Solid Waste Management in Middle East Arab Countries

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Solid waste production, specifically construction waste, in Middle Eastern Arab countries has dramatically increased. This is characterized by several factors, including rapid urbanization, common food wasting habits, diverse culture, lack of proper planning of solid waste processes, insufficient equipment, as well as lack of proper funding. The exponential growth in solid waste generation rates has led to hazards to health and the environment, causing issues related to air and water pollution under the already increasing pressure of climate change.

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1. Introduction

Solid waste management has been an issue for centuries for both urban and rural areas in several countries. Despite its many effects on nature and human health, solid waste represents a valuable resource that could be effectively used to produce energy and create a financial return. Solid waste is any waste that is no longer useful to the first user. Solid waste management (SWM) is the process of treating and disposing of these materials. The source of solid waste is what determines its characteristics and properties as well as its composition. The composition of solid waste is the main factor controlling how it could be used in the future. Garbage and rubbish are the main types of solid waste; garbage describes compostable solid waste, construction, and demolition while rubbish is the dry materials and bulky items that cannot be decomposed. A significant part of SWM is recycling. Recycling includes material that is not part of trash or garbage [1].

The current solid waste trends show that by 2050, the global generation rate of solid waste is predicted to reach 27 billion tons per year, with Asia accounting for 30% of the generated waste. Within Asia, there are almost 760,000 tons of solid waste generated daily; China generates almost 0.5 kg per capita per day and India generates 0.7 kg per capita per day [2]. Other estimations predict that Asian solid waste production is expected to rise to 1.8 million tons of solid waste generated per day in 2025. The dramatic increase in solid waste production rates can be due to several factors. These factors mainly include the rapid development of industrial zones, urbanization, and the massive increase in population. These factors lead to the actual numbers being almost twice as high as the estimated numbers.

Solid waste processes include collection, treatment, disposal, and recycling. These processes are found to be rare and insufficient in developing countries [3]. However, the amount of solid waste produced by developing countries is smaller than the amount produced by developed regions. In India, it was found that in 2001, the population was 1029 million, which is predicted to increase to 1400 million by 2028 [4]. It was also found that the highest percentage of the solid waste produced from these in India is domestic waste, which includes food waste, construction, and demolition waste, which is usually buried at construction sites [5]. The improper disposal of waste causes damage to infrastructure as well as contamination of water resources.

Egypt has the highest population among Arab countries in the Middle East region, followed by Iraq, Saudi Arabia, Yemen, Syria, Jordan, the United Arab Emirates, Lebanon, Palestine, Oman, Kuwait, Qatar, and Bahrain [6]. The most populated countries, which are Egypt and Iraq, have populations of 106 million and 42 million people, respectively. The least populated country, Bahrain, has a population of 1.7 million [7]. In all Middle Eastern Arab countries, SWM has been a constant concern due to its effects on SWM workers as well as the increase in the pollution of water and vegetation.

Processes such as treatment recycling and reusing by municipalities were found to be rare in Arab countries. Several studies have analyzed and reviewed the SWM status and statistics in Arab countries. Researchers show that Arab countries are responsible for millions of tons of solid waste annually. It was found that the countries that consume more natural resources usually produce a higher amount of waste [8]. These countries include Saudi Arabia, Oman, the United Arab Emirates, Kuwait, and Qatar. When analyzing the composition of solid waste produced by these countries, it was found that organic compostable waste represents 35% to 65% of the total solid waste produced [9]. The country with the highest amount of organics was found to be Yemen, indicating the potential of using this organic matter in compost production.

There is a lack of social awareness regarding SWM issues [10]. There is a common mentality that solid waste should be disposed of as soon as possible and not viewed as a source of energy that could be taken advantage of. Due to this mentality, several economic, health, and environmental risks have been faced by countries such as Lebanon in the past couple of years, creating a crisis in the country in which waste is disposed of randomly everywhere around the streets [11].

The disposal of solid waste represents the most challenging process of SWM processes in which proper disposal methods that take into consideration the environmental risks and health risks must be created and managed carefully [12].

