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Recommendations for Strengthening the Kingdom of Saudi Arabia's Management of Non-Hazardous Solid Waste Informed by a Comparative Assessment of the Management of Non-Hazardous Solid Waste in the United Arab Emirates

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RECOMMENDATIONS FOR STRENGTHENING THE KINGDOM OF SAUDI ARABIA'S MANAGEMENT OF NON-HAZARDOUS SOLID WASTE INFORMED BY A COMPARATIVE ASSESSMENT OF THE MANAGEMENT OF NON-HAZARDOUS SOLID WASTE IN THE UNITED ARAB EMIRATES

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Note: All sources and references are cited according to the Blue Book format.

1.0 Literature Overview:

1.1 Introduction:

Despite significant changes in the category and volume of waste, the Kingdom of Saudi Arabia (KSA) still manages refuse the same way it did decades ago. Before 1975, waste generators were responsible for collecting and disposing of nonhazardous solid waste (NSW). The KSA later set up the Ministry of Municipalities and Rural Affairs (MOMRA) in 1975 as a result of the oil boom. One of the initial tasks of MOMRA was to manage and develop NSW system. In addition to management, MOMRA also distributed waste bins throughout the KSA and hired waste haulers to be responsible for NSW. As I will explain in greater detail later, the NSW has not undergone any changes or improvements in the last forty-seven years.[1]

Myriad developments, from population growth to industrialization, have heightened the challenge of effective waste management worldwide, including in the KSA.[2] The KSA's ineffective management of NSW is evident from looking at numerous metrics, including the per capita volume of waste produced and the costs of waste management.[3] The KSA is one of the

[1]Alqaseem Municipality , The History Of The Development of The Municipality Services in Saudi Arabia, SaudiArabiaAlasiahMunicipality Website, http://asyah.8m.net/history_asyah3.htm

[2]Vijayalakshmi Murugesan, Modern Waste Management Techniques64 (2020) ("In the 21st century, rapid growth of the population, urbanization, industrialization, modernization and digitalization results in the increase in wastes such as domestic, industrial, commercial, mining, radioactive, agricultural, hospital, and electronic wastes.").

[3] Saudi Arabia Non-hazardous Solid Waste Law, Article03, section 08 defines Non-hazardous solid waste as all unwanted materials that have turned to be worthless to their generators".

world's top producers of NSW per capita.[4] In fact, the volume of waste generated in the KSA each year is 15 million tons, or 1.4 kilograms per capita based on a population of 35 million.[5] The government of the KSA has invested significant effort and funds into waste management, which is evident based on its Nonhazardous Solid Waste Law (NSWL) and high governmental spending. It is estimated that the KSA spends 3.5 billion riyals annually on collecting and treating NSW.[6] Despite these efforts, Riyadh, the capital city of the KSA is ranked among the most polluted cities worldwide, due to the weakness in its waste management system.[7] The most prominent reason for the high level of air pollution is the burning of NSW in open areas. Furthermore, less than 15% of the NSW is recycled in the KSA, due to the absence of effective recycling programs.[8] Moreover, the fishery wealth is in jeopardy, due to the lack of stringent laws which combat the improper disposal of waste into the Red Sea. Overall, the rapid increase in population, industrialization, urbanization, and the total volume of waste is expected to reach 100 million tons in ten years.[9] The KSA's systems for managing NSW, barely adequate for achieving minimum goals (waste removal) for existing waste streams, are seriously ill-equipped to handle projected changes in the volume and content of NSW streams. This can be attributed to

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[4]Abdul-StattarNizami, Recycling Prospects in Saudi Arabia, Ecomena EchoingSustainability In Mena (Aug. 27, 2020), https://www.ecomena.org/recycling-saudi-arabia-ar/

[5]Abdul-StattarNizami, Recycling and Waste to Energy Prospects in Saudi Arabia, , Bioenergy Consult Powering A Greener Future(Feb. 14, 2021), https://www.bioenergyconsult.com/recycling-waste-to-energy-saudi-arabia

[6]AbdulslamAlthmeery, *,3.5*Billion Saudi Riyals Is Governmental Spending on Contracts Related to Waste Management, Aleqtsadiah News(Aug. 24, 2021), https://www.aleqt.com/2021/08/24/article_2157631.html

[7]Sharif Taha , Riyadh Ranked Among Most Polluted Cities Globally, Arab News(Mar. 14, 2014), https://www.arabnews.com/news/538861

[8]Laith A. Hadidi, Ahmed Ghaithan, Awsan Mohammed, Khalaf Al-Ofi, Deploying Municipal Solid Waste Management 3R-WTE Framework in Saudi Arabia: Challenges and Future, 2020 SUSTAINABILITY MDPI 7, <7-8>

[9]90% of the Waste Dumped at the Red Sea Are Plastic, BBC NEWS (Apr. 8, 2019), https://www.bbc.com/arabic/tv-and-radio-47854020

several causes. First, the lack of incorporating technology in the waste management field creates difficulties in managing the increasing waste volume. For example, the UAE as well as other countries have incorporated GPS systems to track waste transporters. This measurement helps to prevent the improper dumping of waste, as well as improve the oversight on waste transportation.[10] Second, the KSA waste management lacks an adequate understanding of the environmental system, which has led to a vicious circle where waste disposal harms are simply shifted between media. Even when NSW is successfully collected and transported for disposal, the methods of disposal cause environmental damages. For example, subsequent open burning of collected waste in the KSA is causing significant air pollution and improper landfill management poses low water quality and other risks. Third, the lack of public awareness, coupled with a weak legal framework, has led to negative individual behavior. Many people who utilize the beaches and parks do not dispose of their waste in designated areas.[11] Due to these major and minor contributing factors, the KSA's waste management system has been weakened, making it difficult for the government to meet the needs of the waste management system as it grows. There is a pressing need, therefore, for the waste management system in the KSA to keep up with the changes and developments in the waste management field.

This paper's analysis identifies significant deficiencies in the KSA's NSW law, underscoring the urgent need for the KSA to adopt advanced waste management solutions, and look to the UAE as a source of ideas for improving the KSA waste management system. As

[10]MajdahMalaoy, 85% of Waste Transporters Trucks Are Equipped with Tracking System,Albyan(Oct. 8, 2011), https://www.albayan.ae/across-the-uae/news-and-reports/

