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Circular economy approach to recycling of high-density polyethylene (HDPE) for the production of pet products

Abordagem de economia circular para a reciclagem de polietileno de alta densidade (PEAD) para a produção de produtos para animais de estimação

Enfoque de economía circular para el reciclado de polietileno de alta densidad (PEAD) destinado a la fabricación de productos para mascotas

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The article is original because it presents a practical and replicable empirical result, in addition to assisting the literature with new results, it can inspire future research and action projects for HDPE recycling.

ABSTRACT

The generation of waste remains a constant in anthropogenic activities, particularly inorganic waste, which poses significant threats to living organisms due to its slow degradation in the environment. This study, conducted in Zamora, Michoacán, Mexico, proposes the recycling of high-density polyethylene (HDPE) within a circular economy framework, reintroducing this waste as raw material for new processes to produce pet products. The objective is to generate positive environmental impacts by reducing inorganic solid waste, social impacts by providing the population with new pet products, and economic impacts by reusing inert HDPE material. An experimental design with an artisanal basis was employed, generating empirical knowledge and applying critical thinking to validate the results. The study successfully produced a range of pet products, including identification tags and food and water containers, achieving a categorization of these products. The results presented in this paper are expected to be a practical contribution to sustainable development and recycling discussion, a necessary task for the green growth of economies, especially in developing countries.

Keywords: circular economy, pets, HDPE, products, recycling.

RESUMO

A geração de resíduos continua sendo uma constante nas atividades antrópicas, principalmente os resíduos inorgânicos, que representam ameaças significativas aos organismos vivos devido à sua lenta degradação no meio ambiente. Este estudo, realizado em Zamora, Michoacán, México, propõe a reciclagem do polietileno de alta densidade (PEAD) no âmbito de uma economia circular, reintroduzindo estes resíduos como matéria-prima para novos processos de produção de produtos para animais de estimação. O objetivo é gerar impactos ambientais positivos através da redução de resíduos sólidos inorgânicos, impactos sociais ao fornecer à população novos produtos para animais de estimação e impactos econômicos através da reutilização de material inerte PEAD. Foi empregado um desenho experimental de base artesanal, gerando conhecimento empírico e aplicando pensamento crítico para validar os resultados. O estudo produziu com sucesso uma gama de produtos para animais de estimação, incluindo etiquetas de identificação e recipientes para comida e água, conseguindo uma categorização destes produtos. Espera-se que os resultados apresentados neste artigo sejam uma contribuição prática para o desenvolvimento sustentável e a discussão sobre reciclagem, uma tarefa necessária para o crescimento verde das economias, especialmente nos países em desenvolvimento.

Palavras-chave: economia circular, animais domésticos, PEAD, produtos, reciclagem.

RESUMEN

La generación de residuos sigue siendo una constante en las actividades antropogénicas, principalmente los residuos inorgánicos que por no ser asimilados en el medio ambiente de manera rápida son los que presentan mayor afectación a los seres vivos. La presente investigación fue desarrollada en la ciudad de Zamora, Michoacán, México y propone el reciclaje del PEAD con enfoque de economía circular, es decir, que vuelva a introducirse ese residuo como una materia prima en otro nuevo proceso donde el resultado final sea un producto para mascotas, lo anterior con el objetivo de generar impacto positivo en el aspecto ambiental por la disminución de residuos sólidos inorgánicos, impacto social por tener la población un nuevo producto de uso en sus mascotas, e impacto económico por aprovechar las condiciones inertes de la materia PEAD para ser nuevamente reutilizado. En esta investigación se empleó un diseño experimental con base artesanal, que generó conocimiento empírico y se aplicó pensamiento crítico para validar los resultados. Como resultados se obtuvieron una serie de productos para mascotas como son placas de identificación y recipientes para comida y bebida de las mascotas, logrando tener una categorización de dichos productos. Se espera que los resultados presentados en este articulo sean una contribución práctica al debate sobre el desarrollo sostenible y el reciclaje, una tarea necesaria para el crecimiento verde de las economías, especialmente en los países en desarrollo.

Palabras clave: economía circular, mascotas, PEAD, productos, reciclaje.

