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Plastic bags – the main culprit in plastic pollution?

A literature review on polyethylene bags

Thesis

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ABSTRACT

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Name of thesis PLASTIC BAG – THE MAIN CULPRIT IN PLASTIC POLLUTION? A literature review on poly-ethylene bags.		
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<p>In some people’s mindset, consumption of plastic bags is the root of plastic pollution and natural hazards despite there has been very few evidence or numeric figures to support it. Because of that, this thesis has been done to answer two main questions: (1) How has plastic bags contributed to environment pollution and (2) What is consumers’ perception toward plastic bags. The method of research is literature review with 9 articles retrieved from Centria UAS’ database. These articles have been written from 2010 to 2020, therefore, the validity and reliability of this thesis is strong. The article collection period was done from 1 July 2020 to 9 July 2020.</p> <p>There are ten key points that have been concluded after the article analysis process: (1) The conclusion of plastic bags being the culprit in plastic pollution has a weak foundation. (2) Paper bags are not a sustainable solution to replace plastic bags. (3) Biodegradable bags may have the same effect on plants as PE bags. (4) The reduction of plastic bag use will lead to environmental improvement is a misbelief. (5) PE waste can be recycled into industrial energy. (6) Recycling may be a long-term solution for plastic pollution, not the cutting of plastic products alone. (7) Public education is important in plastic pollution alleviation. (8) Public information is lacking, hence, it has led to the misbelief that governments’ policies are enough to help the environment and to provide a dangerous mindset to consumers that they have done enough. (9) Overstating the success of governmental policies may overshadow the real problem. (10) Possible indicators for behavior change toward greener alternatives are age, income, education and gender.</p> <p>Limitation for this study is the small scale of samples (n=9) and limited language articles which may affect and create variation in results. Further studies are recommended to confirm these findings.</p>		
Key words Plastic bags, PE bags, HDPE bags, LDPE bags, plastic bag consumption, consumers’ attitude.		

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20th July 2020.

Vy Nguyen.

CONCEPT DEFINITIONS

Abbreviations

UNs	United Nations
PE	Polyethylene
HDPE	High-Density Polyethylene
LDPE	Low-Density Polyethylene
BE	Beach-exposed
ME	Marine-exposed
NGOs	Non-governmental organizations
ACT	Australian Capital Territory
HM	Heavy metals
UAS	University of Applied Sciences

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1 INTRODUCTION

Global warming, or climate change, has been in discussion for years by environmental experts and activists. In recent decades, the rate of ice melt has developed dramatically and affected both humans and animals. The sea level will rise and evade land, and by 2100, approximately 200 million people will lose their homeland. (European Commission 2020a.) Moreover, it is predicted that the weather will keep getting hotter if there is no proper method to delay and prevent natural hazards of global warming. 10 years from now, Europe will be hit with frequent intense heatwaves every other year. (European Commission 2020b.) Earthquakes and cyclones are likely to occur as a part of climate change. These are the irreversible outcomes humans must face in the future if we do not cooperate to save the planet (European Commission 2020c.)

In the crisis of environment pollution, ENGOs or Environmental Non-governmental Organizations have been established to raise awareness and educate the public population on global warming and its consequences (Berkeley 2020). Environmental campaigns run by United Nations (UNs) or other ENGOs have received positive response from public such as Climate Action Summit or Clean Sea (United Nations 2020a). One of the most popular and environmental trends is International Mother Earth Day, which is celebrated every year on the 22nd of April. The campaign started in 1970, the birth year of international environmental movement in the modern time. Until now in 2020, the campaign has been run for 50 years with more than 190 countries engaged in the activities. (Earth Day 2020.) In collaboration with Earth Day, Earth Hour is a project from 2007 had the attention from both youngsters and older generations. On the last Saturday of March every year, people are encouraged to turn off their light and electric appliances in one hour from 20:30 to 21:30 to save the energy and tackle the climate change. According to the 2018's record, 188 countries joined the project. (Earth Hour 2020.)

Among these campaigns to save the planet, #BeatPlasticPollution, a part of #ForNature by UNs has been exceptionally popular. The main call for this large campaign is that people must work together to care for the environment and bring back the green color to Earth. In an effort of reduce environmental pollution, plastic pollution has become one of the main targets. (United Nations 2020b.) The call for plastic bags consumption, the main core of community campaign in any countries, has led to the misbelief that plastic bags are the main culprit in plastic pollution and therefore, the elimination of plastic bags will solve this problem. There are strict regulations involve the manufacture and waste management of plastic

products and bags do not seem to have satisfied environmental activists. Because of this, several countries have taken the next step by banning the use of plastic bags or applying plastic-bag levy (Parker 2019.) While these policies have appeared to be sufficient and affective, there has not been a great amount of evidence-based knowledge on the contribution of plastic bags to environmental pollution and consumers' awareness on the real problem.

Therefore, using the opportunity of thesis, the author has decided to conduct a theoretical research on the topic to enhance personal knowledge on plastic bags and at the same time, provide readers with a fruitful research work. To guarantee the success of this thesis and avoid misleading information, the goal and purpose of this thesis has been set. This thesis aims to provide readers' knowledge on plastic bags using only evidence-based knowledge and articles which have been performed in recent years. The purpose of the thesis is to identify the situation of plastic bags and their impact(s) on Earth.

2 RESEARCH QUESTIONS

The concept of plastics is broad. There are currently many types of synthetic and semi-synthetic plastics available. (Plastic Europe 2020b.) Without narrowing down, the successfulness of this thesis work is unachievable. Therefore, as mentioned, the author has decided to specifically research on plastic bags and its impact on the environment. The purpose of this thesis is to find out the current situation of plastic bags and their movements, and the aim is to provide a perspective on the connection between plastic bags and environmental pollution. Further information on methodology will be specified in the following chapter of the thesis.

There are two main research questions which the author wants to solve after this process:

1. How has plastic bags contributed to environmental pollution?
2. What is consumers' perception toward plastic bags?

3 THEORETICAL FRAMEWORK

In this chapter, readers are provided with relevant concepts and background knowledge of this thesis' topic. There are three subtitles on this chapter: Plastics, Environment and Pollution and The story of plastic bags. The author has limited what needs to be studied, since plastic and plastic bags are very general and wide topics.

3.1 Plastics

This chapter of the thesis will provide readers with overall plastics knowledge: history, chemical characteristics and how it is produced, plastics waste and how humans have managed to deal with them. To mention plastics, let's firstly define precisely the word "polymer" that can be sometimes be confusing to people.

