Universitat Autònoma de Barcelona

Bachelor Thesis. Life Science Faculty

Plastic management in life science laboratories: an ecofeminist perspective

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1. Introduction

1.1. What is ecofeminism?

Eco-feminism is a movement that emerged in the mid-1960s, in the so-called second wave of white feminism and the green movement. This movement connects the repression and subordination of women with the exploitation and degradation of the environment. The fundamental claim of ecofeminism is that the liberation of women comes together with the liberation of the environment from human destruction. Its creation started from the hybridization of three different movements: feminism, environmentalism and pacifism (Merchant, 1990). Françoise D'Eaubonne in 1974 coins the word ecofeminism, explaining that the origins of human society were governed by a matriarchal system, where there was equality between men and women. However, over time, this system was replaced by a patriarchal one, which ended up dissolving equality (d'Eaubonne, 1974). Nowadays, ecofeminism is intersectional and studies among others the relationship between genus, species, ethnicity and class. It also promotes the end of sexism, racism, capitalism and ethnocentrism within the feminist movement (Opperman, 2013). Some of its most important principles include: showing the importance of recognizing women's contributions to a new culture of sustainability; trying to make women visible both in their daily and anonymous ecological actions and in scientific or humanistic ones; and the search for a different way of relating to nature through degrowth[1] (Gaard G., 2011).

Within the ecofeminist movement, there are four main variants: modern science and ecofeminism (Mies & Shiva, 1993), vegetarian ecofeminism (Gaard G. C., 2002), material ecofeminism (Mellor, 2000) and spiritual ecofeminism (Eisler, 1990). Particularly, the ideas presented by Maria Mies (1986) and Vandana Shiva (1989), which are encompassed in "modern science and ecofeminism", are of great relevance for this project. These two women created this variant called modern science and ecofeminism with the purpose of fighting against capitalism and the current sexism of this world (Mies & Shiva, 1993). According to modern science ecofeminism, a process of degrowth would be instrumental to achieve the elimination of oppression and, with it, a more sustainable, fair and conscious society.

Starting from this theoretical framework, there are two questions that can be approached from an ecofeminism perspective regarding modern science. First, are woman oppressed in the

[1] Degrowth is a political, economic, and social movement based on ecological economics, anti-consumerist and anti-capitalist ideas (D'Alisa, 2015)

scientific world? And, is our social structure, specifically economy in science, sustainable for our planet?

To answer the first question we can simply look at the most prestigious price in science, the Nobel Prize. From its beginnings in 1901 until now, 896 people have been awarded with this prize, from whom only 48 are women. This amounts to almost 5% of the prizes. If we focus in the scientific disciplines (physics, chemistry and medicine or physiology), only 3% of the total 599 prizes were awarded to women (Gibney E. , 2018). A possible explanation of the low number of women awarded could be because of their absence in the history of science. However, there are many examples of how women's contributions to science have been unrecognized and neglected by their male partners. A clear case is the astronomer Jocelyn Bell, who discovered pulsars in 1968 but Anthony Hewish, her professor, was who took credit for the discovery and was awarded with the Nobel Prize in physics (Hewish, Bell, Pilkington, Scott, & Collins, 1968). As Jocelyn Bell, there are more women who were behind major scientific discoveries whose credit went to their husbands or male professors (*see list in Annex I*).

On the other hand, when the eco- prefix is added to feminism, it refers to environmentalism[2], that extends the concepts of ecology to the terrain of social reality. Thus, environmentalism proposes and defends the search of forms of development that are in balance with nature (Ribas, 2015). This project will approach environmentalism in science from the important point of plastic consumption.

1.2. The problem of plastic nowadays

Over the last 30-40 years, the amount of plastic has grown almost exponentially (Fig. 1). In the 1950s, around 2 million tons of plastic were produced in a global scale every year but, by 2014, the amount increased to 367 million tons per year. In addition to the increasing amount, plastic entails another problem: its waste management. In 2018, out of the 8.3 billion metric tons of plastic produced, 6.3 billion metric tons became plastic waste (Parker, 2018). From the amount of plastic currently produced and discarded, only 9% is recycled. The 91% remaining will end up incinerated (12%), dumped to a landfill or, more commonly, released into the oceans (79%).