Due to the current non-arranged systems of SWM, solid waste is disposed of at random dumps around cities and in streets. Moreover, the assigned containers were found to be of inadequate capacity, leading to waste being disposed around it rather than in it. This causes aesthetic issues as well as danger to public health and the infrastructure of a city. The collection, storage, treatment, transportation, and disposal processes of SWM must be organized properly in order to reduce the solid waste's negative impacts on the environment and take advantage of waste in a way that benefits the citizens and the government.

There is a noticeable lack of comprehensive SWM systems in Middle Eastern Arab countries. The complications in the SWM aspect are mainly caused by insufficient planning as well as the lack of laws and regulations that organize the solid waste disposal process. In order to achieve a successful SWM system, there should be organized cooperation between governments, private companies, and educational institutions, as well as sufficient funds. When meeting these requirements, followed by proper techniques, equipment, and technologies, there could be a noticeable change in the SWM situation in Middle Eastern Arab countries.

The United Arab Emirates and Qatar are the most successful examples in terms of SWM in Middle Eastern Arab countries. There have been implementations of SWM programs in several regions of these two countries. Overall, governments and the private sector have made noticeable efforts in the processes of collection and transportation of solid waste as well as disposing of this waste in landfills that are properly designed based on engineering specifications. Regardless, the effectiveness of these efforts has not yet been confirmed, showing that more efforts and planning are required to reach the SWM goals in the region.

The need for these plans and efforts is urgent specifically in Middle Eastern Arab countries due to the rapid increase in solid waste generation rates throughout the region. The current efforts regarding increasing public awareness and slowly cultivating more developed techniques in the SWM sectors are not enough to lead to successful, noticeable results. In light of the aforementioned challenges, studying the current status of solid waste generation rates, composition, and the already implemented plans and efforts and their success is essential in order to reach the goals of successful SWM systems.

Successful SWM factors are key to achieving clean sustainable countries in the Arab world. One of the main key factors towards successful SWM is flexibility. Any SWM plan should have a margin of change in case of any expected changes in the economy, climate, political status, and people’s habits, all of which affect the generation and characteristics of solid waste produced. Moreover, support from the main stakeholders in the country is essential to ensure sufficient resources for the development of an efficient SWM system. Another key factor is having clear objectives towards minimizing and material recovery, where the aim is to minimize the generated amount and recycle as much material as possible, especially that which can be used for construction purposes in a clean, environmentally friendly way. Finally, the success of any SWM plan greatly depends on the awareness of society, since public behavior is one of the main causes of the issue.

2. Challenges and Issues of Solid Waste in MENA Arab Countries

Rats and insects that move in landfills transmit diseases such as dysentery, diarrhea, Amoebic dysentery and plague, salmonellosis, trichinosis, endemic typhus, cholera, jaundice, hepatitis, gastrointestinal diseases, and malaria, without the reported cases of poisoning that may occur. Solid waste also affects the environment in many ways such as smells, and toxic gases are constantly emitted into the atmosphere and affect global warming and rainwater intrusion through the open dumping contamination of groundwater resources (leaching). A summary of the negative effects and challenges of solid waste follows.

2.1. Egypt

Several challenges face the SWM industry in Egypt. These challenges include the lack of highly skilled laborers that have the ability to use developed tools in order to minimize the amount of solid waste; the shortage of public land, which leads to solid waste being dumped in random uncontrolled areas, causing severe damage to the environment and people's health; the lack of budget dedicated to SWM solutions due to their high cost; the lack of facilities and equipment that can be used for recycling; the lack of coordination between the government and the private sector; as well as the poor management in terms of construction activities at construction sites [13][14]. The random dumpsites and uncontrolled landfills lead to the leakage of leachate into the groundwater. This affects the groundwater quality and produces high concentrations of toxins and heavy metals that cause health diseases and major issues [15]. Studies have found that the improper disposal of hazardous waste had led to the increase in the endemicity of hepatitis B virus (HBV) infection, respiratory infections, gastrointestinal infections, and skin infections, especially among solid waste workers [16][17]. Using the high percentage of organic waste in highly populated regions, a suitable proposed solution is anaerobic digestion systems [18]. Moreover, the Egyptian Waste Management Regulatory Authority has been increasing recycling grades and increasing refuse-derived fuel production [7]. The political agenda of Egypt Vision 2030 includes several major projects such as the national project for the development of Siena, the national project of roads, and the establishment of a couple of new cities in which it is planned to include several recycling applications. Finally, in 2020, the waste management regulation law was issued by the Egyptian ministry of environment in hopes of controlling random disposing methods.