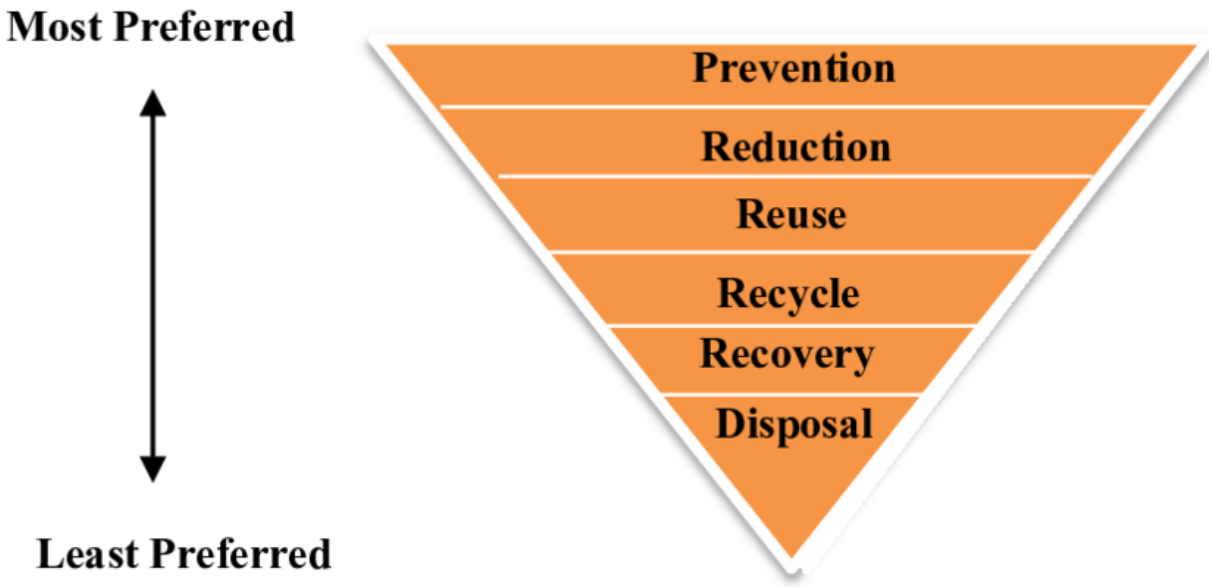
[11]Mohamed Alabdulah, The Beaches Are Polluted Due the Littering, OKAZ NEWS (Jan. 6, 2019), https://www.okaz.com.sa/citizen-voice

grounds for this analysis, the paper begins with a general overview of NSW waste management approaches and explains how comparative legal analysis informs the paper's recommendations.

1.2 Overview of Waste Management Approaches:

In any society, NSW management is a vital service. In addition to planning, it also involves, legal, financial, and engineering tasks.[12] Therefore, in order to ensure the effectiveness of the waste management system, experts from different fields need to participate in this process.

. The objective of this section is to examine the major approaches that have been developed to manage NSW effectively. In addition, it will examine the major benefits and drawbacks of each approach.



Waste Management Hierarchy[13]

[12]Rick Leblanc, Ariana Chaves, An Introduction to Solid Waste Management, The Balance Small Business (Oct. 27, 2020), https://www.thebalancesmb.com/an-introduction-to-solid-waste-management-2878102

[13]Ishmael Mensah, Waste Management Practices of Small Hotels in Accra: An Application of the Waste Management Hierarchy Model, 5 J. GLOBAL BUS. INSIGHTS 37

The waste hierarchy focuses on preventing waste from occurring in the first place. In waste generation, preparation for reuse is given a higher priority over recycling, followed by recovery, and then landfill disposal. The stages of the waste hierarchy are described in more detail in the following sections.

1.2.1 Waste Minimization or Prevention:

In accordance with the waste hierarchy, there are five stages for dealing with waste. The first stage is waste prevention, also known as waste reduction, which can be achieved by improving the design and manufacturing of products to last longer.[14]Waste prevention is defined as "measures taken before a substance, material or product has become waste"[15]. This approach includes reducing the volume of waste and reducing the toxicity of waste. For example, manufacturers can employ advanced methods in the manufacturing process to reduce the usage of harmful material inputs, utilize modern leakage detection systems, or utilize chemical neutralization processes to reduce the volume and/or toxicity of waste.[16] England has adopted guidelines for the private and public sectors to follow a waste hierarchy when dealing with waste. The waste hierarchy focuses on preventing waste from occurring in the first place. Additionally, when creating waste, preparation for reuse is given higher priority than recycling, then recovery, and then disposal in a landfill. I will clarify the first and second stages in this section while the remaining stages will be discussed in more detail in the following sections. In accordance with the waste hierarchy, there are five stages that need to be followed when dealing with waste. The first stage is waste prevention, also known as waste reduction, which can be

[14]Department For Environment, Food And Rural Affairs UK , Guidance On Applying The Waste Hierarchy 3 (2011)

[15]Nilsa Johanssona, Waste Policies Gone Soft: An Analysis of European and Swedish Waste Prevention Plans, 2018 NAT'LLIBR. MED. 2

[16]Waste Management Strategies. (2021, March 9). https://eng.libretexts.org/page/27763

achieved by improving the design and manufacturing of products to last longer. For example, the use of hand dryers over paper, in the workplace, has led to a significant reduction in the use of paper toilet. Consequently, waste prevention techniques reduce the need to manufacture new materials and products, resulting in a reduction of waste

The second stage is the preparation for reuse, which can be accomplished through inspecting, cleaning, repairing, and refurbishing parts or whole components of the waste. This waste reuse strategy is widely regarded as one of the most effective waste management practices. It enables waste owners to sell reusable waste to others, creating a circular economy system.[17] Waste reuse is defined as "any operation by which products or components that are not waste are used again for the same purpose for which they were conceived"[18]. For example, using reusable water bottles and refillable pens and pencils in schools can significantly reduce waste.

Both waste prevention and waste reuse eliminate the need to produce new products; however, they differ in terms of the methods used. Waste prevention aims to prevent waste from being created in the first place, whereas waste reuse aims to reuse products several times over.

To summarize, the waste prevention approach aims to reduce the quantity of waste, as well as reduce the negative impacts that waste has on the environment. Preventing waste is the most effective strategy for managing refuse. It is not always possible to prevent waste from being created, which is why waste reuse is the second preferred strategy used to reduce it.

[17]Chaudhery Hussain, Mosaic Paulraj, Sabiha Nuzhat, Source Reduction And Waste Minimization 123 (1 ed. 2021)

[18]Tina Ringenson, Mattias Höjer, Anna Kramers, Anna Viggedal Et Al., Digitalization And Environmental Aims In Municipalities 4 (2018)

1.2.2 Recycling:

The third stage in the waste hierarchy is recycling waste into new materials or products.[19]Recycling is defined as the process of reusing and repurposing NSW that has been generated from residential, commercial, and industrial areas. It is the third most preferred method for treating waste due to its advantages. First, the adoption of recycling reduces the need to use new materials in production channels. Recycling can thus reduce the energy consumption and other detriments generated from the extraction of virgin materials. Recycling also reduces the volume of waste received at landfills, hence mitigating negative environmental impacts resulting from burying or incinerating NSW. Finally, recycling helps to extend the life cycle of different types of materials that have already served an initial function.[20] These advantages can be clearly seen in building deconstruction. Building deconstruction refers to the selective disassembly of buildings in order to salvage valuable materials for reuse or recycling such as wood and windows.[21]

In summary, when effectively implemented, recycling provides many benefits for waste management, as well as the environment by limiting the production of new materials, consumption of energy, and the volume of waste produced. However, the implementation of recycling programs can be challenging. It should be noted that it can be difficult to achieve effective implementation of recycling due to cost and it can be equally difficult to prevent sham recycling. While an extended analysis of the criteria for implementing effective recycling

[19]Department For Environment, Food And Rural Affairs In UK , Guidance On Applying The Waste Hierarchy <3-4> (2011)

[20]MUSTAFA KAFI , ENVIRONMENTAL ECONOMICS 401 (2013)

[21]Environmental Protection Agency, Racra In Focus Construction, Demolition, And Renovation 14 (2004)

programs are beyond the scope of this thesis, any effort to increase recycling should adopt best practices.[22]

