Public policies to mitigate plastic pollution and adhere to the circular economy: A case study from Ecuador

Políticas públicas para mitigar la contaminación plástica y adherirse a la economía circular: un estudio de caso de Ecuador

S. Naranjo-Silva

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Artículo de investigación científica y tecnológica

Abstract **— Most plastics do not biodegrade; instead, they fragment into microplastics that pollute air, water, and soil. These microplastics are ingested by animals, potentially entering the food chain and contaminating drinking water. By 2050, nearly 12,000 million tons of plastic waste are projected to accumulate in landfills and natural environments, leading to oceans potentially containing more plastic than fish. This study uses Ecuador as a case study to examine public management strategies aimed at promoting plastic waste industrialization, reducing single-use plastics, and fostering a circular economy for this overused yet controversial material. The investigative-experimental methodology combines local data on Ecuadorian policies with academic research from 2018 to 2022. The findings reveal that Ecuador has implemented various legal regulations to monitor and reduce single-use plastics, including *The Law on Rationalization, Reuse, and Reduction of Single-Use Plastics* and *The Law on Inclusive Circular Economy*. These frameworks serve as reference models for other nations seeking to reduce plastic production and consumption. The results underscore the urgent need for a paradigm shift in managing solid waste—specifically, how it is generated, disposed of, and treated. Ecuador's regulatory approach demonstrates a transition from a linear economy to a circular economy, providing a promising path for sustainable plastic waste management.**

Index Terms**— Circularity, Ecuador, Laws, Plastic, Polymer, Waste.**

Resumen**— La mayoría de los plásticos no se biodegradan, sino que se fragmentan convirtiéndose en microplásticos que contaminan el aire, agua y suelo, donde los animales los consumen y llegan a la cadena alimentaria y agua potable. Además, en 2050 tendrá cerca de 12.000 millones de toneladas de plásticos en vertederos y naturaleza; por lo tanto, los océanos contendrían más plástico que peces. Por ello, este manuscrito usa al Ecuador como un caso de estudio de gestión pública para aplicar acciones que promuevan la industrialización de residuos plásticos y reducción de plásticos de un solo uso, así como la economía circular de este controvertido material por su sobreutilización. La metodología es investigativa-experimental porque recopila información local de las acciones ecuatorianas, pero también se complementa con datos académicos de 2018 a 2022. Los resultados muestran que Ecuador mantiene varias normas legales para monitorear y controlar la reducción de plásticos, la cual está amparada por la Ley de Racionalización, Reutilización y Reducción de Plásticos de un Solo Uso, y la Ley de Economía Circular Inclusiva, sirviendo estos lineamientos como caso de estudio referencial a otros países que buscan reducir la producción y consumo de plásticos.**

Es evidente la necesidad de un cambio de paradigma en cómo se generan, despachan y tratan los residuos sólidos. Ecuador ha marcado uncamino a seguir en materia de residuos plásticos, implementando una normativa que controla los procesos de generación y recuperación de material plástico, incentivando el cambio de una economía lineal a una circular.

Palabras claves **— Basura, Circularidad, Ecuador, Leyes, Plástico, Polímero.**

I. INTRODUCTION

Worldwide, paradoxically, plastic arose, among other reasons, to solve an environmental issue by seeking to replace elephant tusk ivory in products as dental pieces, piano keys, knife handles, eyeglass frames, and billiard balls, as well as substituting other elements like tortoiseshells with which containers were made as plates, or glass for drinks that continually broke during transport due to their fragility, or even arriving as an affordable democratizing element to all social classes and to free women from the burden of washing all kitchen utensils and food at all times [1], [2].

However, its production and use have become so widespread since the last century that today it is possible to find residues from Antarctica to the Arctic, from Everest to the Mariana Trench at a depth of 12,000 meters. For example, global plastic production went from 2 million tons in 1950 to more than 400 million in 2020, as shown in Fig. 1 [3], [4].