2.2. Iraq

The main challenges facing the Iraqi government are the side effects of ISIS damages and war happening in Iraq in recent years, financial constraints that prevent enough power from being produced to meet demand, and finally, the population growth rate [19]. The proposed solutions to mitigate these problems are as follows. The country must improve its domestic energy infrastructure, particularly in the power industry. The reusing system is performed by facilities in the following process: the waste is collected and then separated to be sold to industries to reuse it safely [20]. However, it was noticed that the disposal sites are not hygienic, and waste recycling is not common in the city; as a result, the recycling system seems to not gain as much popularity in Iraq's SWM system [21].

2.3. Saudi Arabia

There are many challenges and negative effects in SWM facing the KSA. First, as more than 75% of the country's population lives in cities, the government must take steps to improve the country's recycling and waste management situation [22]. Second, uncontrolled dumping of waste (in non-engineered landfills) has the potential to pollute groundwater and soil, as well as attract disease-carrying insects and rats. Next, the improper collection and management of leachate could pollute the soil and water. Then, a bad odor is created when solid waste heaps decompose biologically. Anaerobic conditions are created by the compaction of landfill layers and the biodegradability of organic waste, resulting in the creation of methane gas. The landfill gas might start a fire and cause a disaster [23]. There are different solutions to reduce the negative effects of solid waste. One is the

conversion of waste such as food waste, manure, and plant residues to compost for agricultural purposes. Waste can be a significant source of valuable products and energy, in terms of waste composition and energy needs in Saudi Arabia. Technologies such as anaerobic digestion and pyrolysis have received a lot of attention. In addition, waste has economic benefits; for example, biogas can be utilized as a sustainable energy source that is cheaper than traditional fossil fuels because it contains up to 70% methane. The energy recovered from solid waste is environmentally safer because anaerobic digestion does not produce any more greenhouse gases. Finally, the improved biogas has a high probability of being used as a vehicle fuel or as a source of electricity for the grid. Saudi Arabia's energy requirement is 55,000 MW, which is provided by fossil fuels and natural gas. Upgrading biogas offers a way to minimize natural gas demand and fossil fuel dependence. Municipal solid waste in Saudi Arabia is collected from individual or community bins and disposed of in landfills or dumps. An active informal sector drives waste sorting and recycling. The recycling rate ranges between 10% and 15%, owing to the presence of an informal sector that extracts paper, metals, and plastics from municipal waste.

2.4. Yemen

The main challenge that faces SWM in Yemen is the fact that there are currently no policies or laws for SWM [9]. As a result, waste is dumped randomly with no regulation. Moreover, dumpsite locations are not selected based on engineering parameters that include hydrological or topographical suitability. There is also no protection whatsoever for the soil beneath these non-sanitary landfills, leading to the contamination of soil and groundwater. Finally, there is a limited budget dedicated to the construction of engineering landfills [24]. The random disposal of solid waste leads to air pollution as well as groundwater pollution, and this problem becomes more dangerous in seasons of high rainfall intensity. AIDS (Acquired Immune Deficiency Syndrome), hepatitis, and tuberculosis are some of the diseases that were found to be common in the Yemeni community due to the improper disposal of solid waste [25]. Solutions that might be proposed to solve the increasing issue of SWM in Yemen include involving the private sector to increase the treatment projects, introducing laws that include public cleaning, preparing an awareness program and conferences, training the local people in order to increase the social awareness level regarding the issue [26].