1.2.3. Recovery:

The fourth stage is to treat waste with energy recovery. This is achieved by using anaerobic digestion, incineration with energy recovery, and gasification and pyrolysis.[23]

Separation of organic waste from the waste stream for biological treatment (biodegradation) can significantly reduce waste volume.[24] The biodegradation of waste can be achieved through aerobic composting, mechanical biological treatment, and anaerobic digestion.[25] Aerobic composting degrades organic fractions from the waste using microorganisms. Mechanical biological treatment "describe[s] a number of different residual waste treatment processes that involve both mechanical and biological treatment of municipal solid waste."[26] In this method, different types of waste are processed through plants, which in turn separate them, so they can then be treated differently.[27] In anaerobic digestion, bacteria break down organic materials such as food waste, wastewater biosolids, and waste from animal sources. Anaerobic treatment can be used to treat different types of waste and requires little energy.[28] In gasification, carbon-containing materials, such as coal, can be gasified to produce

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[22]Pablo García-Rubio, 5 Best Recycling Practices from Around the World, BBVA (Feb. 25, 2020), https://www.bbva.com/en/sustainability/5-best-recycling-practices-from-around-the-world

[23]Ibid

[24]Navarro Ferronato& Vincenzo Torretta, Waste Mismanagement In Developing Countries: A Review Of Global Issues, United States National Library (2019),), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6466021/

[25]IPCC, Climate Change 2007: Working Group : Mitigation of Climate Change, Intergovernmental Panel On Climate Change (2007),

[26]Ibid

[27] Ibid

[28]How Does Anaerobic Work*?* ,Environmental Protection Agency,(Jan. 22, 2021), https://www.epa.gov/agstar/how-does-anaerobic-digestion-work

synthesis gas. When temperatures reach over 1,500 K, carbon interacts with water as steam and oxygen to create raw synthesis gas. The end result of this process is mostly carbon monoxide and hydrogen, with some minor components.[29] In pyrolysis, lignocellulosic derivatives decompose at a high temperature in an oxygen-deficient environment.[30] Gasification and pyrolysis differ in the way they use air during the process. While gasification contains air, pyrolysis does not.

In summary, biological treatment separates organic waste from the municipal waste stream and separates organic fractions from the waste. By separating waste, the waste management system can benefit from the different types of waste, after it has been separated.

1.2.4 Disposal:

The fifth and least preferred stage of the waste disposal hierarchy is the discarding of waste through incineration (without energy recovery) or at a landfill.[31] In the absence of meaningful efforts at waste reduction, reuse, recycling, or recovery in the KSA, most NSW is disposed of using these least-preferred methods, which are described in greater detail below.

1.2.5 Incineration:

Incineration is one of the most common approaches used to treat NSW in the KSA and worldwide. There are three types of waste incineration. The first is open burning which is widely used in countries with weak waste management systems. Open burning is defined as "the process in which unwanted products, byproducts, and materials are incinerated, typically at low temperatures and in an uncontrolled manner"[32].This method of incineration causes many

[29] Ronald Breault, Gasification Processes Old And New: A Basic Review Of The Major Technologies <217> (2010)

[30]Hassan Alhaj Ibrahim, Introductory Chapter: Pyrolysis 01 (1 Ed. 2020)

[31]Ibid

[32]Alexander Cogut, Open Burning Of Waste: A Global Health Disaster, Regions Of Climate Action (May 13, 2019), https://regions20.org/2019/05/13/open-burning-waste-global-health-disaster/

negative impacts on the environment and public health. First, the emissions produced during open incineration can pollute the air, soil, and water by releasing toxins contained in waste. Second, research demonstrates a link between the toxic substances released from open burning and lung cancer as well as other health issues. Therefore, open burning is considered one of the more dangerous methods to treat waste.

The second kind of waste incineration is controlled burning which is defined as "the burning of waste in a specially designed combustion chamber"[33]. This method of incineration is, however, safer than the open burning of waste. Controlled burning decreases the volume of waste, reduces air emissions and air pollution (through post-incineration removal of dioxin and other toxins), and can be used to generate heat and energy. Controlled burn incineration can also reduce the need to transport waste long distances since controlled burning plants can be located near cities. Finally, unlike decomposition that occurs in landfills, controlled burning eliminates the production of methane gases since there are no methane gases released as a result of the combustion process. Unlike open burning and landfill dumping, controlled burning can be carried out in any type of weather condition.[34]

The final type of waste incineration is the use of energy recovery technology. This dynamic effect occurs when "evolving thermal energy is used for the production of steam, hot water or electric energy"[35]. Countries with fewer landfills or land most often use this form of

[33]Linda Rothkopf, Solid Waste Incineration, Encyclopedia, /www.encyclopedia.com/environment.
[34]Rinkesh, What Is Waste Incineration? Conserve Energy Future.
[35]Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.

energy technology. This technology not only generates heat and energy, but it is also useful for reducing waste volume and destroying toxic materials in the waste.[36]

In summary, waste incineration is one of the most popular approaches used for waste management and can be conducted through open burning or controlled burning technology.

1.2.6 Landfill Dumping:

Landfills have historically been one of the most common means of disposing of waste. Today, however, landfill disposal is typically disfavored because landfills can be expensive to locate and operate and they also contribute to soil, water, and air pollution. A landfill is a designated area for the dumping of garbage, rubbish, or other sort of NSW. Landfills can take on different forms, as I will illustrate: Municipal solid waste landfills are built to accommodate NSW. Industrial waste landfills are built to accommodate different types of industrial waste such as metal, lumber, and building components. Hazardous waste landfills are used to contain different types of hazardous waste such as flammable solid or substances, toxic and infectious substances, and radioactive waste. A fourth type of landfill is green waste landfills. This type of landfill is used to house green waste such as weeds, leaves, and flowers.[37]

Locations with more mature and sophisticated waste management regimens will not only separate waste streams into different landfill types, but set requirements for landfill location, design, and operation indexed to the type of waste being disposed of. Locations with rudimentary waste management may simply landfill all waste indiscriminately with few controls. Effective landfill controls are important because leachate from landfills can infiltrate soil, groundwater and

[36]Jeroen Jgosse, Waste Incineration And Informal Livelihoods: A Technical Guide On Waste-to-energy Initiatives <02> (2019)

[37]Jon Behm, What Is A Landfill? A Guide To The Main Landfill Types, 2020 Dumpsters

surface water. Waste decomposition in landfills can also produce odors, methane (which exacerbates climate change), and result in the release of other hazardous air pollutants.[38]

As discussed in greater detail below, the KSA only contain one type of landfill, which is used to receive all types of NSW and non-hazardous waste.[39]

1.3 Literature Examining Waste Management in the KSA:

The above approaches constitute the primary methods for managing NSW. The current study aims at investigating and evaluating how the KSA has implemented various waste management approaches to manage waste across the country. Prior limited scholarship evaluates waste management in the KSA. In 2020, Osama Labib reviewed NSW management in the KSA. The study provided a useful descriptive overview of waste management in the KSA. These included: waste generation, collection, and disposal. Furthermore, it provided an analysis of composting, recycling, and environmental awareness.[40] It does not, however, review laws governing waste management in the KSA, nor does it comprehensively explore potential reforms, including the role of the private sector in waste management. It is also limited to the KSA and does not provide a comparative view with other countries.

