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Journal of Quantitative and Statistical Analysis

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The works must be unpublished and refer to topics of statistical analysis data analysis, multivariate analysis, statistic's and probability, statistical analytical, calculation and other topics related to Physical Sciences Mathematics and Earth sciences.

Presentation of the content

In the first article we present, *Comparative Analysis of disposable diaper degradation using two biodegradable agents* by MARTÍNEZ-VICHEL, Guadalupe, ALVARADO-SANTIAGO, Francis De Jesús, LÓPEZ-VALDIVIESO, Leticia and VALLES-RIVERA, Diana, with adscription in the Instituto Tecnológico de Villahermosa, in the next article we present *Analysis of the income elasticity of demand for recreational and environmental of three ecosystems in Mexico* by BLAS-CORTES, Jonatan, OMAÑA-SILVESTRE, José Miguel, QUINTERO-RAMIREZ, Juan Manuel and MONTIEL-BATALLA, Blanca Margarita, with adscription in the Colegio de Posgraduados, Campus Montecillo, Consejo Nacional de Ciencia y Tecnología and Universidad Autónoma de Baja California, in the next article we present *Evaluation of the usability and accessibility of applications for mobile devices of pictograms in students with autism spectrum disorder of CAM Tehuacan* by VAZQUEZ-ZAYAS, Eduardo, OLGUIN-GIL, Liliana Elena, VAZQUEZ-GUZMAN, Francisco and BOLAÑOS-MARQUEZ, Yaoli Guadalupe, with adscription in the Instituto Tecnológico de Tehuacán, in the next article we present *Application of simulation as an improvement proposal for the street sweeping process of a municipality in the High Mountains region* by GARCÍA-JUÁREZ, Stephanie, CABRERA-ZEPEDA, Gabriela, AGUIRRE-Y HERNÁNDEZ, Fernando and ROLDÁN-REYES, Eduardo, with adscription in the Instituto Tecnológico de Orizaba.

Content

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Comparative Analysis of disposable diaper degradation using two biodegradable agents

Análisis Comparativo de la degradación de pañales desechables empleando dos agentes bio-degradantes

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Abstract

This project allows knowing the degree of degradation of disposable diapers using two different biodegradable agents: Isoptera Termites and Activated Sludge. For this degradation process, used diapers were used that contained liquid waste and in their original complete form, for the degradation control the following physicochemical parameters were evaluated: pH, TDS, CE, Temperature, % of degradation, mass and volume reduction. Being part of a very useful product on the market, diapers become part of the large amount of urban solid waste that is generated by excessive use over the years, becoming one of the most notoriously present wastes along with plastic waste. The search for an alternative to accelerate degradation made it possible to compare the best result to contribute to the improvement of the environment

Degradation, Biodegradable, Sludge

Resumen

El presente proyecto permite conocer el grado de degradación de los pañales desechables empleando dos agentes biodegradantes distintos: Isópteras Termitas y Lodos Activados. Para este proceso de degradación se emplearon pañales usados que contenían residuos líquidos y en su forma completa original, para el control de la degradación se evaluaron los siguientes parámetros fisicoquímicos: pH, TDS, C.E, Temperatura, % de degradación, reducción de masa y volumen. Al formar parte de un producto de gran utilidad en el mercado, los pañales pasan a formar parte de la gran cantidad de desechos sólidos urbanos que se generan por el uso desmesurado a lo largo de los años, convirtiéndose en uno de los desechos más notoriamente presentes junto con los desechos plásticos. La búsqueda de una alternativa para acelerar la degradación permitió comparar el mejor resultado para contribuir a la mejora del medio ambiente.

Degradación, Biodegradantes, Lodos

Citation: MARTÍNEZ-VICHEL, Guadalupe, ALVARADO-SANTIAGO, Francis De Jesús, LÓPEZ-VALDIVIESO, Leticia and VALLES-RIVERA, Diana. Comparative Analysis of disposable diaper degradation using two biodegradable agents. Journal of Quantitative and Statistical Analysis. 2022. 9-25: 1-6

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Introduction

Solid urban waste is generated in large quantities as a result of the excessive use of containers, packaging, seals, storage, etc., mainly of different types such as plastics, paper, cardboard and glass. There is a waste that is widely used by human beings that represents around 12% of the total waste generated in large cities: disposable nappies.

Disposable nappies made of polyethylene have two types of disadvantages: (1) deterioration when, after use, they become litter and (2) visual and physical environmental pollution after use. In the latter case, due to their resistance characteristics, they are difficult to degrade.

In the latter case, due to their resistance characteristics, they are hardly degraded by soil micro-organisms, remaining visible in the environment for 500 years (Mangiarotti *et al*., 1994). In addition, when incinerated at low temperatures, they generate toxic volatile substances such as dioxins and furans, which are associated with cancer in humans, damage to the reproductive system and developmental disorders in most living beings (Klemchuk, 1990).

In recent years, microbial degradation of polymers and plastics has been considered as an alternative to solve the problem of the final disposal of these wastes, which, unlike incineration, present operating conditions that would not be drastic or costly. Some scientists have pointed out that the biodegradation of polyethylene by microorganisms could be a solution to reduce plastic pollution (Méndez *et al.*, 2007; Limón, 2001 and Silva, 2009).

In Mexico, there is no known process to treat this waste, so it is taken, in its entirety, to open dumps in rivers, ravines, in the open air, sewers and even thrown into the sea, or in the best of cases to sanitary landfills as final disposal (GODF, 2010). The study of the degradation of disposable nappies can mitigate the presence of this phenomenon by knowing the main factors that cause it and, consequently, a method can be determined that can inhibit it to a certain degree depending on depending on the conditions of use. On the other hand, when talking about polymeric materials as waste, it is best to consider the ageing of polymers to avoid further contamination.

Composition of disposable nappies

A disposable nappy generally consists of (I) a liquid-permeable membrane lining the inner surface made of non-woven polypropylene (PP) or polyethylene, (II) a waterproof membrane on the outer surface made of PP, HDPE, starch, cloth or woven rubber, (III) an absorbent core (spongy pulp material) consisting of a fibrous material (cellulose, hemp or synthetic materials) wrapped in waterproof paper, (IV) a polymeric material made of polypropylene (PP) or polyethylene (PP) or polyethylene (PE), (V) a waterproof membrane on the outer surface made of PP, HDPE, starch, cloth or woven rubber, (VI) an absorbent core (spongy pulp material) made of a fibrous material (cellulose, hemp or synthetic materials) wrapped in waterproof paper; (IV) a super absorbent polymeric material, usually sodium polyacrylate (SAP), which has a high water binding capacity, making it possible to retain urine within the absorbent part (the efficiency of a nappy is highly dependent on its ability to absorb and retain urine), and finally (v) minor amounts of tapes, elastic and adhesive material.

The typical composition of a disposable baby nappy has been described by EDANA (2011): cellulose pulp 36.6%, SAP 30.7%, PP 16%, HDPE 6.2%, tape, elastic and adhesive 10.5%. A used baby nappy will also contain residues formed by faeces and urine, consisting of approximately 30 g carbon, 10-12 g nitrogen, 2 g phosphorus and 3 g potassium that can be degraded. The mass of these wastes has been reported in several studies: Torrijos *et al*. (2014), determined a content of 192 g of excreta, composed on average of 18% faeces and 82% urine; Colón and colleagues (2011), reported an average waste per nappy of 171 g, with a different distribution (6% faeces and 94% urine).

Metodology

The methodological development of this project considered the following experimental stages:

a. Collection of used nappy waste from municipal waste dumps.

b. Construction of reactors for activated sludge and reactors for termite isoptera.

c. Procurement of sludge to be activated as a degradation agent.

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d. Procurement of termite isoptera as a degradation agent.

e. Preparation of samples of used disposable nappies for each reactor.

f. Physico-chemical analysis of the waste after degradation.

g. Determination of the percentage of degradation of the nappies with the two degradation agents.

Reactors for the degradation of the nappies.

The reactors were designed based on the model proposed by Kalamdhad and Kumar (2013); Fernandez, *et al*., (2010); and Kalamdhad and Kazmi (2009). They were constructed with a plastic container of 20 L and 2.5 L capacity respectively. A ¼ in. hose was placed in each reactor for aeration.

Activated Sludge Reactor

The recommendations indicated in the standard were followed: NOM-004-SEMARNAT-2002, (ENVIRONMENTAL PROTECTION. - SLUDGE AND BIOSOLIDS. - SPECIFICATIONS AND MAXIMUM PERMISSIBLE LIMITS OF CONTAMINANTS FOR FINAL USE AND DISPOSAL); to collect a portion of sludge taking care to maintain the physical, chemical and biological integrity of the sample to be placed inside the reactor.

The main constituents of sludge are: suspended solids, biodegradable organic matter, nutrients, pathogens, metals, and organic toxics. An aeration source must be available to transfer oxygen for degradation to take place.

Heukelekian and Ingols (1947) reported that the initial organic matter removal was always accompanied by oxygen uptake always accompanied by oxygen uptake, as the rate of oxygen consumption was maximal during the first 30-60 minutes of contact during the first 30-60 minutes of contact, and gradually decreased to a constant level. This experimental evidence was sufficient to support the idea that adsorption was not the predominant mechanism of the process. If adsorption were to occur, it would have to be accompanied by a biochemical reaction.

Termite isoptera reactor

For the construction of this reactor it was necessary to take a sample from a termite mound following all precautions and using personal protective equipment. The termite mound was taken from a tree next to a village in a rural area (Poblado C-23 Venustiano Carranza, H Cárdenas, Tabasco).

Figure 1 Sampling of Termite isoptera Termites
Source: Project collaboration team, 2020

The sample was placed in the reactors, which were constructed in triplicate to replicate and establish the degradation measurement parameter with greater certainty.

Figure 2 Termite isoptera reactors with sample of disposable nappies in place
Source: Project collaboration team, 2020

According to the research of Caballero (2014), showing the most appropriate conditions for the conservation of temperature, homogenisation and aeration of activated sludge was carried out to compare the results to be obtained against the degradation of Termite Isoptera.

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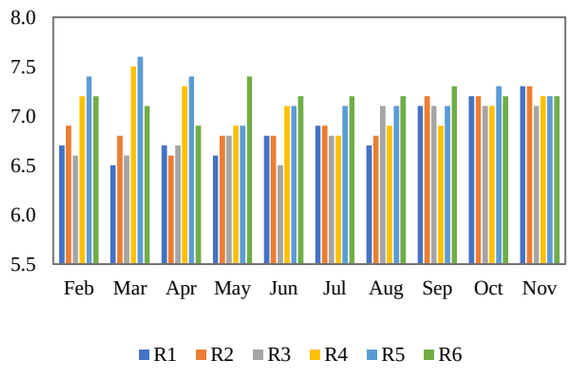
Results

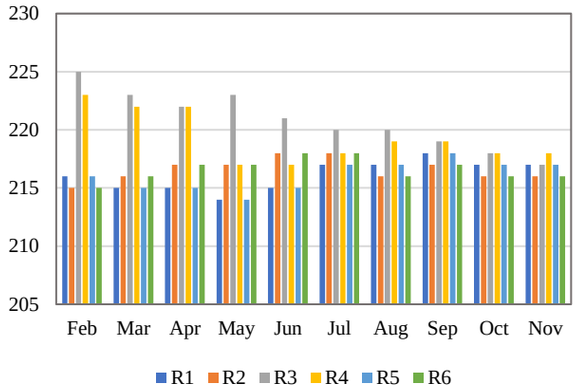
During the degradation process of used disposable nappies by means of activated sludge and Termite Isoptera, the following parameters were analysed every 3 days: pH, Electrical Conductivity, Total Dissolved Solids (TDS), Humidity and temperature, as established by the standard: NOM-004-SEMARNAT-2002 ENVIRONMENTAL PROTECTION. - SLUDGE AND BIOSOLIDS. - SPECIFICATIONS AND MAXIMUM PERMISSIBLE LIMITS OF CONTAMINANTS FOR USE AND FINAL DISPOSAL, and the analysis techniques were worked according to the MEXICAN STANDARD NMX-AA-25-1984. ENVIRONMENTAL PROTECTION - SOIL POLLUTION - SOLID RESIDUES - pH DETERMINATION - POTENTIOMETRIC METHOD, the KURSCHNER AND HOFFER method was used in the analysis of mass reduction and cellulose quantity.

The results of the determinations carried out during the period in which the reactors were kept in the reactors are presented.