2.5. Syria

The waste treatment industry is thought to be underdeveloped in Syria [27]. Due to the destruction of infrastructure, damage or looting of collection vehicles and waste containers, the devastation of government institutions, and the displacement of residents into safe areas as a result of the 2011 conflict, municipal SWM in Syria is a serious challenge for both national and local authorities. Although municipal or private organizations collect 85% of all solid waste in all Syrian towns and the majority of rural villages, an estimated 80% is disposed of at open dump sites on the outskirts of towns. This results in air pollution when dioxin and other pollutants are emitted during open-air burning, a common procedure for reducing waste volumes. Hazardous and non-hazardous wastes were usually mixed with home waste, posing a threat to water, soil, and air quality. Hazardous waste makes up roughly 1% to 3% of overall waste volume, but it was identified as one of Syria's most significant sources of pollution due to poor

management. Waste segregation was not adopted at Syria's medical centers until 2010, posing a risk to healthcare employees, waste handlers, patients, and the general public.

2.6. Jordan

In Jordan, in the summer, the smell of rotten waste begins to spread, and the spread in the atmosphere of many gases resulting from waste causes many diseases. A large proportion of solid waste in Jordan can be recycled (65% of total waste). Only 5–7% is recycled or salvaged, mainly by the informal sector, and it faces some challenges, such as the high price of electricity, limited storage space, and exposure to price fluctuations; for glass, the internal demand is weak, so it is difficult to recycle in Jordan and there is no official recycling agency. The common method in Jordan for dealing with and disposing of the waste is landfills; there are 21 working landfill sites in Jordan, of which seven are closed landfill sites.

2.7. United Arab Emirates

The SWM industry in the UAE faces several challenges, including the inadequate quality of the solid waste produced, the poor design that leads to an excessive amount of solid waste, the huge budget required to initiate SWM projects, as well as the fact that some solid waste types are not suitable for all SWM processes [28][29][30]. Solid waste leads to emissions in the air and the pollution of soil, consequently leading to health effects that include diseases such as neurological diseases and cancer. Several solutions have been proposed. In 2002, a new hazardous solid waste treatment facility was established in Jebel Ali. A year later, at the same location, a faculty that converted hazardous medical waste into non-hazardous waste was established with almost USD 1,000,000. Several laws and rules were applied to private companies to collect and transport toxic waste to the Jabel Ali treatment facility [31]. Moreover, the vision of the UAE in the waste management aspect is to recycle almost 75% of the municipal solid waste generated [32].

3. Applications of SWM Practices in Construction

Today, various solid wastes can be reused. As a result, in the contemporary world where natural resources have run out, evaluating construction wastes, which are employed as key aggregate sources in the construction industry, has become important. Construction waste materials are a significant environmental issue posing a risk to the environment. It is critical to both reuse and properly dispose of these materials. The construction industry can make use of waste. A summary of construction applications of SWM in different Arab countries follows.

3.1. Egypt

Due to the high amounts of sand and concrete waste, recycled aggregate could be used in concrete production. Researchers have shown that the characteristics of the concrete produced with recycled aggregate are suitable for construction in Egypt. Moreover, the use of silica fumes as a mineral admixture can also enhance the performance of recycled concrete. **Figure 1** shows the amount of construction and demolition waste generated in greater Cairo,

and the figure shows that wood or timber is the most generated construction waste, followed by sand. Moreover, other researchers show that tires, packaging, and electronic waste are also highly produced construction waste in Egypt. Currently, there have been plans to use recycled material in the construction of pavements and tiles. There have also been exercises of reusing agricultural waste for the production of bioplastic, textiles, and paper product insulators [9]. Generally, recycling construction materials still needs to be explored in order to reuse the high amounts of construction and demolition waste in Egypt.

