
Managing solid plastic to achieve the Egyptian sustainable development goals

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Abstract:

Egypt faces significant challenges related to solid waste management. The country generates an estimated 80,000 tons of solid waste daily, with only around 60% of this waste collected and disposed of properly. The remaining 40% of waste is either burned, dumped in open spaces, or ends up in water bodies. Inadequate solid waste management practices have significant environmental and public health impacts. Burning waste contributes to air pollution and respiratory diseases, while dumping waste in open spaces contaminates soil and water sources. In addition, uncollected waste in cities and rural areas attracts pests and can cause diseases.

This research aims to shed light on the role of solid plastic waste management in achieving sustainable development goals in Egypt during the year 2023. This research follows inductive approach through reviewing previous studies in solid plastic concerning and the concept of sustainability; successful countries in recycling solid waste;

current situation in Egypt; policies and practices related to solid plastic waste management in Egypt; challenges and opportunities associated with solid plastic waste in Egypt.

Keywords: Solid Plastic, Sustainable Development Goals, Egypt.

إدارة البلاستيك الصلب لتحقيق أهداف التنمية المستدامة المصرية

المستخلص:

تواجه مصر تحديات كبيرة تتعلق بإدارة النفايات الصلبة، حيث تنتج الدولة ما يقدر بـ 80.000 طن من النفايات الصلبة يوميًا ، وحوالي 60 ٪ فقط من هذه النفايات يتم جمعها والتخلص منها بشكل صحيح. يتم حرق الـ 40٪ المتبقية من النفايات أو التخلص منها في أماكن مفتوحة أو ينتهي بها المطاف في المسطحات المائية. ممارسات إدارة النفايات الصلبة غير ملائمة ولها آثار بيئية وصحية كبيرة. يساهم حرق النفايات في تلوث الهواء وأمراض الجهاز التنفسي ، بينما يؤدي إلقاء النفايات في الأماكن المفتوحة إلى تلوث التربة ومصادر المياه. بالإضافة إلى ذلك ، فإن النفايات المتراكمة في المدن والمناطق الريفية تجتذب الآفات ويمكن أن تسبب الأمراض.

يهدف البحث لإلقاء الضوء على دور إدارة النفايات البلاستيكية الصلبة في تحقيق أهداف التنمية المستدامة في مصر خلال عام 2023. ويتبع هذا البحث النهج الاستقرائي من خلال مراجعة الدراسات السابقة في البلاستيك الصلب فيما يتعلق بمفهوم الاستدامة. وكذلك يعرض البلدان الناجحة في إعادة تدوير النفايات الصلبة ؛ والوضع الحالي في مصر، والسياسات والممارسات المتعلقة بإدارة النفايات البلاستيكية الصلبة في مصر وأخيرًا التحديات والفرص المرتبطة بالنفايات البلاستيكية الصلبة في مصر.

الكلمات الدالة: البلاستيك الصلب ، أهداف التنمية المستدامة ، مصر.

1. Introduction:

Plastics have become an integral part of modern society due to their versatility, low cost, and durability. However, the widespread use of plastic has resulted in environmental issues such as pollution, particularly in developing countries like Egypt. To address this issue, managing solid plastic waste is a critical step towards achieving the Egyptian sustainable development goals. Proper management of solid plastic waste can not only reduce environmental pollution but also provide economic opportunities, such as recycling and resource recovery. This introduction will explore the importance of managing solid plastic waste in Egypt and its potential impact on achieving sustainable development goals (Abdel-Shafy, and Mansour, 2018).

Solid plastic waste is a growing environmental problem that affects countries all around the world. With the increasing use of plastics in various industries and the lack of proper waste management systems, plastic pollution has become a significant threat to the environment and human health (Klemeš, et al., 2020).

The problem of solid plastic waste is a global issue that requires a coordinated effort from governments, industry, and individuals. To tackle this problem, there needs to be a shift in the way we use and dispose of plastic products. Reducing the use of single-use plastics and promoting the use of eco-friendly alternatives is one way to address this issue. Governments can also play a vital role in enforcing regulations that limit the use of

non-recyclable plastics and promoting sustainable waste management practices (Singh, and Sharma, 2016).

In developed countries, the use of plastics has become ubiquitous, with plastic packaging used extensively in the food and beverage industry. The convenience and durability of plastics have made them a popular choice for manufacturers, but the long-term effects on the environment have become apparent. In countries such as the United States, the use of plastics has increased dramatically over the years, and waste management practices have struggled to keep up with the rise in plastic waste. The result is that large amounts of solid plastic waste end up in landfills, where it takes hundreds of years to decompose, or it ends up in the natural environment, polluting waterways and harming wildlife (Dey et al., 2021).

2. Literature review in solid plastic concerning:

To emphasize the importance of a collaborative and comprehensive approach towards plastic waste management in India, involving various stakeholders and leveraging modern technologies to minimize the environmental impact of plastic waste. Banerjee et al., (2014) recommended that:

- The adoption of an integrated solid waste management approach that includes waste reduction, segregation at source, collection, transportation, and disposal.