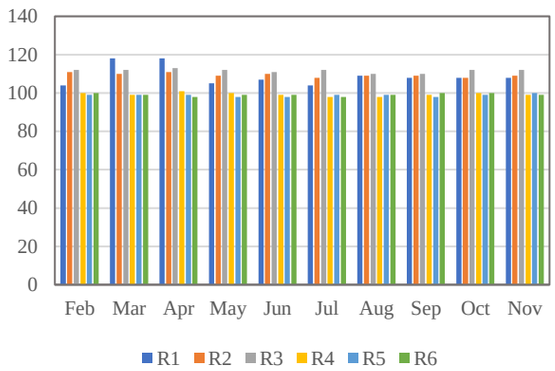
Graph 1 pH Behaviour from Feb to Nov
Source: Project collaboration team, 2020

The pH results are between 6 and 8 "pH classification of the sample (sludge)", most of the essential elements perform well at pH between 6.5 and 8 complying with the specific standard for this item.



Graph 2 Behavior of the Electrical Conductivity from Feb to Nov
Source: Project collaboration team, 2020

Salinity is a parameter used to evaluate the electrical conductivity of a saturation extract of the sludge at the point of salinisation; the results obtained for this parameter indicate that it is a non-saline residue which does not affect the crops in the environment; this salinity is suitable for the development of pastures for livestock activity, as well as for use as fertiliser.



Graph 3 TDS Factor Behaviour from Feb to Nov
Source: Project collaboration team, 2020

The TDS factor of an extract of disposable nappies with termites and activated sludge showed results of 97 and 114 PPM, with a high TDS range, however, these values are within the parameters established by the current Standard. To compare the mass loss reduction between the different reactors, the final weight of each sample and the percentage of dry weight reduction were obtained.

The mass reduction on a dry basis in the controls was from 31% to 35% in the activated sludge reactors, for the reactors with Termite Isoptera from 96.88% to 98.53%. The greatest mass reduction (98.53329%) was obtained from reactor number six corresponding to the one with the presence of Termite Isoptera as a degrading agent.

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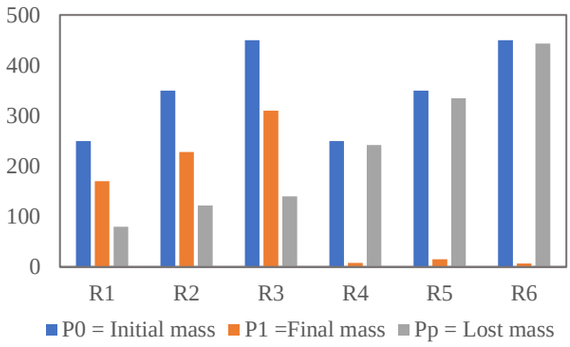

Graph 4 Loss of mass of samples placed in the reactors
Source: Project collaboration team, 2020

For the determination of the cellulose content, the six samples of disposable nappies were analysed, taking into account that each nappy has a cellulose content of 68% in its original state, the formula used to calculate the percentage of cellulose was:

$$\% \, Cellulose = \frac{C}{M} * 100 \qquad (1)$$

Where:
C: Weight of filtered cellulose
M: Weight of the sample

Total cellulose content						
R1	R2	R3	R4	R5	R6	UNITS
170	238	306	170	238	306	g. of Cellulose
127.50	171.36	195.84	34.00	45.22	42.84	g. of Cellulose Remaining
75.00	72.00	64.00	20.00	19.00	14.00	% Cellulose Remaining
42.5	66.64	110.16	136.0	192.78	263.16	g Gradients
25	28	36	80	81	86	% Degraded

Table 1 Results of the calculation of the total cellulose content in % and in grams
Source: Project collaboration team, 2020

When determining the percentage of cellulose content for each of the reactors, a lower percentage of cellulose content was observed in the reactors containing termite isoptera (from 14% to 20% as shown in the results in Table 1, R4, R5 and R6) compared to the activated sludge reactors where the percentage of cellulose content was 64% to 75% (R1, R2 and R3, from Table 1), indicating that in the termite isoptera reactors there was more cellulose degradation.

Conclusions

According to the results obtained in this study of degradation of used disposable nappies (contaminated with urine), which were treated with two degradation agents, activated sludge and Termite Isoptera, in order to accelerate their degradation, a higher percentage of degradation was observed in the Termite Isoptera reactors compared to the activated sludge reactors.

The percentage of cellulose content at the end of the experiment allows us to see the degradation action over time, indicating that a nappy is composed of 68% cellulose. In the reactors with the first degradation agent (activated sludge) the cellulose reduction was for R1-25%, R2-28%, R3-36%, with the second degradation agent (Isoptera termites) the cellulose reduction reached R4-80% R5-81% R6-86%; therefore, there is a higher level of degradation of the disposable nappies in the reactors containing Isoptera termites.

References

Aumonier, S. y Collins, M. (2005). *Life cycle assessment of disposable and reusable nappies in the UK*, Environment Agency: Bristol, UK. p. 203.

Bonilla, V., & N. T. (2008). Secado Solar de Lodos. *Tesis de Maestria.* Mexico.: ingeniería Ambiental. UNAM

Caballero, J. (2012). Estudio de los efectos de la densidad de lombriz y la relación superficie/volumen en un vermireactor *de alta tasa*, alimentado con lirio acuático seco y lodo residual precomposteados. Tesis Doctoral en Ciencias del Agua. Centro Interamericano de Recursos del Agua. Facultad de Ingeniería. Universidad Autónoma del Estado de México. México.

Colón, J., Ruggieri, L., Sánchez, A., González, A., Puig, I. (2011). Possibilities of composting disposable diapers with municipal solid wastes. Waste management research the journal of the International Solid Wastes and Public Cleansing Association ISWA, 29, pp.249–259.

Conway, M., Jooste, F. y Smith, M. (1996). Treatment of absorbent sanitary paper products. p.14.

ISSN 2410-3438

Cordella, M., Bauer, I., Lehmann, A., Schulz, M., Wolf, O. (2015). Evolution of disposable baby diapers in Europe. Life cycle assessment of environmental impacts and identification of key areas of improvement. Journal of Cleaner Production. 95, 322-331.

Delfín Alcalá, Irma, Durán-de Bazúa, Carmen, (2003), *Biodegradación de Residuos Urbanos Lignocelulósicos por Pleurotus*, Universidad Nacional Autónoma de México, Distrito Federal, Revista internacional de Contaminación Ambiental, 19(1) 37-45.

DOF. (2000). NOM-0021-SEMARNAT-2000. Protección ambiental. Lodos y Biosolidos. Establece las especificaciones de la fertilidad, salinidad y clasificación de suelos, estudio, muestreo y análisis. México.

DOF. (2002). NOM-004-SEMARNAT-2002). Lodos y Biosólidos. Especificaciones y límites máximos Permisibles de contaminantes para su aprovechamiento y disposición final.

DOF. (2003), *Ley General para la Prevención y Gestión Integral de los Residuos.* México, (Fecha de consulta: 4 de noviembre 2019), Disponible en: http://www.diputados.gob.mx/LeyesBiblio/pdf/263.pdf.

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Analysis of the income elasticity of demand for recreational and environmental of three ecosystems in Mexico

Análisis de la elasticidad ingreso de la demanda de servicios recreativos y ambientales de tres ecosistemas en México

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Abstract

The objective of this research is to estimate the income elasticity of demand for environmental services of three ecosystems in Mexico. In the three studies of stated preferences about the willingness to pay for an environmental quality improvement project, we used a sample size of 289 observations for the Primas Basalticos ecosystems and 150 for the La Michilía Biosphere Reserve and the Molino de Las Flores National Park. The selection of interviewees was random among visitors. To carry out the estimation, a cluster analysis was carried out to determine the income strata, where the indicator was formulated and calculated in each ecosystem for three income strata (high, medium and low) based on a segmentation of the consumers of recreational services through the two-stage clustering method. In this way, the recreational services of the three ecosystems in both cases behave as a normal good; that is, if the income of the high and middle income consumer increases, the demand for recreational services will increase less than proportionally.

Normal good, Inferior good, Willingness to pay, Two step cluster analysis

Resumen

Estimar la elasticidad ingreso de la demanda de servicios ambientales de tres ecosistemas de México; es el objetivo de esta investigación. En los tres estudios de preferencias declaradas acerca de la disponibilidad a pagar por un proyecto de mejora de la calidad ambiental, se utilizó un tamaño de 289 observaciones para los ecosistemas de los Primas Basálticos y de 150 para la Reserva de la Biosfera La Michilía y del Parque Nacional Molino de Las Flores. La selección de los entrevistados fue aleatoria entre sus visitantes. Para realizar la estimación se realizó el análisis de clúster para la determinación de los estratos de ingresos, donde se formuló y calculó el indicador en cada ecosistema para tres estratos de ingreso (alto, medio y bajo) a partir de una segmentación de los consumidores de servicios recreativos a través del método de conglomerados en dos etapas. De esta manera, los servicios recreativos de los tres ecosistemas en ambos casos se comportan como un bien normal; es decir, si el ingreso del consumidor de ingreso alto y medio se incrementa, la demanda por servicios recreativos se incrementará menos que proporcionalmente.

Bien normal, Bien inferior, Disponibilidad a pagar, análisis de conglomerados en dos etapas

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Introduction

Despite the development of several proposals to define environmental goods and services, there is no commonly accepted definition or single criterion for their classification. The Organization for Economic Cooperation and Development (OECD) and the European Statistical Office (Eurostat) propose a fairly comprehensive definition, stating that this sector is composed of "activities that produce goods and services aimed at measuring, preventing, limiting, minimizing or correcting environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems. This includes cleaner technologies, products and services that reduce environmental risk and minimize pollution and resource use". This universe would include equipment and its components, final consumption products, the provision of services and the construction or operation of facilities; ECLAC (2005).

There are currently several factors that stimulate the growth of demand and willingness to pay for environmental and recreational services. The same trend can be seen in public awareness of the value of this type of services and the costs of reducing them.

For traded products and services, market prices indicate the value for which buyers and sellers agree to exchange. However, for many environmental services there are no market prices and, consequently, it is difficult to quantify their importance or estimate their value. There is a lack of sufficient information that takes into account the underlying process that generates environmental services and their consequences for human well-being. In many cases, benefits may be uncertain and, if anything, occur only in the future.

A common approach to estimating environmental values is the concept of total economic value, which includes the full set of economic values that people attach to each form of land use. The aggravation of many environmental and natural resource use problems, together with the development of institutional and technological capabilities to respond to them, have led in recent decades to the search for possible solutions, including the market for environmental goods and services.

There are currently a large number of documentary references that address the problem of the deterioration of natural resources; some of these are the reports of the United Nations Intergovernmental Panel on Climate Change and the Framework Convention on Climate Change, as well as the American Journal of Climate Change and the International Journal of Global Warming, among others, which address the serious environmental problems worldwide and, where appropriate, the possible solutions proposed through consensus.

In relation to this, Mexico faces major environmental challenges that can be divided into three main groups: lags in infrastructure (notably potable water and drainage, and sanitary landfills for waste); environmental imbalances associated with structural problems and socioeconomic heterogeneities (for example, deforestation linked to problems of poverty and low productivity in the primary sector); and problems associated with industrialization processes under unsustainable patterns of production and consumption (for example, vehicle emissions) (ECLAC 2005).

In relation to the above, environmental goods and services constitute an important support element for environmental policy. Although it is true that measures for the effective protection of the environment and the sustainable use of natural resources require much more than technological solutions and physical infrastructure, particularly in countries with high levels of heterogeneity and socioeconomic complexity, as in the case of Mexico, their contribution to the diagnosis and monitoring of the state of ecosystems and the effects of pollution is unquestionable; in the prevention and attention to natural disasters; in the planning, instrumentation and verification of a series of provisions established for environmental care; in the reduction of environmental impacts and risks and in the increase of the efficiency rate in the use of natural resources.

These last two characteristics give environmental goods and services an economic significance, in the sense of their direct contribution to the maintenance of natural capital. They also generate, directly or indirectly, a significant number of sources of employment and a wide range of satisfiers. Their contribution to the economy, in terms of value added, is relatively modest but growing.

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The valuation of environmental assets is not a subject that is currently being exhaustively addressed in Mexico. This is an arduous and not very simple task, since there is no market for this type of assets, and it is even more necessary and indispensable nowadays in order to allocate the necessary resources for their delimitation, conservation and adequate use, due to the demand to protect and provide these spaces and resources to the countries as an important asset for their wealth and quality of life.

In a market society, giving monetary value to environmental assets is very important as a guiding axis in decision making regarding the allocation of the necessary resources for their conservation and improvement and, therefore, for the implementation of a public policy aimed at a culture of conservation, which can result in welfare for citizens, and thus the destination of spaces and the conservation of environmental assets can justify their value in relation to other uses of these land areas.