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Sebastian Naranjo-Silva: Department of Sustainability, Polytechnic University of Catalonia, Barcelona, Spain; Emeil: hector.sebastian.naranjo@upc.edu

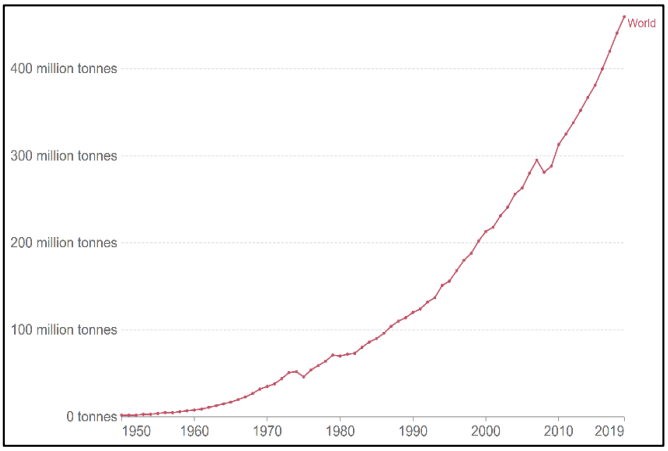

Fig. 1. Global plastics production. [3]

As shown in Figure 1, plastic production dramatically increased around the 70 years analyzed. Moreover, about 13 million tons of plastic waste annually reaches the oceans. They arrive by waterway and are concentrated in the world's great rivers and their main tributaries, but if this trend continues, by 2050, it will have close to 12,000 million tons of plastic waste in landfills and nature; therefore, the oceans will contain more plastic than fish in 2050 according to the United Nations [5], [6].

According to Greenpeace, between 60% and 80% of marine debris is plastic, and the majority are fragments smaller than five millimeters, that is, microplastics. Every minute, one million plastic bottles are sold worldwide, and each plastic bottle takes about 450 years to decompose. If it is not out in the open, the figure is close to 1,000 years [7], [8].

In addition, 42% of the plastic used in the world goes to the packaging of food and manufactured products. In other words, single-use plastics barely spend a few minutes in the hands of consumers. In 2015, 55% of global plastic waste was discarded, and if you add up plastic production throughout history, in that same year, the world had already produced 7.8 billion tons of plastic, more than one ton of plastic per person in the world [1], [9].

Projections show that 2050 greenhouse gas emissions associated with the production, use, and disposal of plastics will represent 15% of permitted emissions. Over 800 marine and coastal species are affected by plastic pollution from ingestion, entanglement, and other hazards [10], [11].

Also, on average, 200 plastic bags are used per person annually, and they take around 400 years to degrade. Microplastics have been detected in commercial table salt, and some studies state that 90% of bottled water and 83% of tap water contain plastic particles [12], [13].

Against this background, from January 16 to 20, 2023, the Cooperation in a Fragmented World meeting was held within the framework of the World Economic Forum in the city of Davos in Swiss. In the meeting, the President of Ecuador announced the country's intention to host the Diplomatic Conference to sign the legally binding Treaty on Plastic Pollution, scheduled for early 2025.

But, because Ecuador seeks to host this Treaty, it is essential to mention that the country has been working for a long time on the issue of plastic pollution; 2008 in the Constitution of the Republic, the country proved to be the first in Latin America and one of the few worldwide that promotes the ecological transition as a transversal public policy. From there, Ecuador has taken decisive steps to limit plastic pollution by issuing regulations, laws, and instruments such as a tax of 2 c.USD for each non-returnable plastic bottle a consumer purchases, and the tax on plastic bags without material recycling is 8 c.USD for each required bag, among other elements [14], [15].

