

Has enough been done in plastics recycling?

¿Se ha hecho suficiente en el reciclaje de plásticos?

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Abstract

The need to segregate urban solid waste is a fact, something that has been achieved in a certain way thanks to the dissemination and awareness that has been promoted through environmental education, taught in educational institutions at all levels and the transmission of information through social networks. The follow work addresses the problem of the deficiencies present in the environmental management of plastic waste, due to the lack of classification and separation of the same. It is no longer just a matter of separating the urban waste produced, with the aim of reducing, reusing or recycling it, since, even in the best case scenario of correctly separating plastics from all other solid waste, reuse or Recycling is practically not possible if these are mixed together. This research hypothesizes that a large majority of people do not know how to distinguish the different types of plastic with which the products and containers that are used on a daily basis are manufactured. The objective of this research is to propose strategies to solve the problem raised based on the results obtained.

Types of plastic, recycling, Environmental Education

Resumen

Es un hecho la necesidad de segregar los residuos sólidos urbanos, algo que en cierta manera se ha logrado gracias a la difusión y sensibilización que se ha promovido a través de la educación ambiental, impartida en las instituciones educativas a todos los niveles y a la trasmisión de la información a través de las redes sociales. El siguiente trabajo aborda la problemática de las deficiencias presentes en la gestión ambiental de los desechos plásticos, debido a la falta de clasificación y separación de los mismos. Ya no se trata solo de separar los residuos urbanos producidos, con el objetivo de reducir, reutilizar o reciclarlos, ya que, aun en el mejor de los casos de que se lograra separar correctamente los plásticos de todos los demás residuos sólidos, la reutilización o reciclaje prácticamente no es posible, si estos se encuentran mezclados entre sí. En esta investigación se plantea la hipótesis de que una gran mayoría de personas no saben distinguir los distintos tipos de plástico con los cuales se fabrican los productos y envases que se utilizan de forma cotidiana. El objetivo de esta investigación, es proponer estrategias para resolver la problemática planteada con base en los resultados obtenidos.

Tipos de plástico, reciclaje, Educación Ambiental

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1. Introduction

Solid waste management is today a global problem and a challenge that affects human health, livelihoods, development and the environment.

There are a large number of researches in the literature that deal with the need for separation of the different urban solids that are produced in huge quantities all over the planet, this with the purpose of reducing, reusing or recycling them, and in this way diminishing the impact on nature that humanity is producing.

According to a report presented to the World Bank in 2018, called What a waste 2.0, 2010 million tons of municipal solid waste are generated annually in the world, and it is predicted that due to the accelerated advance of urbanization and rapid population growth, the amount of waste, will increase by 70% in the next 30 years (Kaza *et al.*, 2018).

As for plastic waste that is polluting the oceans, constituting 90% of marine detritus, only in 2016, 242 million tons were generated in the world, the equivalent of a set of 1376 Empire State buildings (World Bank, 2018).

Although progress has been made in solid waste management, it does not show significant efficiency. "Countries are developing rapidly without having established adequate systems to manage the different composition of waste produced by citizens" (World Bank, 2018), and at the same time, it is the poorest and most vulnerable countries that are mostly affected.

Although, countries that show great progress in the percentage of waste that is recycled, still present significant proportions in incineration and landfill disposal of such waste, recognizing, that incineration is controlled and landfill disposal is performed in an adequate manner. In contrast to countries with less progress in the area of recycling, incineration is carried out incorrectly and even clandestinely, and other waste is disposed of in the open air, causing serious health and pollution problems.

An estimate published by Kaza *et al.* (2018), indicates that in low-income countries, more than 90% of waste is burned or deposited in the open air.

On the other hand, countries that are recognized with great progress in recycling, such as Germany, show high recycling rates that could be misinterpreted. The percentage data is taken from the volume of waste that arrives at the recycling plants, but not everything that arrives is recycled, since within the recycling process there is a new reclassification, where in the end, only a fraction of the incoming waste is recycled, the rest is incinerated (Revista Técnica de Medio Ambiente, 2022).

