\right) = 31.46514751456868m^2 \tag{17}$$

Again a result is obtained with a negligible difference concerning equation (10), which in turn confirms the validity of equation (11). The number of decimals has been exaggerated to prove the accuracy of the proposed equations.

Second validation

A second exercise is done for a new radius R=3.6m. As a groin vault will continue to be considered, the diameters for both vaults will be the same, and the lunettes start from the same level. Therefore, R=R_2=3.6m, h=h"=0m, so from equations (12) to (15) x_i=y_i=0, x_f=y_f=3.6m. Returning to equations (10) and (11), we have,

$$A_L = \frac{\pi \cdot R_2}{90} \int_0^{3.6} sen^{-1}\left[\frac{\sqrt{12.96 - \left(\sqrt{12.96 - x^2}\right)^2}}{3.6}\right] dx$$

$$A_h = \frac{\pi \cdot R_2}{90} \int_0^{3.6} sen^{-1}\left[\frac{\sqrt{12.96 - y^2}}{3.6}\right] dy$$

So, A_L=14.7950407906m², A_h=25.92m².

Verification

The area of the vault is:

$$A_B = \pi \cdot R \cdot (l) = \pi \cdot R^2 = 40.71504079 m^2$$

Recalculating the lunette area with the difference of the vault area minus the hollow area (equation 16), we have,

$$A_L = A_B - A_h = 14.7950407906 m^2$$

It can be seen that the value of A_L matches with that calculated with equation (10). If equation (17) is applied again, now with λ=3.6m, we have:

$$A_L = 2 \cdot \lambda^2 \left(\frac{\pi}{2} - 1\right) = 14.7950407905 m^2$$

Then, equation (10) or equation (16) gives the same result as equation (17) taken as a reference. It is important to clarify that equation (17) is only applicable to complete lunettes that start from the diameter of their end arc. In this work, the equations offer solutions to groin vaults or vaults with lunettes, as shown in Figure 2.

RESULTS AND DISCUSSION

Case Study

Once the proposed equations have been reviewed, they will be applied to the vault of the San Juan temple in Malinalco, State of Mexico. Figure 8 shows the arches covered with canvas, which support the orthogonal vaults. The height of the arches of the main nave is slightly higher than that of the side arches. This is shown in Figure 9. The figure on the left depicts the barrel vault, which goes in the longitudinal direction, and to the right, it shows the lunette, that is, the side view of the temple.

Figure 8. Temple of San Juan, Malinalco, State of Mexico. Source: Own elaboration

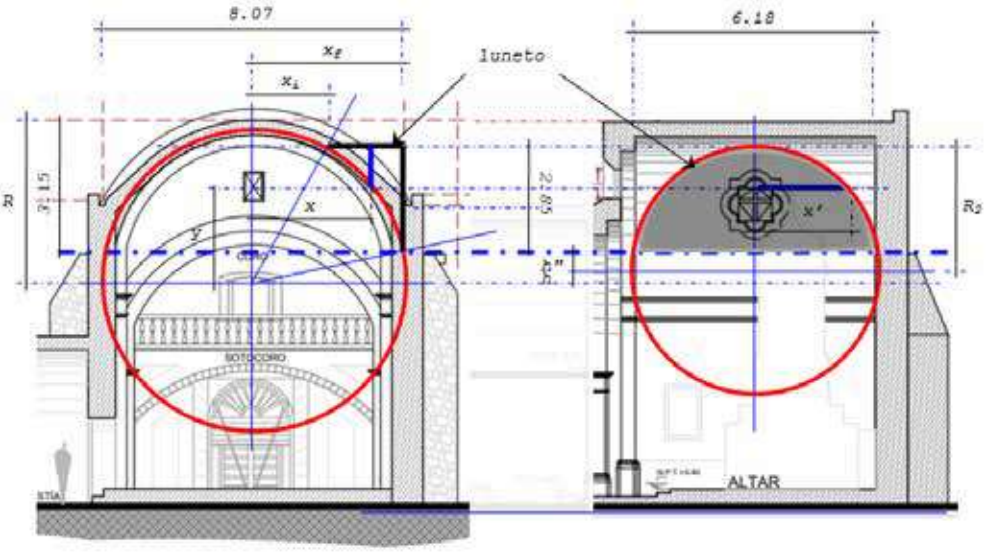


Figure 9. Barrel and lunette vault. Source: Mixed elaboration with INAH (2020)