In addition to quantifying the monetary amount that consumers would be willing to pay to access the referred recreational services, it is necessary to define whether for different consumer strata (based on their economic and socio-demographic characteristics) the goods and services can be considered as normal, inferior or luxury goods. Within this main framework, the objective of the research was to determine the income elasticity of demand for recreational or environmental services in the ecosystems of La Michilía Biosphere Reserve (Durango, Durango), Molino de Las Flores National Park (Texcoco, State of Mexico) and the Basaltic Prisms (Santa María Regla, Hidalgo), in order to establish whether these behave as inferior goods, normal goods or luxury goods.

The working hypothesis was that the recreational services offered by the aforementioned ecosystems behave as a normal good, so that their demand grows when income increases, although in a smaller proportion; also, that the estimation of income elasticities by stratum can show elasticities greater than unity or less than zero in any of the three ecosystems, so that in the first case the environmental services behave as a normal good and in the second as inferior or superior goods.

Methodology

In the three studies of stated preferences about the willingness to pay for an environmental quality improvement project, a size of 289 observations was used for the Basaltic Primas ecosystems and 150 for the La Michilía Biosphere Reserve and Molino de Las Flores National Park. The selection of interviewees was randomized among visitors in the period from March to April 2019.

Cluster analysis

Cluster analysis was used to determine the income strata; a data exploration tool complemented by data visualization techniques (Jain and Dubes, 1988). Cluster analysis is basically about solving the following problem: given a set of n individuals characterized by the information of p variables Xj, (j = 1, 2, ..., p), the aim is to classify them in such a way that the individuals belonging to a group (cluster) are as similar as possible to each other and the different groups are as dissimilar as possible.

The two-stage clustering tool through SPSS software was developed by Chiu, Fang, Chen, Wang and Jeris (2001) for the analysis of large data sets. Two distance measures can be used: Euclidean distance and Log Likelihood distance. The latter can handle mixed type attributes. The log likelihood distance between two clusters i and s is defined as:

$$d(i,s) = \xi_i + \xi_s - \xi_{\langle i,s\rangle} \quad (1)$$

Where:

$$\xi_i = -n_i \left[\sum_{j=1}^{p} \frac{1}{2}\log\left(\hat{\sigma}_{ij}^2 + \hat{\sigma}_j^2\right) - \sum_{j=1}^{q}\sum_{l=1}^{mj} \hat{\pi}_{ijl}\log(\hat{\pi}_{ijl})\right]$$

$$\xi_s = -n_s \left[\sum_{j=1}^{p} \frac{1}{2}\log\left(\hat{\sigma}_{sj}^2 + \hat{\sigma}_j^2\right) - \sum_{j=1}^{q}\sum_{l=1}^{mj} \hat{\pi}_{sjl}\log(\hat{\pi}_{sjl})\right]$$

$$\xi_{\langle i,s\rangle} = -n_{\langle i,s\rangle} \left[\sum_{j=1}^{p} \frac{1}{2}\log\left(\hat{\sigma}_{\langle i,s\rangle j}^2 + \hat{\sigma}_j^2\right) - \sum_{j=1}^{q}\sum_{l=1}^{mj} \hat{\pi}_{\langle i,s\rangle jl}\log(\hat{\pi}_{\langle i,s\rangle jl})\right]$$

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ξ_v can be interpreted as a type of dispersion (variance) within cluster v ($v = i, s, \langle i,s \rangle$. $\xi_v$consists of two parts. The first, $-n_v \sum \frac{1}{2} \log (\hat{\sigma}_{vj}^2 + \hat{\sigma}_j^2$ measures the dispersion of the continuous variable x_j within cluster *v*. If only were used $\hat{\sigma}_{vj}^2$, $d\ (i,s)$ would be exactly the decrease in the log likelihood function after the merging of clusters *i* and *s*. The term $\hat{\sigma}_j^2$ is added to avoid the degeneracy situation of $\hat{\sigma}_{vj}^2 = 0$. The entropy $-nv \sum_{j=1}^{q} \sum_{l=1}^{mj} \hat{\pi}_{vjl} \log (\hat{\pi}_{vjl})$used in the second part as a measure of dispersion for categorical variables. Similar to hierarchical clusters, those clusters with the smallest distance $d\ (i,s)$are merged at each step. The log likelihood function for the step with *k* clusters is computed as:

$$l_k = \sum_{v=1}^{k} \xi_v$$

The function l_k is the exact likelihood function. The function can be interpreted as the dispersion in the clusters. If only categorical variables are used, l_k is the entropy within the *k* clusters.

a) Number of clusters

The number of clusters can be determined automatically by two steps: the Akaike Information Criterion, defined as:

$$AIC_k = -2l_k + 2r_k$$

where $r_k$is the number of independent parameters of the Bayesian Information Criterion:

$$BIC_k = -2l_k + r_k \log n$$

Computed in the first phase. BIC_k or AIC_kgives a good initial estimator of the number of clusters (Chiu *et al*., 2001). The maximum number of clusters is set equal to the number of clusters where the ratio BIC_k/BIC_1 is less than c_1 (currently $c_1 = 0.04$)) for the first time.

The second phase uses the rate of change $R\ (k)$ in distance for *k* clusters, defined as:

$$R(k) = d_{k-1}/d_k$$

where $d_{k-1}$is the distance if *k* clusters are merged into $k-1$ clusters. The distance d_k is defined similarly. The number of clusters is obtained for the solution where a large jump in the change ratio occurs.

The change ratio is calculated as:

$$R(k_1)/R(k_2)$$

For the two largest values of $R(k)(k = 1, 2, \ldots, k_{max}$ obtained from the first stage). If the rate of change is larger than the threshold value c_2 (currently $c_2 = 1.15$)) the number of clusters is set equal to k_1, otherwise the number of clusters is set equal to the solution with $\max(k_1, k_2)$.

b) Assignment of cluster members

Each object is deterministically assigned to the nearest cluster according to the distance measure used to find the cluster. The deterministic assignment may result in biased estimates of cluster profiles if the clusters overlap (Bacher and Wenzig, 2004).

The variables used for cluster formation in the Basaltic Prism ecosystem were: Willingness to Pay; Price; Household Income; Age; Schooling; Family Size; Gender and Marital Status. In the case of Molino de Las Flores National Park, the following variables were used: Willingness to Pay; Household Size; Age; Income; Gender; Education; and Preception of environmental quality.

The variables used to segment the sample of environmental consumers of the Michilía de Durango ecosystem were: Probability of answering YES to the question about willingness to pay to improve the recreational services of La Michilía (dependent variable); Estimated price to pay to access La Michilía Biosphere Reserve; Monthly family income of the head or person in charge of the household; Age of the interviewee; Gender of the interviewee; and, Preferences of the interviewee to visit or not to visit La Michilía Biosphere Reserve.

Income elasticity

Microeconomics defines income elasticity of demand as the percentage change in demand for a good in response to a percentage change in consumer income. The expression for its calculation is as follows:

$$\eta_I = \beta \frac{I}{Q}$$

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In this case β is the (linear) parameter estimated from the multiple linear regression model associated with the independent variable income.

The ease of calculation and interpretation of income elasticity does not occur with the discrete choice model, in which the dependent variable is no longer continuous but of the dichotomous type; that is, it assumes only values of zero and unity. In the case of the independent variables these can be of the continuous or qualitative type (dichotomous or polychotomous). In this case the expression for the calculation of income elasticity is:

$$\eta_I = \theta \times \frac{I}{0.5} = 2\theta I$$

In this case θ it is the marginal effect of the variable and is given by $\vartheta = \frac{\beta_{Ing} e^{\beta' x}}{(1+e^{\beta' x})^2}$ in whose expression β_{Ing} the parameter associated to the income variable; I represents the average income of the respective cluster or sample. Regarding the denominator, whose value is 0.5, it represents the probability used in the calculations shown in this research. This is due to the fact that the regression model that is estimated corresponds to estimating the probability that the event under study takes the value of zero or unity.

According to Vaughan (2010), in the case of probability models (as in the dichotomous logistic regression model) the use of the conventional microeconomics expression to calculate elasticity is inadequate, because the dependent variable is itself a unitless number between 0 and 1:

$$\eta_x = x \frac{\partial \Pr(x)}{\partial x}$$

Since

$$Ln\left(\frac{\Pr(x_i)}{1-\Pr(x_i)}\right) = \beta_0 + \beta_1 x_{i1} + e_i$$

From where the elasticity can be calculated as follows:

$$\frac{\partial\left[ln\left(\frac{\Pr(x_i)}{1-\Pr(x_i)}\right)\right]}{\partial x} = \beta_1$$

Therefore, the quasi-elasticity is:

$$\eta(x_i) = \beta_1 x_i P(x_i)(1 - P(x_i))$$

It measures the percentage change at a point in the probability due to an increase in x. The result depends on the point at which the change is evaluated. The quasi-elasticity evaluated at the mean is given by:

$$\eta(\bar{x}) = \beta_1 \bar{x} P(\bar{x})(1 - P(\bar{x}))$$

where:

$$\Pr(\bar{x}) = \frac{e^{\beta_0+\beta_1\bar{x}}}{1+e^{\beta_0+\beta_1\bar{x}}}$$

Assuming that $\Pr(\bar{x}) = 0.5$, the formula for calculating the quasi-elasticity is:

$$\eta(\bar{x}) = \beta_1 \bar{x} P(\bar{x})\big(1 - P(\bar{x})\big) = \beta_1 \bar{x}(0.5)(1 - 0.5) = \beta_1 \bar{x}(0.25)$$

Therefore:

$$\eta(\bar{\chi}) = (0.25)\beta_1 \bar{x}$$

Where $\beta_1$is the estimated parameter in the logistic regression and $\bar{x}$ is the average value of the corresponding independent variable, e.g., average household income.

Results

Once the relevant variables in the formation of the clusters of consumers of recreational services had been defined, the SPSS runs were carried out. Since the number of existing clusters was unknown a priori, the computational algorithm determined them automatically based on the statistical criteria referred to above. The self-clustering criterion was the Bayesian Information Criterion (BIC), which is computed for each potential number of clusters. The smaller the value of the BIC, the better the model and, therefore, the better solution for determining the number of clusters. The optimal number of clusters occurs when there is the lowest change in the Bayesian Information Criterion (BIC) and the highest ratio of distance measures (Ramirez, 2013).

Basaltic Prisms

The lowest BIC clustering criterion is 1.351 which occurs when the ratio of distance measures is maximum at 2.134. Therefore, the optimal number of clusters of consumers of recreational services in this ecosystem is three (Table 1).

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No. of cluster	Schwarz Bayesian Criterion (BIC)	Change of BIC	Exchange Ratio in BIC	Distance Measurement Ratio
1	1,831			
2	1,565	-265.897	1.000	1.184
3	1,351	-213.959	0.805	2.134
4	1,287	-64.238	0.242	1.591

Table 1 Result of the self-aggregation of the Basaltic Prism ecosystem
Source: Adapted from Ramírez (2013)

The consumer of environmental services of the Basaltic Prisms ecosystem (cluster 1) is characterized by being the youngest (29.25 years old), the one with the highest schooling (years of study) and the one with the highest income. In the second cluster is the oldest consumer (41.07 years old), with the lowest schooling (12.93 years of study) and the lowest number of family members (Table 2).

Conglomerate	Price ($)	Income Family Income ($/mont)	Age (years)	Schooling (years)	Size of Family (members)
1	24.30	9,295	29.25	14.51	4.08
2	25.80	8,751	41.07	12.93	3.54
3	24.64	8,689	40.56	13.30	4.08
Combined	24.84	8,934	36.46	13.65	3.93

Table 2 Centroids of continuous variables
Source: Adapted from Ramírez (2013)

More than two thirds of those demanding recreational services from basaltic prisms are willing to pay for improvements that could be made to the site (68.4%) (Table 3).

DAP	Absolute	Relative (%)	Genre	Absolute	Relative (%)	Edo. civil	Absolute	Relative (%)
yes	195	68.4	Man	151	53	Married	114	40
	90	31.6	Woman	134	47	Single	171	60
Total	285	285	Total	285	100	Total	285	100

Table 3 Frequency distribution of categorical variables.
Source: Adapted from Ramírez (2013)

Molino de Las Flores National Park

The lowest BIC is 1,042.212 which occurs when the ratio of distance measures is maximum at 1.390 so the optimal number of clusters is three (Table 4).

No. of clusters	Schwarz Bayesian Criterion (BIC)	Change of BIC	Exchange Ratio in BIC	Distance Measurement Ratio
1	1216.009			
2	1115.662	-100.347	1.000	1.187
3	1042.212	-73.450	0.732	1.390

Table 4 Self-grouping result for Molino de Las Flores Park
Source: Prepared from SPSS outputs

Table 5 shows the centroids (means) of the continuous variables of Molino de Las Flores and their standard deviation.