Based on the Davos World Economic Forum in 2023, Ecuador also became the first country in Latin America and the Caribbean to join the "Global Plastic Action Partnership" (GPAP) initiative, which promotes multisectoral and systemic action against plastic waste and its contamination in different countries of the world through the analysis of data on the generation, collection, separation, and treatment of plastic waste to project scenarios [16], [17].

This GPAP Alliance will allow Ecuador to develop an action platform for plastics as a collaborative space aimed at promoting the ecological transition, sustainable production and consumption, uniting multiple actors from the Government, private sector, informal economy, civil society, and academy to reduce plastic pollution in Ecuador, development of metrics, strategies and a national action plan.

With various regulations such as The Single-Use Plastics Law and The Circular Economy Law, Ecuador has been demonstrating that the country is committed to caring for the environment, the conservation and sustainable use of biodiversity, the fight against climate change, and all types of pollution. Based on the constitutional recognition of everyone's right to a healthy and balanced environment, the Government is promoting the ecological transition towards a circular, resilient, and low-emissions economy across the board.

For this reason, to conserve and sustainably use the unique biodiversity that inhabits Ecuador, actions are promoted to benefit the planet for the current and future generations. Under this global perspective, the Ecuadorian Government, with various projects, finds the fulfillment of Sustainable Development Goals continuously.

This document aimed to develop a comprehensive understanding of Ecuador's efforts in combating plastic pollution within the framework of the Sustainable Development Goals and Environmental Actions. Specifically, it sought to position Ecuador as a benchmark in public policy management by examining actions that promote the industrialization of polymer waste, the reduction of single-use plastics, and the advancement of a circular economy. The development of the document involved a detailed analysis of Ecuador's policy initiatives, regulatory frameworks, and practical interventions aimed at managing plastic waste. This includes examining how Ecuador implements strategies to transform plastic waste into valuable resources through recycling and industrial processes, reducing environmental impact, and fostering sustainable growth. The manuscript highlights Ecuador's role in tackling plastic overuse and advancing innovative waste management practices that align with global sustainability targets.

II. METHODOLOGY

The methodology is investigative-experimental, investigative because it finds data around the primary source of information, for this analysis, data was collected from various governmental entities since the systematized information of Ecuadorian platforms, for which they are named below:

- Ministry of Production, Foreign Trade, Investment and Fisheries of Ecuador
- System of Accounting Information of Companies by Sector from The Ecuadorian Internal Revenue Service (SAYKU by their Spanish acronym name)
- National Institute of Statistics and Censuses of Ecuador
- Superintendency of Companies of Ecuador

On the other hand, the methodology is experimental because it determines the actions of the Ecuadorian Government around the reduce plastics use, with local information collected from the database of Google Academic. It selected this database because there is significant uncertainty about the subject, especially since Ecuador is a developing country with few plastic pollution investigations. However, Google Academic provides ease of use, applying agility to academic searches, free services, and linking documents with higher visibility.

In the Google Academic database, around 56 documents related to the subject were found in the first round, including research articles, reports, web page blogs, and theses. Therefore, with the specific keywords: "Ecuadorian plastic pollution", "Ecuadorian Circular Economy Actions", and "Policies to reduce plastics in Ecuador". Only 25 academic documents referenced in the manuscript were selected; it is also important to mention that a period was determined from 2018 to 2022 to verify current investigation information.

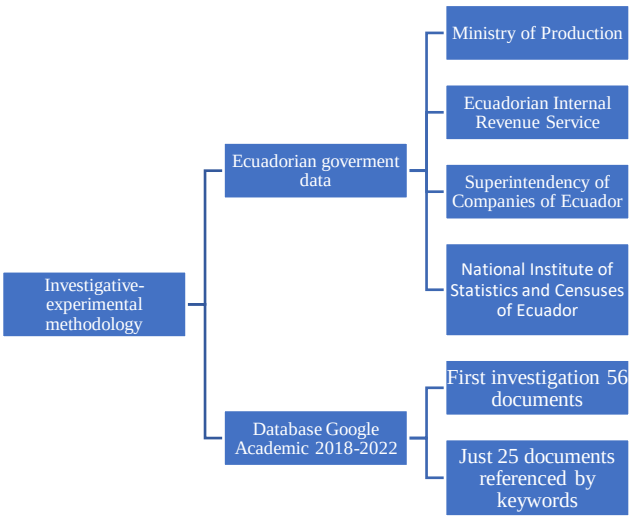

Fig. 2. Methodology.