For the project data, we found R=4.159m and R_2=3.1m. In addition h=0.759m and h"=0.25m. All the above values were adjusted as best as possible to the available topographical surveys and tried to avoid inconsistencies. Note that the lunette does not start from its diameter. This requires the lunette to be integrated from a height greater than its diameter and consequently, x_f also does not cover the entire radius R. Therefore, now it is not possible, as verification, to obtain the lunette area by subtracting the hollow areas from the vault area since that is only valid for groin vaults. Only three decimal

places will be used from here on since for a real case it is inappropriate to keep more than three decimal places.

The limits for integrals are:

$$x_i = \sqrt{4.159^2 - (3.859)^2} = 1.551m$$

$$x_f = \sqrt{4.159^2 - (1.009)^2} = 4.0136m$$

and the limits y_i and y_f are:

$$y_i = 1.009m$$

$$y_f = 3.859m$$

Lunette area A_L and intersection area A_h,

$$A_L = \frac{\pi \cdot R_2}{90} \int_{1.551}^{4.0136} sen^{-1}\left[\frac{\sqrt{9.61 - \left(\sqrt{17.297 - x^2}\right)^2}}{3.1}\right] dx$$

$$A_h = \frac{\pi \cdot R_2}{90} \int_{1.009}^{3.859} sen^{-1}\left[\frac{\sqrt{9.033919 + y(1.518 - y)}}{3.1}\right] dy$$

Where A_L = 11.237m² and A_h =16.848m². The area of the barrel vault with the gaps caused by the intersection of the lunettes is:

$$A_B - A_h = l_B(l) - A_h \tag{18}$$

Where l_B is the arch of the vault obtained with equation (19) and the angle with equation (20) from h" (figure 9).

$$l_B = \frac{\pi \cdot R}{90}\theta \tag{19}$$

and

$$\theta = tg^{-1}\left(\frac{x_f}{(h + h")}\right) = tg^{-1}\left(\frac{4.0136}{1.009}\right) \tag{20}$$

The length of the vault l is 6.18m (figure 9), so that A_B=68.086m², so that from equation (18), A_B-A_h=34.39m². The total area of the vault with lunettes is 56.864m².

Static Balance

If a barrel vault segment or dome cap where its weight is known is taken, the vertical reaction at its edges should be equal to the weight of that section (Figure 10).

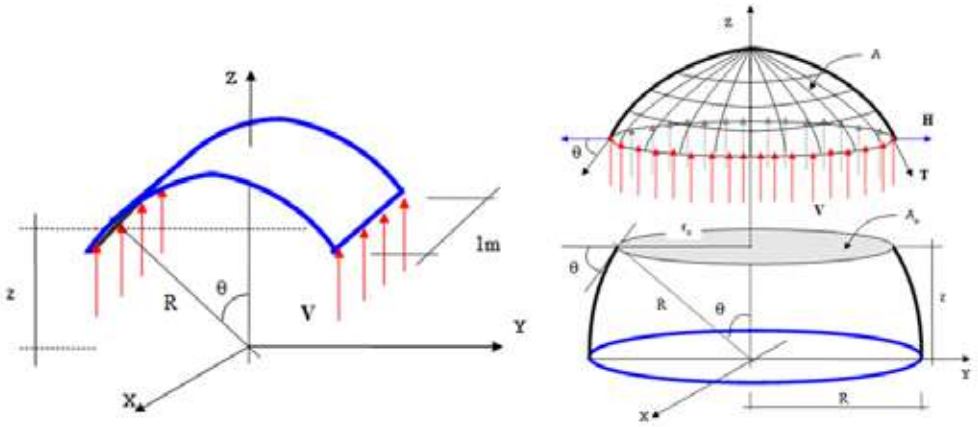


Figure 10. Vault and dome segments in balance. Source: Miramontes, 2016

To determine the weight of any of the sections shown in Figure 10, it is necessary to know their geometry, which indicates that in any cut the tangent can be determined at any point at the height *z*. The arch length for the vault is a trivial topic, so it may be of greater interest to include the equations for obtaining the cylindrical cap area in Figure 10.