Conglomerate	DAP		TAH		ING	
	Media	Typical deviation	Media	Typical deviation	Media	Typical deviation
1	19.46	8.834	4.78	2.412	6,608.41	4,336.206
2	18.40	8.598	4.90	1.669	8042.34	4,703.966
3	15.46	7.787	4.00	1.530	5,864.24	2,863.57
Comb.	17.67	8.507	4.54	1.916	6,818.49	4086.823

Table 5 Centroids of the continuous variables Molino de Las Flores National Park
Source: Elaborated from SPSS outputs

Table 6 shows the frequency distribution of the perception of the environmental quality of the recreational services provided by Molino de Las Flores National Park.

Conglomerate	Not deteriorated		Deteriorated and badly deteriorated	
	Frequency	%	Frequency	%
1	17	81.0	29	22.5
2	0	0.0	50	38.8
3	4	19.0	50	38.8
Combined	21	100	129	100

Table 6 Frequency distribution of Environmental Perception
Source: Elaborated from SPSS outputs.

La Michilía Biosphere Reserve

According to the two criteria used to define the segmentation of the La Michilía sample by stratum, the optimal number of clusters is three (Table 7).

Number of clusters	Schwarz Bayesian Criterion (BIC)	Change of BIC	Exchange Ratio in BIC	Distance Measurement Ratio
1	781.988			
2	657.536	1.000		1.128
3	552.331	0.845		1.866
4	516.867	0.285		1.387

Table 7 Results of self-grouping La Michilía
Source: Prepared from SPSS outputs

Table 8 shows the centroids (means) and standard deviations of the continuous variables used for the analysis of the results of La Michilía.

Conglomerate	DAPC		AGE		ING	
	Media	Typical deviation	Media	Typical deviation	Media	Typical deviation
1	44.70	4.25	38.81	16.22	1,820.00	716.57
2	55.12	11.14	37.69	13.82	3,239.52	1,880.37
3	45.42	4.34	35.14	14.15	1,940.88	732.65
Comb.	48.43	8.78	37.10	14.88	2,447.83	1,482,70

Table 8 Centroids of the continuous variables La Michilía Biosphere Reserve
Source: Prepared from SPSS outputs

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Table 9 shows the distribution of the categorical variable gender used for the segmentation of the La Michilía sample.

Conglomrd	Woman		Man	
	Frequency	%	Frequency	%
1	12	16.9	25	31.6
2	8	11.3	54	68.4
3	51	71.8	0	0.0
Combined	71	100.0	79	100.0

Table 9 Distribution of gender frequencies
Source: Prepared from SPSS outputs

Microeconometric indicators of income elasticity

The willingness to pay was estimated for the three ecosystems through dichotomous logistic regression by posing to consumers a hypothetical scenario of improved recreational services reflected in improvements in their welfare (Table 10).

Stratum	La Michilía (2014)			Molino de Flores (2010)			Prismas Basalticos (2012)		
	Ingreso	DAP	ElasticidadIngreso	Ingreso	DAP	EI	Ingreso	DAP	EI
I	1,820	42.3	-0.44	5,864	6.8	7.64	8,634	47.8	0.17
II	1,941	49.9	0.28	6,608	17.6	0.44	8,751	36.9	0.18
III	3,239	174.24	0.15	8,042	26.9	0.74	9,295	43.3	0.56
Total	2,448	48.4	0.27	6,818	23.6	0.59	8,934	42.0	0.27

Table 10 Estimated income elasticities of the three ecosystems
Source: Own elaboration based on the outputs of the statistical runs

When considering the total sample, the elasticity of demand for the three ecosystems shows that the recreational services offered by the three ecosystems behave as a normal good as the respective income increases. The income elasticities are greater than zero and less than unity. Thus, if the respective income increases by 10 percent, the demand for recreational services in La Michilia Biosphere Reserve will increase by 2.27 percent. In Molino de Flores National Park the demand for recreation will increase by 5.9 percent and in the Basaltine Prisms ecosystem the demand will increase by 2.7 percent.

In the analysis by cluster, the same behavior is observed for cluster three, which is the highest income cluster in the respective ecosystems.

Thus, if income increases by 10 percent, the demand for recreational services increases 1.5 percent for La Michilía; 7.4 percent for Molino de Las Flores and 1.7 percent for Prismas Basálticos. Note that this stratum can be considered the high-income recreational consumer stratum.

The analysis of stratum two or middle income indicates that recreational services also behave as a normal good. Thus if income increases by 10 percent the elasticity increases by 2.8 percent for La Michilía, 4.4 percent for Molino de Las Flores and 1.8 percent for Prismas Basálticos.

In stratum one or low income, the analysis shows contrasts in demand for recreational services in La Michilía and Molino de Las Flores with clusters two and three and with the recreational services of Prismas Basálticos in the same stratum. Consumers in stratum one of La Michilía have by far the lowest income while La Michilía is the ecosystem where consumers have on average the lowest income.

The income elasticity of demand for cluster one in La Michilia is -0.44, which implies that if income increases by 10 percent, the demand for recreational services in this Biosphere Reserve will decrease by 4.4 percent. In other words, recreational services behave as an inferior good for this consumer stratum. Therefore, when the consumer's income increases, its demand or consumption decreases as the consumer's income increases.

The finding described in the previous paragraph although it does not contradict the research of the vast majority of studies that have shown that environmental services behave as a normal good (Kriström, and Pere, 1996; Freeman, 2013; Pereyra and Rossi, (n/d)) and in some cases as a luxury good (Ghalwash, n/d) does not rule out its behavior as an inferior good especially for poorer strata. This is reflected in the concern of some authors who have studied in depth the effects of the implementation of environmental policies that charge a fee for access to the enjoyment of the recreational services of public goods, the privatization of the ecosystems that offer them, and the disappearance of such sites for the purpose of achieving development by exploiting resources of economic importance located within such ecosystems, among others.

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It is argued that such measures have regressive effects against the poorest (Flores and Carson, 1997). In contrast to such behavior of the low-income consumer of La Michilía is the low-income consumer of Molino de Las Flores. According to the estimated income elasticity of 6.8, it implies that, if their income increases by 10 percent, the demand for recreational services in that ecosystem increases by 68 percent. This is a common finding in research on the income elasticity of demand for environmental quality (Hökbya and Söderqvist, 2003).

The analysis of the WTP of each of the ecosystems does not allow comparison between the three ecosystems studied, but does allow comparison between strata of each ecosystem. Between clusters of the Basaltic Prisms it is possible to observe that the low-income consumer has a higher willingness to pay than the middle and high-income stratum. Thus, the former has a WTP of $47.8 versus $36.9 and $43.3 for strata two and three.

This finding is not confirmed by the cases of La Michilía or Molino de Las Flores. In the La Michilía ecosystem, WTP increases as consumer income increases. The same occurs in the case of Molino de Las Flores, i.e. the two higher income clusters also have a higher WTP as their income increases.

Although the finding that the poorest have a greater willingness to pay than those with higher incomes is not verified, this concern has been studied by a large number of researchers given the potential regressive effects on lower income consumers that may occur due to policy prescriptions that suggest the privatization of public environmental goods or the disappearance of an ecosystem where this type of consumer has free access.

Calculation of probabilities

In econometric terms, the income elasticity of demand for recreational services in the Basaltic Prisms shows that if the average income for the entire sample ($8,934) increases by 10%, the probability that the consumer of recreational services in this ecosystem will be willing to pay $42.0 pesos for an ecosystem improvement project will increase by 2.7%.

The probability that the consumer would answer yes when asked if he/she would be willing to pay $42.0 pesos for improvements in the recreational services of the Basalt Prisms is 71.0%. This probability increases by 2.7% if consumer income in this case were to increase by 10% (from $8,934 pesos to $9,827 pesos). Increasing the probability of an affirmative response by the consumer by 2.7% increases this probability from 71.0% to 72.9%.

The calculations of the procedure for this calculation are given by the multiple regression logistic model. Thus, for the Basaltic Prism ecosystem, the probability for the entire sample (n = 285), given an estimated WTP of $42 pesos, the estimation procedure is as follows:

$$P(Si/DAP) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_1+\beta_2 X_2)}} =$$

$$P(Si/42) = \frac{1}{1+e^{-(\beta_0+\beta_1 PREC+\beta_2 IFAM)}} =$$

$$P(Si/42) = \frac{1}{1+e^{-(1.52484-0.05212PREC+0.000074655IFAM)}} =$$

$$P\left(\frac{Si}{42}\right) = \frac{1}{1+e^{-(1.52484-0.05212)(24.8421)+(0.000074655)*(8934.4))}} =$$

$$P(Si/42) = 0.7103$$

The interpretation of this expression is the following: the probability that the consumer accepts to pay $42 for a project to improve the recreational services of the Basaltic Prisms is 71.03%. Now, the income elasticity as a measure of sensitivity of the effect on the probability of a change in consumer income indicates that if income increases by 10% the probability will increase by 2.74%. That is, the probability increases from 71.03% to 72.45%.

The problem can be stated as follows: By how much will the probability of the consumer agreeing to pay $42 for an environmental services improvement project increase if the following data are available?

Concept	Initial value	Increase	Final value
Elasticity	0.274467		
Income	$8,934	$893 (10%)	$9,827
Probability	0.7103	ΔPr = ¿?	Pr_1 = ¿?

The calculation of the probability increment (ΔPr) is computed as follows: ΔPr = (0.7103) (0.0274467) = 0.019463, then:

Pr1 = 0.7103 + 0.0195 = 0.7298

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Pr1 = 0.7298

Thus the final table of figures is as follows (rounded to four decimal places).

Concept	Initial value	Increase	Final value
Elasticity	0.274467		
Income	$8,934	$893 (10%)	$9,827
Probability	0.7103	0.0195	0.7298

That is, if income increases by 10%, the probability that the consumer will be willing to pay $42 for improvements in recreational services will increase from 71.03% to 72.98% as indicated by the income elasticity of demand for recreational services.

Conclusions

Analysis of the results of the microeconometric estimation of the income elasticity of demand for recreational services in the three study ecosystems indicates that for the full sample recreational services behave as a normal good so that demand increases less than proportionally if income increases by 10 percent. The income elasticity for La Michilia Biosphere Reserve is 0.27, increasing demand by 2.7 if income increases by 10 percent, while the income elasticity for Molino de Las Flores National Park is 5. 9 so the demand for recreational services will increase by 5.9 percent if income increases by 10 percent and the income elasticity of Basalt Prisms is 0.27 so the demand for recreational services will increase by 2.7 if income increases by 10 percent.

The magnitude of the elasticity for the La Michilia ecosystem, which has the lowest income, and the Basalt Prisms ecosystem, the ecosystem with the highest income consumers, is equal. This finding is in line with the research results of theoretical and empirical authors. In addition, the intra-cluster analysis of each ecosystem shows similar behavior to the result obtained for the whole sample except for the lowest income cluster (stratum one). In the case of stratum three (high income), the elasticity shows that for consumers in this conglomerate recreational services behave as a normal good, since its calculated elasticity is greater than zero and less than unity, as suggested by economic theory. For stratum two (middle income), the income elasticity of the quality of recreational services behaves as a normal good while the low income conglomerate shows a mixed behavior.

For La Michilía as an ecosystem, whose visitor population has the lowest income, the income elasticity shows that for this group the enjoyment of recreational services is an inferior good. Therefore, as their income rises, ceteris paribus, the demand for this environmental service will decrease**.**

References

Bacher, J., Wenzig K.y Vogler, M. (2004). SPSS TwoStep Clustering. A First Evaluation. SSOAR. Veröffentlichungsversion / Published Version Arbeitspapier / working paper. Universität Erlangen-Nürnberg, Sozialwissenschaftliches Institut, Lehrstuhl für Soziologie, 2004-2. En: Corvan Dijkum, Jörg Blasius, Claire Durand (eds.): Recent Developments and Applications in Social Research Methodology. Proceedings of the RC33 Sixth International Conference on Social Science Methodology, Amsterdam, Opladen, Barbara Budrich.

CEPAL (2005). Bienes y servicios ambientales en México. Caracterización preliminar y sinergias entre protección ambiental, desarrollo de mercado y estrategia comercial. Santiago de Chile, 2005.

Chiu, T.; Fang, D.; Chen, J.; Wang,Y., y Jeris, C. (2001). A Robust and Scalable Clustering Algo-rithm for Mixed Type Attributes en Large Database Environment. Proceedings of the seventh ACM SIGKDD international conference on knowledge discovery and data mining.

Flores, N. E. and Carson, R. T. (1997), "The Relationship between the Income Elasticity of Demand and Willingness to Pay". Journal of Environmental Economics and Management 33, 287-295.