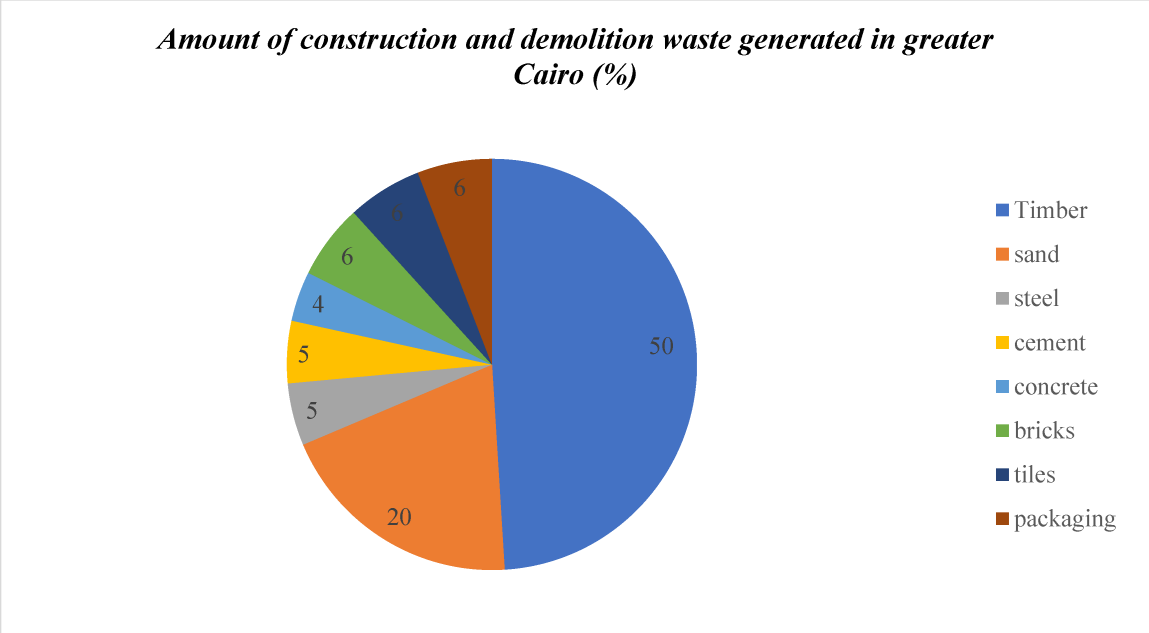

Figure 1. The amount of construction and demolition waste generated in greater Cairo.

3.2. Iraq

In the engineering sector, the best practice is to use recycled aggregate from construction waste sites in new concrete [33]. Iraq generates about 5,859,345 tons of construction waste every year [34]. The main types of construction waste materials are concrete, metals, and wood.

3.3. Saudi Arabia

In Saudi Arabia, it was discovered that just 13.6% of C&D waste is recycled and repurposed each year, with the remaining 86.4% ending up in landfills. The majority of the country's C&D waste represents a prospective supply of potentially recyclable construction materials such as debris gravel, metals, and sand. This will not only meet the KSA's gravel and metal manufacturing needs but also handle waste disposal difficulties while providing significant economic benefits. However, in order to achieve the objective of sustainable building waste management, it is necessary to highlight the many elements that may have an impact on the country's construction waste management practices [35].

3.4. Yemen

Due to the relatively large amount of scrap tires wasted in Yemen, there is potential to use these scrap tires as fuel for cement kilns, as they may meet 14% of cement kilns' energy requirements [26]. Generally, the types of construction waste produced in Yemen contain sand, concrete, gravel, metal, glass, and wood. However, no data regarding any applications in the civil engineering aspect have been found, except for the collection of wood waste for cooking and fuel by local people.

3.5. Syria

Since the start of the Syrian crisis in 2011, solid waste treatment and transportation services have been disrupted across the country, but there is an experimental project underway to reconstruct damaged towns in a cost-effective, time-efficient, and environmentally friendly manner. According to a Syrian study, there would be 142.5 million tons of concrete and 6.65 million tons of steel as debris, in addition to metals and plastics, and approximately 0.78 million tons of solid waste [36].