$$A = 2\pi R^2\left(1-\cos\left(\frac{\pi\theta^o}{180^o}\right)\right) \tag{21}$$

$$\theta = \cos^{-1}\left(\frac{z}{R}\right) \tag{22}$$

Knowing area *A*, the volume is obtained by multiplying it by thickness *t*, and in turn, the weight *W* is obtained by multiplying it by the volumetric weight of the material γ_m (equation 23),

$$W = A \cdot t \cdot \gamma_m \tag{23}$$

The vertical reaction *V* is obtained by dividing the weight by the support length, which is obtained directly from the cut section. With this, the tangential force *T* and the horizontal force *H* can be obtained for any of the above cases:

$$T = \frac{V}{\operatorname{sen}\theta} \tag{24}$$

$$H = T\cos\theta \tag{25}$$

This principle applies to the section to be analyzed in the San Juan temple. Once the area of the vault was determined, including the lunettes, a thickness of 0.2m was proposed with local tezontle (Miramontes, 2021). For this material, a specific weight of 1.735T/m^3 was obtained, so its total weight is 19.732Ton. Three samples used to calculate the weight of the material are included in Figure 11, and the results for dry weight and wet weight are shown in Table 1. In addition to its own weight, the vault receives an additional load due to the coating and finishing materials. Table 2 describes the weights per square meter to be considered in the vault analysis.

To evaluate the support offered by the lunette to the rest of the vault, the weight of the isolated lunette must be obtained, and its centroid calculated using the Varignon theorem. For this, it is necessary to calculate the static moment given by:

$$\dot{X} \cdot A_L = \frac{\pi \cdot R_2}{90} \int_{x_i}^{x_f} x \cdot sen^{-1}\left[\frac{\sqrt{R_2^2 - \left(\sqrt{R^2 - x^2} - h\right)^2}}{R_2}\right] dx \tag{24}$$

The result of equation (26) is divided by the area of the lunette, and distance $\dot{X}$ is obtained. To obtain $\dot{x}$, we simply take the difference with the barrel vault's radius. It is important to add that the lunette is not the only one that offers support to the vault since an arc function is also generated in the area A_h (see figure 7).

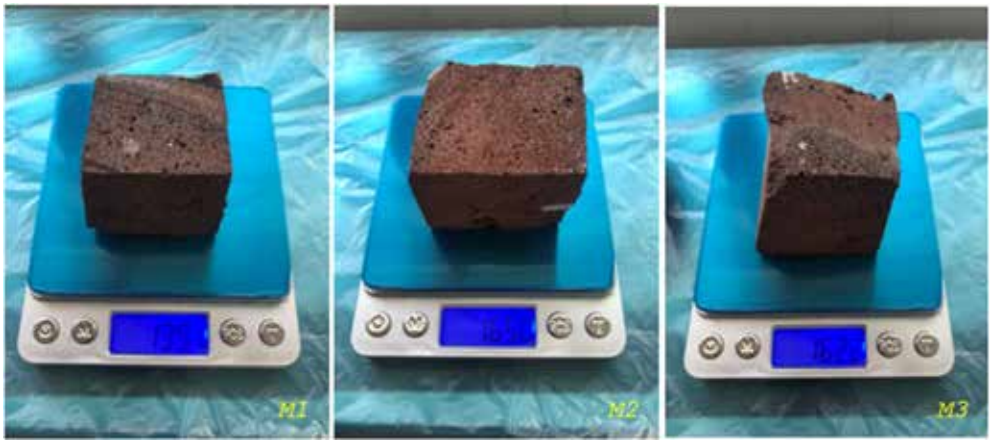


Figure 11. Dry weight of samples. Source: Own elaboration

Table 1
Vault's materials volumetric weights

SAMPLE	Volume cm³	W_s gr	W_h gr	γ_s Ton/m³	γ_h Ton/m³	% empy
M1	84	139.1	145.7	1.655	1.735	7.857
M2	113	165.0	174.1	1.460	1.541	8.054
M3	114	162.2	171.3	1.423	1.506	7.982