Plastics are materials which are easily shaped and formed depending on usage purposes. In chemistry, plastics are made of large chains of molecules that are named "polymer". "Poly" means many and "mer" is shortened from monomer. The word "polymer" describes briefly the popular chemical characteristics of plastics themselves. The reaction of chains of molecules link together to produce polymer is called polymerizing. There are many types of polymers, to name a few: plastics such as PVC (formula: $(C_2H_3Cl)_n$), synthetic and/or natural fabricated wools and silks such as nylon 66 (formula: $NH_2[CH_2]_6NH_2$), rubber such as Nitrile Rubber polymerized from Acrylonitrile ($CH_2=CHCN$) and Butadiene ($CH_2CH=CH_2$) and glues such as urea formaldehyde (formula: $C_2H_6N_2O_2$). Simply put, not all polymers are plastics but all plastics are polymers. (Ministry of Education and Training 2020.)

3.1.1 The history of plastics

Before the invention of this materials, human once faced a serious risk of animal extinction, which would only have been solved by the creation of plastics. In the middle of 19th century, when billiard became popular, wild elephants had been killed to make billiards' balls from ivory and the elephant was at risk of extinction. Therefore, the Brunswick Group (a famous US billiard supplier) offered a \$10,000 award

for an invention which could solve this problem. In 1869, John Wesley Hyatt made a revolution in history, by discovered a substance from analyzing the cellulose of cotton fiber, that is replaceable to natural substances like tortoiseshell, horn, linen, and ivory. At that time, plastic and polymer were applauded that they are the savior of many animals, and they also can replace wood and protect the nature. (Science History Institute 2020.)

Plastics development was strong through World War II, when weapons and protective equipment, also necessities for the war required a large amount of natural resources. At that time, nylon, as known as a synthetic silk was an important salvage, was invented in 1935 by Wallace Carothers and nylon quickly being used for liners in protective clothing, rope and other necessities. After World War II and the Great Depression, plastics became more popular because of the pricing and their safety. Due to the easy-to-make, and from the common material, plastics and polymers were also a great help for us in economic and social fields, especially after the Bakelite invention of Leo Baekeland, which is 100% synthetic plastic with no molecules of nature. With the development of science and technology, there are currently many types of plastics. (Science History Institute 2020.) Plastics plays an important role in industrial manufacture, without which we will hardly function sufficiently. Their applications are so broad that they have silently blended into our daily lives and can be easily recognized in any industries, for instance agriculture, healthcare or building and infrastructure. Plastics, which can be either natural or synthetic, can be found in almost every item: from clothes, toys, televisions, computers to housing materials. Furniture and cars, which belong to high class products, have become accessible due to the replacement of plastic for other expensive materials. (Plastic Europe 2020a.)

3.1.2 Environment and Plastic Pollution

Understanding the concept “environment” is important because the core of this thesis is to review the impact of plastic bags on the environment and how it has contributed to environmental pollution. Oxford dictionary defines “environment” as the natural world, or a geographic region, on which its habitants reside and operate (MOT Oxford Dictionary of English 2020a). Tilastokeskus (2020) has given a more specific definition, by saying an environment includes any physical, social and cultural elements belong to the nature (Tilastokeskus 2020). The word itself has various meanings, depending on how and from which perspective people want to use it. Case (2013) has mentioned that an internal space, such as inside

a building, can be an environment (Case 2013, 3). Meanwhile, from an economist's perspective, environment is natural resources which human can utilize or even exploit (Cato 2011, 4). In linguistics, it can be a setting where an activity or a chain of activities occurs, for instance, a workplace environment (MOT Oxford Dictionary of English 2020a).

Furthermore, Oxford dictionary has defined "pollution" as the presence of harmful substance in the environment (MOT Oxford Dictionary of English 2020b). Pollutant is the harmful substance itself present in the environment (MOT Oxford Dictionary of English 2020b). These pollutants can exist in water, soil or air and cause damages to humans' health. Sources of pollutants vary depending on the form of pollution. The main origin of water pollution comes from domestic and industrial waste, for instance agricultural pesticides being dumped directly and illegally to the environment. The main sources of air pollution are industrial waste, such as fuel combustion of vehicles or industrial manufacturing such as factories. Meanwhile, industrial waste such as heavy metal and chemical substances are accounted for the largest portion of soil pollution. Though air, water and soil pollution can originate from natural resources such as volcanos or storms, human still plays the main role in expanding the problems. (THL 2020; National Institute of Environmental Health Sciences 2020; World Health Organization 2020a; Eugenio, McLaughlin & Pennock 2018.)

Concerning the topic of this thesis, plastic pollution is the main subject to discuss. Plastic is cheap and durable, but its durability makes the end-of-life of plastic products questionable. It is fast and easy to manufacture plastic and plastic products but disposing them is the main problem. Since they slowly breakdown over time, if being put to the environment, plastic products can last for a long time and become a pollutant. Small plastic particles, known as microplastics, can evade and affect soil or water quality that later consumed by human or animals. (Rhodes 217-239.) Therefore, World Health Organization has called for research on plastic pollution so that human know what the main problem is and suggest more sustainable solutions for the future (World Health Organization 2019).

3.1.3 COVID-19 and Plastics

Coronavirus is a group of viruses which evade and damage human's respiratory tract. In the past, there have been some diseases rooted from coronavirus such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). In December 2019, COVID-19 virus, a new form of corona virus, posed a threat to global health and later has become a pandemic. The first outbreak happened Wuhan, China which then spread to other countries and the world. COVID-19 spreads through droplets, via human-to-human contact and therefore, with the slow reaction of authorities, several countries have struggled. USA, for example, until 19 July 2020, had more than 3.5 million confirmed cases of COVID-19 and 137,674 deaths. In Europe, Italy had 200 thousand cases with approximately 35 thousand deaths, while Spain has more than 260 thousand cases and almost 28.5 thousand deaths. (World Health Organization 2020b.)