- The use of modern technologies such as waste-to-energy, pyrolysis, and gasification to convert plastic waste into valuable resources and reduce the burden on landfills.
- The promotion of responsible behavior among citizens through awareness campaigns and community participation to encourage them to adopt sustainable waste management practices.
- The development and implementation of policies, regulations, and incentives by the government to encourage the adoption of sustainable waste management practices by various stakeholders.
- The establishment of public-private partnerships to leverage resources and expertise to improve the efficiency and effectiveness of plastic waste management in India.
- The need for continued research and development of innovative solutions to address the challenges of plastic waste management in India.

Elsaid, and Aghezzaf, (2015) aims to develop a framework for sustainable waste management that considers the challenges and opportunities in the field. The framework will be used to guide decision-making and improve the effectiveness of waste management practices. The paper provides a review of the literature on sustainable waste management, including policies and practices related to waste reduction, reuse, and recycling. The authors then analyze the challenges and opportunities

associated with waste management and develop a framework that incorporates principles of sustainability. They concluded that sustainable waste management is essential for reducing the negative impacts of waste on the environment and human health. The framework developed in the paper can guide decision-making and help to address the challenges and opportunities associated with waste management. They recommend that policymakers and waste management practitioners adopt a sustainable waste management framework that incorporates principles of sustainability, such as the waste hierarchy, circular economy, and extended producer responsibility. They also suggest that collaboration between stakeholders and the implementation of innovative technologies can improve the effectiveness of waste management practices.

In this context; Ibrahim, and Mohamed (2016) highlights the urgent need for sustainable management of solid waste in Egypt. The current practices of landfilling and informal sector waste management are no longer sufficient to handle the increasing amount of waste generated in the country. The authors recommend the implementation of an integrated solid waste management system that involves waste reduction, reuse, recycling, and recovery, along with supportive policies, public education, and a shift towards a circular economy approach. They suggest the establishment of waste sorting and recycling centers, the implementation of waste-to-energy technologies, the

development of an enabling policy and regulatory environment, and public education and awareness campaigns to promote sustainable waste management practices.

Awasthi et al., (2017) reviews the technologies for utilizing plastic solid waste (PSW) and assesses their potential for sustainable waste management. The authors found that recycling, pyrolysis, gasification, and conversion to fuel are promising technologies for the utilization of PSW. The authors suggest that policymakers and stakeholders promote these technologies as a sustainable solution to the plastic waste problem. They also recommend more research to improve these technologies, promote a circular economy for plastics, and develop public awareness and education programs to encourage sustainable waste management practices.

Daoud et al., (2020) presents a comprehensive review of the current situation in the construction industry in Egypt, including the types and quantities of waste generated and the current waste management practices. The paper identifies poor planning, design, and management practices, as well as a lack of awareness and education, as the main causes of waste generation. The paper notes that most construction waste is disposed of in landfills or illegal dumping sites, with only a small proportion being recycled or reused. The paper recommends the implementation of waste management policies and regulations, waste reduction, reuse, and recycling practices, as well as

increased awareness and education on waste management practices. The paper also suggests the development of innovative technologies for waste-to-energy conversion and other forms of waste management. Overall, the paper emphasizes the importance of sustainable waste management practices in the construction industry to minimize the environmental impact and ensure a sustainable future for Egypt.

In this context; Abdallah et al., (2020) evaluates the current status of municipal solid waste (MSW) management in Egypt and suggests sustainable management strategies. The authors found that the current MSW management practices in Egypt are unsustainable and result in negative environmental and public health impacts. The paper recommends the adoption of sustainable waste management strategies such as waste reduction, reuse, and recycling, as well as the implementation of effective waste collection and transportation systems. Additionally, the paper suggests the involvement of the informal sector and the implementation of extended producer responsibility programs. Finally, the authors recommend that the Egyptian government should invest in waste management infrastructure, including the establishment of waste treatment and recycling facilities, and increase public awareness campaigns to encourage proper waste management practices.

Plastic waste trade and management in Asia is a complex and multifaceted issue that requires a comprehensive and coordinated approach to address. The study identified several key

challenges, including inadequate waste management infrastructure, inadequate regulations, and lack of transparency in the plastic waste trade. Additionally, the study found that the plastic waste trade can have significant negative environmental and health impacts, particularly in developing countries (Liang et al., 2021). Therefore; policymakers and stakeholders in the plastic waste trade should take a more holistic approach to address the issue. This includes improving waste management infrastructure and regulations, promoting transparency in the plastic waste trade, and promoting sustainable waste management practices. The authors also recommend that efforts should be made to reduce plastic waste generation and promote the development of a circular economy for plastics. Finally, the authors suggest that more research is needed to better understand the environmental and health impacts of the plastic waste trade and to develop effective strategies to address them.

Kumari et al., (2022) aims convert solid plastic waste into activated carbon fibers (ACFs) and assess their potential in wastewater treatment. Solid plastic waste is a major environmental concern due to its non-biodegradable nature, while wastewater treatment is a significant challenge in many countries. The study found that ACFs produced from solid plastic waste have high adsorption capacity for various pollutants, making them effective in removing heavy metals and dyes from wastewater. The authors recommend further research to explore

the use of ACFs in wastewater treatment and encourage policymakers and industries to consider the potential of ACFs as a sustainable and cost-effective solution for wastewater treatment. They also suggest promoting recycling and transforming solid plastic waste into useful products, such as ACFs, to reduce plastic waste's environmental impact.