Ghalwash, Tarek (s/f). Demand for Environmental Quality. An Empirical Analysis of Consumer Behavior in Sweden. Department of Economics, Umeå University, Umeå, Sweden.

Hökbya, S. and T. Söderqvist, 2003, "Elasticities of demand and willingness to pay for environmental services in Sweden, "Environment and Resource Economics, Vol. 26, Issue 3, pp 361-383.

ISSN 2410-3438

Jain, A.K and Dubes R. C. (1988). Algorithms for clustering data. Michigan State University. Prentice Hall.

Kriström, B. and Pere Riera (1996). "Is the income elasticity of environmental improvements less than one?" Environmental Resource Economics, Vol. 7, pag. 45-55.

Ramírez Espinosa, J.M. (2013). Caracterización Microeconómica del Consumidor de Servicios Recreativos en los Prismas Basálticos, Huaxca de Ocampo, Hidalgo. Tesis de Licenciatura, División de Ciencias Económico-Administrativas (DICEA), Universidad Autónoma Chapingo.

Vaughan, W. J., Rusell, C. S., *et al*. (2010). "Central Tendency Measures of Willingness to pay from Referendum Contingent Valuation Data: Issues and Alternatives in Project Analysis", Washington, D.C., USA.

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Evaluation of the usability and accessibility of applications for mobile devices of pictograms in students with autism spectrum disorder of CAM Tehuacan

Evaluación de la usabilidad y accesibilidad de las aplicaciones para dispositivos móviles de pictogramas en los alumnos con trastorno del espectro autista del CAM Tehuacan

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Abstract

The objective of this research was to analyze two applications that use pictograms installed on a mobile device with the Android operating system, through surveys applied to teachers, family members and students with autism spectrum disorder (ASD) to evaluate the criteria of usability, functionality, and accessibility. The Omega coefficient was used to evaluate the reliability of the applied instruments so as not to depend on the number of items, the acceptable value should range between 0.70 and 0.90. The evaluations obtained in each one of the surveys were: for teachers of the Multiple Attention Center (CAM) of Tehuacán 0.707 and for parents 0.705, demonstrating that the reliability of the instrument that was applied is adequate. With the results of this analysis, areas for improvement were detected focused on the development of a new mobile application adapted to the needs of students with ASD from the Tehuacán CAM, and as a contribution of a Mexican development in this segment.

Mobile, Usability, Autism

Resumen

El objetivo de la presente investigación fue analizar dos aplicaciones que utilizan pictogramas instaladas en un dispositivo móvil con sistema operativo Android, por medio de encuestas aplicadas a profesores, familiares y alumnos con trastorno del espectro autista (TEA) para evaluar los criterios de usabilidad, funcionalidad, y accesibilidad. Se utilizó el coeficiente Omega para evaluar la confiabilidad de los instrumentos aplicados para no depender del número de ítems, el valor aceptable debe oscilar entre 0.70 y 0.90. Las valoraciones obtenidas en cada una de las encuestas fueron: para maestros del Centro de Atención Múltiple (CAM) de Tehuacán 0.707 y para padres de familia 0.705, demostrando que la confiabilidad del instrumento que se aplicó es el adecuado. Con los resultados de este análisis se detectaron áreas de mejora enfocadas al desarrollo de una nueva aplicación móvil adaptada a las necesidades de los alumnos con TEA del CAM de Tehuacán, y como una aportación de un desarrollo mexicano en este segmento.

Móviles, Usabilidad, Autismo

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1. Introduction

The first contributions on autistic traits were developed in 1926 with child psychiatrist Grunya Efimovna Sukhareva who published a detailed description of autistic traits in several children in a German scientific journal of psychiatry and neurology (Manouilenko *et al*., 2015). "Autism affects 1 in 160 children worldwide and is the most prevalent condition in the psychiatric field. Mexico lacks STI (Science technology and innovation) policies that articulate the needs of this population" (Anzaldo *et al*., 2019, p. 13).

As defined by the World Health Organization (WHO, 2022), "Approximately one in every 100 children has autism. Evidence-based psychosocial interventions can improve communication and social skills, with a positive impact on the well-being and quality of life of both autistic individuals and their caregivers."

In the State of Puebla there are 49 CAMs, whose mission is to offer initial and basic education and job training to children and adolescents with multiple disabilities and pervasive developmental disorder, with the aim of eliminating or reducing barriers to learning and participation in school, classroom, socio-family and work contexts.

Autism is a lifelong neurodevelopmental condition that interferes with a person's ability to communicate and relate to others (Elsabbagh *et al*., 2012). The Mexican Autism Clinic estimates that, in Mexico the incidence of autism is 1 child per 115 (CLIMA, 2021). Considering that the population size of Mexico is 126 million, according to INEGI (2020), there are about 94,800 people with ASD in ages 0 to 4 years and 298,000 people with ASD, in the age range of 5 to 19 years (Fombonne *et al*., 2016).

In the City of Tehuacán, 2 CAMs operate that serve children and adolescents with multiple disabilities and pervasive developmental disorders, including students with autism. The use of applications for people with ASD is important as García, Garrote and Jiménez (2016) state, "ICTs and specifically mobile applications are booming and educationally speaking, they can be a great resource for children diagnosed as ASD as they can improve communication, language, emotions, social intervention and vocabulary".

The number of ICT-based tools for the intervention of people with ASD has experienced significant growth, so much so that people with ASD have been included as a priority target in what has been called Affective Computing (Cuesta, 2012, p. 18).

"Many authors have pointed out the need to develop software and hardware that, combined with specific technology, will increase the vocabulary and communication skills of people with ASD" (Heredia & Navas, 2019, p. 46). This allows students with ASD to use another tool to be able to function in their environment.

"In the therapeutic approach to children with autism spectrum disorder (ASD), it is essential to incorporate the construction and use of alternative and augmentative communication systems (AACS)" (Echeguia, 2016, p. 104), such as pictograms. "The images used in pictograms are not standardized according to the context, since a concept is represented by different types of pictograms" (Orellana, 2016, p. 96).

On the ARASAAC website (Portal Aragonés de Comunicación Aumentativa y Alternativa), it contains images available to facilitate communication with people with autism (García *et al*., 2016).

The aim is for teachers to use the pictogram applications with their students with ASD in the CAM and parents at home. There are different applications for people with ASD on the market, of which two were chosen at the suggestion of those in charge of the CAM, PictogramAgenda and PictogramAgenda, of which the usability and accessibility were evaluated, proposing improvements for the development of a new mobile application, as a contribution of this research.

The methodology section presents the study carried out, the evaluation and measurement instruments used to generate the results. The results section presents in an analytical way the information collected and processed to obtain the usability and accessibility assessment of each of the applications.

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Methodology

The methodological approach applied was non-experimental, since the usability, accessibility and functionality variables do not undergo descriptive modifications. The objective is to evaluate people with autism and their relationship and interaction with mobile applications. The primary source research instruments used were web surveys directed to different people directly related to CAM activities and the use of mobile device applications focused on the support of children with ASD, being the participants teachers, parents or guardians, as well as children with ASD, during the period from January to June 2022.

The applications PictogramAgenda and PictogramaAgenda were chosen at the suggestion and recommendation of Lic. Maricruz Mendoza Morales and Lic. Miguel Debas Escobar, director and psychologist of CAM Héctor Lezama Surroca, respectively, since these two applications have been used, tested and analyzed.

Teachers according to their experience and daily interaction are best suited to select appropriate apps for their students and provide suggestions to parents who express interest in educational apps (Weng, 2015).

Pictograms are graphic symbols used to facilitate language for children with some type of disability. These symbols are essential in the work done with students with ASD, since most children with learning disabilities have an easier time communicating through images, since they have a lower level of abstraction (Domínguez, 2019, p. 6).

To evaluate the mobile applications, a mixed survey with likert-type scale, open and dichotomous response was applied as an evaluation instrument, with the following indicators: learning, usability, efficiency, memorability, interaction with the application, satisfaction, and accessibility, taking as a reference that all students use a mobile device such as a cell phone with Android operating systems and the application is free.

The objective of educational mobile applications is to complement the daily activities performed by families and teachers, where all activities are oriented towards the same purpose, not exceeding its use (Gallardo Montes *et al*., 2021, p.5).

Survey for CAM teachers

It consists of 7 items, offering different scales, 4 of the items have dichotomous answers, 1 item offers 4 non-scaled options referring to the academic level and 2 of the remaining items offer 3 options with a Likert-type scale different one from the other, the options being: 1 Very useful, 2 Not very useful, 3 Not at all useful and 1 Very beneficial, 2 Not very beneficial and 3 Not at all beneficial.

Survey for Parents

It is made up of 10 items, 9 of which offer dichotomous responses, and only 1 item has 3 options on a Likert scale, 1 Very supportive, 2 Not very supportive, 3 Not at all supportive.

Data collection survey for children with ASD

For this particular instrument, its approach only required open-ended questions, being the items focused on gathering information particular to children with ASD, information that in this case is not quantifiable within a Likert-type scale.

Next, the Omega coefficient was applied, where the acceptable value should range between 0.70 and 0.90, using the Jamovi software (www.jamovi.org) to verify the reliability of the instruments, obtaining the following results: survey for CAM teachers 0.707, survey for parents 0.705, which indicates that the instruments used are reliable.

The survey was based according to the system of indicators for the evaluation of mobile applications for users with ASD through 3 dimensions, the design/form dimension with the indicators: availability, ergonomics, usability, and accessibility; content dimension with the aspects: content, and help; pedagogical dimension with the indicators: interactivity, learning, and monitoring as proposed by (Gallardo-Montes *et al*., 2021, p. 5).

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These two mobile applications are found in the catalog of applications that develop communication with students with ASD, within the 50 applications with ratings of 80-90 PictogramAgenda and 70-80 PictogramAgenda, elaborated as a resource for teachers and families (Capel, 2021).

Also using the Google Apps database, 35 mobile apps were found and organized according to user ratings, number of downloads and updates, without excluding whether they are paid or free, with the PictogramAgenda mobile app appearing in 32nd place (García *et al.*, 2016).

3. Results

1. Selecting the sample population.

In the city of Tehuacán there are 2 Multiple Attention Centers that serve children with ASD, where aspects such as ease of access to a mobile device, familiarity with the use of a mobile device and willingness to participate in the study were analyzed. Thus, 19 students who regularly attend the CAM Héctor Lezama Surroca were selected.

Ten instructors who work at the CAM performing activities directly related to students with ASD were selected.

Of the 22 people possible for the study, only 14 were able to participate, of which 12 are directly related to the student, 1 is a therapist and 1 is a shadow teacher, who is a permanent companion of the student, subsidized by the parents themselves.

2. Collection of information

An initial survey was applied to collect information related to the conditions and level of intensity of support for children with ASD. In the CAM 89.4% of the students are male and 10.6% are female. The age distribution of children with ASD is summarized in Table 1.

Age	Children
Less than 7	4
7 a 12	8
13 a 18	5
19 a 24	2

Table 1 Ages of children with ASD
Source: Own Elaboration

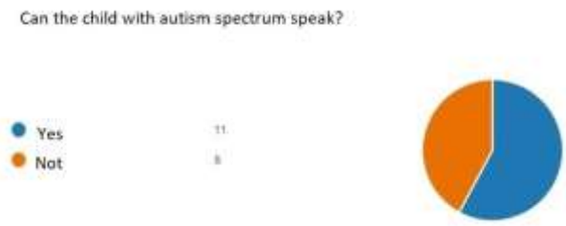
Table 2 shows the distribution of the years of stay of students with ASD in the CAM.

Time	Number of students
Less than one year	2
1 to 2 years	6
More than 2 years and up to 3 years	5
More than 3 years	6

Table 2 Years of stay in the CAM
Source: Own Elaboration

There are 18 students with a medical record and only 1 does not have one, since his parents did not consider it necessary. According to the level of studies, 1 is in early education, 4 in preschool, 7 in elementary school, 5 in high school and 2 received job training.

Of the 19 students, 8 are not able to establish stable communication with others or communicate in any way, but 11 of them are able to communicate by means of words that are understandable, not being able to complete a sentence (Graphic 1).



Graphic 1 Graph of communication through speech
Source: Own Elaboration

The students who can communicate by reading are 4 and 15 have difficulty reading (Graphic 2).

Graphic 2 Graph of communication through reading
Source: Own Elaboration

Students with ASD use different ways to communicate, either through signs, gestures, oral or written expression. The survey showed that 17 express themselves through signs, 7 communicate through oral expression and 6 use pictograms that they know and use in their daily lives (Graphic 3).