The methodology mixed between investigative and experimental serve to collect local information on Ecuadorian actions but also complement academic data of investigation documents from a database, as shown in **Fig. *2***.

Overall, in these research article the primary methodology goal is to develop an experimental approach to evaluate the effectiveness of Ecuadorian public policies designed to reduce plastic pollution while promoting a circular economy. The study involves examining policies aimed at reducing single-use plastics, encouraging recycling, and fostering sustainable industrial practices. Thus, the study control variables such as:

1. Plastic Waste Generation: Measuring the amount of plastic waste generated over time to evaluate policy impact.

2. Recycling Rates: Monitoring changes in recycling rates before and after policy implementation.

3. Single-Use Plastic Usage: Tracking reductions in the distribution and use of single-use plastics as a direct outcome of the policies.

In addition, the experimental design utilized the comparative analysis: comparing specific policies to identify differences in plastic waste metrics.

The combination of controlled variables, rigorous methodology, and appropriate statistical analysis would allow for a robust evaluation of Ecuador's policies in reducing plastic pollution and advancing the circular economy.

III. RESULTS

Over the past twelve years, Ecuador has participated in various initiatives to stop plastic pollution; for example, it is one of the founding countries for the Group of Friends in the General Assembly of the United Nations in New York, an instance that among one of the objectives seeks to combat marine plastic pollution, and for several years, Ecuador has expressed in different multilateral forums the need for a global agreement on plastic pollution [18].

In 2021, Ecuador promoted, together with Germany, Ghana, and Vietnam, the First Ministerial Conference on Marine Litter and Plastic Pollution, which took place in Geneva and concluded with a Declaration of more than 70 countries in favor of an international treaty on this topic [19].

Based on the actions developed so far and the instances in which Ecuador has participated, a list of regulations on various plastic products or materials have been issued; the main ones are listed in **TABLE 1**.

TABLE 1.
ECUADORIAN LAWS AND NORMATIVE

No.	Normative	Date	Environmental instrument
1	Law for Environmental Promotion and Optimization of State Income	November 2011	In Chapter II, the Redeemable Tax on plastic bottles is created to pay for each bottle purchased.
2	Tax Simplification and Progressivity Law	December 2019	Creates a special consumption tax for plastic bags with virgin material, promoting the use of bags with recycled material.
3	Law for the Rationalization, Reuse, and Reduction of Single-Use Plastics	December 2020	Determines a minimal recycled material to be incorporated into plastic bags, cups, preforms, thermoformed sheets, plastic bottles, and expanded polystyrene containers.
4	White Paper on the Circular Economy	May 2021	Establishes strategic lines, one of which is plastic, determining actions to reduce dependence on virgin plastic resin and increase the recovery of post-consumer plastic.
5	Inclusive Circular Economy Law	July 2021	It defines terms such as industrialization of waste to promote initiatives that increase recycling, as well as the implementation of the National Strategy for an Inclusive Circular Economy and national public policies on the subject.

As shown in **TABLE 1**, there are Laws and Guidelines with secondary regulations, each guiding the country's actions in the environmental favor and the plastics reduction. An example is that in January 2019, the Tax Simplification and Progressivity Law was issued, establishing a tax on plastic bags with virgin material, and providing the condition that companies that generate this type of bags with at least 50% recycled material will not pay the tax, in addition to promoting that half the tax be paid for biodegradable bags to the time to request in commercial shops [20], [21].