Egypt is facing challenges in managing its growing waste generation, and the country's reliance on fossil fuels is unsustainable and contributes to pollution. To address these issues, a study was conducted to evaluate the potential of waste-to-energy (WTE) conversion in Egypt. The study recommended incineration and gasification technologies as suitable for the waste characteristics in Egypt, but noted that significant investments in infrastructure, technology, and policy reforms are required for successful implementation. The study suggests several recommendations, including establishing a legal and regulatory framework for WTE conversion, developing public-private partnerships, encouraging public participation in waste reduction efforts, and promoting the use of renewable energy sources to supplement WTE conversion (Ezzat et al., 2022)

Recently; (Nassar et al., 2023) evaluates the feasibility of waste-to-energy (WTE) technologies as a solution for managing municipal solid waste (MSW) in Egypt and reducing its negative environmental impacts. The current waste management system in Egypt is unable to handle the increasing amount of waste

generated, leading to environmental pollution and public health concerns. The study found that WTE technologies such as incineration and gasification can be effective solutions for managing MSW in Egypt. However, the implementation of WTE technologies should be accompanied by measures to reduce waste generation and increase recycling rates, and careful consideration should be given to the selection of appropriate WTE technologies and their location to minimize negative impacts on the environment and public health. The study recommends that the Egyptian government and private sector should invest in WTE technologies as part of a comprehensive waste management strategy and establish clear regulatory frameworks and standards to ensure safe and environmentally sound operation of WTE facilities.

Gap analysis and contribution:

From previous research, we found that too limited research has studied the solid plastic concerning the Egyptian sustainable development goals. Therefore; this research will illustrate challenges and opportunities associated with solid plastic waste in Egypt. In addition, mention successful initiatives or projects related to solid plastic waste management in Egypt. This research considered the first that presents successful initiatives or projects related to solid plastic waste management in Egypt and offers real challenges and opportunities associated with solid plastic waste in Egypt.

3. Research problem:

The problem of solid plastic in Egypt is a significant environmental issue that affects both the health of people and the ecosystem. The use of plastic has become ubiquitous in Egypt, and the country generates millions of tons of plastic waste every year. However, the waste management infrastructure is inadequate, and the plastic waste is not properly disposed of, leading to pollution of the land, air, and water. Plastic pollution has a detrimental impact on the environment, including harming marine life, causing soil degradation, and contributing to climate change. The improper disposal of plastic waste also creates a breeding ground for pests and disease-carrying insects, posing a health risk to people living nearby. Moreover, raising public awareness and educating people about the impact of plastic pollution is also crucial in addressing this issue.

4. Research aims and objectives:

The research aims to shed light on the role of solid plastic waste management in achieving sustainable development goals in Egypt.

Research objectives are:

1. To define existing policies and practices related to solid plastic waste management.
2. To identify the main challenges and opportunities associated with solid plastic waste management in Egypt.

3. To explore innovative solutions and best practices from other countries that could be applied to improve solid plastic waste management in Egypt.
4. To provide recommendations for improving solid plastic waste management in Egypt and support the achievement of sustainable development goals.

5. Research background:

This section will be divided into ten parts. The first introduce the concept of sustainability; illustrates sustainable development goals in Egypt; illustrate some successful countries in recycling solid waste; the current situation in Egypt; policies and practices related to solid plastic waste management in Egypt; challenges and opportunities associated with solid plastic waste in Egypt; successful initiatives or projects related to solid plastic waste management in Egypt; literature review in solid plastic concerning; successful countries in recycling solid waste and technologies improve recycling of solid plastic waste.

5.1 The concept of sustainability:

Sustainability refers to the ability to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. In other words, sustainability involves using resources in a way that ensures their availability for future generations, while also balancing economic, social, and environmental factors. Sustainability can be achieved through various means, including reducing waste

and pollution, promoting renewable energy sources, conserving natural resources, and promoting social and economic equity. The goal of sustainability is to create a system that is both environmentally and socially responsible, while also being economically viable in the long term (Garg, 2015; Hajirasouli, and Kumarasuriyar, 2016; Verma, 2019).

Sustainability is becoming increasingly important as the world faces a range of environmental and social challenges, including climate change, resource depletion, and social inequality. By promoting sustainability, individuals and organizations can help to create a more equitable and sustainable future for all. Sustainability can have a significant impact on the economy by promoting long-term economic growth and stability. By adopting sustainable practices, businesses can reduce their environmental impact, improve their social responsibility, and increase their economic viability (Sachs et al., 2019).

One way that sustainability can impact the economy is by promoting innovation and efficiency. Sustainable practices often require businesses to find new and innovative ways of producing goods and services that minimize their environmental impact while also reducing costs. This can lead to increased productivity, competitiveness, and profitability, which can benefit the overall economy. Sustainability can also promote job creation and economic growth. The shift towards sustainable practices can create new job opportunities in areas such as

renewable energy, waste reduction, and sustainable agriculture. In addition, sustainable practices can help to attract investment and improve a company's reputation, which can lead to increased economic activity. However, it is important to note that the transition towards sustainability can also have short-term economic costs. For example, investing in renewable energy sources may require significant upfront costs that may not be immediately profitable. Additionally, some industries may need to undergo significant changes or restructuring to become more sustainable, which can result in job losses in the short term (Farley, and Smith, 2020).