During the outbreak of COVID-19, the plastic industry has been affected with many companies reported a decrease in sales in comparison to the previous year. However, only small businesses seem to have suffered tremendously, while bigger businesses in the Nordic region have been enjoying a raise in pre-annual sales. (Chem Europe 2020.) Though the variation in sales is unavoidable, the plastic industry still considers this pandemic an opportunity to fight against single-use plastics campaigns and regulations (Scigliuzzio, Saul, Harrington & Pogkas 2020; Tabuchi 2020; Heiges & Neill 2020). In Europe, the plastic industry's public image is said to have been improved as nobody can deny the fact that healthcare professionals must use single-use hygiene protection such as masks and gloves that are made of plastics. In a survey done in 2020 with 155 people from 29 countries, only a small group of people believed that plastics' public image has been worsened during COVID-19. The rest remained neutral or shared that they have viewed plastics more positively. (Chem Europe 2020.)

Furthermore, people are more reluctant to use reusable products in their daily lives because of safety and hygiene. In the USA, some states have postponed or temporarily loosened their regulations on single-use plastic products to guarantee their communities' health. The demand for plastic products has untypically grown, and while the price of oil has hit the bottom during the past few months, virgin plastics are likely to be favored. (Silva, Prata, Walker, Campos, Duarte, Soares, Barcelo & Rocha-Santos 2020.) The possibility of plastic recycling is challenged during the pandemic as people want the risks of being infected remain at the lowest level. Environmental activists are worried as we do not know what our future may look like if the manufacture of plastic products increases while the control and prevention of plastic

pollution are still weak. Mismanagement of plastic waste can pose a threat to our health and our environment. (Murrey 2020; The Guardian 2020; McCormick 2020).

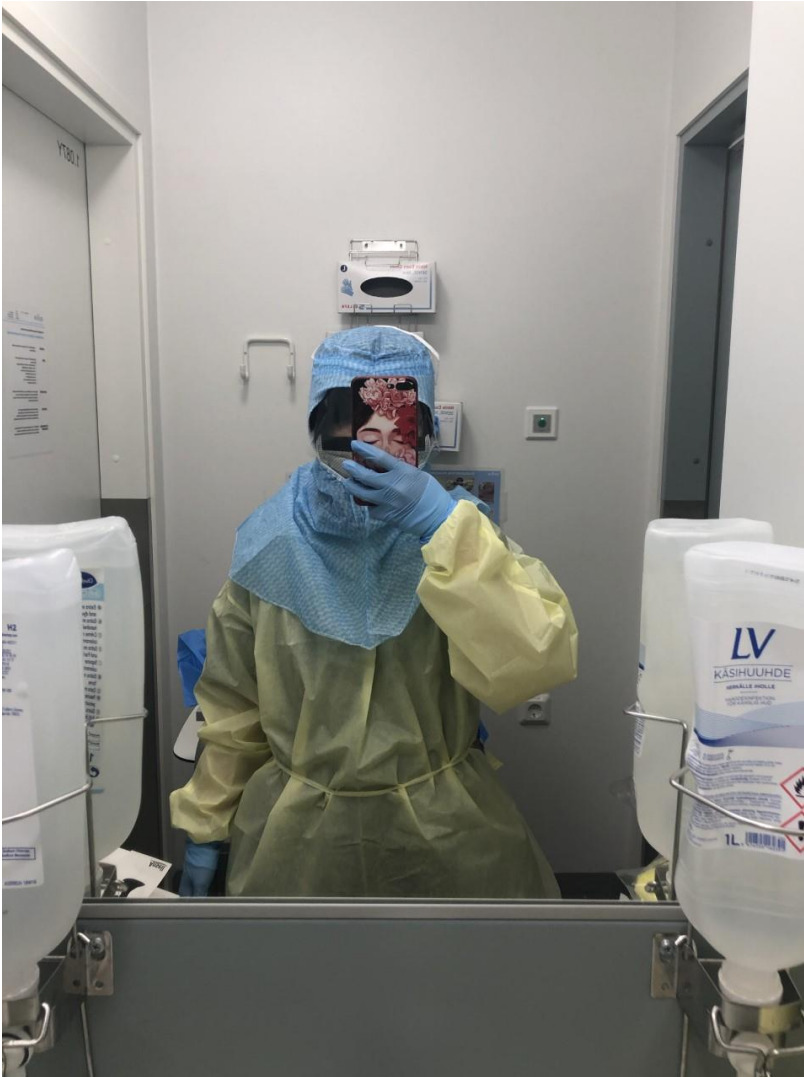


FIGURE 1. Protective clothes for healthcare professionals at SOITE, Kokkola in March 2020.

3.2 Plastic bags

In the fight against plastic pollution, people are encouraged to cut down the use of plastic bags in their daily usage, since they are believed to contribute largely to the destruction of our environment. In this part of the thesis, readers will be provided with knowledge about the most economically substantial material for plastic bags production – polyethylene. It is worth noticing that there are a wide variety of materials to produce plastic bags, for instance, nylon or PVC. (Spalding & Chatterjee 2017, 26-54.) There are, moreover, many more types of plastic bags currently in use, for example, biodegrading plastic

bags or bio-based plastic bags (Mahmoud 2017). Since this thesis was done on a Bachelor's level at Centria University of Applied Sciences, the author has simplified the area of study and hence, focused only on the material. The author, however, acknowledges well the existence of other types of plastic bag materials and plastic bags.

3.2.1 Polyethylene

The most basic type of plastics around us is polyethylene, or polyethylene (PE) with the chemical formula $(C_2H_4)_n$ (Lower 2020). In the past, polyethylene was specifically an ideal material for radar products production due to its low cost and lightness. Nowadays, a single person can consume averagely 10,4 kilograms of polyethylene per year without noticing the existence of it in their daily lives. For example, polyethylene appears in cabling and digital communication systems in electronics and is a vital component in infrastructure equipment production, such as pipe linings, water tubes or drainage tiles. The usage demand of polyethylene has increased over the decades for its cost-saving, durability and flexibility. Throughout centuries, polyethylene evolved through the development of modern technology to suit with utilization purposes. There are three main types of polyethylene: Low density polyethylene (LDPE), linear low-density polyethylene (LLDPE), and high-density polyethylene (HDPE) which can be further divided into small sub-groups of different types of polyethylene. (Spalding & Chatterjee 2017, 4-21.)

In this thesis, the author will focus on the roles of polyethylene in packaging industries. Specifically, the importance of polyethylene in packaging is undeniable. The food and beverage industry depends on polyethylene the most, account for 40% of polyethylene consumption. Smaller sectors in need of polyethylene can range from confectionary, cosmetics to pharmaceutical products. The market size of polyethylene, or plastic packaging, is large and spreading from Asia to America. Despite being cost-friendly, the polyethylene industry is worth of billions of dollars. (Spalding & Chatterjee 2017, 1072-1090.)