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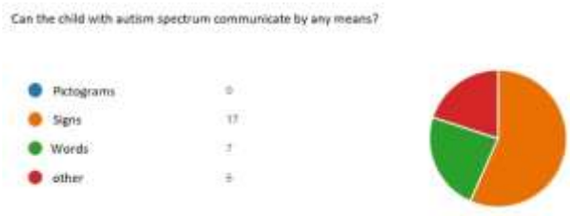


Graphic 3 Communication through other elements different from oral language
Source: Own Elaboration

3. CAM Instructor Survey

Initial surveys were applied to instructors to collect data on the knowledge and acceptance of mobile devices, the following results are shown below:

At the time of the application of the instrument, 10 instructors were found, of which 9 have a degree in Special Education, Bachelor's Degree in Psychology or related to the activities developed in the CAM, and 1 teacher does not have a related career.

All the teachers have access to their own cell phones, only 50% of the teachers know of any application focused on people with autism spectrum disorders. 90% of the teachers consider that the use of mobile applications for students with ASD is beneficial for the student and useful for the teacher's own activities. 100% of the teachers are in the best disposition to use a mobile application designed for students with ASD.

Survey for parents, therapist or caregiver.

This survey is aimed at detecting how often a child with ASD uses or is familiar with the use of a mobile device. The results obtained are summarized as follows:

Of the respondents 71.4% consider that the use of a mobile application is of great help for the integration and communication of the student with his/her environment, 9 respondents comment that the student uses the mobile device and 5 do not use it.

Another result that should be highlighted is that a minimum percentage have a mobile device for their children, using the cell phone of their parents or a relative, regularly to play, observing the interaction of the student with the device, it is concluded that he/she loses interest very quickly (Graphic 4).

Graphic 4 Has its own cell phone for the child
Source: Own Elaboration

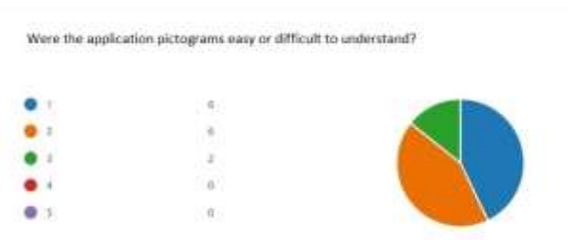
100% of the respondents are willing to use and evaluate a mobile application based on pictograms to be used with the student with ASD.

At the end of the surveys, some parents expressed that they are willing to be trained and include some technological tool that helps them with the development of learning and skills of their children, which is accessible, since they do not have the economic resources to acquire an application that involves an expense.

The PictogramAgenda and PictogramAgenda applications were used for two months, integrating them into the activities carried out at the CAM. After using them, a survey was applied to parents, therapists, and shadow teachers, obtaining the following results:

a) Learning to use the application.

86% considered it very easy to use the application, and considering the size of the cell phone screens it is easy to access, as well as to select an option in the application, they also considered that the pictograms of the application were very easy to understand (Graphic 5).



Graphic 5 Learning how to use the application
Source: Own Elaboration

b) Usability of the application

During 2 months, 50% of the instructors tested and used the application with their students, concluding that the students need constant adult supervision to take advantage of the features of the mobile application. Even so, when questioned regarding how they would rate the usability of the application, 6 of them considered the application very useful for children with ASD.

c) Efficiency of the application

The features that were evaluated and their percentage of efficiency are summarized in Table 3 below:

Characteristic	Percentage
Efficiency of application use	72%
Clear and understandable graphics	86%
Easy to prepare a day's agenda	71%

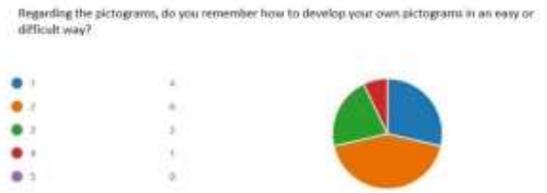
Table 3 Efficiency of the application
Source: Own Elaboration

It was observed that the time that the students were interested in using the application was in the range of 0 to 30 seconds in the majority, the rest of the students managed to maintain their attention in a time of up to 3 minutes (Graphic 6).

Graphic 6 Graph of student attention time to the application
Source: Own Elaboration

d) Memorabilidad

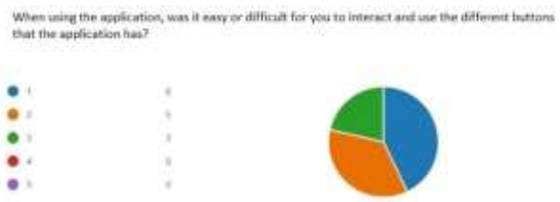
For the development of their own pictograms, such as pictures representing objects, places, things or known people, 28% consider it difficult, 43% regular and only 29% easy. After using the application, 85% considered it easy to remember each of the options (Figure 7).



Graphic 7 Graph regarding the development of own pictograms
Source: Own Elaboration

e) Interaction with the application

29% of the respondents consider the installation easy and 71% not very easy, 14% needed to uninstall some application due to lack of storage space of the mobile device. 72% consider the application useful in daily life and 28% consider it not very useful. 43% considered the interaction with the application buttons easy (Graphic 8).



Graphic 8 Graph of interaction with the application
Source: Own Elaboration

Regarding the continuity of the application management it was obtained that only 1 teacher does not consider continuing to use the application since it does not represent any benefit in their interaction with students with ASD, 2 teachers are undecided, 10 teachers consider very likely to continue using the application in their daily activities in the CAM.

f) Satisfaction

When using the application to create pictograms, more than 70% of the respondents expressed feeling comfortable developing the day's agenda and using the other components of the application. Once the agenda of the day was created the students showed a higher percentage of confidence to interact on their own.

g) Accessibility

Once the accessibility conditions were evaluated for possible physical, visual, auditory or other limitations of the users, it was determined that none of the 2 applications had these characteristics.

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The test time was short due to the gradual return to the classrooms after the pandemic and that teachers did not have electric power to work with their students for a whole day, so the interaction process was little, however, the use of this sample application allowed to further increase the interest of teachers in the use of a support application for children with ASD.

Annexes

CAM Initial Teacher Survey: https://forms.office.com/r/ArXqgZcvEt

Initial Survey for Children: https://forms.office.com/r/9PRFdgBr2W

Final Teacher Survey: https://forms.office.com/r/1pzKcVUFEi

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5. Conclusions

Once the analysis of all the results obtained through the surveys and the usability and accessibility analysis has been carried out, we can conclude that the PictoAgenda and PictogramAgenda applications do not have error correction and feedback, in the progress control of the daily agenda, they do not provide a score achieved or a message indicating that the activity has been completed, the navigation through the application is simple, there is no online help in manuals or tutorials that help to understand the operation of the application. The design of an attractive interface should be sought to attract the child's attention, language and pictograms contextualized to the country.

With this analysis we have the necessary elements to start the design and development of a new application considering improving the criteria listed above in order to achieve a more robust application with a more efficient usability and accessibility level.

6. Referencias

Anzaldo Montoya, M., & Cruz Ruiz, L. P. (2019). Capacidades científicas en el Trastorno del Espectro Autista en México: reflexiones desde el vínculo entre ciencia, tecnología e innovación y políticas sociales. Ciencia y Sociedad, 44(1), 13–26. https://www.redalyc.org/exportarcita.oa?id=87060695002.
https://doi.org/10.22206/cys.2019.v44i1.pp13-26

Capel Sánchez, M. (2021). Análisis y evaluación de aplicaciones para desarrollar la comunicación en el alumnado con trastorno del espectro autista. Edutec. Revista Electrónica de Tecnología Educativa, 75, 168–187. https://dialnet.unirioja.es/servlet/articulo?codigo=7878500.
https://doi.org/10.21556/edutec.2021.75.1681

CLIMA. (2021, January 21). Clínica Mexicana de Autismo. ¿Qué Es El Autismo? https://www.clima.org.mx/el-autismo

Cuesta Gómez, J. L. (2012). Tecnologías de la información y la comunicación: aplicaciones en el ámbito de los trastornos del espectro del autismo [Information and Communications Technology: Applications in the Field of Autism Spectrum Disorders]. In Revista Española sobre Discapacidad Intelectual (Vol. 43, Issue 2). https://sid-inico.usal.es/wp-content/uploads/2018/11/Tecnologias-de-la-informacion-y-la-comunicacion_-aplicaciones-en-el-ambito-de-los-trastornos-del-espectro-del-autismo.pdf

Domínguez Barquero, D. (2019). El Trastorno del Espectro Autista (TEA) y el uso de las Tecnologías de la información y comunicación (TIC). International Journal of New Education. https://www.revistas.uma.es/index.php/NEIJ/article/view/7447.
https://doi.org/10.24310/IJNE2.2.2019.7447

Echeguia Cudolá, J. (2016). Sistemas alternativos y aumentativos de comunicación para el tratamiento de niños con trastorno del espectro autista. Diálogos Pedagógicos, 14(28), 104–126.
https://revistas.bibdigital.uccor.edu.ar/index.php/dialogos/article/view/306/pdf.
https://doi.org/10.22529/dp.2016.14 (28)07

Elsabbagh, M., Divan, G., Koh, Y.-J., Kim, Y. S., Kauchali, S., Marcín, C., Montiel-Nava, C., Patel, V., Paula, C. S., Wang, C., Yasamy, M. T., & Fombonne, E. (2012). Global Prevalence of Autism and Other Pervasive Developmental Disorders. Autism Research, 5(3), 160–179. https://onlinelibrary.wiley.com/doi/10.1002/aur.239. https://doi.org/10.1002/aur.239

Fombonne, E., Marcin, C., Manero, A. C., Bruno, R., Diaz, C., Villalobos, M., Ramsay, K., & Nealy, B. (2016). Prevalence of Autism Spectrum Disorders in Guanajuato, Mexico: The Leon survey. Journal of Autism and Developmental Disorders, 46(5), 1669–1685. https://link.springer.com/article/10.1007/s10803-016-2696-6. https://doi.org/10.1007/s10803-016-2696-6

Gallardo Montes, C. del P., Rodríguez Fuentes, A., & Caurcel Cara, M. J. (2021). Apps for people with autism: Assessment, classification and ranking of the best. Technology in Society, 64, 101474. https://www.sciencedirect.com/science/article/abs/pii/S0160791X2031277X?via%3Dihub. https://doi.org/10.1016/j.techsoc.2020.101474

Gallardo-Montes, C. D. P., Caurcel-Cara, M. J., & Rodríguez-Fuentes, A. (2021). Diseño de un sistema de indicadores para la evaluación y selección de aplicaciones para personas con Trastorno del Espectro Autista. Revista Electrónica Educare, 25(3), 1–24. https://www.revistas.una.ac.cr/index.php/EDUCARE/article/view/12602. https://doi.org/10.15359/ree.25-3.18

García Guillén, S., Garrote Rojas, D., & Jiménez Fernández, S. (2016). Uso de las TIC en el Trastorno de Espectro Autista: aplicaciones. EDMETIC, 5(2), 134. http://www.uco.es/ucopress/ojs/index.php/edmetic/article/view/5780. https://doi.org/10.21071/edmetic.v5i2.5780

Heredia Oliva, E., & Navas, L. (2019). El uso del ipad con el programa AUGIE: ¿Mejora la comunicación de las personas con autismo? Revista de Discapacidad, Clínica y Neurociencias, 6(1), 44. https://revistes.ua.es/dcn/article/view/2019-n1-el-uso-del-ipad-con-el-programa-augie-mejora-la-comunicacion-de-las-personas-con-autismo. https://doi.org/10.14198/DCN.2019.6.1.04

INEGI. (2020). Instituto Nacional de Estadística, Geografía e Informática. XII Censo de Población y Vivienda. https://www.inegi.org.mx/app/areasgeograficas/#tabMCcollapse-Indicadores

Manouilenko, I., & Bejerot, S. (2015). Sukhareva—Prior to Asperger and Kanner. Nordic Journal of Psychiatry, 69(6), 1761–1764. https://www.tandfonline.com/doi/full/10.3109/08039488.2015.1005022. https://doi.org/10.3109/08039488.2015.1005022

OMS. (2022, March 30). Organización Mundial de la Salud. Trastornos Del Espectro Autista. https://www.who.int/es/news-room/fact-sheets/detail/autism-spectrum-disorders

Orellana, L. (2016). Actividades en las aulas de Comunicación y Lenguaje con niños/as con Trastorno del Espectro del Autismo. Una investigacion narrativa. ARTSEDUCA, 82–99. https://dialnet.unirioja.es/servlet/articulo?codigo=5443234

Weng, P.-L. (2015). Developing an App Evaluation Rubric for Practitioners in Special Education. Journal of Special Education Technology, 30(1), 43–58. https://journals.sagepub.com/doi/10.1177/016264341503000104. https://doi.org/10.1177/016264341503000104

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Application of simulation as an improvement proposal for the street sweeping process of a municipality in the High Mountains region

Aplicación de la simulación como propuesta de mejora para el proceso de barrido de calles de un Municipio de la región de las Altas Montañas

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Abstract

The following research is carried out in order to develop a sweeping model that allows efficiencies in the workforce of the Municipality of Orizaba, reducing the time of sweeping the routes and taking advantage of the resources available, facilitating decision-making for the relevant authorities through simulation. The project was carried out in three stages, contemplating the analysis of the initial information, which allowed us to study the scanning process, identifying the activities that are carried out and how they are carried out, the next stage consisted in the construction of the simulation model through SIMIO which allowed observing the behavior of the data collected, finally in the stage 3 that is currently being developed, an alternative is proposed to improve the scanning process, which will be implemented as a pilot test, as well as contributing to the design of a manual that allows standardizing this process.