The United Nations has identified 17 Sustainable Development Goals (SDGs) to be achieved by 2030. These goals were adopted by all UN Member States in 2015 as part of the 2030 Agenda for Sustainable Development (Ezinna et al., 2021). The 17 SDGs are:

1. No Poverty.
2. Zero Hunger.
3. Good Health and Well-being.
4. Quality Education.
5. Gender Equality.
6. Clean Water and Sanitation.
7. Affordable and Clean Energy.
8. Decent Work and Economic Growth.
9. Industry, Innovation and Infrastructure.

- 10.Reduced Inequalities.
- 11.Sustainable Cities and Communities.
- 12.Responsible Consumption and Production.
- 13.Climate Action.
- 14.Life Below Water.
- 15.Life On Land.
- 16.Peace, Justice and Strong Institutions.
- 17.Partnerships for the Goals.



Figure (1) Sustainable Development Goals.

Source: Russo, and Pellicanò, 2019.

The SDGs are designed to address global challenges such as poverty, inequality, climate change, environmental degradation, and social justice. They provide a framework for

countries and organizations to work towards sustainable development and a better future for all.

5.2 Sustainable development goals in Egypt:

Egypt is a country that has made significant progress towards achieving the Sustainable Development Goals (SDGs) set by the United Nations. These goals aim to end poverty, protect the planet, and ensure peace and prosperity for all. Egypt's commitment to these goals has resulted in a number of positive impacts across the country. One of the most significant impacts of the SDGs in Egypt has been the reduction of poverty. Egypt has implemented a number of policies and programs to promote economic growth and reduce poverty. For example, the government has launched a number of initiatives to promote entrepreneurship and job creation, particularly in the fields of renewable energy and agriculture. These efforts have helped to reduce poverty rates in Egypt from 27.8% in 2015 to 23.6% in 2019 (Nasr-Allah et al., 2020).

Another impact of the SDGs in Egypt has been the promotion of environmental sustainability. Egypt is heavily dependent on the Nile River for its water supply, and as a result, the country is particularly vulnerable to the impacts of climate change. In response, the government has implemented a number of policies to promote environmental sustainability, including a national program to increase the use of renewable energy sources and a campaign to promote sustainable tourism. These efforts

have helped to reduce the country's carbon footprint and mitigate the impacts of climate change.

The SDGs have also had a positive impact on gender equality in Egypt. The country has made progress in promoting women's rights and increasing their participation in the workforce. The government has implemented a number of policies to support women entrepreneurs and has increased funding for programs that promote gender equality. As a result, women's participation in the workforce has increased, and their representation in political and public life has improved.

There different Sustainable Development Goals (SDGs) in Egypt, along with some relevant statistics (Hussein, and Pollock2019; Eissa, 2020; Shehata, and Dahawy, 2020. World Bank, 2021; Omranand Negm, 2022.):

- No Poverty: The percentage of people living below the national poverty line in Egypt decreased from 27.8% in 2015 to 29.7% in 2018. The government has implemented social protection programs to support vulnerable groups.
- Zero Hunger: The prevalence of undernourishment in Egypt was 6.2% in 2017, a decrease from 7.5% in 2015. The government has implemented food security programs and increased investment in agriculture.
- Good Health and Well-being: Life expectancy at birth in Egypt is 73 years, and the maternal mortality rate has decreased from 84 deaths per 100,000 live births in 2010 to 35 deaths per

100,000 live births in 2017. The government has invested in healthcare infrastructure and implemented health insurance programs.

- **Quality Education:** The literacy rate in Egypt is 73%, and the net enrollment rate in primary education is 97%. The government has increased investment in education and implemented programs to improve access to education.
- **Gender Equality:** The gender gap in labor force participation in Egypt is 47.4%, with only 22.4% of women participating in the labor force. The government has implemented policies to promote gender equality and empower women.
- **Clean Water and Sanitation:** 93% of the Egyptian population has access to improved water sources, but only 34% have access to improved sanitation facilities. The government has invested in water and sanitation infrastructure to improve access to clean water and sanitation.
- **Affordable and Clean Energy:** Renewable energy accounts for only 3% of total energy consumption in Egypt. The government has implemented policies to increase the use of renewable energy and reduce dependence on fossil fuels.
- **Decent Work and Economic Growth:** The unemployment rate in Egypt was 7.5% in 2020. The government has implemented policies to promote economic growth and create job opportunities.

- Industry, Innovation and Infrastructure: Egypt ranks 100th out of 190 countries in the World Bank's "Ease of Doing Business" index. The government has implemented policies to promote innovation and improve infrastructure.
- Reduced Inequalities: Income inequality in Egypt has increased in recent years, with the Gini coefficient increasing from 30.8 in 2015 to 32.5 in 2018. The government has implemented policies to reduce inequalities and support vulnerable groups.
- Sustainable Cities and Communities: The urbanization rate in Egypt is 43%, and the government has implemented policies to promote sustainable urban development.
- Responsible Consumption and Production: Egypt generates 23 million tons of waste per year, and only 60% of solid waste is collected and disposed of properly. The government has implemented policies to promote responsible consumption and production and improve waste management.
- Climate Action: Egypt is one of the country's most vulnerable to the impacts of climate change, including sea level rise and desertification. The government has implemented policies to reduce greenhouse gas emissions and adapt to the impacts of climate change.
- Life Below Water: Egypt has a coastline of over 3,000 km, and the government has implemented policies to protect marine biodiversity and promote sustainable fishing practices.