Whether LDPE, LLDPE or HDPE, they can all be suitable for manufacturing plastic packages, depending on the requirements of packaging, for instance: toughness, resistance, tightness or the needs for packages' decorations. Both LDPE and LLDPE are utilized to produce shrink films commonly seen in logistic packaging. HDPE or medium density polyethylene (MDPE) can sometimes be ideal if the main goal is to produce lighter and thinner logistic packages. Otherwise, LDPE and LLDPE meet the demands

for products' safety and reduce transportation risks due to its stretchiness, durability and stiffness. (Spalding & Chatterjee 2017, 1072-1090.) The application of polyethylene is even more apparent in medical packaging. In 2012, it exceeded polyvinyl chloride ($(C_2H_3Cl)_n$ or PVC, polyesters, and other polymer materials to become the largest portion of medical packaging, with the application ranges from containers, lids, caps to medical devices, to name a few: syringes, fluid (IV) bags or medical trays. (Spalding & Chatterjee 2017, 1155-1166.)

There are two methods to produce polyethylene: radical polymerization and catalyst polymerization. The first method involves the use of high pressure to polymerize ethylene through a chain of reactions. As mentioned above, the basic formula of polyethylene consists of a large chain of two carbon molecules and four hydrogen molecules ($(C_2H_4)_n$ or $(CH_2-CH_2)_n$, with n can range from 1000 to 100.000 depending on the types of polyethylene in need. The suitable temperature to produce polyethylene with radical polymerization can range from $64^\circ C$ to $190^\circ C$, using different types of initiators to polymerize polyethylene. The second method involves the use of catalysts to synthesize polyethylene, in which extra materials, known as catalysts, contribute to the fastening of chain reactions without themselves being affected by the chemical reactions. There are several types of available catalysts in the market: Chromium-based, titanium-based Ziegler-Natta, metallocene and binary transition metal catalysts. Each catalyst creates a unique chain of reactions, after which polyethylene is produced with variation in molecule weights. For instance, chromium-based catalysts such as chromocene $(C_5H_5)_2Cr$ inserted into ethylene polymerization at $90^\circ C - 110^\circ C$ producing low-weight molecule polyethylene. In our daily lives, polyethylene can be spotted almost anywhere under a more popular name: plastic bags or plastic pouches (Figure 1). (Spalding & Chatterjee 2017, 26-54.)



FIGURE 2. Plastic bags made from LDPE (Spalding & Chatterjee 2017, 1155-1166).

3.2.2 The story of plastic bags

Even though plastics were first viewed as a life-saving invention, our view has gradually changed over time. So far, the world has witnessed the greatest efforts of humans in reducing the use of plastic materials, in order to save the planet and its habitants. Many NGOs are aiming to promote plastics utilization sufficiency such as re-use or recycle to achieve an eco-friendly future. (Plastics Europe 2020.) Thousands of campaigns to raise awareness on plastic reduction and eco-friendly lifestyle are promoted worldwide. Non-governmental organizations (NGOs), governments and corporations have joined hands to improve the situation, in a hope to save our environment from being evaded by plastics. Information on plastics have flooded the internet, which has made it hard to distinguish between facts and myths. (National Geographhy 2018; Tenenbeum 2019.)

In Finland, the government has been promoting the reduction of plastics usage in everyday life, first and foremost by decreasing the consumption of plastic bags. According to Yle.fi, Finnish people have been more willing to lean towards environment-friendly alternatives, with the depletion of approximately 90 million plastic bags in 2018 in comparison to the previous year. However, despite the trend "going green", Finland has been quite behind in giving up plastic bags. Finnish corporations also have joined the battle against plastics, by experimenting and developing new materials from natural resources such as fibers from wood, in a hope to offer a sustainable alternative. A study performed in 2018 showed that,

while some believed plastic bags should be banned for good, others suggested that plastic bags recycling would be better for the environment. (Yle 2018; Yle 2019.)

Other countries around the world have made the same attempts to reduce the use of plastic bags in everyday basis. For instance, Jakarta (Indonesia) has banned single-use plastic bags, Japan charges small prices for plastic bags at supermarkets and stores, UK has called for better solutions to encourage the reduction of plastic bags use. (Washington 2020; Johnston 2020; BBC 2019.) General information on plastics, specifically plastic bags, and their effects on our planet are available and freely accessible on the internet. However, it is very hard to differentiate between facts and myths, especially in the era where people can express their opinions anonymously. (Plastic Ocean 2019; Plastic NZ 2020.) The link between plastic bags and environmental pollution is transparent, yet the lack of evidence-based information may be misleading and confusing. There are many unanswered questions to this alerting problem, and hence, the author would like to take this opportunity of thesis work to research on how plastic bags contributed to environmental pollution. The purpose of this thesis is to identify the situation of plastic bags and their impact(s) on our planet. The aim of this thesis is to provide readers with newly updated and evidence-based knowledge concerning plastic bags, thereby improve and enhance awareness on plastics and environment pollution.

4 STUDY METHOD

This chapter of the thesis discusses how the thesis is conducted, what kind of research method is used, how data collection is performed and what the criteria for the process are. The author has stated clearly the aim and purpose of the thesis, and from that, research method is chosen accordingly. There are limitations to this thesis due to several reasons, which will be included at the end of the work. However, the author has used only updated and reliable resources to provide readers with precise and science-based knowledge.

4.1 Literature Review

There are many research methods which one can choose depending on the purpose. One of the commonly met challenges in research processes is to narrow down what needs to be done and what keywords to use. Literature review, among the methods, allows researchers to broaden their knowledge theoretically on their chosen topics and suggest further studies in the future. To conduct a literature review research, it is crucial to firstly identify a sector of the chosen topic that interests researchers the most. Aims and purposes of the work must be specified before drawing a plan for the literature review process. After that, it is possible to determine what direction to conduct the work. (Adams, Khan & Raeside 2014, 33-45.)

There are three main types of literature review: Evaluative, Exploratory and Instrumental Review. While Evaluative review discusses and compares previous theoretical researches, Exploratory rather sharpens the knowledge and studies what has already been done in the field. Instrumental review, furthermore, provides a point of view on the best way to conduct a research on the topic. It is possible to mix these types of methods together to achieve the best outcomes and answer sufficiently to the research questions. In literature review, theoretical framework is important because it needs to provide a strong foundation of knowledge to the topic. (Adams, Khan & Raeside 2014, 33-45.)