However, let us not forget that there were already actions that were being carried out in Ecuador, such as the Redeemable Tax on Plastic Bottles (IRBP by their Spanish acronym), which works as a mechanism that recovers the income of base recyclers, promotes recycling, supports the circular economy and provides added value market for the collection of plastic bottles [22].

But with the consumption of single-use plastics, not just bags or bottles, sought to increase the amount of plastic waste recovered in other materials such as High- and low-density of Polyethylene, Expanded Polystyrene, Polyethylene terephthalate, and Polypropylene, so it needed to comply with the Plastics Law for the Rationalization, Reuse, and Reduction of Single-Use Plastics of 2020, private investments arose to obtain post-consumer raw material [23], [24]. Thus, with these regulatory implementations, it is crucial to analyze the sector, for which data was collected from the Ecuadorian Internal Revenue Service, with the International Industrial Classification of Economic Activities selected the plastic production code (CIIU-C2220), and the following trend of total assets and net exports is verified in **Fig. 3**.

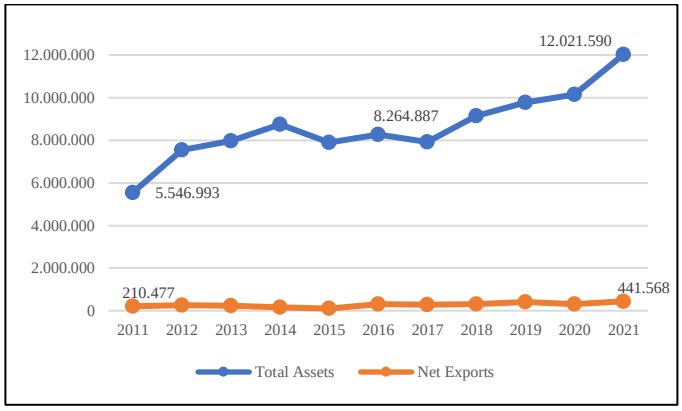

Fig. 3. Ecuadorian plastic sector (2011-2021). Code C2220

The period (2011 to 2021) was analyzed both for the assets of the sector and for net exports; it is observed that the plastics sector invests, pays taxes, and develops jobs, therefore, comparing the figures from 2011 to 2021 in a total of assets, the sector grew by 117%, and it exported 110% more than ten years ago.

According to information from the Superintendence of Companies in 2021, 83% of the companies dedicated to manufacturing plastic products were micro, small, and medium-sized. In addition, 85% of the companies in this sector were located in the provinces of Guayas and Pichincha, and the entire sector provides 12,550 jobs, of which 75% corresponded to large companies [25].

On the other hand, from another governmental area, the Ministry of Production, Foreign Trade, Investment and Fisheries of Ecuador has made several efforts to carry out different initiatives that, in line with the regulations, help compliance and increase the processing of plastic waste. One of the examples is that secondary regulations to the Plastics Law were generated through Resolution No. 0138-R in April 2022 to create a registration platform for Producers, Importers, and Recyclers of single-use plastics.

According to information from the Ministry of Production of Ecuador, there have been around 80 records since July 2022, and the platform serves the sector for creating interconnections between the actors and generates statistics for the next steps to follow. In addition to the 2022 year, from the industrialization of plastic plants, around 77,800 tons of plastic bottles were recovered, 12,500 tons of material for plastic bags, 827 tons of plastic cups, tubs, and cutlery, and 625 tons of expanded polystyrene containers. All these products were recovered, producing recycling material to incorporate in new products giving a second life system cycle for the plastics.

IV. Discussion

According to the United Nations Organization, in 2018, most plastics do not biodegrade but fragment to the point of becoming microplastics that pollute air, water, and soil, where animals consume it and can reach our chain food like table salt, bottled water, and drinking water. From international studies, babies are born with nano plastics in their blood, or such remains have even been found in breast milk [26], [27].