- **Life On Land:** Egypt has a rich biodiversity, but is facing threats from habitat loss and degradation. The government has implemented policies to protect ecosystems and promote sustainable land use practices.
- **Peace, Justice and Strong Institutions:** Egypt ranks 141st out of 180 countries in the World Press Freedom Index. The government has implemented policies to promote human rights and strengthen institutions.
- **Partnerships for the Goals:** Egypt has established partnerships with international organizations and other countries to

Despite these successes, there are still significant challenges facing Egypt in achieving the SDGs. One of the biggest challenges is the need to address inequality and promote social inclusion. While poverty rates have decreased overall, there are still significant disparities in access to education, healthcare, and other basic services, particularly in rural areas. The government will need to continue its efforts to promote inclusive growth and ensure that all Egyptians have access to the resources and opportunities they need to thrive (Nasr-Allah et al., 2020).

5.3 The current situation in Egypt:

According to a 2019 report by the United Nations Environment Programme (UNEP), Egypt imports more than one million tons of plastic waste annually, making it the fourth largest importer of plastic waste in the world after China, Malaysia, and Turkey. The majority of this plastic waste is

believed to come from Europe and North America, and it is often sent to Egypt for recycling or disposal. However, due to the lack of proper waste management infrastructure and regulations, much of this plastic waste ends up in landfills or the environment, causing significant environmental and health hazards. In Egypt, the SWM system is weak and inefficient where 81% of generated SW are dumped on streets of residential areas and at illegal dumping sites without any treatment as indicated in Figure (2):

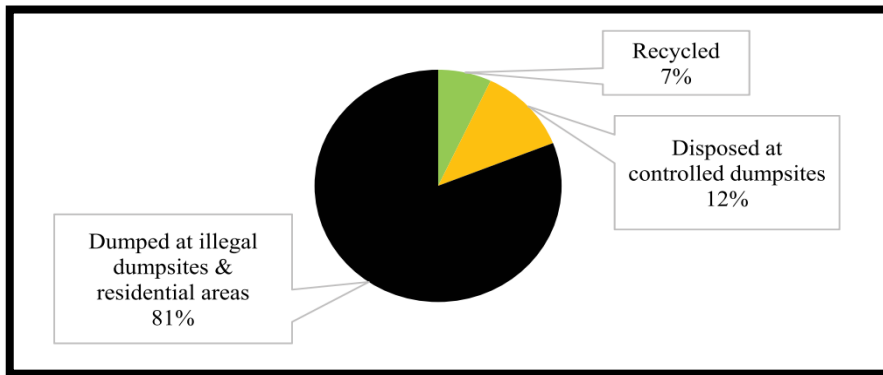


Figure (2): Current status of solid waste management (SWM) in Egypt.

Source: Daoud, et al., (2020).

According to a report by the World Bank, Egypt produces approximately 20 million tons of municipal solid waste per year, with plastic waste representing a significant portion of this waste stream. It is estimated that around 12% of the total municipal solid waste generated in Egypt is plastic waste. Unfortunately, the management of plastic waste in Egypt remains a significant

challenge. Currently, the majority of plastic waste in Egypt is disposed of in landfills, which can result in environmental pollution and health hazards for nearby communities. According to a study published in the Journal of Cleaner Production, only around 25% of the plastic waste generated in Egypt is collected, with the remainder ending up in the environment or informal waste collection systems.

The recycling rate of plastic waste in Egypt is also very low, estimated at only 8%. This is due to a variety of factors, including limited infrastructure and investment in recycling facilities, low public awareness of the importance of recycling, and inadequate policies and regulations related to waste management.

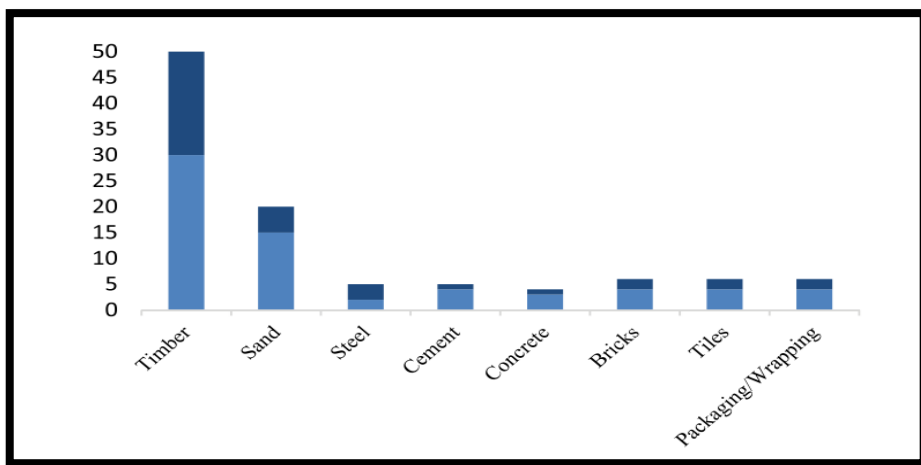


Figure (3): Patterns of construction and demolition waste (CDW) generated in Greater Cairo.