INTRODUCTION

The research stems from the need to reduce the negative environmental impact generated by the high consumption of plastic once it has been used. Forbes Mexico (2021) mentions that the National Association of Plastic Industries (ANIPAC) reported that the apparent consumption of resins in Mexico was 6 million 933 thousand tons in 2020, where HDPE was a participant with 1 million 202 thousand tons, once it is used, most of it becomes garbage where it finally ends up in the streets, landfills, rivers, lakes, seas, etc. This has a direct impact on the environment. This shows the importance of giving a second use to this material, reducing the pollution it generates. In addition, thanks to the characteristics that HDPE has, it is possible to convert it into new products.

Background HDPE

High-density polyethylene as presented by Roca (2005) was created in 1953 by Karl Ziegler and his collaborators at the Max Planck Institute, based on the work initiated by the Italian Natta, who studied the polymerization process at low pressure. The reaction with a catalytic complex of aluminum and titanium tetrachloride resulted in the production of a polyethylene of higher density and melting temperature, as a consequence of its greater regularity. This polyethylene was called high density polyethylene (HDPE), due to its properties, or low pressure polyethylene, due to its method of production. Two years later, in 1955, the first factory of this material was inaugurated in Germany.

Roca (2005) also reports that simultaneously the Phillips Petroleum Co. in the USA was developing an industrial process to obtain high-density, highly crystalline polyethylene using medium pressures and chromium oxide supported on silica as a catalyst. The first industrial plant was set up in Pasadena in 1957.

The HDPE in the current context

The evolution of humanity for Herrera et al (2024) has been driven by advances in society, science and technology, has had a significant impact on Mother Earth or nature, resulting in serious effects on the environment, ecosystems and biodiversity. In this context the HDPE has been a direct contributor to contemporary issues.

Over the years, POLNAC (2022) states that HDPE has become one of the most consumed plastics at international level, reaching an estimated value of $74.5 billion U.S. dollars, and the trend is for it to continue to rise, as a result of estimates that show that by 2027 its value will reach $97.4 million U.S. dollars.

Envaselia (2018) explains that high-density polyethylene (HDPE) is a type of thermoplastic polymer that is characterized by its high strength, durability and versatility. It is produced from the polymerization of ethylene and is obtained through a chain polymerization process. HDPE is important for several reasons, as it is one of the most important plastics to recycle, it avoids the production of new plastics and reduces waste. It is important to be responsible with the use of HDPE as it is often unnecessary consumption and look for more sustainable alternatives with the same characteristics, you should have the same properties, such as flexibility, which makes it ideal for a wide range of applications, obtaining the efficiency, durability and safety of the products.

La Razón de México (2021) interviewed the president of the National Association of Plastics Industries (ANIPAC) who announced that in 2020 almost half of the consumption and production of plastic materials in Mexico will be directed to short-life products, an action that is very similar worldwide.

The reuse and recycling of plastic materials according to Méndez (2021) has proven to play an important role in the transition path towards a circular economy. It is important to promote and facilitate recycling programs to ensure that HDPE products reach recycling centers instead of being disposed of in landfills, this will help reduce pollution levels and the consequences it brings in itself, since it is preferable to give another chance to what already produced, there are a variety of products that can be manufactured with them, there is just not the necessary support to make them.

HDPE has transformed various industries from construction and packaging to automotive and agriculture as demonstrated by Rojas (2023), it is used in various industries due to its properties and benefits. Some of the most common applications of HDPE are: Containers and packaging, piping and conduction systems, automotive industry, construction industry, chemical industry, among others.

HDPE and recycling trends in international literature

Recycling HDPE (High-Density Polyethylene) is an essential strategy in mitigating environmental issues associated with plastic waste. Blanco et al. (2024) delve into the circularity of post-consumer HDPE milk bottles through open-loop recycling and assess their environmental impacts. The study emphasizes mechanical recycling and highlights the significant contamination challenges posed by polypropylene (PP), a common issue in mixed plastics recycling. They suggest blending with virgin HDPE and using compatibilizers to enhance recyclability. The environmental benefits of incorporating recycled

HDPE are evident, showing reductions in the carbon footprint when compared to using virgin materials.