3.6. Jordan

There are different types of construction materials in Jordan (with their range of actual waste percentage), such as concrete (2–12%), steel (2–10%), formwork (10–40%), sand, and aggregates (3–15%), cement (3–20%), bricks (5–10%), stone (5–20%), tiles (3–11%), ceramic (3–11%), pipes (3–7%), and paint (3–7%).

3.7. United Arab Emirates

There are several potential uses of solid waste produced in construction material. For example, fine recycled aggregates that can be obtained from construction and demolition waste can be used in the production of concrete. **Figure 2** shows the percentage of construction material found in solid waste, showing that packaging materials are the highest percentage, followed by wood in the second place [7]. Other statistics show that metals, glass, aluminum, electronic devices, and tires are construction solid waste materials produced in considerable amounts in the UAE. In Dubai, tires have been used as fuel in the generation of energy as part of some industrial energy-saving plans. In 2007, almost 27.7 million tons of construction waste was dumped in the landfills, and in the first half of 2008, the generation rate of construction waste in Dubai reached 35,000 tons daily. This makes the UAE one of the biggest producers of construction waste, with almost 75% of the general solid waste generation amount.

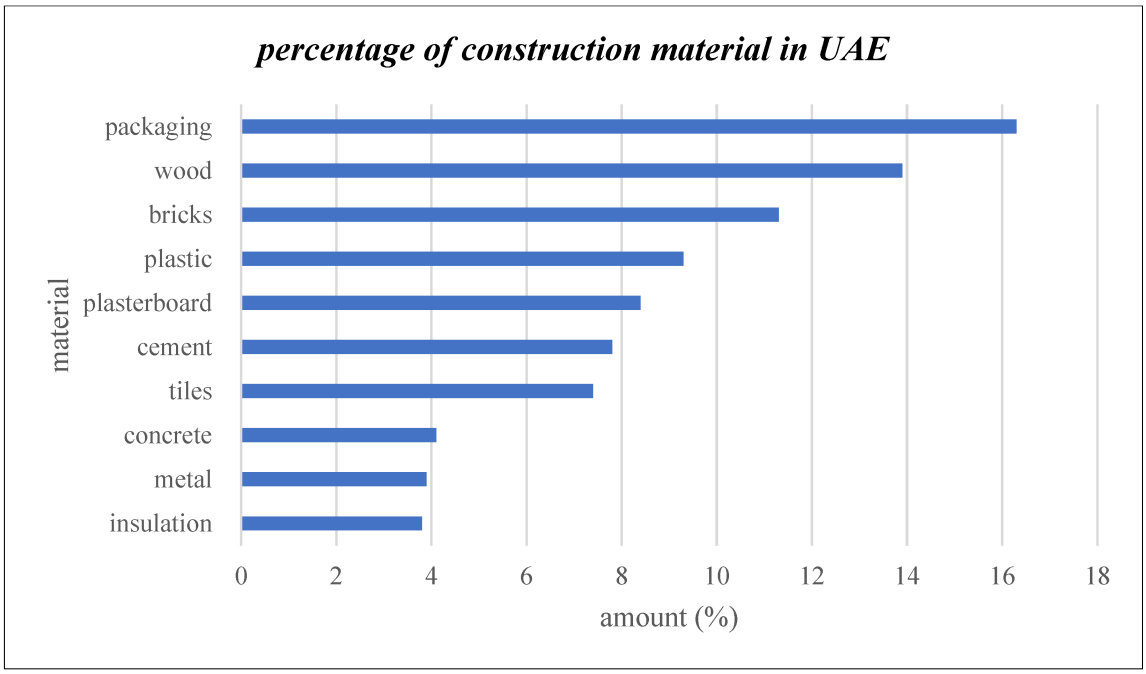

Figure 2. Percentage of construction materials used in the UAE.