Source: Daoud et al., (2020).

The plastic waste trade in Egypt has been a subject of controversy, as some environmental activists and civil society organizations have raised concerns about the potential negative impacts on the environment and human health. In response to these concerns, the Egyptian government has taken some steps to regulate the plastic waste trade, such as banning the import of certain types of plastic waste and implementing stricter regulations for waste management. However, more efforts are needed to address the challenges associated with plastic waste in Egypt and to ensure a more sustainable approach to waste management (Spitz, and Trudinger, 2019).

5.4 Policies and practices related to solid plastic waste management in Egypt:

There are several existing policies and practices related to solid plastic waste management in Egypt (Abdel-Shafy, and Mansour, 2018), including:

- The Egyptian National Solid Waste Management Program: This program aims to promote sustainable solid waste management practices, including the reduction, reuse, and recycling of plastic waste.
- The Egyptian Environmental Affairs Agency (EEAA): The EEAA is responsible for regulating and monitoring waste management activities in Egypt, including those related to plastic waste.

- The Egyptian Plastic Technology Center: This center provides training and technical assistance to plastic manufacturers and recycling companies in Egypt.
- The National Company for Cleaning: This company is responsible for collecting and transporting solid waste in Egypt, including plastic waste.
- The "Clean Homeland" campaign: This campaign aims to promote awareness of the importance of waste management and encourage citizens to adopt sustainable waste management practices, including the proper disposal of plastic waste.

5.5 Challenges associated with solid plastic waste in Egypt:

The main challenges and opportunities associated with solid plastic waste management in Egypt (Ibrahim, and Mohamed, 2016), include:

- There is a shortage of recycling facilities, particularly in rural areas, which makes it difficult to collect, sort, and recycle plastic waste.
- Many people in Egypt are not aware of the importance of recycling or do not have access to information about how to recycle properly.
- While there are regulations in place to govern solid waste management, there is often a lack of enforcement, which leads to illegal dumping and other forms of mismanagement.

- There is a shortage of funding for solid waste management programs, which limits the ability to invest in infrastructure and technology to improve recycling rates.
- There is a lack of involvement from private sector companies in the recycling industry, which limits the availability of financing, technology, and other resources.

5.6 Opportunities associated with solid plastic waste in Egypt:

The main opportunities associated with solid plastic waste management in Egypt (Tarek, and El-Haggar, 2019), include:

- Growing demand for recycled plastics: As consumers become more aware of the environmental impact of plastic waste, there is a growing demand for recycled plastics, which presents an opportunity to expand the recycling industry in Egypt.
- Government support: The Egyptian government has expressed a commitment to improving solid waste management and has launched several initiatives to promote recycling and other sustainable practices.
- Public-private partnerships: The government and private sector companies can work together to develop innovative solutions and invest in infrastructure to improve solid waste management.
- Potential for job creation: Expanding the recycling industry could create new jobs and boost the economy.
- Innovative technologies: There are new technologies available that can help improve recycling rates, such as smart waste

bins, waste-to-energy systems, and advanced sorting technologies.

5.7 Successful initiatives or projects related to solid plastic waste management in Egypt:

There are several successful initiatives and projects related to solid plastic waste management in Egypt (Abdelbasir et al., 2018; Mostafa et al., 2018). Here are some examples:

- **Recyclobekia:** This is an Egyptian company that recycles electronic waste, including plastic components. The company collects e-waste from homes and businesses, dismantles the components, and sorts the materials for recycling. Recyclobekia has processed over 8,000 tons of e-waste and has received international recognition for its sustainable practices.
- **ECO-Schools program:** This program, implemented by the Egyptian Ministry of Education, encourages schools to adopt sustainable practices, including waste reduction and recycling. Many schools have established recycling programs for plastic waste and other materials, and some have even started producing handicrafts from recycled materials.
- **Clean Shores Alexandria:** This initiative aims to clean up the beaches and coastal areas of Alexandria, one of Egypt's largest cities. The project includes collecting and recycling plastic waste found on the beaches, as well as educating the public about the importance of waste reduction and proper disposal.

- **Integrated Solid Waste Management Project:** This project, funded by the World Bank, aims to improve solid waste management practices in Egypt's major cities, including Cairo and Alexandria. The project includes the construction of new waste treatment facilities, the implementation of waste reduction and recycling programs, and the provision of training and technical assistance to local authorities.
- **Wastebusters Egypt:** This is a social enterprise that provides waste management services, including recycling, to businesses and communities in Egypt. The company has developed innovative recycling technologies and has helped many organizations reduce their waste footprint.

These initiatives and projects demonstrate that there is potential for effective solid plastic waste management in Egypt. By implementing sustainable practices and leveraging innovative technologies, it is possible to reduce the amount of plastic waste that ends up in landfills and the environment.