Singh et al. (2017) provide a comprehensive review of plastic solid waste (PSW) recycling, discussing various methods and their effectiveness. The paper emphasizes the challenges posed by the vast amounts of plastic waste generated daily and the need for effective recycling strategies. The authors explore different recycling methods and their impacts on the properties of recycled materials, highlighting the potential for using recycled HDPE in new applications.

Chamas et al. (2020) discuss the degradation rates of plastics in the environment, stressing the importance of mechanical recycling to address the environmental challenges posed by short-lived HDPE products like milk bottles. The study highlights the barriers due to polyolefin incompatibility in mixed plastics recycling and suggests practical solutions such as blending with virgin materials and using compatibilizers.

Dahlbo et al. (2018) evaluate the recycling potential of post-consumer plastic packaging waste in Finland, with a focus on the mechanical and rheological properties of recycled HDPE. Their findings indicate that even plastic wastes from mixed municipal solid waste (MSW) can be valuable raw materials. The study underscores the high recycling potential of MSW plastics, particularly HDPE, and the need for dedicated sorting facilities to optimize recycling outcomes.

The present study aligns with the literature by focusing on the practical application of recycled HDPE within a circular economy framework to produce pet products. By employing an experimental design with an artisanal approach, this research generates empirical knowledge and validates its findings through critical analysis. The production of pet products such as identification tags and food and water containers not only reduces inorganic solid waste but also provides social and economic benefits.

The HDPE and the circular economy

The concept of circular economy is not an incipient topic, although it is still an area of opportunity to be implemented, Delgado (2019) defines circular economy as a system that proposes to make the most of resources, through the use of materials with biodegradable characteristics and also to reuse as much as possible those that cannot return to the cycle of nature.

The definition by Barrera et al (2022) is taken as a reference, which defines the circular economy as that which in its focus and main strategy uses the reduction of waste based on the use of its properties, in order to be incorporated again as raw material or product, allowing the satisfaction of needs as many times as possible.

In this sense, this research seeks to answer the following questions: How can the circular economy be applied to HDPE to generate a product for domestic use? Here is where the proposal of recycling HDPE for productive purposes in pet articles is born, another question is the following: Is it possible to reduce the pollution generated by plastic waste (HDPE)? Recycling helps that all used plastic does not end up in soils, rivers, seas, etc., reducing the pollution that HDPE generates in the environment.

In addition, the development of new products generated based on HDPE recycling will contribute in that no new material will have to be used for its manufacture decreasing the use of reprocessing it to give it a second life as products for pets, this avoids the production of new plastics allowing the reduction in the amount of waste that reaches the landfills. The recycling of plastic materials has proven to play an important role in the transition towards a circular economy, which makes it an extra benefit for society.

The main purpose of the researchers is to generate a positive impact on the environment of the region, because derived from bad anthropogenic practices, the environment has been exploited and affected negatively, one of the main problems is the huge amount of plastic that pollutes the environment, it is estimated that plastic (HDPE) takes between 100 and 1,000 years to decompose, it is considered a material of very slow decomposition and long term, it is the most used organic compound worldwide, so its presence in daily activities is more than evident. This research seeks to generate products for pets based on recycled HDPE, to give it a second life, so that it does not end up polluting the soil or water in the region, the process of making the products is sought to be sustainable.

Empirical HDPE plastic recycling in Latin America.

There are several cases in developing countries as it is within Latin America that have made an approach to plastic recycling, although in many of these is born with an empirical aspect, the purpose is to generate better conditions for the region and with a vision for the future, for example, Arce-Bastias (2022) demonstrates how the mechanical recycling of plastic, In her study, her objective was to evaluate the environmental performance of plastic recycling for the production of poles in Mendoza, allowing the generation of a product of common use within the Argentine population.

Another interesting case to mention is that of Rodríguez et al (2015) through a proposal of a procedure for the recycling of high density polyethylene (HDPE) in the municipality of Holguín in Cuba, as results of their research, the proposal

of a procedure for the environmental management of plastic waste, validated by means of an experiment, stands out. The recycled material obtained as a result of the proposal presents an acceptable quality and is suitable for different uses, which was demonstrated through its structural, thermal and mechanical characterization. Although they do not present a specific product as such, they make clear the effective possibilities for the use of HDPE.