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[2] There is a big discussion between the meanings of environmentalism and ecologism nowadays. Ecologism is a philosophy that believes in a thoroughgoing root and branch transformation of society. Environmentalism believes that dangers to the environment can be tackled within the existing political, economic and cultural order (Kevin Harrison, 2018).

Plastic within the oceans has become one of the major problems of plastic management. Nowadays, between 4.8-12.7 million tons of plastic are discharged into the seas and oceans every year (Jambeck, et al., 2015). It is also estimated that the plastic amount in the seas is around 8.5 million metric tons on the seabed and 79.000 metric tons floating only on the surface of the Great Pacific garbage patch[3] (Jambeck J. , 2018). Furthermore, it can also be quantified the amount of plastic every country deposits into the ocean. One study conducted in 2015 estimated how much plastic was dumped into the ocean by 192 different countries *(Fig. 2*). The country that throws the biggest plastic amount is China, with more than 5 metric tons per year, followed by countries like Malaysia or Vietnam with 1-5 metric tons per year.

The consequences of this quantity of plastic in the oceans are one of the most important problems in the world, oceans contamination. This contamination affects marine animals such as seabirds, marine mammals, turtles and fish. These animals become entangled and may drown, become injured, have their ability to catch food or avoid predators impaired, or incur wounds from abrasive or cutting action of attached debris (Laist, 1987). Also plastic is mistaken for food and ingested by birds, whales, manatees and sea lions among others, causing them suffocation and a reduced sensation to feed when the debris becomes permanent in their digestive tract (C. Krause, Von Nordheim, & Bräger, 2007). Furthermore, it does not affect just marine animals but also humans, having an impact on fishing industries, economy and human health. All these problems confirm that action must be taken immediately before reaching an irreversible point. This problem affects everybody and therefore, awareness and action maneuvers must be carried out not only around the world, but also in all social groups. Tackling the problem of plastic at a global level is difficult and costly. Some of the most important world organizations such as ONU, UNESCO or Greenpeace are already acting and promoting measures to reduce or modify the consumption of plastic. However, it is a long process often ineffective due to the lack of awareness about the plastic problem in the society. It is for this reason that this work focuses on a smaller scale, delimiting the problem of plastic to biology or life science laboratories in order to create an impact on a local area. The importance of studying this field is due to just one article can be found regarding previous studies about the amount of plastic used in laboratories. The only precedent that could be found was conducted by Exeter University in 2015 (Urbina, Watts, & Reardon, 2015) in which they investigated and found that 267 tons of plastic were used by biology scientist in 2014. Due to this lack of knowledge and control, it is necessary to focus on this topic in order to achieve a sustainable production of scientific knowledge.

[3] The Great Pacific garbage patch is a gyre of plastic debris particles in the north central Pacific Ocean.