Several concepts have been introduced to the conduction of literature review. Besides academic literature and professional literature that aims toward academic and professional readers such as University and instructors and students, social workers or government employees. There is also a type of literature review called “grey literature”, with neither unreliable and invalid nor highly trustable information. The process of conduct may be somewhat the same, however, the target group of audiences is more of general

readers. The standards of these work can be somewhat lower than academic and professional journals' literature review, for instance researches. (Hammond & Wellington 2012, 99-102.)

In this thesis, the author has chosen literature review in order to make use of accessible and evidence-based information to answer to the thesis' learning questions. The author finds this research method most suitable for the deepening of knowledge and believes it will provide not only the authors, but also readers with a profound perspective on the current situation of plastic bags. The type of literature review which the author aims to is exploratory literature, and the target audiences are professional readers and academic readers. However, since the use of languages is simplified, general readers who yearn for evidence-based knowledge will be able to comprehend this thesis' outcomes.

4.2 Article research

The resources, whether it is for theoretical framework or articles collection, should be cautiously focused on since it decides the validation and reliability of the work. If sources are found from the internet, they should be retrieved from trusted and authorized organizations and departments, national laws and legislations, or published articles from magazines and journals of the field because it will help reduce the risks of misleading or bias information that negatively affects researches' outcome. (Adams, Khan & Raeside 2014, 33-45.) The easiest way is to make use of the University's database and minimize the size of sources from Google. Information obtained from Wikipedia does not count as reliable information, even if Wikipedia is an easy-to-read and sometimes handful source for daily basis quick searches. (Wang & Park 2016, 32-54.)

To avoid unreliable information, the author has used solely Centria University of Applied Sciences (UAS)' electronic database for Chemistry and Technology and minimized the sources of information down to EBSCOhost, Science Direct and Emerald. With EBSCOhost, all sub-databases are included in the data research process: Academic Search Complete, CINAHL, ERIC, GreenFILE, Library, Information Science & Technology Abstracts, MEDLINE, OpenDissertation and Teacher Reference Center. The choice of keywords was: "polyethylene bags", "polyethylene bag", "plastic bags" or "plastic bag". To enhance the sufficiency and reduce the size of data collection, inclusion and exclusion criteria was needed (Table 1).

TABLE 1. Inclusion and exclusion criteria for Article Research.

Inclusion criteria	Exclusion criteria
Relevant to this thesis' topic and provide a general picture of plastic bags AND our environment.	Irrelevant to this thesis' topic and does not provide a general picture of plastic bags AND our environment.
Articles and journals in English.	Articles and journals in foreign languages other than English.
Peer-reviewed full-text articles.	Peer-viewed articles with only abstract or not fully accessible.
Evidence-based theoretical knowledge with reliable references.	Subjective opinions on the subject without reliable sources and evidences.
Retrieved from Centria University of Applied Sciences' database.	Retrieved from other sources than Centria University of Applied Sciences' database such as Google.
Published time from 2010 – 2020.	Published time before 2010.

4.3 Article analysis

Data process was from 1 July 2020 to 9 July 2020. The process consisted of multiple filters for articles selection to be well achieved. The first step was by keywords, following by limited factors which would be listed in the inclusion criteria (Table 1). The next level of filter was by articles' titles, and lastly, by abstract. Due to a generalized choice of keywords, the size of data retrieved from Centria UAS's database was gigantic. After being limited by inclusion criteria and titles, 16 results were found with 3 replicates due to similar keywords. Through the final layer of filter, which is the work' abstracts, the author has chosen 9 articles which can potentially provide a profound perspective on the subject and give a general answer to the thesis' research questions (Table 2). The reasons for article rejection after being filtered by abstracts are: 3 replicates, 2 out of which have already been approved; 1 concern general health of workers at plastic bag factory; 1 concern solely chemical analysis of plastic bags; 1 concerns the life cycle of plastic bags, however, focusing on legislation and regulations of European Union; and 1 concerns the observation and experiment of consumers' behaviors and how to direct them toward using fewer plastic bags.

TABLE 2. Data Collection Process.

Source	Keywords	Results	Limited by inclusion criteria	Filtered by titles	Filtered by abstracts
EBSCOhost	“Polyethylene bag”	263	59	0	0
	“Polyethylene bags”	708	4	0	0
	“Plastic bag”	2.388	21	6	3
	“Plastic bags”	4.368	46	6	5
Emerald	“Polyethylene bag”	84	1	0	0
	“Polyethylene bags”	84	1	0	0
	“Plastic bag”	2.000+	34	1	0
	“Plastic bags”	764	34	1	0
Science Direct	“Polyethylene bag”	4.707	80	0	0
	“Polyethylene bags”	14.337	398	0	0
	“Plastic bag”	23.814	290	1	1
	“Plastic bags”	45.655	380	2	0

4.4 Validity

Validity is an important measure through which readers are able to recognize whether the results of a study is accurate and valid (Gerish & Lathlean 2015, 161-163). The validity of this thesis was determined by the current peer-reviewed articles retrieved from evidence-based database that Centria UAS has provided students with. All of the articles used in the article analysis are max up to 10 years old, strictly following the Centria UAS’ thesis guidelines. Articles have been carefully reviewed and under any circumstances, avoiding bias of results is mandatory. Information written in this thesis was guaranteed with the highest accuracy, since the use of sources have been delicately selected (Centria UAS 2020).

5 RESULTS

The 9 selected articles were divided into two groups. The first group consisted of 4 articles which answer to the first research questions, and the second group of 5 articles answer to the second research question. In the first group, the method of research is practical, as experiments were carried out to provide a conclusion on plastic bags' chemical characteristics and their impact on our environment. Meanwhile, most of the articles from the second group were conducted through literature review by using available national data to analyze and study. Though there is a difference in research method, both groups have achieved interesting results and were able to suggest further study questions. In this part of the thesis, the author will analyze these results in detail and if possible, compare the experiments.

5.1 The impact of plastic bags

Alam, Billah and Yajie (2018) experimented on different types of plastic bags: PE, HDPE, LDPE, PP, PS and Nylon. Most of the samples collected from local providers were analyzed by their heavy metal contents, leaching and thermal decomposition rate, and energy if they were to decompose. It was concluded that PE bags content the highest amount of C and H, in comparison to other materials which automatically turn them into an ideal source of energy under thermal treatment at the variation rate of temperature from 550°C to 850°C. Heavy metal (HM) components in these PE samples did not exceed regulations, however, the amount of HM would increase if colored. Among the samples, PVC bags and product would pose a greater threat to humans' health and the environment because of their leaching behaviors. (Alam, Billah & Yajie 2018.)

