International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

The Study of Polymers and Their Impact Currently to High School Level: Recycling and Problems with Plastics, Microplastics and Additives

Adolfo Eduardo Obaya Valdivia[1], Citlali Ruiz Solórzano[2], Lucila Giammatteo[1,3], Carlos Montaño-Osorio[1], Yolanda Marina Vargas-Rodríguez[1]

[1]MADEMS (Química) Facultad de Estudios Superiores Cuautitlán-Universidad Nacional Autónoma de México, Campo No. 1. Av. 1 de mayo, Sta. María Las Torres, Cuautitlán Izcalli, Estado de México, México. C.P. 54740. México.
2 CCH Naucalpan. Estado de México. UNAM
3 ITESM. Campus Estado de México
Ymvargas[at]unam.mx*

Abstract: ***The results obtained in the implementation of a contextualization strategy in which 105 sixth-semester high school students belonging to five groups are presented, addressing the content". The study of polymers and their impact currently on the world". This topic corresponds to the second unit of the Chemistry IV course of the College of Sciences and Humanities, which is High School level. It was applied in the penultimate week of classes by addressing learning: "It argues the need to make responsible use of synthetic polymeric materials, by digging into documentary sources their identification and recycling methods." A printed initial questionnaire was conducted to know the depth of the knowledge acquired during the course which was developed through a contextualization strategy in which 5 short videos were observed and discussed. After the strategy was reassessed with another questionnaire answered in a Google Drive form, the results indicate that teaching polymers framed in the recycling topic had a positive impact in the learning process.***

Keywords: Polymers, Recycling, High School, Plastics, Microplastics

1. Introduction

Polymers are macromolecules made up of repetitive fundamental units called monomers. These are used for the manufacture of a large number of products, such as bags, containers, containers, as well as more specific products such as ion exchange resins. At College of Sciences and Humanities (CCH) which belongs to the High School of the National Autonomous University of Mexico, UNAM, polymers are studied from the chemical point of view from the characteristic polymerization reactions (addition and condensation) of the monomers where students are presented with everyday products such as polyethylene, polypropylene, PET, etc.

The 2015 Guidelines approved by the American Chemical Society Professional Training Committee require the curriculum for certified bachelor's degree to include the principles governing macromolecular, supramolecular, mesoscale and nanoscale. The justification for this new requirement recognizes that the synthesis, analysis, and physical properties of small molecules give an incomplete picture of the higher-order interactions that occur in these systems. Programs can meet this requirement through an in-depth course on these systems or coverage distributed across two or more required courses. It is anticipated that most undergraduate programs will include at least some synthetic polymer coverage, but there may be concerns in many departments about how best to implement such coverage. Kosbar & Wenzel (2017), suggested topics illustrating important aspects of the chemistry and properties of synthetic polymers.

The College of Sciences and Humanities (CCH), belongs to the UNAM High Scool and has been characterized by its innovative model of studies. Therefore, it clarifies in its mission that students "will be actors of their own training, of culture, of their environment, capable of obtaining, hierarchical and validating information, using classical and technological tools to solve new problems." This is how teachers develop strategies to generate and promote these skills in students.

The diversity of methodological strategies in class improves learning, since according to De la Torre, N. L. M., and Dominguez, G. J. (2012), that knowledge is not delivered 'ready' is a key point from the perspective of the students. In other words, the strategy that the teacher chooses should be aimed at developing meaningful learning in the student.

In this sense, Jaimes, L. and Mejía, A. (2005) emphasize that teachers should enrich activities by investing the necessary time in the class by making students feel their experiences. Thus, teaching related to aspects of technology would be encouraged as a way of complementing science, and the use of scientific processes and the linkage of teaching would be encouraged to the interests of students and to aspects that are significant to society. Generating activities according to the daily life of students allows, first to generate interest, and second, to contextualize. In Figure 1, the differences between a class with a traditionalist approach and another by applying contextualization are framed.