Another scholarly review from 2016 authored by Muzammil Anjum examines the KSA's waste disposal system and its environmental impacts, as well as the use of pyrolysis and anaerobic digestion as the most appropriate waste management process for the KSA. The review

[38]Isabelle M. Cozzarelli& Scott C. Christenson , The Norman Landfill Environmental Research Site What Happens To The Waste In Landfills?, 2003 Science For Changing World

[39]Saudi Arabia And Environmental Technologies, International Trade Administration (May 19, 2019), Https://www.trade.gov/market-intelligence/saudi-arabia-environmental-technologies

[40]Manaf Abd Binti Latifah, al., A Review of Municipal Solid Waste Management Practices in Saudi Arabia, 2020 DISPOSAL & MGMT. WASTE J

aptly illustrates the advantages of the usage of pyrolysis and anaerobic digestion.[41] However, it does not clearly explain how the concerned authorities can implement the review's recommendations, nor does it mention which authority is responsible for implementing the review's recommendations. In 2021, Raed Bin Sadan published a scholarly review on "the impact of national and municipal environmental standards on the development of an effective solid waste management system in Jeddah". In the review, numerous environmental laws and standards governing NSW in the city of Jeddah were examined. The review did, however, recognize the significance of Islamic Sharia Law in the formation of environmental laws. The research revealed challenges Jeddah faces, when it comes to collecting and disposing of NSW. As such, this dissertation aims at presenting Islamic Sharia Law principles in more detail, to provide a better understanding of the environmental protections under such laws.[42] Another review was authored by Omar Ouda entitled "Environmental and economic benefits of recovered paper: A case study of KSA". The review suggested the adoption of waste-to-energy technology in KSA. It laid out the benefits of converting waste into energy. However, the review did not address the social and economic barriers to waste energy technologies in developing nations such as KSA.[43]

Prior analyses of NSW management in the KSA are thus limited in both number and scope. This paper expands on the existing literature by providing a comprehensive overview and

[41]Muzammil Anjuam& Rashid Miandad, A Review of Municipal Solid Waste Management Practices in Saudi Arabia, 2020 RES.GATE

[42]Raed Bin Sadan, Impact of National and Municipal Environmental Standards on the Development of Effective Solid Waste Management Systems in Jeddah, Kingdom of Saudi Arabia (Sept. 2021) (SJD dissertation, Elisabeth Haub School of Law at Pace University),
) http://digitalcommons.pace.edu/lawdissertations <65-66>

[43]Omar Ouda, Environmental and Economic Benefits of Recovered Paper: A CaseStudy of Saudi Arabia, 2017 ACADEMIA

discussion of the frameworks and the laws governing waste management in the KSA. It also explores the role of the private sector and privatization in waste management as a potential for reform of waste management implementation. Furthermore, it undertakes a comparative legal analysis of waste management in the KSA and the UAE to inform recommendations for how waste management in the KSA can be improved.

1.4 Research Methodology:

In addition to traditional research referencing relevant legal authorities and studies on the operation of waste management in the KSA, this dissertation also employs comparative legal analysis to draw its conclusions. It addresses the NSW waste management system from an integrated standpoint. Additionally, the dissertation examines both the KSA and the United Arab Emirates (UAE) from a fundamental structure standpoint. This dissertation uses social events and activities from the UAE and the KSA to create a clear picture of the differences and similarities when it comes to waste management practices.[44] This type of comparative analysis helps identify cases that do not fit the standard procedures, thus calling for a review of the existing framework.[45] For example, looking at the waste management standards and criteria in the UAE and comparing them with the KSA, it is easy to discern why one country does well in this area, yet another does not, ultimately providing useful recommendations.

Through comparative analysis, the KSA can learn different methods from the UAE to improve its waste management efficiency and effectiveness. Furthermore, through this

[44]Emma Lees & Jorge E. Viñuales, The Oxford Handbook Of Comparative Environmental Law Abstract (2019)

[45]AbdulrzaqMiqran, Types Of Methodologies Used In Research, 2020 U. Feres Mentouri Constantine <9-10>

comparative analysis dissertation, the less obvious concepts and assumptions surrounding waste management are examined, especially within the context of the KSA.

Following the methodology described above, this dissertation discusses the following topics to meet the objectives of the comparative analysis:

- Overview of the types and volumes of NSW generated in the KSA.
- Reviewing existing laws and regulations in the KSA that govern NSW management.
- Overviewing of the volumes of NSW in the UAE.
- Exploring the latest standards and techniques for NSW in the UAE.

Conclusion:

This paper undertakes a close examination of current waste management in the KSA. It also examines the authorities that govern the implementation of these approaches. It then employs comparative analysis, comparing the implementation of waste management approaches in the KSA with the implementation of waste management in the UAE to draw conclusions and recommendations on how the KSA can improve its waste management frameworks.[46] The paper's most important recommendations include reducing the volume of organic and plastic waste through the adoption of more effective policies, re-regulating the construction and demolition waste, encouraging the sorting of waste before reaching the landfills, improving public awareness with regard to the importance of waste management, establishing comprehensive recycling programs, imposing strict standards to separate medical waste from the municipal waste stream, and adopting controlled burning for incineration.

[46] Ibid

2.0 Chapter 2: Overview of Waste Management in the KSA:

2.1 Waste Generation:

Waste generation can be defined as "unwanted materials left over as a result of human habitation or manufacturing and production processes,"[47] is a major social and environmental problem. If handled improperly, NSW can cause many negative environmental impacts. For instance, there are many environmental issues related to the mismanagement of waste such as infectious diseases, land and water pollution, obstruction of drains and loss of biodiversity.[48] However, there are many kinds of NSW produced, each having a different impact on the surroundings and adverse effects on human health. Waste can be hazardous and nonhazardous, depending upon its effects on the environment and health of living beings.[49] Therefore, the KSA's legal system has provided definitions to differentiate between NSW and hazardous waste. Hazardous waste in the KSA is defined as any type of solid or liquid waste, which causes severe threats to the environment or human health.[50] NSW is defined as all unwanted materials that have turned to be worthless to their generators. NSW includes plastic, glass, wood, paper, metals, chemicals, and other waste materials generated by commercial, agricultural, residential, and

[47]Ashby Addiss, The Ultimate Glossary Of Waste & Recycling Terms, Rubicon (July 16, 2018), Https://www.rubicon.com/blog/rubicon-waste-

[48]Navarro Ferronato& Vincenzo Torretta, Waste Mismanagement In Developing Countries: A Review Of Global Issues, 2019 Us Nat'lLibr. Med

[49]Types Of Waste And Their Definitions. (2017, April 2). Albayan. Https://www.albayan.ae/five-senses/culture/

[50] General Principals For Nonhazardous Waste Management, 05, Issued 2001

industrial sources. Even though these wastes are categorized as nonhazardous, their improper management poses significant threats to the environment and human health.[51]

Rates of consumption, population growth, industrialization, and economic growth directly affect waste generation. However, the KSA urbanization is one of the primary reasons for the enormous waste generation. In fact, the promise of jobs, prosperity, and better living standards pull people out of the villages and small towns into cities leading to population growth in urban areas.[52] Along with all the reasons mentioned above, another major external cause of waste generation is the large number of pilgrims every year.[53]

2.2 Analysis for the Volume of the Types of Waste Received at the Municipal Solid Waste Landfills in the KSA:

The rate of NSW generation in the KSA is 15.3 Mt/y, while the average volume is 1.4kg/capita/d.[54] These NSW consists of two major components:

- Organic Waste like food comprises 65.5% of the total waste from various sources like restaurants, canteen, homes, and hotels, etc.
- Plastic Waste produced from the widespread use of disposable items.