Source: Own elaboration

Table 2
Weight per m² of other materials

SURFACE	MATERIAL	WEIGHT kg/m²
	Mortar	55.5
EXTRADOS	Tiles	54.0
	Waterproofing	2.0
INTRADOS	Mortar (or stucco)	37
TOTAL		**148.5**

Source: Own elaboration

Of (21) results $\dot{X}A_L$=35.113m³, which $\dot{X}$=3.125m. This indicates that the results or weight of the lunette plus the weight of the materials is at $\dot{X}$=0.89m from its end. If the total weight is,

$$W_L = A \cdot t \cdot \gamma_t + A \cdot W_m = 11.237(0.2)(1.735) + 11.237(0.149) = 3.899 + 1.669 = 5.568 Ton$$

a horizontal force H_L = 1.599Ton is generated at the highest point caused by the rotation of the lunette. Figure 11 shows a model where the distances of the resulting W_L to the center of the vault and the end of the lunette are linked.

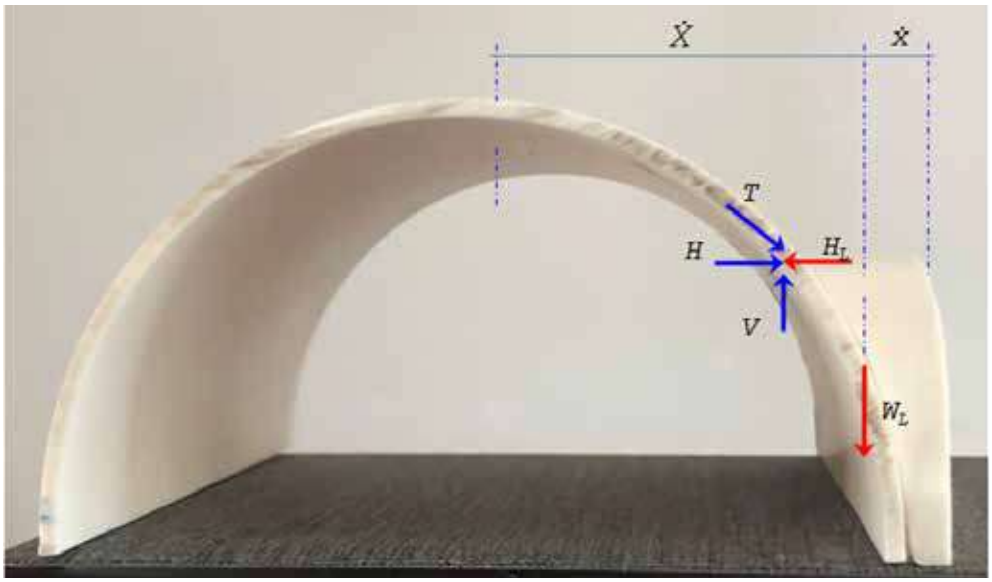


Figure 12. Model vault with lunette. Source: Own elaboration

From Figure 8, *V, T*, and *H* values are obtained for the arc that is formed at the highest point of the lunette, so that with equations (22) to (25), we have: θ=21.895°, *W*=1.575Ton, *T*=2.112Ton and *H*=1.960Ton. For the lowest point of the lunette, we have θ=75.96°, *W*=5.465Ton, *T*=2.816Ton and *H*=0.683Ton, and *H*=0.683Ton. The average of *H*=1.322Ton is lower than the H_L total of the lunette.

Note that the compression (tangential force *T*) increases as it descends in the arch of the vault while the horizontal force *H* decreases. For complete half-point arcs *H*=0. If you take a unit width of the vault and the maximum value of *T*, you can see that the compressive stress is very low, that is,

$$\sigma = \frac{T}{b \cdot t} = 1.408 kg/cm^2$$

σ is lower than the common compression capacity in stone masonry, which is very close to 20kg/cm² (2.0MPa) according to the Complementary Technical Standards for the Design and Construction of Masonry Structures or according to some experimental results (NTC, 2020; Mauritius, 2021).