Three other articles have been thoroughly analyzed to determine what extend plastic bags have made impact on the environments' habitants. These articles are experiment-based provide an expected, yet unexpected view on how plastic bag particles can influence the growth and functions of bugs and plants. These articles were marked as (1), (2), (3) in order to easily summarize and point out the highlights of these experiments (Table 3). In the first (1) experiment, Kokalj, Horvat, Skala and Krzan (2018) have concluded that after 14 days of observation, terrestrial isopods *Porcellio Scabber* functioned normally without any affects when being exposed to plastic bag particles. They suggested that further study could be done with longer duration to confirm this result. (Kokalj, Horvat, Skala & Krzan 2018.)

In the second (2) experiment performed by Menicagli, Balestri and Lardicci (2019), it was concluded that the impact of plastic bags on *Lepidium sativum L.* species had an interesting variation. Not all plastic bags, under weather conditions, influenced negatively on seedling germination. They, with a small amount in water sources, could even enhance the possibility of germination if being soaked to sea water. (Menicagli, Balestri & Lardicci 2019.) In contrast to this result, the experiment (3) showed that the presence of plastic bags in soil lowers the percentage of seedling survival and quality (Menicagli, Balestri, Vallerini, Castelli & Lardicci 2019).

TABLE 3. Comparison of the experiments.

Experiment	(1)	(2)	(3)
Time	Spring 2016	March 2018	February 2018
Samples	Terrestrial isopod <i>Porcellio Scaber</i> .	<i>Thinopyrum junceum</i> and <i>Glau-cium flavum</i> seeds.	<i>Ammophila arenaria</i> , <i>Thino-pyrum junceum</i> and <i>Glau-cium flavum</i> seeds.
Bag samples	Unspecific types of plastic shopping bags available in local area.	HDPE and biodegradable bags Master-bi [®] .	HDPE and biodegradable bags Master-bi [®] .
Method	Small plastic bags particles, after grinded, washed and dried, being mixed with food used to feed isopod.	HDPE and biodegradable bags before cut into micro-plastic particles to mix with liquid used to water the sample seeds, were divided into three group: <ul style="list-style-type: none"> • 1/3 were stored carefully as virgin samples. • 1/3 were placed on shored, partially covered with sands as beach-exposed (BE) bags. • 1/3 were soaked in sea water as marine-exposed (ME) bags. 	HDPE and biodegradable bags before cut into micro-plastic particles to mix with soil used to grow the sample seeds, HDPE and biodegradable bags before cut into small pieces to mix with sand used to grow the sample seeds, were divided into two groups: <ul style="list-style-type: none"> • 1/2 were stored carefully as virgin samples. • 1/2 being weathered for four months on a embryo dune.
Result	No impact was observed of feeding.	<i>T. junceum</i> seeds germinated slower in the exposure to a high concentration of ME bags. <i>G. flavum</i> geminted earlier in the exposure to all types of plastic bags. Both <i>T. junceum</i> and <i>G. flavum</i> , in the exposure of small ratios of ME bag, had a higher percentage of germination.	All seed types had a lower percentage of growth in the presence of bags. The exposure to HDPE particles resulted in shorter roots and lower seedling heights.

Possible suggestion & Conclusion	The duration of feeding met the standard time of experiments (14 days), however, possibly needed more time to see obvious effects.	Development abnormality were observed, however not all abnormalities were negative. Both seeds were affected positively in the exposure of low concentration of ME bags.	Plastic bags affected the growth of seedlings, to what extent, depending on bag types and plants' sensitivity to the exposure of bags.
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5.2 Consumers' attitude toward plastic bags

Five articles to answer to the second research question were further grouped into two groups: (1) Analysis of consumers' behaviors toward plastic bags and (2) authorities' efforts in making changes and consumers' responses toward new environmental policies.

In the first group, Zambrano-Monserrate and Ruano (2020) have used of national data resources to analyze consumers' behavior patterns in Ecuador, while Crowley (2020) has a clearer approach by survey citizens from three areas: Sarrat, Vintar and Solsona of Ilocos Norte province. Both studies provide interesting highlights on consumers' behaviors. On one hand, Zambrano-Monserrate et al. suggested gender and education have a strong connection with consumers' decision to use plastic bags. Females are more open to replace plastic bags with other reusable alternatives, and households with education level below elementary school are more prompted to use plastic bags. (Zambrano-Monserrate & Ruano 2020.) On the other hand, Crowley states the opposite by saying the level of education does not predict consumers' pattern of using plastic bags. Only age may be an indicator since older participants of the survey are more likely to use reusable plastic bags. (Crowley 2020.)

In the second group, there were three regions to be researched: Australian Capital Territory (ACT), Toronto and South Africa. These regions were introduced to plastic-bag levy (Toronto and South Africa) or plastic-bag ban (ACT) as the governments' effort to reduce the frequent sales of plastic bags at supermarkets and stores, hence possibly led to a decrease in plastic-bag waste. Macintosh, Simpson, Neeman and Dickson (2020) have conducted a survey to find out both consumers' and retailers' attitude toward plastic bags after ACT had enacted the ban on polyethylene with the thickness of lower than 35 μm . Because of this, there was a decline in single-use HDPE bags consumption for four years, yet after that, the consumption even increased faster. At the same time, the decline in single-use HDPE has led to an increase in reusable LDPE-bag sales. The ACT failed to measure how the ban of plastic-bag had

improved environmental pollution, while still claimed the amount of plastic-bag waste to landfills had lessened in 2014. (Macintosh, Simpson, Neeman & Dickson 2020.)

Rivers, Shenstone-Harris and Young (2017) have taken advantage of national survey database to complete their study on how plastic-bag levy changes consumers' behavior. There were certain highlights they have pointed out consistent with the study of Dikgang, Leiman and Visser (2012) and partly with Macintosh et al. (2020). The study has shown that the plastic-bag levy did not motivate directly consumers to change their behaviors, only to encourage those who have been using reusable plastic bags to continue their habit. The levy policy has had a better impact on consumers with level of education equal to or higher than postsecondary education and affected mostly wealthier households. (Rivers, Shenstone-Harris & Young 2017.) Dikgang et al. (2012) has found the same result that the higher-income households had been more sensitive to this policy. However, the success of this policy only lasted for a few years before the sale of plastic-bags increase again, as Macintosh et al. (2020) recently observed.