Additionally, the management of NSW in the KSA becomes more challenging during the Hajj annual pilgrimage because of the increased usage of disposable items by the pilgrims. The amount of NSW sent to landfill sites at Buraiman, Jeddah, is 1.5 million tons per year, while

[51]Nonhazardous Waste Law Saudi Arabia, article 03, page 05, issued 2013/07/25.
[52]Final 2030 Solid Waste Master Plan, Massachusetts Department Of Environmental Protection ,www.mass.gov/guides/solid-waste-master-plan
[53]George Webster, Holy Cities Face Threat from Polluting Pilgrims, 2011 BBC
[54]Ibid

during the Hajj season, it is as high as 4,500 tons/day. As a result, there is an additional 4500 tons of extra NSW sent to the landfill, due to the yearly pilgrims who visit the KSA.[55]

Moreover, there are five types of waste received at the landfills in the KSA. These types include, food waste, plastic waste, medical waste, construction waste, electronic waste, and textile waste.[56]

To begin with, food waste, in the KSA, is the most significant NSW stream because it comprises of about 37. % of the total amount of NSW organic waste which comprises 65%.[57] In fact, the KSA is one of the highest food waste producers per capita globally, since the average citizen in the KSA produces 250 KG of food waste annually compared to the global average of 115 Kg annually. Most of the food waste in the KSA comes from dinner parties, weddings, and restaurant buffets. Therefore, food waste plays a vital part in the management of NSW.[58]

Plastic waste is the second type of waste received at the landfills. It is considered the second largest NSW stream with a 5.2% proportion.[59] Despite the negative environmental impacts that are resulted from mismanaging plastic waste, the KSA continues to use old-fashioned approaches to manage this type of waste.[60] The country collects different elements of the plastic waste stream and dumps them in landfills without sorting or recycling.[61]

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[55]Abdullah Saeed Al-Ghamdi and AsadSeraj Abu-Rizaiza, "Report: Pipeline Transport of Solid Waste in The Grand Holy Mosque In Makkah", Waste Management & Research 21, no. 5 (2003)

[56]Bijaya K. Adhikari,"Characterization Of Food Waste And Bulking Agents For Composting," Waste Management 28, No. 5 (2008))

[57]Tolba and Saab, 2008; Ouda et al., 2013 Khan And Kaneesamkandi, Solid Waste Management In Saudi Arabia Review..

[58]Awn, M. (2017, March 6). Saudi Arabia Food Waste Rate Is 427 Kg. Sas Post. Https://www.sasapost.com/wasting-food/

[59]Tolba And Saab, 2008; Ouda Et Al., 2013; Khan And Kaneesamkandi, Solid Waste Management In Saudi Arabia Review.

[60].Kokaio, V. (2021, June 7). The Increasing Threats Of Plastic Waste. Al-eqtsadiah. Https://www.aleqt.com/2021/06/07/article_2107756.html"

[61]Ouda, Solid Waste Management In Saudi Arabia, Oct/19/2017..

Medical waste is the third type of waste received at the landfill in the KSA. Although medical waste is considered hazardous waste it is dealt with differently. In the KSA, the medical waste is found in the municipal NSW stream. Additionally, both medical waste and NSW are buried in the same landfill.[62] To further illustrate, the KSA obligates medical centers and hospitals to treat medical waste before disposing of them at garbage bins.[63] The treatment of medical waste at the medical centers includes autoclave, chemical disinfection, and microwave. Once the medical waste gets treated in the medical centers, they dispose of them at medical garbage bins which, eventually transport the medical waste to the same landfills, where NSW are disposed of.[64]

The KSA health centers and hospitals produce up to 25,207 tons of medical waste yearly.[65] With that said, the stream above can be categorized into general waste, infectious waste, medical hazardous waste, and radioactive waste. Firstly, general medical waste consists of materials that are used for general purposes in different hospitals. The materials mentioned above include all types of NSW. Secondly, infectious waste comprises waste that can cause infections to the people if not correctly disposed of. These wastes consist of human tissues, blood, and other contaminated materials, which can cause infectious diseases. Thirdly, medical hazardous waste is considered hazardous because of their danger to people as these materials include some chemical containers, sharp surgical items, and other objects that can cause harm if

[62]Zafar, S. (2019b, May 24). The Mismanagement Of Medical Waste In The Middle East. Ecomena. Https://www.ecomena.org/medical-wastes-ar/

[63]Samiah Seed. (2013, September 9). The Production Of Medical Waste From The Hospitals. Watanksa. Https://www.alwatan.com.sa/article/197612

[64]Aldbas, A. (2009). The Disposal Of Medical Waste. Imam University.

[65]Al-zahrani Ma, Fakhri Zi, Al-shanshouri Ma, Al-ayedMh. Healthcare Risk Waste In Saudi Arabia. Rate Of Generation. Saudi Med J. 2000 Mar;21(3):245-50. Pmid: 11533792.

not disposed of properly. Lastly, radioactive wastes are considered the most dangerous in this group. If not well monitored and eliminated, radioactive wastes emit radiation that harms human beings, plants, as well as animals.[66]

Construction waste is the fourth type of waste received at the landfills in the KSA. This type of waste consists of debris produced during the construction, renovation as well as demolition of buildings, roads, and bridges. Research indicates that the waste mentioned above jeopardizes the environment and the waste management system. For instance, debris from buildings and road construction makes the environment abhorrent and undesirable. What is more, wastes from construction materials can hurt pedestrians. A study was conducted to examine 81 construction companies in the Eastern Province of the KSA, which determined various factors that critically affected the sustainable management of C&D waste in the country. The research found that in the studied firms, only 39.5% of them had a pollution control plan for their projects. Moreover, it was determined that 13.6% of C&D waste is recycled and reused every year, whereas the remaining 86.4% of C&D waste eventually goes to landfills.[67]

Electronic waste is the fifth type of waste received at the landfill in the KSA. E-waste consists of electronic products, including computers, television, and cell phones; the KSA produces four million tons of electronic waste. Due to the advancement of technology in the modern world, this type of waste has substantial threats because of its fast growth. Notably, the electronic sector faces continuous innovation and improvement in technology, which contributes to the dangerous disposal of outdated devices and machines. Electronic waste can lead to

[66]Alsaad, M. (2004, August 21). The Mismanagement Of Medical Waste In Saudiarabia Is Resulting Many Negative Side Affects. Al-sharq,alawsat. Https://archive.aawsat.com/details.
[67]Finz Article Review, ”sustainable Management Of Construction And Demolition Materials.”

different health challenges; for instance, the emission of harmful radiation is associated with cancer and other severe chronic disorders.[68]

Textile waste is the sixth type of waste received at the landfills in the KSA. This stream of waste consists of 6.4% of the total available waste received at the landfill.[69]

Thus, the types of waste received at the landfills in the KSA varies, due to the absence of the proper classifications and regulation for the waste. Consequently, the landfills receive both hazardous and NSW, which are all treated in the same manner in the landfills. All types of waste received at the landfills are treated with open incineration or waste that is buried under ground.