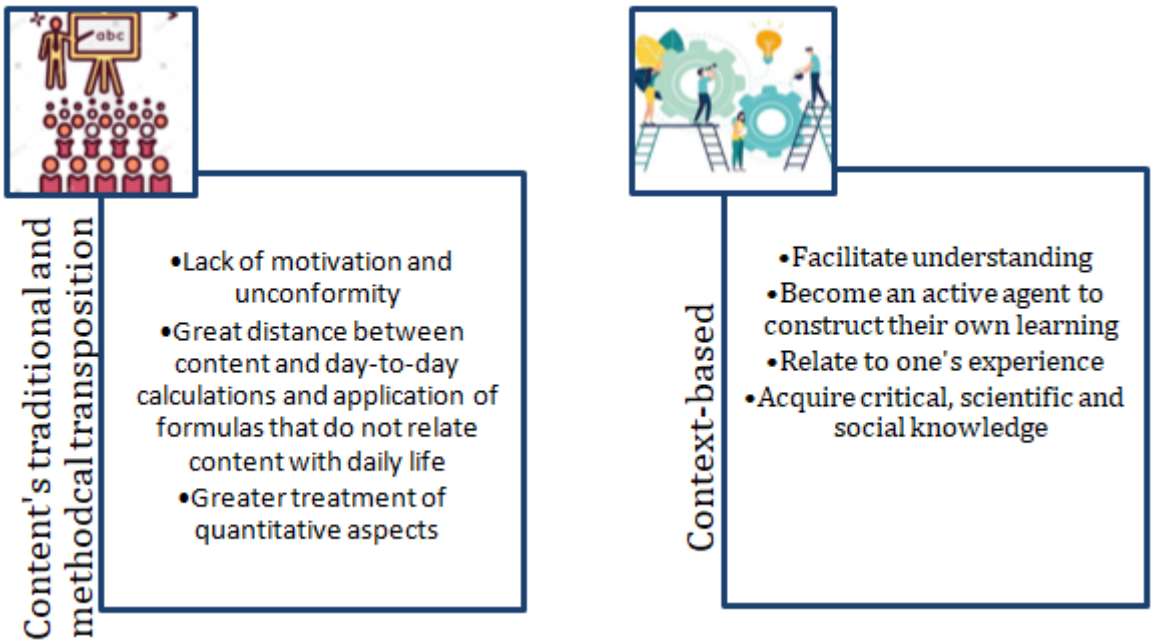

Figure 1: Differences between traditional and context-based strategies

Traditionalist learning considers content detached from the reality of students or the execution of sequences of steps to solve exercises without the promotion of critical thinking. Opposite to this, in contextualization students become involved in their learning processes, relating their own experience and acquiring social, scientific and critical knowledge.

Rioseco, M., and Romero, R. (1997) propose, teaching in the context of the particular world enables meaningful learning. In the case of science, contextualizing with current events allows to integrate society and the environment with disciplinary content; so Ros, A.C. (2011) differentiates two approaches: one is based on the concepts to interpret and explain the context, and in the other, the context for introducing and developing concepts and models is related. In both cases, it is based on the vision of the learning located, where the situation and context, in which learning takes place, is emphasized.

The main thesis of the learning is that knowledge must be acquired in a self-dependent and active process, in an authentic context, that is, learning is produced through the reflection of experience, from collaborative work and exploring the meaning of events in a particular space and time.

According to the above, the traded learning exposes the importance of the social dimension in the construction of knowledge as well as significant knowledge. So, the didactic sequences in context generally focus on inquiry or debate of problems in chemistry and society. Rioseco, M., and Romero, R. (1997) found that context and social circumstances are important variables that interact with individual characteristics to promote learning and reasoning. The choice of context would therefore be what makes the activity authentic. In this sense, Chiappe, L.A. (2009) emphasizes that the closeness and familiarity of the context of the contents and activities, allows a better appropriation of them.

Given the above, the objective of this work is to integrate students' daily life to the learning process in the subject of polymers from the chemical perspective framed in the subject of chemistry of the CCH, also relating the social impact of the use of polymers on a day-to-day basis, such as waste generation and the endpoint (microplastics and the garbage islands). In such a way, the student relates and structures the concept of polymers from both perspectives, as well as becoming aware of the current problem society faces with polymers.

2. Methodology

The present study involved 105 sixth-semester high school students from five groups. The content was addressed from the second unit: "The study of polymers and their impact today", of the CCH Chemistry IV course. The process performed is described in Figure 2.