References

1. Rinkesh. What Is Solid Waste Management? Sources and Methods of Solid Waste Management. Conserve Energy Future. 2020. Available online: https://www.conserve-energy-future.com/sources-effects-methods-of-solid-waste-management.php (accessed on 22 May 2022).
2. Kumar, A.; Agrawal, A. Recent trends in solid waste management status, challenges, and potential for the future Indian cities—A review. Curr. Res. Environ. Sustain. 2020, 2, 100011.
3. Ahsan, A.; Alamgir, M.; El-Sergany, M.; Shams, S.; Rowshon, M.; Daud, N. Assessment of Municipal Solid Waste Management System in a Developing Country. Chin. J. Eng. 2014, 2014, 1–11.
4. Sahu, S.; Nair, S.; Sharma, P. Review on Solid Waste Management Practice in India: A State of Art. Int. J. Innov. Res. Dev. 2014, 3, 261–264.
5. Vishnu, B.; Singh, L. A study on the suitability of solid waste materials in pavement construction: A review. Int. J. Pavement Res. Technol. 2020, 14, 625–637.
6. BBC News. Profile: Arab League. 2017. Available online: https://www.bbc.com/news/world-middle-east-15747941 (accessed on 19 May 2022).
7. Hemidat, S.; Achouri, O.; El Fels, L.; Elagroudy, S.; Hafidi, M.; Chaouki, B.; Ahmed, M.; Hodgkinson, I.; Guo, J. Solid Waste Management in the Context of a Circular Economy in the

MENA Region. Sustainability 2022, 14, 480.

8. Umar, T. A Comparative Study of MSW to Emery in Oman. In Biotechnological Applications of Biomass; IntechOpen Limited: Winchester, UK, 2020.
9. Hussein, L.; Uren, C.; Rekik, F.; Hammami, Z. A review on waste management and compost production in the Middle East–North Africa region. Waste Manag. Res. J. A Sustain. Circ. Econ. 2021, 40, 1110–1128.
10. Zafar, S. Solid Waste Management in the Middle East—Major Challenges. Eco MENA. 2022. Available online: https://www.ecomena.org/swm-middle-east/ (accessed on 19 May 2022).
11. Abbas, I.; Chaaban, J.; Al-Rabaa, A.; Shaar, A. Solid Waste Management in Lebanon: Challenges and Recommendations. J. Environ. Waste Manag. 2019, 4, 53–63.
12. Ibrahim, M.; Mohamed, M. Towards Sustainable Management of Solid Waste in Egypt. Procedia Environ. Sci. 2016, 34, 336–347.
13. Daoud, A.; Othman, A.; Ebohon, J.; Bayyati, A. Quantifying materials waste in the Egyptian construction industry: A critical analysis of rates and factors. Ain Shams Eng. J. 2021, 12, 4275–4289.
14. Hashem, E. Factors affecting Solid Waste Recycling in Egypt. J. Int. Bus. Econ. 2020, 8, 1–10.
15. El-Mathana, M.; Mostafa, G.; Galal, M.; Elawwad, A. Assessment and simulation of a solid waste dumpsite impact on the surrounding water resources: A case study in Abu Zaabal, Egypt. Heliyon 2021, 7, e08421.
16. El-Wahab, W.; Eassa, M. Seroprevalence of HBV among Egyptian municipal solid waste workers. Heliyon 2019, 5, e01873.
17. Kasemy, A.; Rohlman, S.; Latif, A. Health disorders among Egyptian municipal solid waste workers and assessment of their knowledge, attitude, and practice towards the hazardous exposure. Environ. Sci. Pollut. Res. 2021, 28, 30993–31002.
18. Abdallah, M.; Arab, M.; Shabib, A.; El-Sherbiny, R.; El-Sheltawy, S. Characterization and sustainable management strategies of municipal solid waste in Egypt. Clean Technol. Environ. Policy 2020, 22, 1371–1383.
19. Anssari, O.M.; Alkaldy, E.A.; Almudhaffar, N.; AlTaee, A.N.; Ali, N.S. A feasibility study of electrical energy generation from municipal solid waste in Iraq: Najaf case study. Int. J. Electr. Comput. Eng. (IJECE) 2020, 10, 3403–3411.
20. Elagroudy, S.; Elkady, T.; Ghobrial, F. Comparative Cost Benefit Analysis of Different Solid Waste Management Scenarios in Basrah, Iraq. J. Environ. Prot. 2011, 2, 555–563.