Certain German environmental organizations, such as Friends of the Earth, consider that less than 16% of recyclable waste, can be reused (Sensoneo, 2022). The problem lies in the mixing of different types of recyclable materials in items that arrive in the incoming load to the recyclers, whether it is packaging made up of different materials (cardboard, aluminum, plastic) or a mixture of different types of plastics. If these are not separated before entering the recyclers, it is very likely that they will be discarded and end up in incinerators.

It is essential to separate solid waste into the waste that is produced daily, but it is also important that when separating plastics, they are sorted for effective recycling, since they cannot be recycled if they are together.

In some places, the recycling companies are in charge of segregating the different plastics they receive, but in other cases, it is the users of the recyclers who must separate them.

Effective separation is not possible if we do not know how to identify the plastic material from which our packaging or product is made.

Most human beings have had contact with some type of plastic from an early age, but real knowledge of the different plastics can only be acquired through environmental education.

Unfortunately, many people do not have this opportunity, and even if they possess this knowledge, this does not certify that an individual assumes the commitment to participate in the solution of this problem.

As stated by Carrington *et al.* (2014) referred by Ramírez L. (2022), "positive environmental attitudes and intentions, unfortunately are not always and fully reflected in people's behavior".

In the present work, the idea is raised that many of the people who use plastic containers or products in their daily lives, do not know the different types of plastic that exist, nor how to identify them correctly.

For this purpose, a short survey with very specific questions was prepared and applied to a sample of 236 individuals.

The results of the survey were then analyzed, showing, to a large extent, the confirmation of the hypothesis that was initially proposed.

The purpose of this work is to make known the importance of the segregation of plastic waste generated as urban solid waste, which can only be carried out through proactive environmental education, provided by educational institutions, government and civil associations interested in the environment.

To this end, a series of strategies are proposed, using, among other things, the wide diffusion of social networks.

2. Theoretical Framework

2.1 Recycling

The correct management of solid waste is a core issue that concerns all countries in the world.

According to the World Bank report (2018), "of the 2010 million tons of municipal solid waste, at least 33% is not managed without risk to the environment", and it is expected that by 2050, the volume of waste generated annually, will increase to 3400 million tons.

Some studies have been conducted for several years, to know the huge amount of plastics that end up in the seas and are harming birds, aquatic mammals and fish.

"The prediction that by mid-century the oceans will contain more plastic waste than fish" (Parker, 2018), has become a repeated phrase and a warning of the danger we are subjecting our planet to.

Even countries that have shown great progress in the subject of recycling such as South Korea, Germany and Sweden, have not managed to obtain a significant figure of recyclable waste that can be reused.

If we visualize some published data regarding the countries that manage their waste better and worse, as mentioned in the Technical Magazine of the Environment (2022), we find the "Global Waste Index" prepared by the association Sensoneo, in its 2022 edition.

For this study, Sensoneo took into account the waste management of the 38 member states of the OECD (Organization for Economic Cooperation and Development). The report was previously conducted in 2019, which allows for a comparative analysis with the data for 2022.

Among the factors taken into account for the ranking of the countries evaluated, as well as the calculation of the score obtained are the waste generated, recycling, energy recovery of waste, landfill, illegal waste management (open dumping) and other waste.

The country ranked number one in solid waste management is South Korea. Considering the most important factors, this country generated 400 kilograms of waste per capita per year, of which 243 kg were recycled, representing 60.8% recycling. In addition, there was a very low amount of landfilled waste (46 kg) and 0 kg deposited in the open air.

In contrast, the country that showed the worst management of its solid waste (of the 38 analyzed) was Turkey, with 424 kg per capita per year generated, only 47 kg recycled (11%), 347 kg dumped and the very surprising amount of 176 kg deposited in the open air.

Our country, with 359 kg per capita per year generated, 13 kg recycled (3.6%), 219 kg dumped and 89 kg deposited in the open air, was in an unfavorable 35th place.

The achievement of high recycling rates depends directly on the correct separation of the solid waste generated, but as mentioned, within the recycling process, there is a new reclassification of waste that decreases the actual rate of recycled materials.

This reclassification is generally carried out by the recycling companies, but it does not always happen that way. In our case, in the city of Chihuahua, the recycling companies only accept waste previously separated by the users of their services.