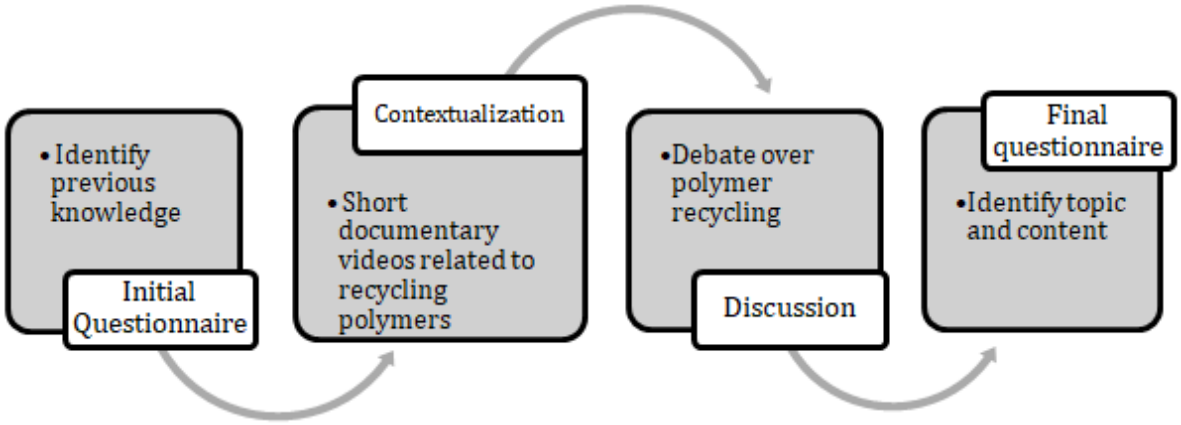

Figure 2: Investigation sequence

The learning was addressed, "It argues the need to make responsible use of synthetic polymer materials, by digging into documentary sources its identification code and recycling methods" through a contextualization strategy, in the penultimate week of school.

Figure 3 presents the characteristics of the content, which has applications in daily life and industrial processes; requiring prior chemical knowledge and the application of formulas and equations linked to polymerization processes. These are addressed from the three levels of representation: macroscopic, nanoscopic and symbolic, being essential to understand the relationship between chemical structure and properties of matter.

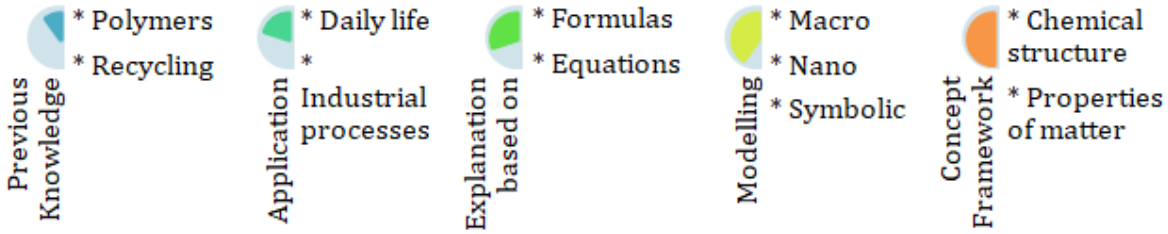

Figure 3: Polymerization content characteristics

The strategy began by answering a printed questionnaire (see Chart 1) to investigate the previous knowledge by responding in the classroom 93 out of the 105 students.

Chart 1: Previous Questionnaire

Previous Questionnaire Evaluation	1.What do you understand by polymer? Include the concepts of "mere" and monomer in your definition
	2. Can you think of three examples of polymers which you have contact with in a daily basis?
	3. What differences exist between thermosetting and thermoplastics? Consider structure, physical characteristics and their behavior at a high temperature. Include two examples of each type.
	4. What characteristics are taken into account in polymer classification?

Students were subsequently asked to review short video documentaries which relate the content, the importance of recycling and the final disposal of polymers. After watching the videos, they answered questionnaires about conceptual content and its daily application inviting to reflection. The teacher immediately encouraged discussion among students based on the revised information. The documentary videos, their duration in minutes, the link from which they were retrieved and the respective questionnaires are presented below:

Polymers and their impact on health and the environment

After watching the video "The History of Plastic" (6 minutes)
https://www.youtube.com/watch?v=Cz-OZyK9M_Q
Answer:
What are single-use plastics? What percentage of total plastics do they constitute? State 3 examples
What can we do to avoid the consumption of single-use plastics?
What solutions are scientists exploring for plastics that have already been produced and discarded and for future production?
Share a reflection about this video.