Sweep process, Simulation, Sustainable Awareness

Resumen

La siguiente investigación se realiza con el fin de desarrollar un modelo de barrido que permita eficientar la mano de obra del Municipio de Orizaba, logrando disminuir el tiempo de barrido en las rutas y aprovechar los recursos que se tienen disponibles, facilitando la toma de decisiones para las autoridades correspondientes, a través de la simulación. El proyecto se realizó en tres etapas, contemplando el análisis de la información inicial, la cual permitió estudiar el proceso de barrido, identificando las actividades que se realizan y como se llevan a cabo, la siguiente etapa consistió en la construcción del modelo de simulación a través de SIMIO lo cual permitió observar el comportamiento de los datos recolectados, finalmente en la etapa 3 que actualmente se desarrolla, se propone una alternativa de mejora al proceso de barrido, la cual se implementará como prueba piloto, así mismo, se contribuirá con el diseño de un manual que permita estandarizar dicho proceso.

Barrido, Simulación, Conciencia Sustentable

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Objectives

General Objective

To design a simulation model of the sweeping service through the SIMIO application, in order to improve sweeping times, reducing operating costs and resources required by the Public Cleaning Department of the Municipality of Orizaba.

Specific Objectives

– Perform an initial diagnosis to identify the current state of the routes, through a study of times and movements of the sweeping process, considering the resources used and operating costs.

– Design the real model of the sweeping process in the SIMIO Simulation software, analyzing the variables of time, distance and working personnel.

– Build the simulation model with the sweeping process improvement alternative.

– Implement the pilot test of the simulation model alternative oriented to time reduction.

– Create the sweeping process manual to standardize times and activities.

Metodology

The research work was carried out based on the sweeping process carried out on routes 7 and 8 established by the Department of Public Cleanliness and Ecology during the 2022-2025 administration. Carrying out the analysis of the form of sweeping called "aircraft wing", which has been used in previous administrations to carry out manual sweeping of public roads, green areas, sidewalks, roads and parks.

The methodology is based on the one proposed by Law and Kelton (2000) which indicates the method that should follow the simulation process through the scientific method.

Stage 1 Analysis of initial information.

Stage 2 Simulation evaluation of the scanning process.

Stage 3 Pilot test of alternative scanning process improvement.

Contribution

Apply the simulation in order to model a real system of the street sweeping process, which presents to the Goverment Authorities a proposal for improvement, by minimizing the scanning times, contributing to better management of available resources

Introduction

Currently, the contamination and mismanagement of MSW represents a serious problem worldwide, since the lack of an adequate collection system can have serious consequences for public health. That is why several countries have sought to generate new ways to encourage the population to create an awareness of recycling and seek to generate less waste. Mexico is one of the countries with the most pollution problems in the streets, due to the lack of an environmental culture.

This represents an area of opportunity for the authorities to create programs that promote environmental awareness among citizens. Orizaba is a municipality that has worked to promote sustainable awareness, implementing actions and programs aimed at caring for the environment (Osenguenda R. 2021). The sweeping and public cleaning program, allows offering the inhabitants of the Municipality to transit through the streets without pollutants, providing clean recreational spaces, where children can play freely. (UV Orizaba, 2018)

These programs make the quality of life of the inhabitants better, by favoring services focused on the conservation, restoration and use of ecosystems and natural resources available. Therefore, this project seeks to offer a sweeping alternative that allows the efficient use of the resources available for such activity. In this way, the Public Administration of the City Council will be able to better manage the resources favoring the promotion of a sustainable culture in the citizens.

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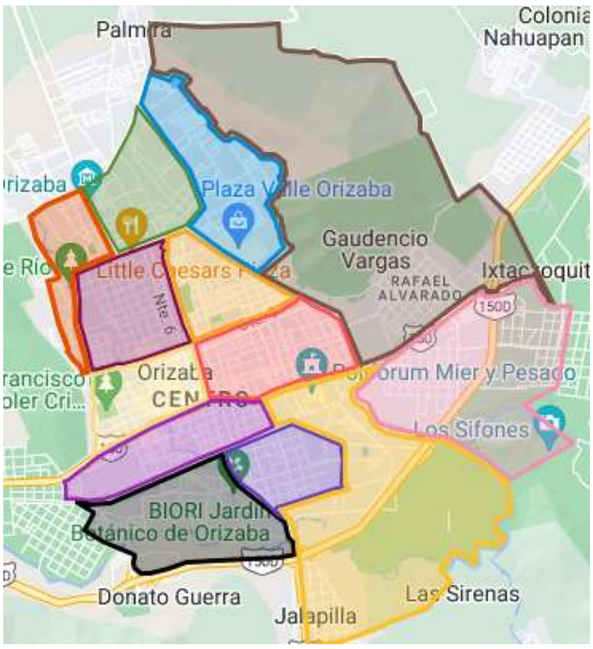

Figure 1 Sweeping routes Municipality of Orizaba

The municipality of Orizaba is divided into 13 routes, in which the sweeping process is carried out manually, with a staff of 54 employees and 4 supervisors, in two different shifts, morning and evening, working in the following schedules; the morning shift from 4 am to 1 pm and in the evening from 1 pm to 8 pm.

Methodology to be developed

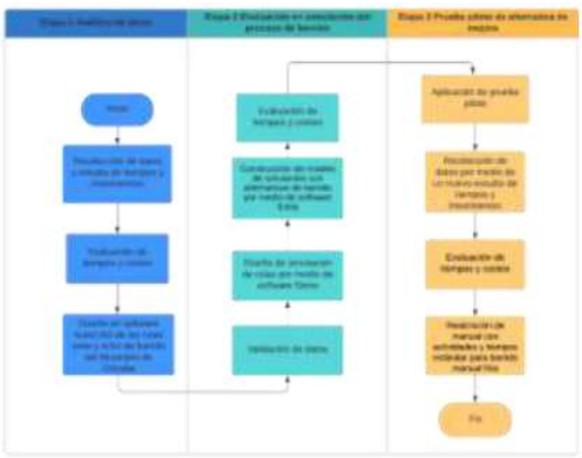

Figure 2 Methodology
Source: Prepared by the authors

Stage 1 Analysis of initial information

Data collection and time and motion study:

Within the first stage, the following activities were carried out; starting with data collection that was carried out by means of a study of times and movements of routes 7 and 8, which allowed for a more in-depth analysis of the activities that are carried out within the manual sweeping process. The main objective of the time and motion study is to eliminate or improve unnecessary tasks that can directly and indirectly affect the productivity and quality of the process (Salvendy G. 2001). Since this tool allows to analyze the processes, breaking them down to determine which are the activities, tasks or specific steps to complete the final process (Render B. 2009).

Time and cost evaluation: Subsequently, an evaluation of the costs that were provided by the Department of Public Cleaning was performed, to analyze the economic shrinkage that the process currently has, this table can be seen in Figure 4 Economic shrinkage.

Design in AutoCAD Software of the sweeping routes 7 and 8 of the Municipality of Orizaba:

The design of the streets of the Municipality of Orizaba was performed in DWG format, using the AutoCAD program, this software allows creating 2D and 3D models, having a higher precision to work with the plans more accurately (Seys S. 2019). This software is compatible with SIMIO software, and allows exporting the plan, generating the layout to be used as a basis for the design. The plan covers sweeping routes 7 and 8, starting from the exit point, which is located at 440 Poniente 10 Street, Lourdes, in the Municipality of Orizaba, and considers the streets Oriente 9, Oriente 7, Oriente 5, Oriente 3, Colón Street, Oriente 2 and Oriente 4.

Stage 2 Evaluation in simulation of the sweeping process

Data validation:

By means of MINITAB software, which is a statistical tool with a user-friendly interface that is focused on data analysis and process improvement based on the implementation of quality control tools and SIX SIGMA (Minitab).

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Therefore, the data analysis of the time and movement study was carried out considering the time variable in relation to the distance, in order to analyze the probability distribution to which this variable adjusts. In the first instance, descriptive statistics data were obtained, with a total of 265 data, a minimum of 0.317 minutes and a maximum of 15.083 minutes, which corresponds to the time it takes operators to sweep one linear meter of the routes.

Estadísticas

Variable	N	N*	Media	Error estándar de la media	Desv.Est.	Mínimo	Q1	Mediana	Q3	Máximo
Tiempo total	265	0	4.208	0.158	2.574	0.317	2.492	3.717	5.367	15.083

Figure 3 Descriptive statistics
Source: Own Elaboration

An individual distribution identification test was applied, which includes a Chi-square test and the Anderson Darling test, which determines the distribution to which the data best fit, which can be observed in the probability graph, in the time variable. Therefore, when analyzing the goodness-of-fit test, it is concluded that it resembles a normal distribution.

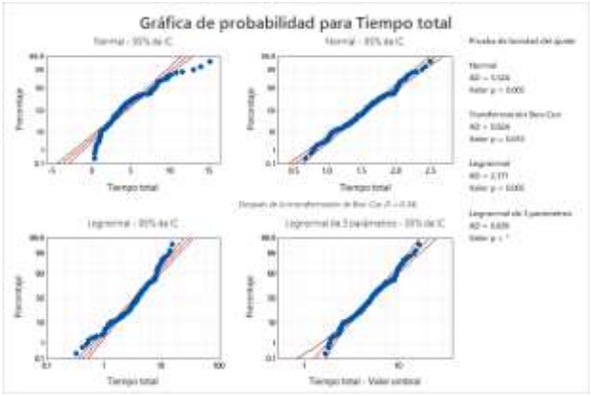

Figure 4 Distribution identification test
Source: Prepared by the authors

According to the value of the Anderson-Darling (AD) normality test that can be observed in the graph, with a total of 5.524, it is greater than the significance level of .005 having the following hypothesis; $P > \alpha$: Therefore, it is concluded that there is sufficient evidence to say that the data follow a normal distribution.

Design of route simulation by means of SIMIO software:

The construction of the simulation model was based on SIMIO, which is a software for modeling, simulation and 3D animation of process flows that allows modeling the behavior of logistic, industrial and service systems, that is, of a real or imaginary system, which in this case is the sweeping process of the established routes (Simio). The basis used for this model was the AutoCAD layout, which recreates the path followed by the operators, comparing it with the real times obtained in the study of times and movements.

Construction of the simulation model with the sweeping alternative:

In this section, the sweeping alternative is proposed, which seeks to reduce the time that the workers spend during the street sweeping route. The next step to be carried out in conjunction with the Department of Public Cleaning will be to implement the pilot test in order to validate the model.

Results

By means of the study of times and movements, the results shown in Table 1 were obtained. The minimum total travel time is 8 hours and 25 minutes, while the maximum time is 9 hours and 21 minutes. This table allowed a more in-depth analysis to establish the dead and effective times.

Calles	Tiempo de recorrido	Demoras	Tiempo de ocio	Tiempo efectivo	Distancia
Oriente 9	8:25:12	1:08:28	38.28	7:16:44	7783.66
Oriente 7	8:55:49	01:25:44	55.44	7:30:05	9000.63
Oriente 5	8:53:14	0:40:14	10.14	8:13:00	6238.1
Oriente 3	9:21:00	01:12:22	42.22	8:08:38	8273.09
Colón	8:38:45	01:06:40	36.4	7:32:05	7832.66
Oriente 2	9:07:25	01:01:43	31.43	8:05:42	7803.87
Oriente 4	9:04:09	0:57:30	27.3	8:06:39	12132.44
Promedio	8:55:05	1:04:40	34.46	7:50:25	8437.78

Table 1 Travel time of the streets
Source: Own Elaboration

Based on the analysis of times and movements, a process flow diagram was obtained, which can be seen in Figure 5. This diagram shows the activities performed by the operator from the time he arrives at the base work area until he finishes the manual sweeping of the route assigned to him.