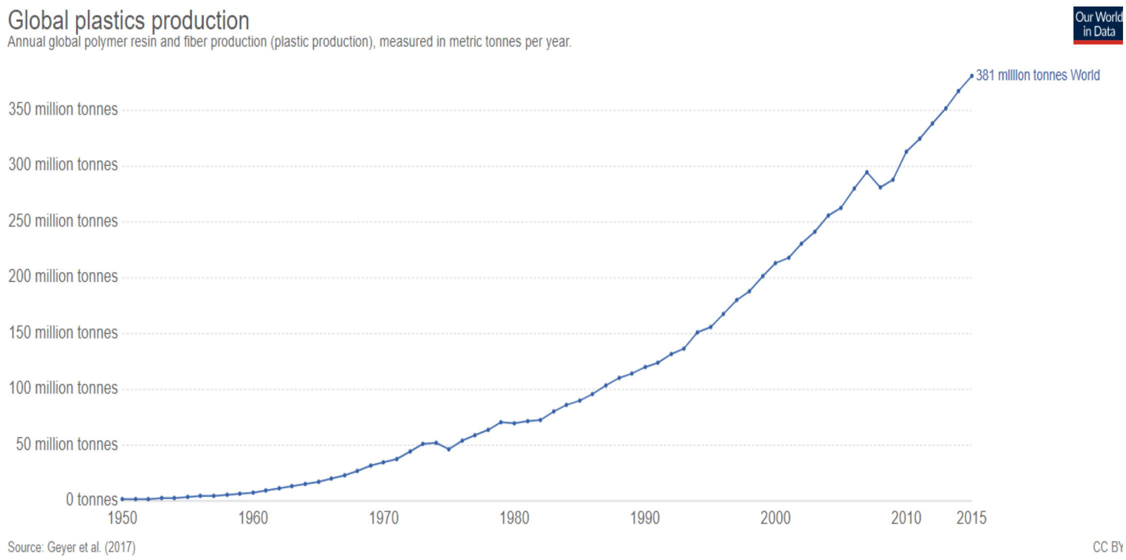

Figure 1. Annual global polymer resin and fiber production (plastic production), measured in metric tons per year.

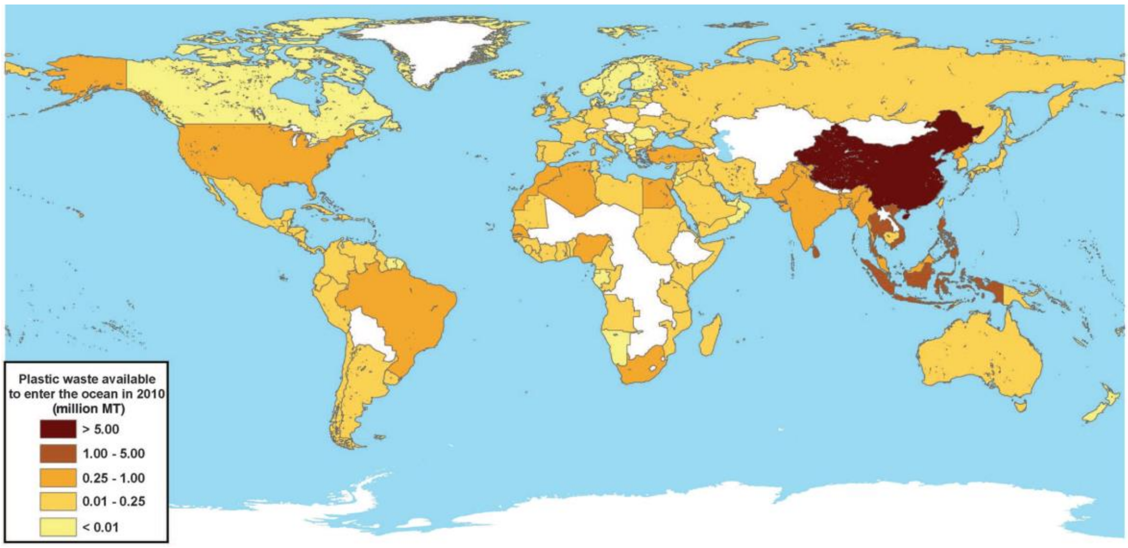

Figure 2. Global map with each country shaded according to the estimated mass of mismanaged plastic waste that can enter the ocean as plastic debris (millions of metric tons) generated in 2010 by populations living within 50 km of the coast.

2. Hypothesis and goals and proposed methodology

- Hypothesis

  There is not a control or tracking of the plastic used in UAB's life science laboratories.

- Goals

  It has been mentioned how generally, plastic in laboratories is not tracked, taking the global problem of plastic into research and scientific fields. Therefore, the main aim of this project is to evidence that there is no adequate control and management of plastic use in life science laboratories from the UAB. In this way, I will answer if it makes sense to apply environmentalism to science or not. It is clear that the planet is constantly receiving the impacts produced by the human species (Garcia, 2003), and science may have an important role in these impacts.

  - Proposed methodology

  This project also proposes three different and alternative processes that could be possible solutions to the problems plastic usage can entail. Moreover, I will create a dissemination plan to raise awareness about the reality of these issues.