After watching the video "Living Without Plastic" (14 minutes)
https://www.youtube.com/watch?v=hpmLHorl4NE
Answer:
What is the numerical data about the plastic that Patri and Fer give?
Which of the actions they took to stop using plastic do you find the easiest to implement with your family?
Which of the actions they took to stop using plastic do you find the most difficult to implement with your family?
Why are they the most difficult? What items from the ones Patri and Fer use(yourself or at home) have to do with polymers (plastics, fibers, rubbers, coatings or adhesives)?
Share a reflection about this video

After watching the video "What to Learn from... SWITZERLAND A country WITHOUT WASTE?" (9 minutes)
https://www.youtube.com/watch?v=Es1YCxdT34U
Answer
Briefly describes the accident of the Sandoz company in Switzerland
What is done in Switzerland with garbage that cannot be recycled?
What numerical data do they give in the video about recycling in Switzerland?
What is the "formula" to prevent garbage contamination?
Share a reflection about this video.

After watching the video "Bisphenol A (BPA): A Toxic in Your Kitchen“ (11 minutes)
https://www.youtube.com/watch?v=EzkLzc0O3dU
Answer
What is BPA?
Where is BPA located?
What effects does it have on humans health?
What can we do to avoid the effects of BPA?
Share a reflection about this video.

After watching the video „How to remove microplastics from your hygiene and beauty routine?“ (3 minutes)
https://www.youtube.com/watch?v=yVJl1fAUYdo
Answer
What are microplastics?
Where are the microplastics located?
What effects do they have on humans?
What can we do to avoid the effects of microplastics?
Share a reflection about this video.

The strategy ended by answering a questionnaire that the 105 students responded in a Google Drive Form, presented in Chart 2, which asked questions related to polymer recycling and how is this related to their daily lives.

Chart 2: Final questionnaire format

Final Evaluation Questionnaire	1. What is polymer recycling? Explain it with your own words. Name at least two examples of recycling.
	2. What are single-use polymers?
	3. Which polymers do you separate at home to be recycled? Which components have those polymers? Name at least one component.
	4. What are microplastics?
	5. How would you define a biopolymer?
	6. Do you consider polymers good or bad for humanity? Justify your answer.
	7. What are the environmental risks of an inadequeate polymer disposal?
	8. Based on the videos seen in class, How would you now define "polymer"?

3. Results and Discussion

This section presents the results of the evaluation questionnaires, both before and after watching the video. In both cases, the representative answers of some students are presented by question. Subsequently, their respective analysis is performed.

Previous Questionnaire

Polymer definition	Representative Student 1	A polymer is a union (set) of monomers, and monomers are sets of meres.
	Representative Student 2	The are macromolecules made up of "meres"
	Representative Student 3	They are chains constructed by the repetition of many meres.
Polymers in our daily lives and examples	Representative Student 1	Rubber from tires, water bottles and plastic bags
	Representative Student 2	Polyethylene, polyvinyl chloride and polypropylene
	Representative Student 3	PET, Nylon, PVC
Thermosetting and thermoplastics	Representative Student 1	Thermoplastics are deformed with temperature while thermoset are not.
	Representative Student 2	Thermoplastics are softened with heat and harden when they are cooled. Thermoset decompose with heat instead of melting.
	Representative Student 3	Thermoplastics soften with heat and can be molded again. They can be recycled. Thermoset can´t be deformed and are not recyclable.
Polymer classification	Representative Student 1	They are classified according to their density, elasticity, hardness and flexibility.
	Representative Student 2	By structure, by origin, by physical properties.
	Representative Student 3	Apart from what was mentioned before, by its use, obtention and monomers.

In general, students defined the polymer as the set, binding or repetition of basic units. 15% of students specified that they are macromolecules or molecules. 30% of the answers suggest that they are long chains of units. 50% confuses monomer and other chemical compounds.