The main recycling companies in the city of Chihuahua include: REMISA, dedicated to recycling ferrous and non-ferrous materials, Recilogic, which offers recycling services for different types of plastic, Copamex, which handles paper and cardboard recycling, Kalisch Recycling, provides scrap metal recycling, Tecnologías de Reciclado, accepts scrap and electronic devices, among others.

The information shown, referring to the recycling companies and their main processes, was obtained through a digital consultation of the pages corresponding to these companies and is shown in the bibliographic references.

2.2 Plastics

Why the concern about plastics?

"The mass production of plastics, which began only six decades ago, has accelerated at such a rapid rate that it has created 8.3 billion metric tons, most of which are disposable products that end up as waste" (Parker, 2018).

Plastics are very useful materials because of their durability, versatility, efficiency, hygiene and price. If treated correctly they can be reused, recycled or in the worst case, incinerated (producing an energy value), but if there is no good management of plastic waste, they end up polluting the soil, the sea and the air, becoming a serious danger to the health of living beings, the environment and its ecosystems, (Zschimmer and Schwarz, 2021).

The versatility of this material is so great that a large part of what surrounds us at home, work, school or public places is made of some type of plastic (food packaging, water bottles, cell phones, cars, bicycles, shoes, etc.).

If we are talking about objects of daily use such as the tires of cars or bicycles or the soles of shoes, it is required that they last in good condition for a long time, this is achieved with the use of plastics. In some cases we use plastics for a very short time, however their permanence in the environment when discarded can be very long, causing a serious pollution problem. Plastic bags, made of low-density polyethylene, take about 150 years to decompose completely. However, plastic bottles can take up to 1,000 years to degrade if they remain buried (Estrada R., 2020).

According to Plastics Europe (2020) cited by Gil C., (2020), plastic is a synthetic material that can be molded, that is, it is malleable, which allows it to be melted, pressed or extruded to obtain different shapes such as sheets, fibers, plates, tubes, bottles, boxes, etc.

The properties of plastics are very different, depending on the initial chemical compound (monomer) and the final product obtained, as well as the procedure followed for their manufacture, which is why they cannot be recycled as a whole, but must be separated for treatment.

Even so, some plastics are easier to recycle than others. For example, high-density polyethylene, which is used in beauty product packaging, as well as polyethylene terephthalate and polypropylenes, are plastics suitable for recycling, while low-density polyethylene (used for the manufacture of plastic bags) and polystyrene are very difficult to recover because they require a lot of energy in the process (García P., 2021).

Precisely the existence of the great diversity of plastic materials and the possibility of recycling them led to the creation of identification codes by the American Society of the Plastics Industry in 1988.

The classification uses a triangle formed by three continuous arrows, inside which a number from 1 to 7 is enclosed. On the outside of the triangle, the acronym identifying the type of polymer used in the manufacture is usually placed (Figure 1).



Figure 1 Symbology of low density polyethylene plastic
Source: SP Group

The following table shows the classification of the different plastics used, with their numerical codes and the name of the chemical compound from which they are formed.

Code	Abbreviation	Polymer Name	Uses
1	PETE o PET	Polyethylene terephthalate	Bottles for: non-alcoholic beverages, water, oil, etc.
2	PEAD o HDPE	High Density Polyethylene	Bottles for: Detergent, milk, grocery bags, etc.
3	PVC	Polyvinyl chloride	Pipes, outdoor ornaments, protective wall sheets, etc.
4	LDPE o PEBD	Low Density Polyethylene	Tablecloths, cream containers, bags for garbage cans, etc.
5	PP	Polypropylene	Caps for bottles, straws, cutlery, etc.
6	PS	Polystyrene	Cups, disposable plates, yogurt containers, etc.
7	Other o 0	Others	Teléfonos, artículos médicos, juguetes, etc.

Table 1 Classification of plastics
Source: (Gallegos C. et al., 2018)

As mentioned, in the city of Chihuahua, recycling companies require that the material to be subjected to the recycling process is already separated into the different types of plastic most commonly used.

On the other hand, there is no major problem when the users are companies or industries whose plastic waste is well identified and is of only one type or not very varied.