6 DISCUSSION AND CONCLUSION

In this part of the thesis, the author gives a conclusion to the research questions and discusses the plastic bag problems based on the results (Section 5). Sources and examples are provided to support and strengthen the findings. Furthermore, reliability, limitation and recommendation for further study are included also.

6.1 Discussion

The results have shown that plastic bags' components do create abnormalities in soil and water that affect directly to plants. However, it is noticeable that in all the experiments, plastic bags were cut into small particles before being put into water or mixed with soil. Therefore, a better word for the culprit of plastic pollution, rather than "plastic bags", should be "microplastics" as WHO has called for investigation and study (World Health Organization 2019). Microplastics or small plastic particles can come from any plastic materials degrading in the environment over time. Plastic bags may be accounted for a large portion of plastic waste being dumped into the environment irresponsibly, but there are other types of waste that need to be mentioned as well. For instance, in the pandemic COVID-19, single-use plastic protection equipment has been found on shores and in the ocean (Kassam 2020; Bengali 2020). In the USA, plastic straw has been suggested to be banned in the support of plastic pollution reduction. However, Stanford University has a different point of view, by saying that straws are just a small portion of plastic products accounted for approximately 1% of the real problem. (Jordan 2018.) Therefore, instead of blaming directly plastic bags and how they have damaged our environment, or name any plastic products as culprits, human needs to be reminded of how plastic was discovered in the past and has become a so-called "hero". The reduction of plastic bags may contribute to plastic pollution alleviation, however to what extent, is undetermined.

Believing that plastic pollution is prevented by the reduction of plastic bags consumption, or plastic bags are the sole problem, is not accurate. Rivers et al. (2017) challenged the belief policy on plastic bags positively improved the plastic pollution problem, and the outcomes may have been overstated by the government without any transparent measurement (Rivers et al. 2017). It is crucial to understand further what our society is dealing with before concluding. Otherwise, humans may return to the time where plastic had not yet been discovered and create more problems to human's health.

There has been a strong debate on polyethylene bags, mainly because of how they are irresponsibly dumped into the environment by consumers. Rujnic-Sokele and Baric (2014) has argued that waste problem was not caused by plastic bags themselves, but rather the thoughtlessness of consumers. There are claims that plastic bags have killed thousands of animals per year, without any evidence to support these statements. (Rujnic-Sokele & Baric 2014.) Meanwhile, a study conducted in 2019 has pointed out that human's urbanization activities is the main reason for direct animal death. However, the number only accounted for 28% of animal death rate, while the larger portion was caused by natural forces. Hence, the impact of plastic bags on animal deaths may seem somewhat logical yet should be studied and confirmed. (Sunny College of Environmental Science and Forestry 2019.) Rujnic-Sokele et al. (2014) believes what matters more is the education of waste disposal manners because if people are to switch to more eco-friendly alternatives but keep the same littering habit, the environment will again be flooded with a so-called biodegradable waste (Rujnic-Sokele et al. 2014).

There has already been a minor lesson in Vietnam on alternative products of plastics. In the attempt to reduce plastic use, Vietnam has not only encouraged to reduce plastic bags, but also plastic products. Therefore, bagasse foam boxes were introduced to the market with green characteristics such as short degradation time (6 weeks), lowest cancer risk to humans, leakage-free and microwave-friendly. The demand for bagasse foam boxes increased quickly and small companies started to import the products to Vietnam. It is very easy to find a local provider of this product, and consumers are led to believe that this is how they contribute to reduce plastic pollution. However, according to Dr. Cao Anh Duong, the head of Vietnamese Sugarcane Research Institute, bagasse may pose a higher threat to human's health because of how they are manufactured. The use of chemical glue, without which makes it impossible to produce foam boxes, is even more toxic and dangerous. (Binh 2020.)

Moreover, in an effort of plastic reduction, consumers have turned to paper bags which is morally believed to be "greener" or eco-friendly. Schlanger (2019), an environmental reporter, has recently raised a question about deforestation, a problem which humans have been trying hard for decades to prevent in the plastic bags reduction trend (Schlanger 2019). This is the same question which was discussed 10 years ago by The Environmental Magazine when the dilemma of plastic pollution and deforestation was still robust (Lindsey 2010). Nowadays, the flooding of inaccurate information can stand in the way of sciences and plastic pollution prevention. Rivers et al. (2017) and Macintosh et al. (2020) emphasize the lack of public information on plastic pollution results in consumers' low awareness on the problem. Macintosh et al (2017) has pointed out that participants of their survey assumed that the ACT plastic bag ban act had improved the environment without any evidence and statistic figures (Macintosh et al. 2017).

In an interview mentioned above, the Stanford University's presenter mentioned how misleading these bans can be, as they provide a feeling of consumers' having completed their part of the job (Jordan 2018).

Motivation indicators for a change in consumers' behavior should be further studied in order to better shape their patterns toward more eco-friendly direction. So far, there are a few motivation indicators for change that we can use as a baseline to develop more studies: age, education, gender and income. Crowley (2020) states that education does not predict consumers' behavior, a result probably from the lack of environmental education at school (Crowley 2020). In any matter, education is believed to be the key to success. The lack of education and public information, altogether with consumers' misbelief of "being done" with their part, may create a larger problem.

It is proven by Menicagli et al. (2019) that biodegradable bags had created abnormalities in seedling growth, which again raised a suspicion of how "green" these products are (Menicagli et al. 2019). As discussed, paper bags may not be as well the best and greenest solution. Because of that, Alan et al. (2018) has stated that plastic recycling and reusable conventional PE bags can be a sustainable solution for our future (Alan et al. 2018). Recycling has been the uttermost important choice for European countries in recent years, with many have aimed to minimize the amount of plastic waste to landfills and reduce waste to less than 5%, while the rest being converted into energy (PlasticEurope 2015). Educating the public population on plastic pollution is needed, rather than levy or other political policies, because the chance of success is uncertain or temporary. One of reasonable explanations of why these policies succeeded only in a short run with the sales being increased dramatically the following years can be that consumers have adapted plastic bag levy to their daily lives after a period of time, and levy is no longer a reminder for them to use less plastic bags. The inconvenience of having to bring their own plastic bags to the shop will become a perfect excuse to the continuity of plastic bags consumption which brings the community back to the starting point. (Dikgang et al. 2012; Macintosh et al. 2020; Rivers 2017.)