When questioned about their relationship in daily life, most named synthetic polymers. Only 4 students mentioned natural polymers such as DNA, RNA and cellulose. Some gave scientific names, others the acronyms by which they are known and others, objects made with these compounds. Accordingly, the distinction between name, acronym and articles made with polymers is required. From the answers obtained in the question: *differences between thermosetting and thermoplastics* in which they talk about their softening or deformation at "relatively low or high" temperatures, it is necessary to define the concepts of transitional temperature vitrea and degradation temperature. Also, since they differentiate thermoplastics from thermosetting by being "recyclable" or not, it is necessary to note that in this process only a percentage of material that has already been used and always requires virgin material to be occupied. In addition, 25% of the students confused the structure they have, so this will be further explored in the following courses. As for the characteristics that are taken into account for the classification of polymers, only one mentioned that they may be organic and inorganic so it will be necessary to emphasize the existence of silicon and phosphorus polymers, among others

Final Questionnaire

Polymer recycling, examples	Representative Student 1	Reuse the polymers that have more than one useful life, such as plastic bottles or fabric bags.
	Representative Student 2	It is the process to recover plastic waste.
	Representative Student 3	It refers to take materials as plastics or fibers to a plant to be treated and converted into materials that can be used again. PET bottles are an example of this
Single-use polymers	Representative Student 1	The ones that can only be used once and can´t be recycled
	Representative Student 2	Those that are used once and then disposed of
	Representative Student 3	Plastics that end up in the trash and then go to the sea (packaging products, bags, straws)
Microplastics	Representative Student 1	Tiny plastic particles used in a huge variety of cleaning products.
	Representative Student 2	Tiny plastic particles that are present in rivers and oceans, but we don´t notice them because they are barely visible.
	Representative Student 3	Small plastic particles present in different products. We need to be careful with them because due to their size, they can´t be eliminated by filtration systems and that is the way they end up in rivers and seas, where animals ingest them.

Biopolymers	Representative Student 1	Macromolecules present in living beings
	Representative Student 2	Polymer originated in nature
	Representative Student 3	Macromolecules present in living beings, such as proteins, polysaccharides and nucleic acids.
Are polymers good or bad?	Representative Student 1	Eventhough they have a strong impact on the environment, I consider they are good since they have allowed us to create ways for storing things and replacing expensive components or hard to get when making certain objects.
	Representative Student 2	Bad, since they damage our health and our environment without us noticing that they are there, simple because we dont notice their present anymore eventhough we depend on them.
	Representative Student 3	Bad. They contaminate our planet, being this our only home. It would be better if we could decrease their consumption.
Risks of inadequate disposal	Representative Student 1	Contamination.
	Representative Student 2	Air,water and soil contamination.
	Representative Student 3	Sickness in humans and death of certain species by contamination.
Family problems due to bad disposal	Representative Student 1	I don´t know anyone with a problem
	Representative Student 2	No, but there are lots of allergic people due to the damage in the weather.
	Representative Student 3	Not a health problem per se. Nonetheless, my mom used to live in a neighborhood where due to the bad disposal there were floodings in raining season since sewage was clogged.

Polymer concept	Representative Student 1	Macromolecules formed by the linking of monomers.
	Representative Student 2	Macromolecules formed by many meres, classified into many types and they are even present in ourselves.
	Representative Student 3	Macromolecule formed by thousands of units called meres. Mi definition does not change but the videos helped me reflect on the bad use and lack of plastic recycling.

Based on the responses from the final evaluation questionnaire, it was found that there is confusion between the terms recycling and reuse, so it is suggested to emphasize that recycling is a series of processes, both chemical and physical, including selection, crushing, washing and drying; while reusing is to give different use to objects.

Likewise, students comment on the use that polymers have in their daily lives: "They are very essential, but human beings have abused on their consumption and given them misuse. Polymers, as well as very useful, have been a threat and a danger to the planet , that's why you have to learn how to use them responsibly". When students are questioned whether they are good or bad, they describe: "I don't know how I could say that they are good or bad because they are everyday objects (not completely fundamental or necessary) so I think I don't know if they could be defined as good or bad, but to see the use we give them and waste management."

With regard to natural polymers, one student replied: "Polymers are definitely good for humanity, for example, DNA is essential for life, even petroleum derivatives like polyethylene are of great importance. However, the misuse that human beings have given to plastics has led us to the consequences that are suffered today."

When questioned about the health risks they may cause due to bad disposal, 8 out of 105 students gave affirmative answers such as: "Yes, instant soups come in styrofoam cups and at the time of heating components were detached so my partner was hurt." "Yes, heating food in the microwave in tuppers make it poison"- "I don't really know yet, but I think sometimes diseases stem from all that pollution that is caused."

Students described the concept of natural polymer as natural substances, chemical species of high molecular weight, large size and predominantly elongated shape that are part of the cell walls of animal and plant cells, as well as exoskeletons of invertebrates and vertebrate endoskeletons.