Gau and Zamboni (2023) show how the recycling of plastics in Uruguay does not escape the reality lived in their discards, processes and possible utopian futures, their study was limited to the city of Las Piedras in the department of Canelones, in this aspect they present how thanks to the recycling of plastic derivatives such as HDPE, they obtain "lockers" that according to the technicality of this area, are containers that serve as utensils for use or shelter as they are commonly called boxes in other countries.

Garcia et al (2018) presented a study in Mexico to recycle bottle cap plastics and automotive fenders with a glass fiber reinforcement to manufacture household sewers through an experimental arrangement considering caps as the main resin, varying the concentration of glass fiber and automotive fender plastic.

Also in Mexico, Solis and Santa Ana (2022) generated the design of a composite material, with recycled high density polyethylene matrix, reinforced by short glass fiber class E, with the objective of producing structural profiles to be used in reinforcements for light roofs of large span. Giving another additional use to HDPE even in the construction industry, showing how the use of HDPE can be used in various applications.

MATERIALS AND METHODS

For the development of this research, the empirical method was used, which according to Rodriguez and Perez (2017), the empirical method means referring to experience, it refers to the use of the senses, both in the observation of objects and phenomena and in the experimentation or physical manipulation of them, the senses and the physical aspect of things are in the foreground of attention.

For the classification of the research, the definitions of Hernández and Mendoza (2018) are used, giving it a mixed approach, with an exploratory scope and an experimental design. The above as a result of the fact that experimental designs were started empirically and through the design of the researchers in the application of the process.

According to Hernández and Mendoza (2018), exploratory studies are conducted when the purpose is to examine a new or little-studied phenomenon or research problem, about which there is considerable doubt or which has not been addressed before. That is, when the literature review revealed that there are only unresearched guidelines and ideas vaguely related to the study problem, or if it is desired to inquire about topics and areas from new perspectives.

Vázquez (2020) says that these studies are generally carried out when the object is to examine a topic or research problem that has been little studied or for which there is no previous information. That is, when the literature review revealed that there are only vaguely related ideas to the problem, for example, if someone wants to investigate what the inhabitants of a commune think about the new mayor.

Regarding experimental research, Vasques (2020) highlights that the essence of this conception of experiment is that it is required to intentionally manipulate an action to analyze its possible results. This aspect was carried out in this research because it was necessary to experiment with the HDPE to obtain the desired objective.

For Baena (2018) experimental research is presented due to the manipulation of an untested experimental variable, which complies to be in rigorously controlled conditions, the above with the purpose of describing in what way or cause a particular event or situation occurs. In experimental designs, the researcher is not only in practical conditions to carry out an experiment, but also knows, to a large extent, the nature of the phenomenon under investigation.

According to Hernández et al (2014), an experiment is one that presents more harmonious characteristics with a scientific sense of the term, it refers to a study in which one or more independent variables (supposed antecedent causes) are intentionally manipulated, to later analyze the consequences that the manipulation has had on one or more dependent variables (supposed consequent effects), this within a controlled situation for the researcher.