[68]Arqam. (2021a, May 26). Billions Of Riyals Are Lost Yearly Due To The Mismanagement Of Electronic Waste. Https://www.argaam.com/ar/article

[69]Abdulaziz S. Alidi, "Assessment of Municipal Solid Waste Management Practices in Saudi Arabia," Journal of Environmental Systems 23, no. 3 (1994)

Table 1: Composition of Municipal NSW Produced in the KSA (Tolba and Saab, 2008; Ouda et al., 2013; Khan and Kaneesamkandi

1	Organic materials	65.5	Food waste and paper materials
	Food waste	37.0	Food stuff, fruits and vegetable refuse, peel
	Paper	28.5	etc.
			Wasted papers, cardboard, box board , bags, magazines, tissue papers, newspapers, toilet papers
2	Plastics	5.2	Disposable glass, spoons, plates, wrapping films, wrapping film, bags, plastic bottles and polythene
3	Glass	4.6	Bottles, glassware, bulbs, ceramics etc.
4	Wood	8.0	All products comprised of wood
5	Textile	6.4	Cloths, dippers etc.
6	Metals/minerals	8.3	Cans, knives, wire bottles, aluminium cans, foils
7	Others	2.0	Leathers, rubber, fibers, rubber, yard waste, soils, tyres ,appliances and electronic appliances

Table 2: NSW Production in Different Cities of the KSA (Ouda et al., 2013; Tolba and Saab, 2008; CDSI, 2004

Region/ City	**Population (millions)**	**Amount of waste (×10^3 tons per year)**
Saudi Arabia	30.8	15,300
Major cities of KSA	14.12	8633
Riyadh	5.328	2871
Jeddah	3.456	1888
Makkah	1.675	915
Madina	1.180	645
Al-Taif	0.987	540
Dammam	0.903	1093
Al-Hassa	0.60	681

2.3 Waste Disposal:

2.4 Overview of the Current Practices of Waste Disposal in the KSA:

2.4.1 Collection of the NSW:

The collection of NSW occurs in two stages. The first stage is where the waste is collected from residential, commercial, and industrial sites. The second stage is where the waste is collected by waste transporters from designated garbage bins.

In the first stage of collection, the NSW is collected in containers of different sizes and placed throughout the cities. The storage of NSW is done in containers ranging from 0.25 to 5-meter cube volume capacity. However, the KSA does not have specific standards or criteria on the appropriate bags to be used for disposing of NSW. Thus, people use an assortment of containers to dispose of their NSW such as old shopping bags, plastic trash cans, or sometimes the waste is disposed of without bags. The second stage involves collecting the waste from the garbage bins by waste transporters. NSW collection trucks, ranging from 5-10-meter cube capacity, carry the waste to the designated landfills. Additionally, the vehicles are equipped with compaction facilities compacting NSW to decrease its volume for further loading.[70]

2.4.2 Disposal at Landfill Sites:

NSW is generally collected, in the KSA, by waste transporters and finally disposed of at communal landfill sites. Landfilling refers to construction of a well-engineered site, designed specifically to accommodate NSW and mitigate any environmental impacts like soil, air, and water pollution. Although landfill is the least favorable method of choice for disposal of NSW,

[70]Gharaibeh, E. S. (2011). Evaluation of Current Municipal Solid Waste Practice and Management for Al-Ahsa, Saudi Arabia. King Faisal University

its importance cannot be neglected. There is, however, a collection of requirements that need to be followed when selecting landfills sites, which will be discussed in depth in the following chapter. All of the landfill sites in the KSA are government-owned but are operated by private contractors under civil authorities.[71]

2.4.3 Incineration:

Incineration is a waste treatment process that involves the combustion of waste material in a NSW incinerator, and a type of facility designed and operated at specific conditions.[72] Incineration will also be discussed in depth in later chapters. The KSA does, however, rely heavily on open incineration due to the lack of alternative methods of waste treatment such as recycling, or converting waste to energy. Incineration is considered as the second choice of waste treatment in the KSA and is used on two occasions. Firstly, landfill operators use waste incineration as a method of waste treatment, in case the landfills reach its capacity. Secondly, individuals who live in rural areas where there are no garbage bins, burn their waste in open areas and deserts.[73]

To sum up, there are only two methods for waste disposal in the KSA. The primary method is burying the waste at the landfill sites. The secondary method is disposing of the waste through an open incineration method. The latter method is used more often as opposed to the primary method.

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[71]Department Of Cleanness. (2016). General Introduction. General Commission OfRyiadh. Clean.alriyadh.gov.sa

[72]Nanjing Clover, What Is Called Incineration?, BCEPE (), http://www.bcepe.com/what-is-called-incineration/

[73]M. (2020, February 10). Review for the current waste treatment in Ryiadh. Royal Commission for Riyadh City. https://www.rcrc.gov.sa/ar/magazine_topic/006336

3.0 Chapter Three: Existing Laws and Regulations on NSW Management:

This overview of the laws that govern waste management in the KSA considers the goals, objectives, regulations and the standards that have been set for these existing laws. The environmental laws that are in existence in the KSA include laws for medical waste management.

These include, NSWL, and Environmental Standards on Material Recovery and Recycling of Waste (ESR). Each of these laws regulates a given activity that touches on the collection, transportation, treatment and disposal of waste materials within or outside the territory of the KSA. The laws mandate what needs to be achieved within a given period and identify who will be involved in ensuring compliance.

In addition to reviewing specific authorities governing waste management, this chapter identifies overarching authorities that more broadly inform the implementation of waste management laws. The overview gives an insight on the role that Sharia law plays in matters concerning waste management and environment protection in general. This is to be inferred from the various aspects in Quran that are concerned with resource conservation, prohibition of corrupt activities on the land, reduction of careless living by human beings which pollute the universe and by observing cleanliness. Furthermore, the overview examines the Royal Decrees that offer guidelines on how matters of waste management should be handled in the KSA explaining the role played by MOMRA in dealing with the waste management in the KSA.[74]

[74]A decree is a rule of law, defined as 'an order given by king or queen'. Royal decree has no limitations in scope and there is no law that can be passed without backing it up with a royal decree issued by the king to enable the ministries and other governmental agencies to adopt any law Royal decrees are the basis of laws in KSA, issued, amended, and abolished by the King.

Fundamentally, the overview is essential, as it will assist in identifying the gaps that are manifested in the existing laws and regulations.

3.1 I-GCC Uniform Law for Medical Waste Management (GULM)

Medical waste constitutes a significant waste stream in the KSA since both hazardous and nonhazardous medical waste are eventually dumped at the same landfills. Nonetheless, this section reviews the GCC Uniform Law for Medical Waste Management (GULM). GULM consists of general provisions to regulate both hazardous and non-hazardous medical waste; it aims at preventing dangers that can be caused by the mismanagement of medical waste within GCC countries. This section first explains how medical waste is defined and listed under the GULM with respect to medical waste management. It then lays out the criteria and standards of creating medical committees, specifications for the size and type of material used in packing medical materials, and requirements for the training of medical workers and transportation of medical waste. The section concludes by highlighting the most significant defects in GULM.