3. Preliminary results

This research focuses on plastic management within the UAB and its attached research centers in the biology field. In order to find records of plastic usage, I contacted among others the academic management team of the UAB Bioscience Faculty, the internship coordinator of the Biology Bachelor, and the general office of Environment of the university[4], with whom an interview was arranged. None of the people contacted had record of neither the plastic purchased for research nor the total amount of plastic used in the university. Finally, I found Iolanda Sorts Villanueva, the person in charge of the training laboratories of the life science faculty (*Laboratoris integrats*), who could provide some data. In only these laboratories of the Bioscience faculty, corresponding to 15-17 labs, the following was used (Table 1):

[4] This office is in charge of dealing with themes as university debris, biosafety, sustainability and network of natural roads of the UAB among others.

Total year 2017-2018	
VINIL GLOVES T/G C/100	**172**
VINIL GLOVES T/M C/100	**327**
VINIL GLOVES T/P C/100	**267**
YELLOW TIPS 5-200ul T/GILSON B/1000	**108**
BLUE TIPS 100-1000ul T/GILSON B/1000	**94**
NEUTRAL SHORT TIPS 0,1-10ul T/GILSON B/1000	**42**
TIPS 1-5ML TYPE GILSON B/25	**19**
PCR TUBE 0,2ul T/PLANA B/1000	**9**
EPPENDORF 0,5 ML S/GRADUAR B/1000	**10**
EPPENDORF 2ml b/500	**1**
MICROTUBE 1,5 EPPENDORF FLAT TAPE B/1000	**84**
PETRI PLATE c/500	**28**
SEMIMICRO CUVETTE C/100	**89**
15 ml PP CONIC TUBE c/ 500	**17**
50 ml PP c/falcon TUBE c/ 500	**2**
50ML PP CONIC TUBE C/500	**4**
FLASK 125 ml PP B/I BOTTLE C/ 400 STERILE	**1**
GRADUATE PASTEUR PIPETTE 3 ml c/ 1000 STERILE	**2**
PASTEUR PIPETTE 3ML NOT STERILE C/500	**6**
DIGRANSKY'S HANDLE c/ 500	**5**
AUTOCLAVE BAG STERILIN C/200 UDS 406X610	**2**
URINE POTS NOT STERILE c/475	**2**
TUBES PP 10ml NOT STERILE BAG 1000u	**5**
TUBES PP 5ml NOT STERILE BAG 1000u	**5**
TUBES 10 ml STERILE BAG 500u	**9**
TUBES 5 ml STERILE BAG 25u	**128**
SYRINGE 5 ml BOX 1000u	**2**
SYRINGE 10 ml BOX 1000u	**2**
SYRINGE 1ml 100u	**2**

Table 1. Plastic material used for students in the UAB life science's Faculty in the year 2017-2018.

The material show in *Table 1* is the used for bioscience students *without* including that one used by microbiology degree, so the total amount of plastic use in laboratories at the UAB is greater than the one shown.

This means that an approximate 76.600 gloves, 240.000 pipette tips, 123.150 tubes for different utilities, 4.200 syringes among others materials are used in around fifteen university laboratories per year. To calculate the total amount of plastic used in scientific laboratories in the UAB, I would need to add the plastic usage of all the other laboratories in the university, which is unknown at the moment. Given that all this material is plastic, it can be assumed that 91% of all this plastic will end up in landfills or marine landfills. Ultimately, to get a world estimate of science's plastic usage, it will be necessary to repeat the calculations for every research facility (or a representative number of facilities that would allow faithful estimation). It is worth mentioning that, given that all the materials listed are made of plastic, only 9% will be properly recycled.

4. Methodology of the project proposed

In the light of the information discovered, we can see two problems. Firstly, the lack of information regarding plastic usage in life science laboratories. Secondly, the few data obtained suggests that amount of plastic used is huge. For this reason, this project proposes an intervention process in three phases to tackle these problems.

1. Diagnosis of the use of plastic in the laboratories of UAB.

The first step is to keep track of the amount of plastic used by each laboratory. By using computer programming, it is easy nowadays to create a model that relates each plastic product with its weight. Given that most labs already keep track of the cost of all purchases, it would be almost effortless. In more detail, the model would need to incorporate the weight and value of each piece of plastic used in a lab (for example, a 5-20 µl pipette tip weighs around 1 gram and costs around 5 cents) in order to link the spent money with the quantity of plastic it has. Then, if each laboratory saves its bills of expenses, the data of this bill can be collected and entered into the program.