We found that applying this strategy allowed to generate meaningful learning from a context of interest to the student, such as polymer recycling. Discussion and debate in the classroom were encouraged in order to induce connections based on the development of arguments by considering values and activities affecting the environment and society.

4. Conclusions

This research identified certain conceptual deficiencies of the high school students who participated, with the application of the initial questionnaire even though they already knew the subject of polymers. The use of short videos, especially documentaries, was vital in linking students' daily lives to chemistry; in addition to fostering students' arguments for class discussion, thereby developing critical thinking.

The information gathered through the implementation of the polymer contextualization strategy confirmed the impression that this approach is positive and achieved with it, a significant learning. After some time, students clearly remember the topics covered, even for those who had regularly had low returns.

References

[1] .Abrantes de Oliveira, D. et al. (2019). Teaching of chemical solutions framed with the theme saneante, *International Journal of Development Research,Vol. 09*, Issue, 01, pp.25048-25053, Recuperado desde https://www.journalijdr.com/sites/default/files/issue-pdf/15033.pdf

[2] Chiappe Laverde, A. (2009). Acerca de lo pedagógico en los objetos de aprendizaje-reflexiones conceptuales hacia la construcción de su estructura teórica. *Estudios pedagógicos (Valdivia)*, *35*(1), 261-272. https://scielo.conicyt.cl/scielo.php?pid=S0718-07052009000100016&script=sci_arttext&tlng=e

[3] De la Torre Navarro, L. M., y Domínguez Gómez, J. (2012). Las TIC en el proceso de enseñanza aprendizaje a través de los objetos de aprendizaje. *Revista Cubana de Informática Médica*, *4*(1), 83-92.http://scielo.sld.cu/scielo.php?pid=S1684-18592012000100008&script=sci_arttext&tlng=en

[4] Jaimes, L, y Mejía, A. (2005). *Modelo constructivista de aprendizaje en organizaciones educativas*,

Memorias de investigación, Universidad de Los Andes. http://guaica.uniandes.edu.co:5050/dspace/bitstream/1992/341/l/mi_1110.pdf

[5] Kosbar, L., Wenzel, T. (2017) Inclusion of Synthetic Polymers within the Curriculum of the ACS Certified Undergraduate Degree. *Journal of Chemical Education*. 94 1599-16002.

[6] Misión y Filosofía del CCH, (2019). Consultado: https://www.cch.unam.mx/misionyfilosofia

[7] Programa de estudios química III-IV CCH, (2018). Consultado: https://www.cch.unam.mx/sites/default/files/programas2016/QUIMICA_III_IV.pdf

[8] Ros, A. C. (2011). Enseñar química mediante la contextualización, la indagación y la modelización. *Alambique: Didáctica de las ciencias experimentales*, (69), 21-34. https://chemistrynetwork.pixel-online.org/data/SUE_db/doc/28_Alambique%20Contextualizacion%20.pdf

[9] Rioseco, M., y Romero, R. (1997). La contextualización de la enseñanza como elemento facilitador del aprendizaje significativo. *Actas Encuentro Internacional sobre el aprendizaje significativo*, 253-262.https://cmapspublic3.ihmc.us/rid=1GLSV900J-1SDW54M-GZ9/Contextualizaci%C3%B3n%20de%20la%20Ense%C3%B1anza%20como%20elemento%20facilitador%20del%20Aprendizaje%20Significativo.pdf

Videos

- [National Geographic Latinoamérica] (2018, jun, 6) La historia del plástico [archivo de video] Recuperado de https://www.youtube.com/watch?v=Cz-OZyK9M_Q
- [TEDx Talks] (2018, may, 17) Vivir sin Plástico [archivo de video] Recuperado de https://www.youtube.com/watch?v=hpmLHorl4NE
- [Hispanoamericanos Unidos] (2018, ene, 25) Qué aprender de... SUIZA ¿Un país SIN BASURA? [archivo de video] Recuperado de https://www.youtube.com/watch?v=Es1YCxdT34U
- [TEDx Talks] (2018, ene, 25) Bisfenol A (BPA): un tóxico en tu cocina. [Archivo de video] Recuperado de https://www.youtube.com/watch?v=EzkLzc0O3dU
- [National Geographic Latinoamérica] (2018, may, 18) ¿Cómo eliminar los microplásticos de tu rutina de higiene y belleza? [Archivo de video] Recuperado de https://www.youtube.com/watch?v=yVJl1fAUYdo