Certainly, in the COVID-19 pandemic, recycling and reusing seem to be two luxurious words. Hale and Song (2020) has published an article on the subject, in which stated firmly that plastic bags have lower chance of transmitting the virus than other surfaces such as door handles or currency notes, however, nobody wants to risk being exposed to and infected by the virus (Hale & Song 2020). COVID-19 has become another perfect and rational excuse for single-plastic bags and products usage, but mismanagement of plastic waste may continue to worsen plastic pollution. On one hand, humans are now dealing with one of the most dangerous and wide-spread diseases or so-called the "acute disease". Treatment

has not yet been found and the time where everything is under control is yet to come. At the moment, the COVID-19 situation in many countries have been calm and under control. However, learning from pandemics in the past, a second wave of the disease may suddenly come without any notice. Many countries are preparing themselves in case the pandemic takes a bad turn, with Finland producing and stocking protective equipment for health professionals and improving patients' capacity in intensive care department. (Maragaskin 2020; Yle 2020.) On the other hand, plastic pollution has been a "chronic disease" to our environment which, the same with COVID-19, the treatment is still being worked on. And while #StayHome was once a trend to prevent the "acute disease" COVID-19 from spreading (Public Health England 2020), humans must work together to fight against the "chronic disease" plastic pollution.

6.2 Conclusion & Recommendations

Given the evidence-based experiments and figures, the author has been able to conclude several key points and answer to this thesis' research questions. Additionally, there are open questions which can be used to future studies on plastic, plastic bags and plastic products. The key points are: (1) the conclusion of plastic bags being the main problem in plastic pollution has a weak foundation. (2) Paper bags are not a sustainable solution to replace plastic bags. (3) Biodegradable bags may have the same effect on plants as PE bags. (4) The reduction of plastic bag use will lead to environmental improvement is a misbelief. (5) PE waste can be recycled into industrial energy. (6) Recycling may be a long-term solution for plastic pollution, not the cutting of plastic products alone. (7) Public education is important in plastic pollution alleviation. (8) Public information is lacking, hence, led to the misbelief that governments' policies are enough to help the environment and providing a dangerous mindset to consumers that they have done enough. (9) Overstating the success of governmental policies may overshadow the real problem. Public indicators for behavior change toward greener alternatives are age, income, education and gender.

Recommendations for further studies, possible learning questions and hypothesis need to be confirmed are: Motivation indicators for consumers' change, from single use to reusable plastic bags, the effects of PE or plastic bags on plants and animals, possible alternatives for plastic bags and products and the comparison of chemical characteristics of plastic bags and recommendation on a more sustainable material. Furthermore, the study of biodegradable bags can be beneficial since there are little knowledge on its influence on the environment, beside the fact that it is biodegradable and believed to be helpful to the environment. In term of public awareness, there should also be more study on how to improve consumers' awareness on the right use and manage of plastic bags and wastes; and how the government can

be successful in the management of both plastic and diseases in the pandemic period. And lastly, the rate of dilemma reverse, plastic reduction and forest deforestation should be measured to determine which is more acute.

6.3 Reliability

Reliability is important in any research work as it determines whether a study's result should be trusted or not. Reliability coexist with validity of the work, without either, can discredit the quality of the research. The most common reliability discredit factor is bias, where the author of the work has already assumed the answer to their learning questions and therefore, seek information that leads to that pathway. At the end, the outcome is usually not the "fruit" of their learning process, but an expected result. Furthermore, bias can present through the choice of words, such as misleading words to make readers assume a result far from facts (Ruane 2016.) To avoid that scenario, the author has tried to simplify sentences, neutralize words and follow strictly to Centria's Guide for Thesis and Academic Writing (Centria 2020).

6.4 Limitation

There are several limitations to this thesis work. The small size of samples ($n=9$) used to conduct literature review. To meet with inclusion criteria, the research has limited the learning area and eliminated irrelevant articles and unreliable sources. The comparison made in this research may vary if more experiments are done in the future. Moreover, since the choice of article language is limited to English, the author might have missed more valuable information, experiments and knowledge in other languages. Therefore, more studies on the same subject is encouraged to confirm and strengthen the findings of this thesis.

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APPENDIX 1

Source	Search keywords	Results	Limited by inclusion criteria	Filtered by titles	Filtered by abstracts
EBSCOhost	"Polyethylene bags"	708	4	0	x
	"Polyethylene bag"	263	59	0	x
	"Plastic bags"	4.368	46	Adverse effects of non-biodegradable and compostable plastic bags on the establishment of coastal dune vegetation: First experimental evidences.	OK
				Do you need a bag? Analyzing the consumption behavior of plasticbags of households in Ecuador.	OK
				Characteristics of plastic bags and their potential environmental hazards.	OK
				Heavy metals dispersion during thermal treatment of plastic bags and its recovery.	x
				From macro- to microplastics - Analysis of EU regulation along the life cycle of plastic bags.	x
	"Plastic bag"	2.388	21	Plastic bag bans: Lessons from the Australian Capital Territory.	OK
				Plastic bag consumption habits in the Northern Philippines.	OK
				Plastic bag and facial cleanser derived microplastic do not affect feeding behaviour and energy reserves of terrestrial isopods.	OK
				Using nudges to reduce waste? The case of Toronto's plastic bag levy.	OK
				Analysis of the plastic-bag levy in South Africa	OK
Psychological interventional approach for reduce resource consumption: Reducing plastic bag usage at supermarkets.				x	
Emerald	"Plastic bags"	764	34	Inhalation and dermal exposure to toluene among printing workers in a plastic bag factory	x
	"Plastic bag"	2.000+	34	Inhalation and dermal exposure to toluene among printing workers in a plastic bag factory	Replicate
	"Polyethylene bag"	84	1	0	x
	"Polyethylene bags"	84	1	0	x
Science Direct	"Plastic bags"	45.655	380	Adverse effects of non-biodegradable and compostable plastic bags on the establishment of coastal dune vegetation: First experimental evidences	Replicate
				From macro- to microplastics - Analysis of EU regulation along the life cycle of plastic bags	Replicate
	"Plastic bag"	23.814	290	Exposure of coastal dune vegetation to plastic bag leachates: A neglected impact of plastic litter	OK
	"Polyethylene bag"	4.707	80	0	x
"Polyethylene bags"	14.337	398	0	x	

Table of data selection.