A practical example would be the calculation of plastic that has a box of 960 pipette tips: the cost of this box is around 48€, price obtained from the bill. This price is incorporated in the program, which already knows that 1 tip costs 5 cents and is equivalent to 1 gram of plastic. Therefore, it can calculate the amount of plastic this box has, which is around 850-900 grams.

This way an estimated amount of all the plastic that is being bought and used on average in the laboratories can be obtained. Most of this process could be automated, requiring only input when creating a library to link each product to the amount of plastic that it contains and other relevant data.

2. Search for alternatives to plastic in life science laboratories.

In recent years, several labs have looked for alternatives to plastic that could overcome some of its drawbacks while still being affordable and not sacrificing science integrity or quality. One of the characteristics of the plastic that made its use so widespread is its long lifetime and conservation, but what before was an advantage today is its biggest drawback (Osterloff, 2017).

However, there is a big awareness about the possibility of using biodegradable plastics. This way, if the plastic tools for research are made of biodegradable plastics they can degrade more easily than those used today can. One of these biodegradable plastics are Polyhydroxyalkanoates (PHAs), polyesters of hydroxyalkanoates (HA) that are synthesized by some bacteria as intracellular carbon and energy storage compounds and accumulated in the form of granules in the cytoplasm of cells (Lee, 1996). Around 80 types of HAs have been discovered, providing several candidates to create new forms of plastic with different characteristics. Some of the bacteria that produce these plastics are *Alcaligenes eutrophus, Alcaligenes latus* and *Azotobacter vinelandii* (Arp, McCollum, & Seefeldt , 1985). Other forms of naturally-occurring plastics are polylactic acids (PLA). Polylactic acid has proved to be a viable alternative to petrochemical plastics for many applications (Drumright, Gruber, & Henton, 2000). It is produced from cornstarch, yucca or sugarcane and is biodegradable, decomposing into H2O and CO2. In addition, PLA plastics have unique physical properties that make it useful in a variety of applications, including paper coatings, fibers, films and packaging (Drumright, Gruber, & Henton, 2000). In this way, if lab plastic tools were made of biodegradable plastics, their degradation would be faster and therefore more sustainable for the planet.

3. Degradation and recycling of plastic used in the laboratories of UAB

Many plastics end up in the sea for years because they take centuries to degrade. Although most plastics are believed not to be susceptible to bio-degradation, it has been found lately life forms that consume some type of plastic naturally. Therefore, the discovery of organisms that ingest plastic as the main way to obtain carbon opens the doors to a new concept of plastic degradation. Some of these organisms:

- In 2016, a research group from Japan managed to isolate a new bacterium that breaks down a type of plastic, polyethylene terephthalate or PET[5], using two enzymes to hydrolyze it. This new organism was called *Ideonella sakaiensis 201-F6* (Yoshida, et al., 2016).
- In addition, in 2015 another research group found a variety of fungus called *Fusarium oxysporum* that produced an enzyme (*cutinase*) able to degrade PET (Dimarogona, et al., 2015).

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[5] PET is a common polymer resin of the polyester family used in fibers for clothing and containers for liquids and foods among others.

- A research group discovered in 2017 that waxworms (*Galleria mellonella*) could create holes in polypropylene[6] (PE) films if left in direct contact (Bombelli, J. Howe, & Bertocchini, 2017). This shows how this organism can obtain its source of energy and feed itself naturally by degrading polyethylene.
- Also in 2007, a new species of fungus was found that was capable of degrading plastic waste and was called *Pseudozyma jejuensis* (Hyuk-Seong, et al., 2007).

All these organisms open the door to a world of alternative possibilities of plastic biodegradation. More and more discoveries are coming out about new organisms that could be used to degrade plastic in a natural way, and it is interesting to continue studying these fields. In addition, the enzymes responsible for breaking down the plastic within these organisms (for example the cutinase from *Fusarium oxysporum)* can be extracted, purified and marketed. This opens up the possibility to create laboratory tools composed of alternative plastics which could be degraded in a more sustainable way, without the need of dumping it into landfills.