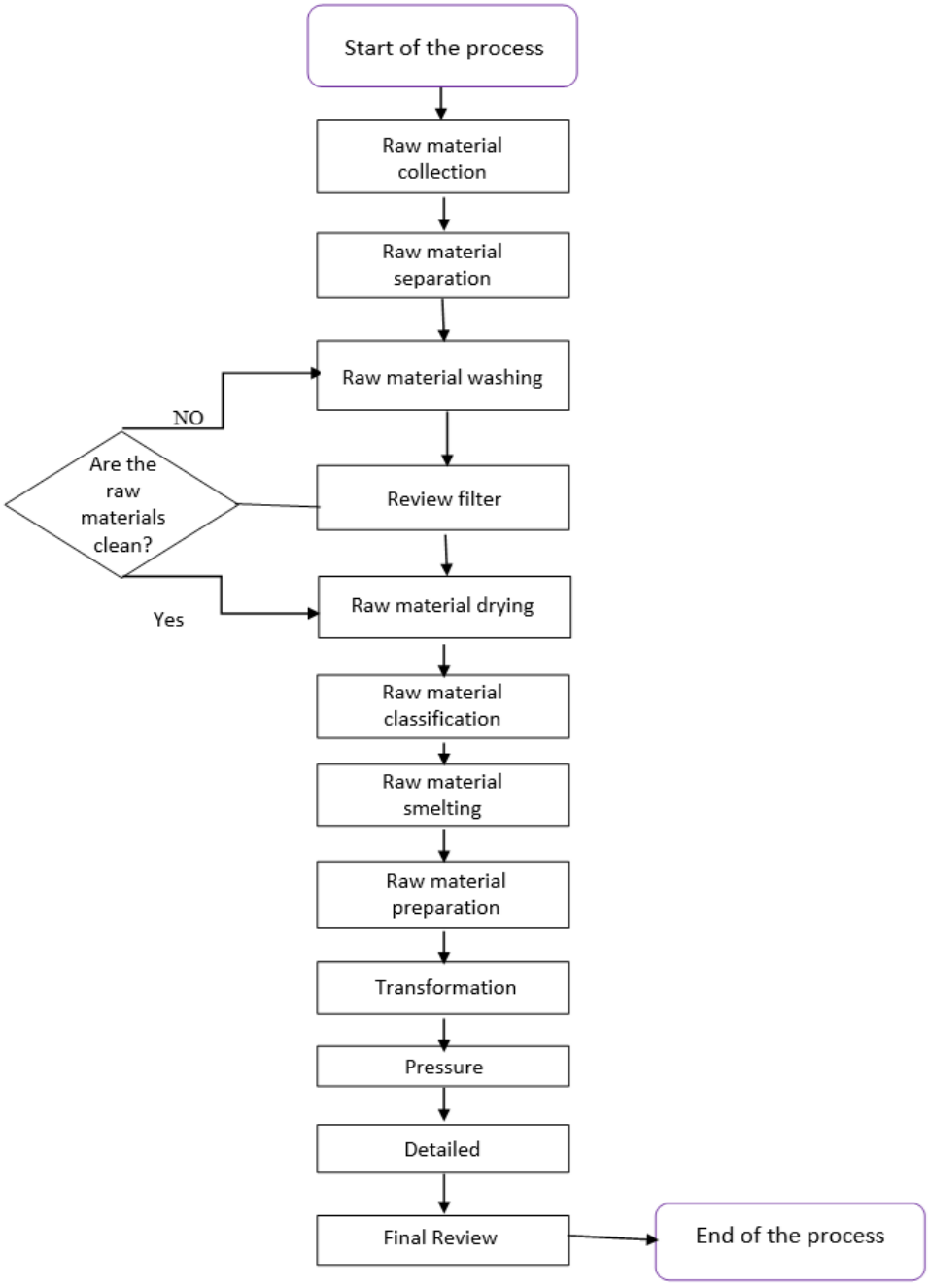
As a research technique, participant observation was also used, as reported by Vásquez (2020), it is necessary to distinguish between "observation" and "participant observation". The former is a technique for collecting data on non-verbal behavior, while the latter refers to something more than mere observation, i.e., it implies the direct intervention of the observer, so that the researcher can intervene in the life of the group. Participant observation is understood as that in which the observer actively participates within the study group, identifying with it in such a way that he/she considers it as one of

the members of the group.

According to Bustos (2009), artisanal production produces objects by transforming basic natural raw materials through non-industrial production processes that involve simple machines and tools with a predominance of physical and mental labor. This aspect was used in this research because it does not use industrialized machinery or sophisticated manufacturing.

For the objective analysis of results, critical thinking was used, Mackay et al (2018) indicates that critical thinking is that skill that people develop as they grow professionally and in their studies, and through which it allows them to make an accurate decision-making process, due to the decisive capacity they have gained from the growth in personal and professional knowledge and experiences. Based on the experimental and empirical design of the research, the following artisanal production method for the recycling of HDPE was determined (Figure 1 and Table 1):

Figure 1. Recycling process of HDPE into proposed products.