Nevertheless, both the consumer and the producer are responsible for an increasingly marked generation of waste; being so that the industrial sector to satisfy the demand involves substantial contamination in land, air, and water [28], making solid waste a problem for most countries of the world [29].

Thus, plastic pollution ends up in inappropriate final disposal sites, causing clogging of sewers, visual impacts, accumulation of dangerous vectors, and damage to natural ecosystems and existing biodiversity [30], [31].

At the national level, in Ecuador in 2017, according to data from the National Institute of Statistics and Censuses of Ecuador based on surveys, 47.5% of the households surveyed (30,023) classify waste, that is, five of every ten Ecuadorian households have carried out this practice [32]. Between 2010 and 2016, the classification percentage increased by 16.3 percentage points. Within the different types of waste classified in homes in 2017, plastic was the waste with the highest classification (32.9%), compared to paper-cardboard (21.4%) and glass (12.7%) [33], [34].

The national and global reality contemplates actions to reduce contamination by solid waste, among them plastic waste. Therefore, from 2019 to 2020, specific legislation was conceptualized in Ecuador as necessary to start with the organization of the recycling chain and thus reduce the number of plastics that reach sanitary landfills, involving all the actors that form part of the chain of manufacturing, distribution, marketing, and use of single-use plastics [35], [36].

Meanwhile, the Organic Law for the Rationalization, Reuse, and Reduction of Single-Use Plastics of December 2020 was promulgated with the purpose that Ecuador contributes to the fulfillment of the Sustainable Development Goals 11, 12, 13, and 14 in the fight against poverty and inequality, preserving the planet, protecting the oceans through responsible production and consumption. In addition, the Law establishes the execution of actions to mitigate the decrease in single-use plastics, and promote their industrialization, being participants in the Circular Economy.

In addition, it is important to mention the initiative for the industrialization of plastics carried out through investments from the private sector, whether in machines, equipment, or technology that will help both the manufacturing process of post-consumer raw materials and the production of plastic products with the incorporation of recycled material to strengthen a circular economy in the sector, bringing important benefits for the environment as seen in **Fig. 3** of assets of companies in the plastics sector.

From the exposed regulations of Ecuador, it is sought to ensure an internal supply of post-consumer plastic as raw material through monitoring material recovered by grassroots recyclers and other managers. For this reason, the analysis includes criteria such as Fig. 4 that are suggested to the consumers, Government, and companies with specific actions to conduct a circular economy of this material.

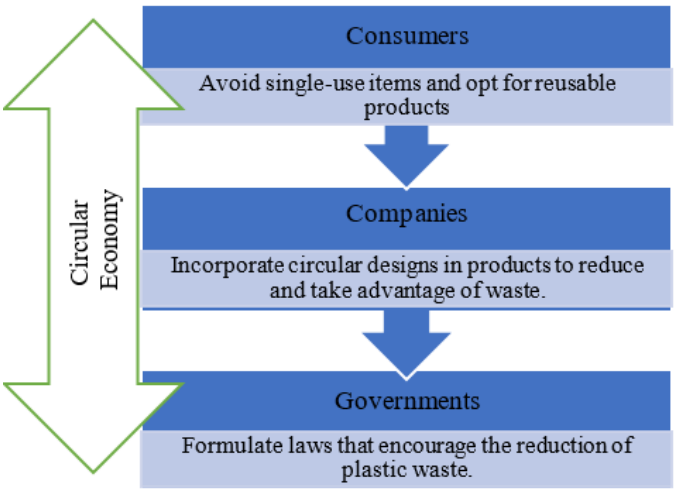

Fig. 4. Guideless of plastic actions

On the other hand, thanks to the promotion of the regulations issued by Ecuador and its active international interest in February 2022 with other countries and key actors from different regions, the 5th resumed session of the United Nations Assembly for the Environment (UNEA 5.2) Resolution 5/14 was adopted, whereby an Intergovernmental Negotiating Committee (INC) was established, with the mandate to develop a legally binding International Instrument on plastic pollution, with an all-encompassing approach a polymer life. With the adoption of said Resolution, the High Ambition Coalition to end plastic pollution was derived, the same one that currently integrates more than 50 countries from different regions and that promotes the inclusion of ambitious goals in the future treaty [37], [38].