21. Aziz, Q.; Aziz, H.; Bashir, M.; Yusoff, M. Appraisal of domestic solid waste generation, components, and the feasibility of recycling in Erbil, Iraq. Waste Manag. Res. J. A Sustain. Circ. Econ. 2011, 29, 880–887.
22. Zafar, S. Municipal Waste Management in Saudi Arabia. Bioenergy Consult. 2021. Available online: https://www.bioenergyconsult.com/municipal-wastes-in-saudi-arabia/ (accessed on 19 May 2022).
23. Miandad, R.; Waqas, M.; Anjum, M.; Ahmed, I. Solid waste management in Saudi Arabia: A review. J. Appl. Agric. Biotechnol. 2016, 1, 13–26.
24. Alemad, A.; Nagi, M.; Ibeda, A.; Naser, R.; Alwathaf, Y.; Elrhaouat, O.; Belghyti, D. The impact of Sana'a solid waste on the quality of groundwater in Yemen. Water Soc. 2014, 178, 171–183.
25. Akhdar, H. Yemen: Medical Waste and Related Health Risks. Holmakhdar. 2021. Available online: https://holmakhdar.org/reports/5052/ (accessed on 20 May 2022).
26. GIZ. Country Report on the Solid Waste Management in Occupied Palestinian Territories. SWEEP-Net. 2014. Available online: http://www.sweep-net.org/ckfinder/userfiles/files/country-profiles/rapport-Egypte-en.pdf (accessed on 23 May 2022).
27. Zwijnenburg, I.; Kristine, E. A Desktop Study on the Environmental and Public Health Impact of Syria's Conflict. Pax for Peace. 2015. Available online: https://paxforpeace.nl/media/download/pax-report-amidst-the-debris-syria-web.pdf (accessed on 19 May 2022).
28. Al-Hajj, A.; Hamani, K. Material Waste in the UAE Construction Industry: Main Causes and Minimization Practices. Archit. Eng. Des. Manag. 2011, 4, 221–235.
29. Alrayssi, Y. The UAE is Making Great Progress with Regard to Waste Management at the Local and Federal Level. Waste Recycling. 2017. Available online: https://www.wasterecyclingmea.com/the-uae-is-making-great-progress-with-regard-to-waste-management-at-the-local-and-federal-level-eng-yousif-alrayssi (accessed on 24 May 2022).
30. Arafat, H. Waste is a Terrible Thing to Waste. Khalifa University. 2018. Available online: https://www.ku.ac.ae/waste-is-a-terrible-thing-to-waste (accessed on 19 May 2022).
31. Al-Qaydi, S. Industrial solid waste disposal in Dubai, UAE: A study in economic geography. Cities 2006, 23, 140–148.
32. Al-Dabbagh, R. Waste management strategy and development in Ajman, UAE. Renew. Energy Environ. Sustain. 2021, 6, 14.
33. Zafar, S. Solid Waste Management in Kuwait. Bioenergy Consult. 2022. Available online: https://www.bioenergyconsult.com/solid-waste-management-in-kuwait/ (accessed on 19 May 2022).

34. Alqabas. Accumulation of Waste. A Health and Environmental Risk. Al Qabas. 2019. Available online: https://alqabas.com/article/5723399 (accessed on 22 May 2022).
35. Alqabas. Household Waste is an Epidemic Risk. Al Qabas. 2016. Available online: https://alqabas.com/article/247002 (accessed on 22 May 2022).
36. UNEP. Bringing Recycling to Kuwait. Young Champions of the Earth. UNEP. Available online: https://www.unep.org/youngchampions/news/story/bringing-recycling-kuwait?%2Far%2Fnode%2F643=&%2Fnews%2Fstory%2Fbringing-recycling-kuwait=&%2Fru%2Fnode%2F643=&%2Fzh-hans%2Fnode%2F643 (accessed on 19 May 2022).