Note. Own elaboration (2024)

Table 1. Description of the HDPE recycling stages in proposed products.

Step	Description
Start process	Start of the manufacturing process of a plate.
Collection	Collect our raw material (HDPE).
Separation	Separate the raw material with the number 2 and/or the word HDPE.
Washing	The raw material is then washed with neutral soap (unscented and colorless) and hot water. In this stage all residues or dirt that the raw material may have are removed.
Review	In this filter the lids are reviewed in detail, to decide whether to co ntinue with the process.
Is the material clean?	If the raw material is not accepted, it returns to the washing area. If it is accepted, it goes to the drying area.
Drying	The washed and approved lids are dried, completely removing any remaining water.
Classification	The raw material must be classi fied by color in order to have an order and knowledge of the available raw material, optimizing time.
Smelting	In the panini plate, place the requested raw material and the required amount in the middle of two Teflon sheets, to prevent them from sticking to the plate, make use of the required safety equipment and leave it for approximately 35 to 40 minutes until the plastic obtains a flexible consistency.
Preparation	The aluminum molds are prepared by brushing a layer of vegetable oil on the outside of one and the inside of the other so that the plastic can be emptied without sticking.
Transformation	Once the desired con sistency is obtained and after preparing the molds, the mixture is taken and placed inside the molds.
Pressure	Subsequently, pressure must be applied on the molds so that the plastic can be molded to the shape of the plates and wait 20 minutes to dry before removing it from the molds.
Detailed	Excesses and/or imperfections are eliminated using the tools.
Review and labeling	Perform final review and labeling.
End process	Completion of the process

Note. Own elaboration (2024)

Using an artisanal process, the corresponding human factor was used throughout the development, the person delegated generated a validation that the waste collected complied with the conditions of being HDPE and not another plastic derivative, in order to maintain the focus of this research, that is, not to deviate in analyzing other inorganic solid waste that had not been initially determined. Figure 2 illustrate that step.

Figure 2. Artisanal HDPE separation

Note. Own elaboration (2024)

For the melting process, electric sandwich machines were used since this allowed to melt the HDPE in an adequate way, although it is not the main purpose of this work, it is worth suggesting to always keep the care of wearing the personal protection equipment as shown in the images to guarantee the safety of the human factor (Figure 3 above).

Figure 3. Casting of HDPE using an empirical handcraft method

Note. Own elaboration (2024)

Due to the melting of HDPE, a mass with the ability to be malleable was obtained, this allows the mass of HDPE can be adjusted to various desired shapes, a metal mold was used to put the molten HDPE to fit the mold, that allowed to obtain the shape previously determined for the required product, then only had to let dry the mass and the final product would be obtained (Figure 4 following).

Figure 4. HDPE molding by empirical artisanal method

Note. Own elaboration (2024)

RESULTS AND DISCUSSION

After the analysis of the literature used since the introduction, it can be observed that there is a wide area of opportunity in the management of HDPE and it can be used in different ways for the generation of new products, as it was exposed, for posts, boxes or even covers, there is convergence among the researchers who wish to recycle HDPE, in that there is no standardized process to be applied for the treatment of HDPE, this is due to the differentiation of final objectives to be achieved. Based on the above, another convergence is the use of empirical methodology for the achievement of the proposed objectives, as well as the constant trial and error validation in order to apply continuous improvement in the defined processes.

The researchers of this study see more as a divergence than a good news and opportunity that there are many ways to carry out the treatment of HDPE and can produce various products that meet human needs, which is beneficial to have several alternatives for implementation and creation where other researchers can continue to join the objective of recycling HDPE for construction purposes to generate new products.