This does not happen in the case of waste from households, educational institutions or businesses, whose plastic waste does not come from any productive activity.

It is in this situation that there must be a knowledge of the plastic classification codes, so that the people who are going to carry out the separation of the different wastes, can do it in a correct way.

Due to the great diffusion that PET plastic has been given, because it has traditionally been used in the manufacture of soft drink and water bottles, most people relate it to beverages or food products and can identify it correctly.

But it is not only used in this type of packaging and additionally, there are other plastics also used in food products such as yogurt, which is packaged in containers made of HDPE.

Based on the hypothesis that the vast majority of people who do not have a formal environmental education do not know the plastic identification codes and therefore will not have the ability to separate them correctly, a survey was conducted and applied to a sample of 236 individuals.

3. Methodology

It was decided to conduct a study with a descriptive scope that was carried out with the participation of students enrolled in the different careers of the Instituto Tecnológico de Chihuahua II. The survey was elaborated using Microsoft Forms. Simple and direct research questions were formulated, taking care that they were not obvious or could lead to a bias in the answers. The questionnaire includes seven questions to determine whether the respondent is aware of the existence of different types of plastic and, above all, whether he/she has the ability to identify one from the other, among other equally important questions to support the research topic.

The sampling used was by convenience and the survey was applied to a group of 236 individuals of different ages and educational levels, with the collaboration of the students selected for this purpose.

Subsequently, the statistical analysis was carried out, which yielded interesting data and at the same time led to the elaboration of proposals that would help in the dissemination of knowledge of the different plastics and that would allow for their classification and subsequent separation.

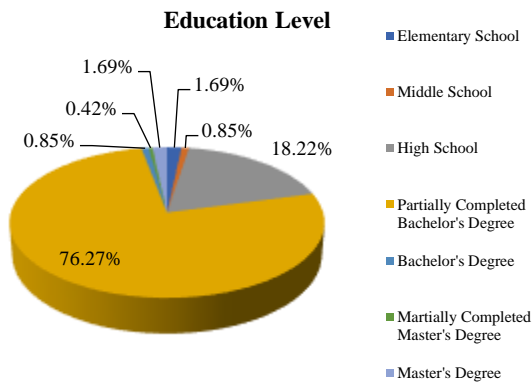
4. Results

The questions contained in the questionnaire are shown below:

1. Schooling
2. Age
3. Is all plastic the same? Why?
4. Do you think there are different types of plastic?

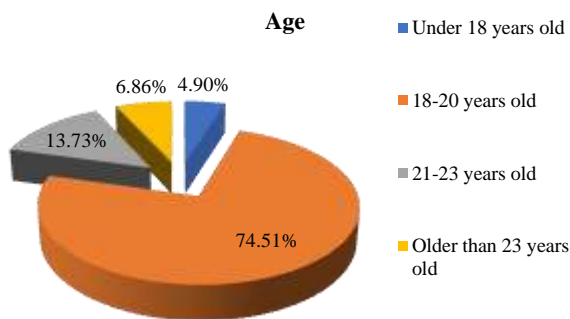
5. Which of the following types of plastic do you know?
6. Which plastics do you use the most?
7. How can you identify the type of plastic from which an object is made?

The answers obtained were the following.



Graph 1 Schooling
Source: Own Elaboration

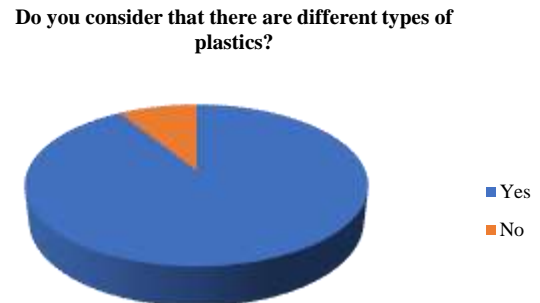
As can be seen in Graph 1, 76.27% of the individuals surveyed had a partially completed bachelor's degree; this is explained by the fact that the students who assisted in the application of the questionnaire selected their classmates as part of the sample.