3.1.1 Definitions and List of Medical Waste:

GULM defines medical wastes as any wastes generated from the medical centers.[75] Such centers include hospitals, pharmacies, and centers for medical research.[76] Based on the law, there are two types of medical wastes: non-hazardous and hazardous medical wastes.[77] NSW generated from the medical centers also fall under the class of medical wastes under the

[75] GCC Uniform Law for Medical Waste Management,19/10/2005, Article1,section1, page5, Saudi Arabia,
[76]GCC Uniform Law for Medical Waste Management , 19/10/2005,Article1,section2, page 5, Saudi Arabia
[77] GCC Uniform Law for Medical Waste Management,19/10/2005, Article1,section 1-1, page5, Saudi Arabia,

GULM.[78] The nonhazardous medical waste is handled according to the criteria and standards described in the NSWL.[79] Hazardous medical wastes (HMW) are handled based on the more stringent criteria and standards imposed by GULM, due the special health threat that HMW can pose to the community.[80]

GULM set out a list of hazardous and nonhazardous medical waste. The list included pathological wastes, contaminated sharps, and isolation wastes. Additionally, the list included contaminated animal and human body parts, stocks of infectious agents, human blood, and its products. The blood products described above include plasma, red blood cells, or any other element that is obtained from the blood.

3.1.2 Standards and Conditions on Creating the Medical Committees:

The GULM sets standards and conditions for creating medical committees that supervise medical waste at the internal and external level within each country. The GULM delegates different responsibilities to both internal and external levels. Under the internal levels, the committee is given the mandate of supervising the medical waste internally inside each country.[81] For example, most medical centers reported the measures they have put in place to help them manage and reduce medical waste. The GULM also requires them to develop a substantiated approach that describes how wastes are collected from medical centers and taken to deposition sites.[82]

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[78] Uniform Law for Medical Waste Management , 19/10/2005,Article1,section2, page12, Saudi Arabia
[79] Uniform Law for Medical Waste Management , 19/10/2005,Article1,section2, page 5, Saudi Arabia
[80]Yves Chartier, Jorge Emmanuel, Ute Pieper, Annette Prüss, Philip Rushbrook, Ruth Stringer, William Townend, Susan Wilburn And Raki Zghondi Et Al., Safe Management Of Wastes From Health-care Activities, Second Edition World Health Org. 42
[81]The Annual Report of the Ministry of Health Affairs (Saudi Arabia , Riyadh : ministry of health , 2017)
[82] Uniform Law for Medical Waste Management, 19/10/2005, Article10,section2, page23, Saudi Arabia

On the external level, the medical committee is mandated to supervise medical waste transportation within the GCC countries.[83] For instance, recyclable medical wastes are packaged and sent from the KSA to Dubai for recycling deposition. Additionally, the committees collaborate with each other effectively to ensure a smooth running of the GCC. This is done through annual meetings. The aim of the meetings is to exchange information between members of the committee and to promote the medical waste industry.[84]

The GULM also gives the committees the authority to apply penalties on health centers and transporters. The approach is applied to ensure that health centers adhere to the strict provisions of the GULM. For example, suppose the medical center or the waste transporter has breached its obligations towards dealing with medical waste or breached its responsibilities under the standards and rules mentioned in this law. In that case, the committees have the authority to abolish its license from providing medical services.[85]

3.1.3 Standards on the Size and Type of Material Used in Packing Medical Materials:

The GULM imposes standards on the size and the type of material used in packing the medical wastes, such as the type of plastic and protective materials used to protect the medical waste. The medical centers have the role of sorting the hazardous and non-hazardous medical wastes. The medical centers collect the hazardous wastes and put them into yellow bags. Such bags have stickers that cite that the waste therein is hazardous. Such tagging of wastes is required for sharp contaminated wastes. This is an additional precautionary requirement when collecting infectious wastes and putting them in bags labeled "infectious wastes." Notably, such

[83] GCC Council for medical affairs. “GCC Council to Operate Medical Affairs Within GCC Borders.” 1976. http://www.ghc.sa

[84] Uniform Law for Medical Waste Management, 19/10/2005, Article31, page30, Saudi Arabia

[85] Uniform Law for Medical Waste Management , 19/10/2005,Article20,page30, Saudi Arabia

stickers must be in a font that is easily legible to ensure that anyone who handles the wastes understands it.[86]

Further, medical centers are obligated to collect all chemical materials and put them into yellow bags. The bags require a sticker that indicates that the contents of the bags are "chemicals." The medical centers are under obligation to use red bags to collect human and animal parts. The stickers on each of the red bags need to indicate the body part in the bag.[87] The centers carry out a further role by collecting the non-hazardous wastes and putting them into black bags, which are then disposed of along with other NSW.

3.1.4 Standards for Training of Medical Workers:

The GULM sets forth standards for training those who transport HMW waste and requires that workers who work in the medical centers pass training programs in dealing with medical waste. Additionally, GULM also obligates workers in medical centers to use unified marks and stickers on medical waste packages, so any other worker who receives the medical material or waste can recognize the type of material he is receiving.

Health centers are operational units under the GULM. The correct labeling of the different hazardous and non-hazardous medical wastes must be under the health centers' oversight. In such settings, the health centers should ensure correct training for the staff to ensure strict adherence to the GULM standards. Any deviations from such standards due to training errors means that the health centers are held culpable under the GULM. However, individual errors due to negligence mean that each responsible person is held accountable for their shortfalls in the health centers.

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[86] Uniform Law for Medical Waste Management , 19/10/2005,Article05,page17, Saudi Arabia
[87] Uniform Law for Medical Waste Management , 19/10/2005,Article5,page18, Saudi Arabia

3.1.5 Standards Used to Transport Medical Waste and Material:

The GULM imposes standards and criteria to transport HMW waste, whether internally or externally in each GCC country. There are established standards under the GULM. The vehicles that transport the medical wastes must be structured to accommodate the wastes. Such standards include the obligation that the vehicles are equipped with sterilization equipment and extinguishers. Moreover, the transporters have the responsibility of sterilizing their vehicles. More importantly, there is a prohibition against transporting medical wastes during peak hours or storing the medical wastes in their vehicles to ensure public safety.

The obligations above apply simultaneously in cases of transporting the medical wastes. If, for instance, a lorry that carries hazardous medical wastes transverses through a highway during peak travel hours, and does not have a sterilizer, the transporters have breached two medical waste protocols under the GULM.[88]

3.1.6 GULM Discussion:

The Gulf Cooperation Council developed the GULM as a uniform law on medical waste management.[89] As explained above, its key features include the creation of medical committees, standards for sorting, identifying and transporting the medical waste, and for disposing of medical waste. However, GULM has disadvantages. It is outdated, in some respects its requirements are not sufficiently specific, and it lacks a meaningful enforcement mechanism.

The first aspect that is important to note is that the GULM was formed in 2005.[90] Since that time, various technical methods and approaches have been developed to deal with medical

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[88] Uniform Law for Medical Waste Management , 19/10/2005,Article3,page35, Saudi Arabia

[89] Hauser Global Law School Program, New York University School of Law, A Brief Overview of the Saudi Arabian Legal System, 2008 HOUSER GLOBAL L. SCH. PROGRAMS

[90] Uniform Law for Medical Waste Management , 19/10/2005,page1, Saudi Arabia

waste. For example, autoclaving is an efficient method to treat biohazard waste. This method mainly uses a heated container to treat biohazard waste. As such, the GULM should be updated to reflect current approaches to medical waste management.[91]

Secondly, the GULM came up with a proposal to elect a committee that will be in charge of the medical waste. It somehow failed to include some of the basic requirements that these committee members had to attain to be members of the committee. For instance, they could have included that the member should be above thirty years and should have worked in the medical department for over five years. Furthermore, it could have indicated that the candidate should have all the required school documents to prove that they studied medicine.