Thus, at the end of 2022, in the first session under the Intergovernmental Negotiation Committee, held in Punta del Este, Uruguay, Ecuador was elected as one of the Vice Presidents of that Committee, and from December 2023, it will assume the presidency of the process until the end of the negotiation projected to 2025.

Of the latest actions, Ecuador seeks to chair the Intergovernmental Negotiating Committee of Plastics to develop the future treaty on plastic pollution from December 2023. Within this framework, the participation of governments, international organizations, academics, scientists, civil society representatives, and the private sector is promoted for the construction and implementation.

From what has been analyzed so far, the voice of scientists will be vital to reach an effective treaty, the knowledge and experience of the academic community will put into perspective the proposals from diplomacy and governments. Therefore, active participation will be essential when making decisions within the framework of implementing a treaty that will curb the plastic pollution of adherents [39].

Strengthening these actions in Ecuador, the National Circular Economy Strategy is built, for which several strategic axes have been defined; one of them has to do with the incorporation of a Platform for the exchange of industrial and residential waste; this initiative has as its primary objective reduce costs for the

industry and increase the demand for raw materials, rationalize the use and improve the distribution of resources, as well as promote a good symbiosis among its actors.

Of the recollected concerning the contamination of plastics in Ecuador, several legal regulations support its reduction and recycling. Still, there was no talk of other elements that could replace it and that, if they were migrated to these, could cause an environmental imbalance, as it is paper, cardboard, and glass. Although they could somehow replace various plastic products, the problem is the general mismanagement of solid waste, that is, how citizens dispose of it, mixing without separating the garbage, therefore municipalities and governments must generate actions so that all cities have a selective separation of materials and thus support recycling plants to industrialize all types of waste [40], [41].

Finally, this study is only a tiny sample of the actions that Ecuador executes in the plastics and waste industrialization sector; the notions raised could serve as a reference to Asian countries with a much broader population density and waste generation, where they must be generated strict, short-term actions seeking to restriction the mindless consumption of plastic and its low recycling rate. On the other hand, the shortcomings of the manuscript are that it is only a case of study with an Ecuadorian perspective, giving data from the actions that the Government did around the different regulations applied, but still a lack of population perception around the actions needed to reduce the plastic use and better the solid waste separation.

V. Conclusion.

Ecuador maintains several legal regulations for monitoring and controlling the reduction of single-use plastics and plastic waste industrialization, which is covered by The Law on Rationalization, Reuse, and Reduction of Single-Use Plastics, and the Law on Inclusive Circular Economy, serving these guidelines as a referential study case to other countries that seek to reduce the production and consumption of plastics.

The need for a paradigm shift in how solid waste is generated, how it is dispatched, and how it is treated is evident. Ecuador has established a path forward concerning plastic waste. This path begins with implementing a regulation that controls the processes of generation and recovery of plastic material,

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Sebastian Naranjo-Silva born in Quito, Ecuador in 1985. He is a professional with around 15 years of work experience in different productive industries. Nowadays, He is a Sustainable Doctorate. He has a Master in Administration of Renewables Sources from the Technological Institute and Higher Studies of Monterrey in Mexico and another Magister in Industrial Management from Ecuador. Still, His degree is in Mechanical Engineering. He is interested in renewable energies, energy planning, hydroelectric scenarios for climate change and recycling strategies. Thus, he has scientific production, including papers published in national and international indexed journals and participation in national and international congresses, forums, and workshops. Finally, His work collaborated with the design of public policies and supported industrial processes. Orcid: 0000-0002-1430-8140.