5.8 Successful countries in recycling solid waste:

There are several countries that have been successful in recycling solid waste. Here are some examples:

1. **Germany:** Germany is known for its efficient waste management system, with more than 60% of its waste being recycled. The country has a well-established system of separate waste collection, where households separate their waste into different categories such as paper, plastic, and glass.

2. Austria: Austria has one of the highest recycling rates in Europe, with around 63% of its municipal waste being recycled. The country has implemented a pay-as-you-throw system, where residents are charged based on the amount of waste they generate.
3. South Korea: South Korea has a comprehensive waste management system, with over 80% of its waste being recycled. The country has a strict waste sorting system, where residents must separate their waste into different categories, including food waste, plastic, and paper.
4. Norway: Norway has a high recycling rate, with over 40% of its waste being recycled. The country has a well-established system of separate waste collection and has invested heavily in waste-to-energy plants and other technologies to reduce the amount of waste sent to landfills.
5. Japan: Japan has a sophisticated waste management system, with over 70% of its waste being recycled. The country has a system of mandatory waste separation, and its government has implemented various policies and regulations to promote recycling.
6. Switzerland: Switzerland has a high recycling rate, with around 52% of its waste being recycled. The country has a well-established system of separate waste collection, and its government has implemented various policies to promote recycling, including a landfill tax and a recycling fee.

7. Sweden: Sweden is a leader in waste management, with around 99% of its waste being recycled or used for energy recovery. The country has a well-established system of separate waste collection and has invested heavily in waste-to-energy plants and other technologies to reduce the amount of waste sent to landfills.
8. Slovenia: Slovenia has a recycling rate of over 60%, with a comprehensive system of separate waste collection and recycling. The country has implemented various policies to promote recycling, including a landfill tax and a ban on certain types of waste.
9. Belgium: Belgium has a high recycling rate, with over 60% of its waste being recycled. The country has a well-established system of separate waste collection, and its government has implemented various policies and initiatives to promote recycling, including a landfill tax and financial incentives for recycling.
10. The Netherlands: The Netherlands has a recycling rate of around 50%, with a well-established system of separate waste collection and recycling. The country has implemented various policies and initiatives to promote recycling, including a landfill tax, financial incentives for recycling, and a system of deposit refunds for certain types of packaging.
11. Denmark: Denmark has a recycling rate of over 50%, with a well-established system of separate waste collection and

recycling. The country has implemented various policies and initiatives to promote recycling, including a landfill tax, financial incentives for recycling, and a system of deposit refunds for certain types of packaging.

12. Singapore: Singapore has a recycling rate of around 60%, with a well-established system of separate waste collection and recycling. The country has implemented various policies and initiatives to promote recycling, including a waste reduction program, financial incentives for recycling, and a system of deposit refunds for certain types of packaging.

These countries have implemented effective waste management policies and practices that have allowed them to achieve high recycling rates. By adopting similar strategies and investing in infrastructure and technology, other countries can also increase their recycling rates and reduce the amount of waste sent to landfills.

5.9 Technologies improve recycling of solid plastic waste:

There are several new technologies available that can help improve recycling of solid plastic waste (Kale, et al., 2015; Zhang, 2019), including:

- **Chemical recycling:** This process involves breaking down plastic waste into its chemical components, which can then be used to create new plastic products. Chemical recycling can be more efficient than traditional mechanical recycling, as it can recycle plastics that are difficult to process through traditional methods.

- **Pyrolysis:** Pyrolysis is a thermal treatment process that converts plastic waste into fuels and other valuable chemicals. This technology is especially useful for plastics that cannot be easily recycled through traditional mechanical methods.
- **Smart waste bins:** Smart waste bins use sensors and other technologies to monitor waste levels, optimize waste collection routes, and help reduce littering and illegal dumping.
- **Waste-to-energy systems:** Waste-to-energy systems use the energy content of solid plastic waste to generate electricity or heat. These systems can be used to supplement traditional energy sources, reducing dependence on fossil fuels.
- **Advanced sorting technologies:** Advanced sorting technologies, such as optical sorters and eddy current separators, use sensors and other technologies to identify and sort different types of plastic waste, improving recycling efficiency and reducing contamination.
- **3D printing:** 3D printing technology can be used to create new products from recycled plastic waste, reducing the need for virgin materials and reducing waste.
- **Biodegradable plastics:** Biodegradable plastics are made from materials that can be broken down by natural processes, reducing the amount of plastic waste that ends up in landfills or the environment. While these materials are not a complete solution to the plastic waste problem, they can help reduce the overall amount of waste produced.

- **Blockchain technology:** Blockchain technology can be used to improve traceability and transparency in the recycling supply chain, helping to ensure that plastic waste is properly sorted, recycled, and disposed of. By improving transparency and accountability, Blockchain technology can help reduce the risk of illegal dumping and other forms of environmental harm.

5.10 Ways to increase recycling rates and reduce the amount of waste sent to landfills, including:

- **Implementing mandatory recycling programs:** Governments can require households and businesses to recycle certain materials, such as paper, plastic, glass, and metal, by providing recycling bins and enforcing penalties for non-compliance.
- **Offering financial incentives for recycling:** Governments can offer financial incentives, such as tax credits or rebates, to individuals and businesses that recycle certain materials.
- **Providing education and outreach:** Governments can educate the public about the benefits of recycling and how to properly recycle materials. This can include providing informational materials, conducting outreach programs, and working with schools and community organizations.
- **Increasing access to recycling facilities:** Governments can increase the number of recycling facilities and collection sites to make it easier for people to recycle.
- **Implementing waste reduction programs:** Governments can implement waste reduction programs that encourage people to

use fewer disposable products, such as single-use plastic bags, bottles, and containers.