CONCLUSIONS

We proposed new equations to calculate the area of vaults with lunettes and, with this value, calculate the weight and forces that are generated along its geometry. The equations were validated for the case of groin vaults by comparing them directly and indirectly, using an equation for complete

lunettes, obtaining a negligible difference, and then applying it in a real case. Therefore, the main objective of this work is considered achieved.

Once the area of the vault is known, the weight of the vault is calculated, and employing basic principles of balance, the forces for a current reconstruction project in a temple in the State of Mexico are determined.

From the results obtained, it is concluded that the efforts by its own weight are lower than the nominal capacity of the material for a static case, which is per the concept and design for this type of structure.

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REFERENCES

Chávez, M. (2021). *Caracterización de las mamposterías de los templos conventuales del Estado de Morelos*. Unidad de difusión de medios digitales. Instituto de Ingeniería UNAM. Proyecto PAPIIT IA100818.

Goggle. (2021). https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcSzKEf7-aJwEJ9v-prcCyC2Tvx04UlxjAJ3pw&usqp=CAU

Huerta, S. (2004). *Arcos, bóvedas y cúpulas. Geometría y equilibrio en el cálculo tradicional de estructuras de fábrica*. Instituto Juan de Herrera. Escuela Técnica Superior de Arquitectura, Madrid. ISBN 84-9728 129-2. 637p.

INAH. (2018). T*emplo San Pedro y San Pablo, Ecatzingo, Estado de México*. - Vista aérea. Instituto Nacional de Antropología e Historia, Estado de México. Video.

INAH. (2020). *Restauración de daños ocasionados por el sismo del 19 de septiembre de 2017, en el inmueble conocido como: "Capilla de San Juan" Malinalco, Estado de México*. Instituto Nacional de Antropología e Historia. Relación de planos.

Laule U., Geese U. (2003). *Románico. Rolf Toman Ed. Feierabend Verlg OHG Mommstraβe 43 D-10629*. Berlin. ISBN 3-936761-44-2. 256p.

Meli, R. (1998). *Ingeniería Estructural de los Edificios Históricos*. Fundación ICA A.C. ISBN 968-7508 46-9. 220p.

Miramontes de León, D. (2016). *Análisis estático simplificado de paraboloides hiperbólicos y elípticos*. XX Congreso Nacional de Ingeniería Estructural. Mérida, Yucatán, México.

Miramontes de León, D. (2021). *Capilla de San Juan. Análisis de propuesta para la bóveda sobre presbiterio. Malinalco, Estado de México.* CONACER Constructores, S.A.de C.V. 20p.

NTC (2020). Normas técnicas complementarias para diseño y construcción de estructuras de mampostería. *Gaceta Oficial de la Ciudad de México*. Vigésima Primera Época, No 454. 134p.

Salinas, A., Costa, D. (2017). *Aplicación de las derivadas e integrales en las fachadas de la Arquitectura moderna*. Universidad Técnica Particular de Loja. La Universidad Católica de Loja. https://www.slideshare.net/DanielCeliCosta/presentacin-daniel-celi-costa

A C A D E M I C
P A P E R

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Viral diseases in Mexico

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Diseases of viral etiology have been present throughout man's history, however, these have been recapitulated by the current pandemic in which we live, which, by the way, we have no vision for the eradication of this or other epidemics that we have, not only locally, but globally.

Dengue had its first record in the year 1635 in America, however, its hemorrhagic presentation was until 1962, and since that date, it has not ceased to be a public health problem.

In our country, it appeared around 1941, when 6955 cases were recorded, marking a rate of 34.4 per 100,000 inhabitants, and has remained since with moderate incidence rates. The anti-vector campaign began in 1957 and fulfilled its mission in 1963 when it was declared eradicated by the Pan American Health Organization, reappearing in the late seventies on the southern border of our country. In the 1990s, serotype 3 was present, having a strong impact, again on the southern border, Gulf of Mexico, and in the north of the country, coinciding with the first epidemic of Hemorrhagic Dengue, being mostly linked with social and economic conditions. Today we find the four serotypes in the population, there is evidence of the circulation of two or more at the same time, a phenomenon related to the increase in cases and consequently the permanence of the epidemic. The latest reports of the Ministry of Health this year indicated on average a national incidence rate of 3.22, but in states such as Morelos reaches 23.11, which, although it is still low, is of consideration and is indicated as a current health problem (Fajardo, *et al*., 2012).