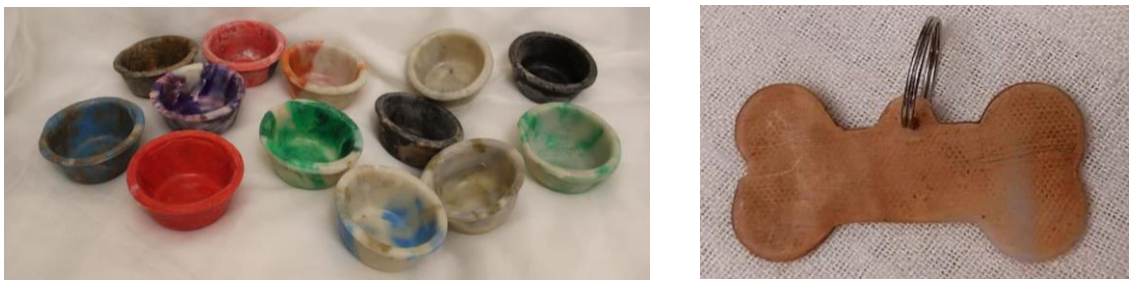
As previously mentioned, the process was carried out in an artisanal manner, not using sophisticated machinery but what was available to the researchers, such as sandwich fryers, metal molds and personal protective equipment acquired by the human factor itself, including gloves, overalls and glasses for the relevant protection.

Being an experimental craft design and being pioneers in the implementation of the methodology at least in the study area, which was the city of Zamora, in Mexico, we were working with trial and error, which allowed us to obtain empirical knowledge that in turn provided the facility to continue improving the target products, adhering to the process stipulated by the researchers and the constant replication of this in the craft elaboration, optimal results were achieved based on the expectations of the researchers.

Through the application of the materials and methods the desired products were obtained, which for this research were the products for pets, people can use the products obtained, the identification plates for pets, allow to be customizable with the name or legend that the user determines, this can be through an engraving and thus the pet has a distinctive for its location, as for the containers generated to feed their pets inside them either with liquids or solids, the products are easy to wash and give the security of having greater resistance.

The objective was always the recycling of HDPE, although in an artisanal manner due to the lack of mechanization in the processes and an automated system, different products were obtained with standardized conditions. In the case of color, uniform products were obtained by separating HDPE waste by each corresponding color from the beginning, but experimental tests were also carried out with different colors of HDPE for the process, which resulted in both products, on the one hand a uniform color and in other cases a fusion of colors, which according to the observation of the researchers, the aesthetic appreciation is even striking, qualitative tests were not carried out to know the perception of people, due to the objective of this research, to demonstrate that HDPE can be recycled to make products for pets.

Figure 5. Products obtained, pet food containers.



Note. Own elaboration (2024)

The development of these prototypes has its degree of difficulty, but it is not impossible to carry out. The methodology used for its realization is in continuous improvement, so we still do not have the appropriate machinery to standardize the process more and more, it is important to note that the replication of this methodology is possible, in the first instance it is not necessary to have sophisticated material for its production, however, it is important to have the right material for its realization.

As this is an artisanal process, the inclusion of the human factor is of utmost importance, since it is the people who validate the inorganic solid waste to be used, separating HDPE waste from those that are not, the effective training of personnel will provide the assurance of obtaining optimal results, allowing the achievement of the stipulated objective.

While the researchers are aware that there may be areas of opportunity to be carried out, this is where the critical thinking exposed in the methodology came in, this helped the researchers to have a real context and become aware of the areas of opportunity to be addressed and the visualization of a future scenario. The reader is reminded that this was carried out in a region which is the city of Zamora, province of the state of Michoacan in Mexico, in this context the interest was the demonstration that based on a process even if it was handmade as a result of an experimental and empirical topic, the HDPE can be taken to an effective recycling, a concept that demonstrates the application of the circular economy.

Main limitations of the study

The present study faced certain limitations, the first being that in the case study area of Zamora, Michoacán there is no HDPE recycler in the area, which originated the documentary research and the empirical implementation of the researchers. Another limitation was the use of specialized machinery, as presented in the methodology section and explained in the results, it was an artisanal issue to carry out the development, so no industrialized machinery was used.

This can be understood as a limitation, not having the effective tools for development, but without wanting to handle optimistic scenarios, the researchers of this study believe that this is also a good thing to take care of, because in this way experimental studies are developed that allow obtaining new knowledge and not only the replication of studies that have already been previously proven. This is a contributor to the generation of new knowledge.