Graph 2 Age
Source: Own Elaboration

Graph 2 shows a high percentage (74.51%) of individuals between 18 and 20 years of age. Here the same situation observed in question 1 is presented again, the students who helped to conduct the survey, took their same classmates to carry out the sampling, which explains the age range presented.

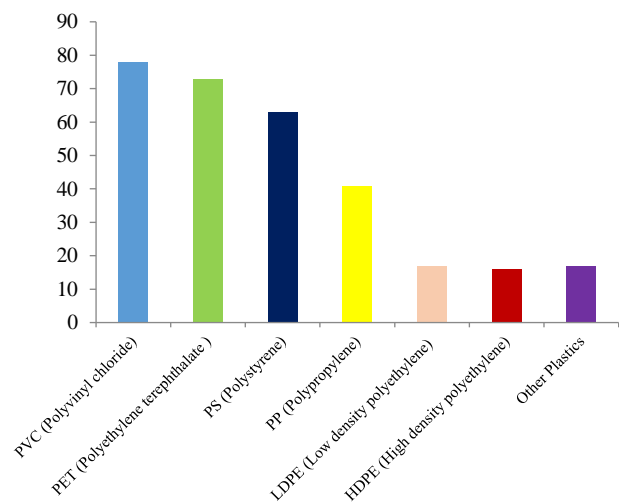
From question 3, there were 17 responses stating that all plastics were the same, arguing that they were composed of the same material. In this case, it is clear that the majority of respondents were aware of the existence of different types of plastics, only 17 of the 236 respondents did not know (7.2%).



Graph 3 Do you consider that there are different types of plastics?
Source: Own Elaboration

In question 4 (graph 3), 90.3% of the answers were affirmative in terms of knowledge of the different types of plastics, a value very close to that found in the answers to question 3.

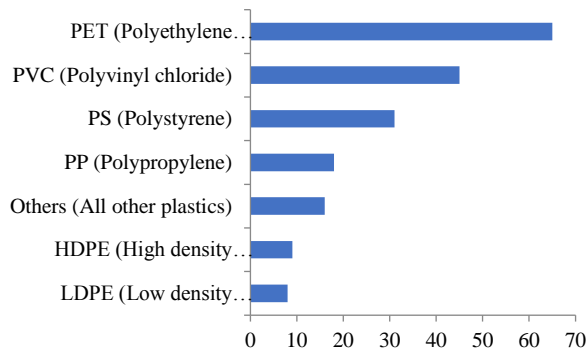
Which of the following types of plastics do you know?



Graph 4 Which of the following types of plastics do you know?
Source: Own Elaboration

Graph 4 shows interesting results, since a high percentage (close to 75%) of respondents know polyvinyl chloride plastic (PVC), used for the manufacture of pipes. In second place is PET with 71% of affirmations and in third place is polystyrene (unicell) with 61%.

In all three cases, the responses obtained are believed to be due to empirical knowledge of most of the respondents and not due to environmental education.



Graph 5 Which plastics do you use the most?

Source: Own Elaboration

In question No. 6 (Graph 5), it is again congruent with what was observed in question No. 5, empirical knowledge of the different types of plastics.

Finally, in question No. 7, 47% of the individuals did know about the existence of the number code to classify plastics, which would indicate that this percentage includes the students of our institute who belong to the sample and who have received environmental training, but even so they do not reach 76.27% of the individuals who declared having a bachelor's degree.

6. Acknowledgements

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7. Conclusions

The survey served to observe that there is a great lack of knowledge in our community about the different types of plastics that exist, which prevents them from being segregated and classified.

One of the suggested strategies is to use social networks to generate a connection, first locally, then nationally and later internationally, to create ecological awareness in society.

The dissemination in social networks can be carried out mainly through Facebook, Instagram, Podcast and TikTok, in such a way that a community is created in which valuable and interesting content is shared on a daily basis that attracts young people due to the widespread use of these media nowadays.

Another suggested strategy is the implementation of ecological clubs that are not optional, but that contribute credits to the curricula of the different careers within the educational institutions, in such a way that allows a proactive environmental education.

It is known, from personal experience, that in environmental education, one thing is what an individual thinks and knows and another is what he/she does.

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