The CHIKV virus was described in 1952, the infection vehicle being a vector's bite, and it is documented that it can be carried out transplacentally.

In May 2014, the first case of chikungunya in the Mexican Republic was confirmed, the highest peak after its appearance was the following year, and 12 588 cases were recorded in 2015. Currently, there are fewer cases recorded, only last year there were seven cases, and so far this year only four confirmations, as reported by the Epidemiological Surveillance System. However, specialists do not rule out a possible resurgence of the virus, so they consider it important to strengthen the control measures and thus avoid its spread (Torres-Longoria, *et al*, 2021).

The first case of Zika recorded in Mexico was in November 2015, by February 2016 the WHO (World Health Organization) had already declared the epidemic as a Public Health emergency. As of November 1 of this year,

there were a total of 12 989 confirmed cases by the Ministry of Health, Veracruz being the state with the most infected and so far in the year, 32 of the 33 confirmed cases are from the state of Morelos (Minassian, 2021).

Zika is transmitted by an arthropod that transmits the ZIKV virus, producing conjunctival and dermal affections, in some cases, neurological affections, specifically Guillain Barré syndrome, but also other serious complications, in the products of pregnant women cause microcephalies and other malformations of the central nervous system. There is also a record of several cases in which the virus is transmitted sexually, although the mechanisms are unknown today (Minassian, 2021).

It should be noted that, in the case of dengue, Zika, and Chikungunya, it is the same type of vector: the female mosquito of the genus Aedes, of aegypti and albopictus subspecies, belonging to the Culicidae family, which are reared in places where water can accumulate and in this case a greater concentration of bottles, cans, jars and even tires, place them as crucial elements for the proliferation of the mosquito and therefore of the viruses.

The Human Papillomavirus (HPV) has accompanied humanity for a long time, definitely talking about HPV is talking about cervical cancer, this relationship was established by Harald Zur Hausen, which earned him the Nobel Prize in 2009, and today more than 100 types are known, and at least 14 oncogenic types are recognized, although 16 and 18 are the causes of more than 70% of cervical cancers and precancerous lesions, as well as types 6 and 11 are the causes of 90% of genital warts. This virus is transmitted primarily sexually, it is said that 90% of people become infected shortly after starting their sexual life without most having an impact on the health of the host (Lizano-Soberón, 2009).

There is indeed no infallible treatment against HPV, however, we work on vaccines that help combat the transmission of the virus, it should be noted that in Mexico since 2012 this vaccine is included in the national immunization scheme. And it is known that between 1980 and 2016 the number of women over 15 years of age who died from neoplasia caused by the virus decreased, this decrease of 54% was achieved thanks to the result of a series of public policies focused on the detection and prevention of this type of cancer (Lizano-Soberón, 2009).

Some data attribute cervical cancer to HIV (human immunodeficiency virus) in 5% of cases. Speaking of the virus was first identified in 1983 by virologist Françoise Barré-Sinoussi and her colleague Luc Montagnier, who in 2008 won the Nobel Prize in Medicine for identifying the origin of the virus in apes. In Mexico, the first case of AIDS (Acquired Immunodeficiency Syndrome), a disease caused by the virus, was reported in 1983, and from that year until the second quarter of this year there were 322 987 cases diagnosed with HIV, 6 568 in this year alone according to CENSIDA (National Center for the Prevention and Control of HIV and AIDS), (Valdespino, 1995).

Unfortunately, the virus is always accompanied by stigma, discrimination, and phobia, despite the work around people and the pharmacological advancement, which allows carriers with access to antiretrovirals to become a chronic disease that can be lived with until old age. Despite the advances, there is still no vaccine, although there is already evidence in Phase III, which bodes well for a cure in a short time.