- Encouraging composting: Governments can encourage composting of organic waste, such as food and yard waste, by providing composting bins and education on how to properly compost.

6. Conclusion:

Raising public awareness and educating people about the impact of plastic pollution is also crucial in addressing this issue. This could be done through campaigns and initiatives to reduce plastic usage, and through educational programs that teach the public about proper waste management practices.

In conclusion, the problem of solid plastic waste in Egypt is a complex issue that requires a multi-faceted approach to address effectively. It is essential that individuals, organizations, and government entities work together to create a sustainable and environmentally friendly waste management system that will benefit both people and the planet. To address the problem of solid plastic waste in Egypt, there needs to be a comprehensive and sustainable waste management system in place. This would involve improving waste collection and disposal practices, promoting recycling and upcycling initiatives, and encouraging the use of eco-friendly alternatives to plastic.

This research mentions general recommendations for solid plastic wastes:

- Reduce plastic waste generation: The most effective way to manage plastic waste is to reduce its generation. This can involve promoting the use of sustainable packaging materials, reducing single-use plastics, and encouraging the reuse of plastic products.
- Implement source separation policies: Governments and municipalities should implement policies that require households and businesses to separate their waste at the source. This can help to reduce the amount of mixed waste and make it easier to separate and recycle different types of waste, including plastic waste.
- Promote recycling: Recycling is an important strategy for managing plastic waste. Governments and municipalities should promote the collection and recycling of plastic waste by providing adequate infrastructure, such as recycling centers and collection points, and developing new recycling technologies and processes.
- Encourage innovation: Innovation in waste management should be encouraged, particularly in the development of new recycling technologies and processes that can improve the efficiency and effectiveness of plastic waste recycling.
- Promote circular economy: Governments and stakeholders should work towards promoting a circular economy for plastics, which

involves reducing waste generation, improving the collection and recycling of plastic waste, and promoting the use of recycled plastic in new products. This can help to reduce the environmental impact of plastic waste and create economic opportunities for recycling and waste management industries.

- **Educate the public:** Public education and awareness campaigns can help to promote sustainable waste management practices and encourage behavior change. Governments and municipalities should invest in public education programs that promote the importance of reducing, reusing, and recycling plastic waste, and provide information on how to properly dispose of plastic waste.
- **Adopt a multi-stakeholder approach:** Effective management of plastic waste requires a multi-stakeholder approach that involves cooperation and collaboration between governments, municipalities, the private sector, civil society organizations, and the general public. Governments and municipalities should work with these stakeholders to develop and implement sustainable waste management strategies that are tailored to the specific needs of their communities.
- **Implement extended producer responsibility (EPR):** EPR is a policy approach that makes producers responsible for the management of their products and packaging waste throughout their entire lifecycle, including disposal. Governments should implement EPR policies for plastic products and packaging to

encourage producers to design products with recyclability in mind, and to bear the costs of managing the waste generated by their products.

- Adopt eco-design principles: Governments should promote eco-design principles that aim to reduce the environmental impact of products and packaging, including plastic products. Eco-design involves designing products with sustainable materials, reducing the amount of packaging used, and making products easier to repair, reuse, and recycle.
- Promote sustainable consumption: Governments should promote sustainable consumption practices, such as buying products with minimal packaging, choosing products made from sustainable materials, and avoiding single-use plastic products.
- Encourage public-private partnerships: Public-private partnerships can help to leverage the expertise and resources of both the public and private sectors to develop and implement sustainable waste management strategies. Governments should encourage partnerships between the public and private sectors to promote the development of new recycling technologies and infrastructure, and to support the implementation of sustainable waste management practices.
- Provide financial incentives: Governments should provide financial incentives to encourage households and businesses to adopt sustainable waste management practices, such as

separate collection of plastic waste and recycling. Financial incentives can include subsidies for recycling infrastructure, tax credits for the use of sustainable materials, and financial rewards for waste reduction.

- Conduct research and development: Governments should invest in research and development to support the development of new recycling technologies and processes that can improve the efficiency and effectiveness of plastic waste management. Research and development can also help to identify new uses for recycled plastic materials, such as in construction, automotive, and other industries.

There are several potential areas for further research such as; discussing the role of different stakeholders in managing solid plastic waste in Egypt, including government agencies, non-governmental organizations, waste management companies, and local communities; Discuss the financing and investment required for effective solid plastic waste management in Egypt, including the costs of implementing new technologies and infrastructure, and potential sources of funding; Discuss the role of public education and awareness campaigns in promoting sustainable behavior and reducing plastic waste in Egypt; Discuss the regulatory and enforcement frameworks in place to manage solid plastic waste in Egypt, and consider whether these are effective in promoting sustainable practices; discussing the social and environmental impact of solid plastic waste in Egypt,

including the impact on human health and the natural environment, and how effective waste management can help to mitigate these impacts.

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