5. Expected results

In here, I proposed a method to tackle the problem of plastic usage in laboratories. With the implementation of a computer model to count the total amount of plastic used in the laboratories (detailed in "diagnosis of the use of plastic in the laboratories of the UAB") it would be possible to estimate this quantity and take measures if it is necessary. This work also shows that, although there is no knowledge about the exact quantity of plastic used, it seems to be a lot. Therefore, the last two parts of the methodology are meant to spark action to start creating tools made of biodegradable plastics and to start adopting measures of plastic degradation using living organisms or their enzymes. Therefore, following this methodology will reduce the amount of plastic waste, making scientific development more sustainable for the planet.

5.1. **Dissemination plan**

In order to raise awareness about the problem with plastic in biology laboratories, I have created an informative flyer. The main objective is to make scientists more conscious of the plastic they are using, hopefully leading them to take action to reduce it. This flyer will be either e-mailed to department heads, staff scientists and students or it could be printed in recycled paper and handed out after faculty areas.

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[6] PE is the most common plastic and is used for packaging.

6. Conclusions and discussion

Initially, the main motivation behind this study was to find out how much plastic is used on average in life-science laboratories in general, and how much of it is recycled. To start with this idea it was necessary to know if there were already some studies about the amount of plastic that is used in science laboratories on average per year. A study carried out at the University of Exeter concluded that in its bioscience department, 280 scientists produced a quantity of 267 tons of plastic in 2014 (Urbina, Watts, & Reardon, 2015). Extrapolating it worldwide they found that among all the biological, medical and agricultural research laboratories the amount of plastic used was 5.5 million tons. However, this data is extrapolated from a single UK laboratory of 280 scientists but each country is governed by different legislation and culture, which suggests that their extrapolation might not be entirely accurate. For instance, in developing countries the use of disposable materials is much lower than in developed countries due to the volume of research and because they wash very well and reuse the material for cost reasons. Therefore, I tried to look at most important laboratories in the world, hoping that their prestige would make access to their plastic logistic information more feasible, but none of them had any files on the amount of plastic they used. Then, the only useful information was the aforementioned study from Exeter University. In this way, the initial question which was how much plastic is used for research became whether anyone kept track of how much plastic was used in research, and apparently it turns out that nobody knows it. This evidences the general ignorance about the real amount of plastic used in laboratories.

To confirm the unknown problem that plastic entails in laboratories, Estibaliz Urarte Rodríguez, Doctor in Biology, specialized in Plant Physiology and currently an important science communicator (with for example "El Jardín de Mendel"), was also interviewed. She stated that she was also aware of this problem and that it was necessary to raise awareness and disseminate this issue to new and existing generations of scientists (see full interview in *Annex II*).

Regarding the initial hypothesis of this work, it can be concluded that there is no tracking or control of plastic usage in the laboratories attached to life science fields in UAB. This work leads to the conclusion that the total ignorance of the quantity and use of plastic is due to the disconnection and lack of coordination between departments and laboratories of scientific entities. In addition, lack of institutional interest could be part of this problem. If each laboratory is independent when it comes to ordering and purchasing its necessary material, it makes sense that they are not aware of the material used by other departments. Thus, implementation of a centralized control of the plastic amount could be a method to solve this disconnection between departments.

To change the plastic consumption to a sustainable one, all of us, science included, should do their bit. For this reason, it would be interesting to show the results obtained in this project not only to scientists and to research entities but to as many people as possible.

Initially, this project was focused on see whether applying ecofeminism to science was useful or not. With the course of the investigation, the focus changed into the plastic problem thanks to a perspective based on ecofeminism. In other words, ecofeminism made me wonder the question that has been the main core of this project. Therefore, I believe that ecofeminism enables people to ask questions about topics regarding how the society of today is and how environment is treated, helping us to look for solutions or alternatives. Thus, ecofeminism can help us to analyze problematic situations as the one discussed in this project.

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