CONCLUSIONS

Recycling HDPE, will have a great positive impact on the environment with this seeks to encourage society to do so, so the proposal of this project is to raise awareness in society what can be achieved with the culture of recycling, being a contributor to the reduction of pollution that the planet is exposed today. The advantages of using HDPE are diverse as have been expressed throughout this document, among them are helping to care for and protect the environment, thanks to the fact that the material is recycled and does not end up polluting, HDPE is a material with high resistance, it is light, flexible and even resists low temperatures, in addition to having a fairly long useful life. Therefore, if it is not recycled, a perfectly reusable raw material is being lost and the industry is being forced to continue using new raw materials, generating a constant consumption and a commoditization of linear and not circular economy as this research has exposed.

Some benefits of HDPE recycling that researchers suggest are:

1. Decrease pollution in the environment.
2. To raise society's awareness of responsible plastic (HDPE) consumption.
3. Involve society in a participatory manner in plastic recycling (HDPE).
4. Promote the use of products made from recycled materials at the social level.
5. Develop a range of pet products made from recycled HDPE material.

For the responsible management of the HDPE, some recommended practices are:

1. Recycling: Promote and facilitate recycling programs to ensure that HDPE products reach recycling centers instead of being improperly disposed of. By recycling HDPE, the generation of new plastics is avoided and waste is reduced.
2. Consumption reduction: The responsible use of HDPE contributes to reduce unnecessary consumption. Sustainable alternatives should be sought and HDPE products should be reused on an ongoing basis as long as the properties of the material allow it.
3. Experimental designs: Experimental designs such as the one in this research should be considered, with the objective of achieving a reduction in the amount of HDPE currently generated and to serve as a contributor to a circular economy and regional development.

It is of utmost importance to present the benefits to sustainable development that this research has sought, this is done based on each axis of sustainable development, defining its environmental, social and economic impact, where we can mention:

Environmental impact: Thanks to the research, the reduction of inorganic solid waste derived from HDPE is achieved, which, if a project like this is not implemented, will continue to contaminate the environment, either in land or water systems, in cities not only is the pollution in the streets, but can also cause other types of damage such as clogging sewage systems

and damage due to poor appreciation of the landscape within the cities.

Economic impact: Although it is not the purpose to perform a commercialization of the subject, the products resulting from this research can be commercialized, although every process entails economic approach and those products show conditions of resistance and durability, as well as the ease of domestic use, the monetary subject was not addressed in this research because it is not the approach that the researchers have wanted to give, On the contrary, it has only been focused on demonstrating that the proposal for recycling HDPE to manufacture products is viable, which shows that it is possible to generate economic benefits as described in the circular economy, only that the financial section was not developed in this document.

Social impact: At present, society is undergoing various changes, global awareness has been achieved on many issues, pet care is increasingly immersed in societies, people get pets in order to have a company, share joys, etc., based on this, the social impact is that people will have utensils for the use of their pets that although there may currently be alternatives for purchase, many of these products are made with virgin materials and some metallic.

It is important to highlight that thanks to the properties of HDPE that were previously described, it is possible to develop new ranges of products for personal use, which serve in the daily life of people, this is suggested by the researchers as future studies or new lines of research, for this it is suggested to ask the question: How can HDPE be recycled in products for personal use? Although the present research does not address this issue, this suggestion is left so that new researchers can venture their studies to this approach and another suggestion raised is: Of the products currently used, which can be replaced by recycled HDPE? Stimulating creativity based on these questions will give new lines of research and future studies to be addressed.

But to be carried out it is important to have the necessary machinery and appropriate equipment that serve for the development of these. In such a way, this is achievable and it is reiterated that the social impact is to present people with an alternative that covers a need and additionally contributes to the environment and to the transition from traditional to sustainable methods.

Based on the above, it is necessary to continue implementing proposals that allow at a global level to address contemporary issues where throughout this research it was evidenced that it is the HDPE, the important thing is to conceptualize the idea and put it into practice, no matter if it is a basic craft design, The important thing is to execute actions that in the end, will give additional benefits as it has been concluded, not only the environmental aspect, but economic and social, achieving with this the generation of sustainable models and being a contributor to regional development, if you are looking to impact the world in a positive way you must start from the region where each person resides

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