A little more than ten years ago, specifically in April 2009, Mexico declared itself a pandemic due to the outbreak of the AH1N1 influenza virus, months later the WHO officially declared the pandemic on June 11 of the same year. It is estimated that the flu left 20 million infected in the world and more than 9,000 people, specifically in our country 72 468 infected and 1,203 deaths, according to data from the WHO (Fernandez, 2009).

In Mexico there is an intense annual vaccination campaign, just for the 2021-2022 campaign, the government will apply 32 328 200 doses between November and February respectively, which will be available to the entire population but which have a focus on vulnerable groups, citizens from 6 months to 5 years and adults over 60 years, according to the Ministry of Health, this to combat the virus that afflicts the population, especially in winter.

We are currently experiencing a pandemic that has affected us not only at the health level but also in economic, education, environmental, scientific, etc. Let us recap, the coronavirus SARS-CoV-2, the cause of the COVID-19 disease, appeared in November 2019 in the city of Wuhan, China, and affects the whole world, the latest data obtained have reported us more than 250 million affected with almost 5 million deaths, in our country about 3 million 800 thousand infected and more than 290 thousand deaths caused by the coronavirus according to the WHO (Shamah-Levy, 2021).

The learning that the epidemics before this pandemic have left us is in question since it is enough to see the behavior of society itself in the face of the coronavirus since currently, a new variant threatens us, the delta plus, the result of ignoring the guidelines of our authorities in health matters. And it is also true that globalization forces us not to stop the activities already established, and that together with the greater number of kilometers of roads, therefore, a greater number of cars, greater number of flights, truck runs, etc., favor the rapid mobilization of population groups from one area to another, as well as the greater exchange of goods by air, land, and sea, among other agents, facilitate the rapid spread of these infectious agents.

However, globalization was not only a counterproductive variable, but also quite the opposite, instant communication, which is also an important part, allows the immediate exchange of all kinds of information, which was, is, and will be crucial for the very advancement of technology, new techniques for research, and thus work on new strategies for the development of vaccines and drugs, that play a primary role in the fight against a pathogen, in the latter case, COVID-19.

REFERENCES

Fajardo-Dolci, G., Meljem-Moctezuma, J., Vicente-González, E., Venegas-Páez, F., Mazón-González, B., Aguirre-Gas, H. (2012). El dengue en México. Conocer para mejorar la calidad de la atención. *Revista médica del instituto mexicano del seguro social*; 50(6):631-639. https://www.redalyc.org/pdf/4577/457745498009.pdf

Fernández, A. (2009). Algunas experiencias de la influenza ah1n1 en México. *Humanitas*. 0(47):140-182. https://humanitas.uanl.mx/index.php/ah/article/view/278

Lizano- Soberón M, Carrillo-García A, Contreras-Paredes A. (2009). Infección por virus del papiloma humano: Epidemiología, historia natural y carcinogénesis. *Cancerología, Revista del instituto nacional de cancerología*; 4:205-216. http://incan-mexico.org/revistainvestiga/elementos/documentosPortada/1272302572.pdf

Minassian, M. (2016). Zika virus: chronicle of an "unexpected" pandemic. *Rev Argent Microbiol*; 48(2):97-99. doi:10.1016/J.RAM.2016.06.001

Shamah-Levy, T., Rivera-Dommarco, J. (2021) Encuesta Nacional de Salud y Nutrición 2020 Sobre Covid-19. Resultados Nacionales. *Secretaría de Salud*; https://ensanut.insp.mx/encuestas/ensanutcontinua2020/doctos/informes/ensanutCovid19ResultadosNacionales.pdf

Torres-Longoria, B., Fragoso-Fonseca, D., Núñez-León, A., *et al*. (2021). Epidemiological surveillance of chikungunya fever in Mexico since its introduction in 2014-2016 and identification of circulating genotypes. *Mol Biol Rep*; 48(2):1967-1975. doi:10.1007/S11033-021-06151-0

Valdespino, J., Garcia, M., del Rio, C., Cruz, C., Loo-Mendez, E., Lopez, A. (1995). Las enfermedades de transmisión sexual y la epidemia de VIH/SIDA. *Salud Publica Mex*; 37(6):549-55. Disponible en: https://saludpublica.mx/index.php/spm/article/view/5883