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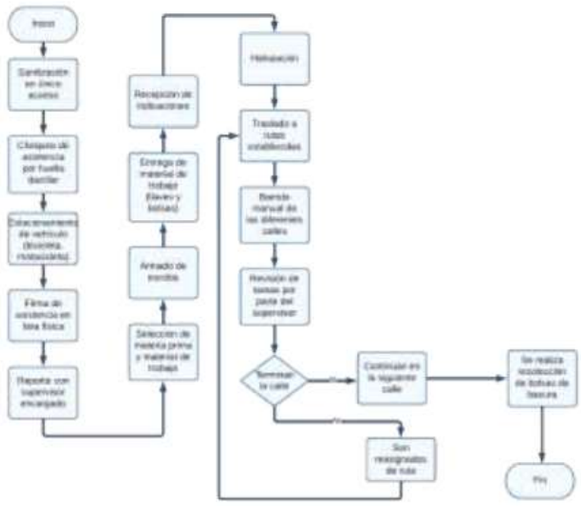

Figure 5 Sweeping process diagram
Source: Own Elaboration

Looking at Table 2, an analysis of idle time versus effective time was established, and it was found that there is a monthly economic loss of $5,441.70 pesos, which is equivalent to the salary of an average operator. This indicates that there is an economic loss in the manual sweeping process, which is an area of opportunity for improvement.

Calles	Tiempo de recorrido	Demoras	Tiempo de ocio	Tiempo efectivo	Distancia	Demoras en minutos	Costo por demoras	Merma económica
Oriente 9	8:25.12	1:08.28	36.28	7:16.44	7785.66	68.28	$ 64.18	$ 35.98
Oriente 7	8:55.49	01:25.44	55.44	7:30.05	9030.63	85.44	$ 80.31	$ 52.11
Oriente 5	8:53.14	0:48.14	10.14	8:13.00	6238.1	48.14	$ 37.73	$ 9.93
Oriente 3	9:21.00	01:12.22	42.22	8:08.38	8273.09	72.22	$ 67.89	$ 39.69
Costa	8:36.46	01:06.40	36.4	7:32.05	7832.66	66.4	$ 62.42	$ 34.22
Oriente 2	9:07.26	01:01.43	31.43	8:05.42	7803.67	61.43	$ 57.74	$ 29.54
Oriente 4	9:04.09	0:57.30	27.3	8:06.39	12132.44	57.3	$ 53.86	$ 25.66
Promedio	8:55.05	1:04.40	34.46	7:50.25	8437.79	64.46	$ 60.59	$ 32.39
						Total	$ 424.14	$ 226.74
						Mensual	$ 10,179.30	$ 5,441.70
							Anual	$ 65,300.37

Table 2 Economic loss
Source: Own elaboration

Figure 6 shows the sweeping model, which was developed using SIMIO software, where areas of opportunity were found, which allowed the development of a new sweeping alternative.

Figure 6 Sweep program layout
Source: Own Elaboration

To perform the validation of the runs that were run in the SIMIO program, the N¨B Test was developed, which allows to know the optimal number of runs so that the data are closer to the real ones. Using the following parameters:

			Var=	4.539220988			
			α=	0.1			
			β=	0.7			
Corridas	Valor de t		√var/i			Comprobación	
i= 6	2.015048373	x	0.869791257	=	1.752671458	≤ β : 0.7	NO
i= 7	1.943180281	x	0.805270229	=	1.564785229	≤ β : 0.7	NO
i= 8	1.894578605	x	0.753261325	=	1.42711279	≤ β : 0.7	NO
i= 9	1.859548038	x	0.710181588	=	1.320616778	≤ β : 0.7	NO
i= 10	1.833112933	x	0.673737411	=	1.235036761	≤ β : 0.7	NO
i= 11	1.812461123	x	0.642383416	=	1.164294968	≤ β : 0.7	NO
i= 12	1.795884819	x	0.615035296	=	1.104532552	≤ β : 0.7	NO
i= 13	1.782287556	x	0.590906799	=	1.053165835	≤ β : 0.7	NO
i= 14	1.770933396	x	0.569412039	=	1.008390797	≤ β : 0.7	NO
i= 15	1.761310136	x	0.550104292	=	0.968904266	≤ β : 0.7	NO
i= 16	1.753050356	x	0.532636191	=	0.933738064	≤ β : 0.7	NO
i= 17	1.745883676	x	0.516733006	=	0.90215572	≤ β : 0.7	NO
i= 18	1.739606726	x	0.502174217	=	0.873585645	≤ β : 0.7	NO
i= 19	1.734063607	x	0.48878049	=	0.84757646	≤ β : 0.7	NO
i= 20	1.729132812	x	0.476404292	=	0.823766293	≤ β : 0.7	NO
i= 21	1.724718243	x	0.464922983	=	0.801861151	≤ β : 0.7	NO
i= 22	1.720742903	x	0.45423367	=	0.781619363	≤ β : 0.7	NO
i= 23	1.717144374	x	0.444249293	=	0.762840174	≤ β : 0.7	NO
i= 24	1.713871528	x	0.434895629	=	0.745355235	≤ β : 0.7	NO
i= 25	1.71088208	x	0.426108953	=	0.729022171	≤ β : 0.7	NO
i= 26	1.708140761	x	0.417834205	=	0.713719636	≤ β : 0.7	NO
i= 27	1.70561792	x	0.410023531	=	0.699343482	≤ β : 0.7	i es el número óptimo de corridas

Table 3 Number of optimal runs
Source: Own Elaboration

Based on these results, it was found that the number of runs that allows the model to have statistical validity is 27, as shown in Table 3.

Based on the analysis carried out jointly with the experts (who carry out the sweeping process), a sweeping alternative was developed by means of the SIMIO software, which can be seen in Figure 9.

Figure 7 Alternative layout of swept form
Source: Own Elaboration

In order to develop the proposal, a graphic analysis was made on different alternative ways, based on this, the simulation model was developed, which can be seen in Figure 9, based on the data obtained through the simulation, the estimated sweeping time applying this model is 7 hours 35 minutes 18 seconds. Having a shorter process time compared to the sweeping time with the current form.

Compared to the sweeping time of 8 hours 25 minutes 12 seconds for the current sweeping time on East 9th Street, there is a total reduction of 1 hour, 9 minutes and 54 seconds.

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Calles	Tiempo de recorrido	Demoras	Tiempo de ocio	Tiempo efectivo	Distancia	Demoras en minutos	Merma económica
Oriente 9 Forma actual	08:25:12	01:08:28	38.28	07:16:44	7783.66	68.28	$35.98
Oriente 9 forma alterna	07:35:18	01:08:28	38.28	06:34:22	8627.09	35	$32.90

Table 4 Cost comparison
Source: Own Elaboration

Based on table 4 of cost comparison, we can see that there is a decrease in the cost per delay, having an economic loss of $32.00 pesos, compared to the economic loss of the way they currently perform, with a cost of $35.98 pesos. This will lead us to have a monthly saving of $789.60 pesos, being the monthly salary of an operator.

Future work

Future work is based on the application of the pilot test with the proposed alternative, during which the time study will be carried out to validate the model, also considering the costs, in order to evaluate the results obtained and compare them with the "airplane wing" sweeping method currently used. For this pilot test we will work together with the sweeping personnel of the public cleaning coordination of the Municipality of Orizaba.

Another of the objectives is that based on the new modifications that have been carried out in the sweeping process, a manual will be created, where work instructions will be developed, as well as procedures and technical references that will allow both operators and supervisors to develop the sweeping process in a better way.

Thanks

I am grateful to the Tecnológico Nacional de México, Instituto Tecnológico de Orizaba, for allowing me to pursue my studies in the Master's Degree in Administrative Engineering, as well as to Gabriela Cabrera Zepeda, M.C., for her support and dedication in the direction of this research.

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Conclusions

The application of the time and motion study allowed the development of the process diagram, identifying the activities that are performed in the sweeping process. Likewise, through the simulation, it was possible to model the real system, analyzing the variables that intervene with the purpose of standardizing the times, favoring the use of resources (labor and inputs). The realization of the simulation model in the alternative way, allowed to achieve the initial objective of the project, which is to reduce the time and resources required to perform the sweeping process, allowing to focus on new projects that allow to continue with the work of the Municipality of Orizaba, seeking to promote a sustainable awareness in the population.

The use of SIMIO software in its academic version allows modeling complex systems where different factors are integrated, managing to recreate the process being studied, through capturing and describing the system, simulating it and at the end it is possible to obtain a 3D animation that allows the user to understand it in a better way. (Simio, 2022).

The contribution of this research project is aligned with the National Strategic Program in Socioecological Systems and Sustainability (Pronaces-SSyS), because it is oriented to the proposal of an alternative that allows minimizing costs in terms of labor associated with shifts and schedules of workers, as well as the resources used in the sweeping process, favorably impacting the public cleaning service and thus the authorities can visualize and exercise new projects for the benefit of the environment favoring sustainable awareness in citizenship.

References

Gobierno de Orizaba (2019) Reglamento de Limpia Pública para el Municipio de Orizaba, Veracruz, de Ignacio de la Llave. Recuperado de:http://sipot.orizaba.gob.mx:9000/rpc/cat/JURIDICO/Fracci%E2%89%A4n%20I/Reglamento%20de%20Limpia%20Publica%20Para%20el%20Municipio%20de%20Orizaba.pdf

Law, Averill M.(2000) Simulation Modeling and Analysis. McGraw-Hill, Third Edition, USA.

ISSN 2410-3438

Osegueda R. (Junio, 2021) Orizaba gana la Escoba de Oro por ser la ciudad más limpia. Recuperado de: https://www.mexicodesconocido.com.mx/orizaba-gana-laescoba-de-oro-por-ser-la-ciudad-mas-limpia.html

PVT Group (2019) ¿Qué es la optimización de rutas? Recuperado de https://company.ptvgroup.com/fileadmin/Resources/Resources-Library/ES/White-Papers/ptv_libro_blanco_que_es_la_optimizacion_de_rutas.pdf

Render B. & Heizer J. (2009) Principios de administración de operaciones. Mexico, D.F. : Pearson Educacion.

Salvendy G, Handbook of Industrial Engineering. Hoboken, NJ, USA: John Wiley & Sons, Inc.(2001) Accedido el 4 de agosto de 2022. Recuperado de: https://doi.org/10.1002/9780470172339

S. SEYS.(2019) Ventajas de AutoCAD respecto a otros programas de diseño CAD - SEYS. SEYS.Recuperado de: https://seystic.com/ventajas-autocad-comparativa-softwares-cad/

Simio (2022) Simio:Simulación de procesos. Recuuperado de https://www.simio-simulacion.es/

S. Minitab.(s.f.) Software: Minitab. Addlink Software Científico. Recuperado de: https://www.addlink.es/productos/minitab-statistical-software

S. Simio. (s.f.) Simio – DSIC. DSIC – Dirección de Servicios de Informática y Comunicaciones.Recuperado de: https://dsic.pucv.cl/?page_id=3119

UV Orizaba (2018) Basura y Predial Reciclar te hace Ganar. Recuperado de https://www.uv.mx/orizaba/cosustenta/files/2014/05/Programa-BYP-Mpio-de-Orizaba.pdf

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Institutional Affiliation of Author including Dependency (No.10 Times New Roman and Italic)

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Abstract (In English, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In English)

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Abstract (In Spanish, 150-200 words)

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Introduction

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

What is your added value with respect to other techniques?

Clearly focus each of its features

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

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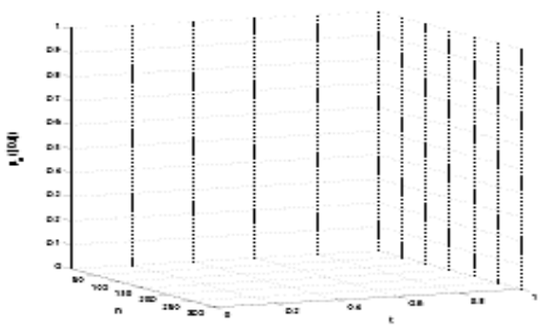

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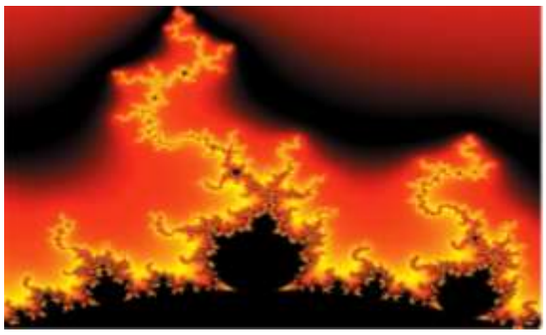

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