The GULM has failed to come up with concise criteria for selecting the committee.[92] Especially, since medical waste can result in serious impacts on the environment, if it was handled improperly. Therefore, there is an urgent need to appoint qualified members in order to ensure better management for the medical waste.

Thirdly, GULM requires that medical centers establish areas in which they collect the medical waste and store them to avoid the possibilities of pollution from waste products. However, GULM fails to specify criteria and standards used in establishing waste collection's areas.[93] For example, the World Bank Group has suggested a collection of standards and criteria to be followed when establishing waste centers at medical centers. First, medical waste centers must be established away from the central kitchen to ensure food safety. Second, access to the medical waste centers is solely limited to certain workers. Third, medical waste centers must be protected

[91]Challenges Face Waste Management Field at GCC ," ecomena. June 29, 2019, https://www.ecomena.org/gcc-waste-management-ar/.

[92]"The Mismanagement in the Medical Sector." Al-Qabass July 24, 2016. alqabas.com/article/.

[93]Four Governmental Entities is Searching for Solution for medical Waste ,Almadinah November 24, 2020

from sunshine. These standards and criteria were suggested to ensure the safety of people, environment, and food within the medical centers.[94]

Finally, GULM indicates that all these proposed measures are to be taken to properly dispose of medical waste. However, GULM fails to specify a meaningful enforcement mechanism. It does not indicate the bodies that will be responsible for punishing countries that break the medical waste disposal laws or include penalties or other accountability mechanisms for countries that fail to meet the requirements of GULM.[95]

3.1.7 Analysis for the Relation Between the Medical Waste and NSW at the KSA:

Medical waste is known for its dangerous impacts on the environment. Therefore, most countries consider medical waste to be hazardous, which is why the medical waste stream is always collected and treated differently. In the KSA, there are two stages to treat medical waste. The first stage is conducted at medical centers through autoclave, chemical disinfection, and microwave. The second stage is conducted at the municipal landfills. While this medical waste is sorted and treated at the point of origin, it ends up being disposed of at the same landfills as non-hazardous wastes. Here, the waste is buried into the ground as the same as any other type of NHSW or burned through the open incineration method. This negatively impacts the soil, water resources, and air quality.[96] Therefore, medical waste management imposes a significant threat to the NSW system at the KSA. Thus, while there are well-set strategies to help sort and treat/disinfect medical waste at the point of origin in the KSA, the medical wastes still end up in

[94]IFC, Environmental, Health, and Safety Guidelines for Health Care Facilities, 2007 INT'L FIN. CORP. IFC <1-12>

[95] Environmental Crime and its punishment in Saudi Arabia , King Abulaziz University ,Naif Sultan, Page 250

[96]Zafar, S. (2019, May 24). The Management of Medical Waste in the Middle East. EcoMENA. https://www.ecomena.org/medical-wastes-ar/

the same landfills as NSW causing a negative impact on the environment and humans living around the landfills.

In developed countries like France, separate landfills have been set aside where medical waste is disposed.[97] These landfills have been enclosed to ensure that the medical waste is contained at one place without finding its way into bodies of water, or residences where it can cause physical harm. Moreover, the incineration of these wastes is done in enclosed environments to prevent the release of harmful gasses into the atmosphere. The resulting ash is used in the manufacture of fertilizer.[98] The KSA can emulate this medical waste management strategy adopted by France to prevent the mixing of medical wastes and non-hazardous wastes in the same landfills. By doing so, the KSA will be able to curb soil, water, and air pollution, together with the physical harm caused by these wastes on humans. Moreover, this will also help in better management of landfills. In sum, the sorting of medical and NSW is a continuous process that should not start and end at the point of origin but continue to the last stage which is disposal at landfills. While the KSA has done well in ensuring the sorting of medical waste at the point of origin, something needs to be done to ensure that the sorting is done even in landfills.

[97]A. Prüss& E. Giroult, Safe Management of Wastes from Health-Care Activities, WORLD HEALTH ORG. LIBR. <25-28>
[98]Ibid

Images of Waste Disposed in Landfills in the KSA

Image 1: Medical waste disposed of together with nonhazardous waste in the city of Jeddah. Retrieved from https://www.aljazeera.com

2: Medical waste disposed of in a landfill together with nonhazardous waste in Mecca. Retrieved from https://ich.unesco.org/en/lists

Conclusion

GULM is the standard-setting organ in enhancing the handling of medical wastes. It has general provisions that cover hazardous and nonhazardous waste. It also sets out standards and criteria to deal with medical waste properly. The GULM obligates medical centers to categorize, handle and label medical waste based on specific standards and criteria. Using bags with different colors to indicate the caution necessary in handling medical waste is another requirement. GULM mandates that medical committees supervise medical waste, whether at an internal or external level. Additionally, GULM imposes standards and criteria to be used when transporting medical waste. These standards and criteria aim at ensuring the safety of the public as well as the transporters. Finally, GULM aims at training the workforce in the medical field to ensure their safety and to improve efficiency in the workplace. Although GULM aims at regulating medical waste, its lack of specificity in some regards, failure to incorporate technical developments relating to the management of medical waste, and lack of meaningful enforcement mechanisms limits its utility.

3.2 The Kingdom of Saudi Arabia NSWL:

NSWL plays a significant role in the management of NSW in the KSA. This section provides an overview of the standards and criteria used under NSWL, including the licensing of waste management activities, requirements in the selection of landfill location, NSWL penalties and punishments, NSW transport liabilities, and the requirements to handle the waste at the landfill. It concludes by highlighting some gaps and defects in the NSWL.

NSWL was structured on July 7,2013 due to a Royal decree 91/A.[99] NSWL defines "nonhazardous solid wastes as all unwanted materials that is worthless to their generators"[100].

NSWL stipulates how the entire process in the disposal of waste shall be conducted. NSW covered by NSWL are commercial, household. organic, and industrial waste. NSWL; however, excludes hazardous industrial waste and hazardous medical waste from its list.[101]NSWL prescribes strict guidelines, procedures, and requirements that must be followed in NSW management. All NSW waste treatment protocols shall be followed as stipulated in NSWL.[102] Landfill sites shall be continuously modified to accommodate the needs of NSWL.[103] Additionally, NSWL stipulates strict penalties and punishment to waste management entities upon breaching NSWL provisions.[104]NSWL comprises the following guidelines.

A- Licensing of Waste Management Activities.

B- Requirements in the Selection of Landfill Location.

C- NSWL Stipulations on Penalties and Punishments.

D- Non-Hazardous Waste Transport liabilities.

E- The Requirements to Handle the Waste at the Landfill.

3.2.1 Licensing of Waste Management Activities:

NSWL requires entities to obtain a license to manage NSW. Obtaining necessary licenses is a very important procedure, since the NSW is operated by the private sector and

[99] Nonhazardous Waste Law Saudi Arabia, introductory, page 01, issued 2013/07/25.
[100] Nonhazardous Waste Law Saudi Arabia, article 03, page 05, issued 2013/07/25.
[101] Nonhazardous Waste Law Saudi Arabia, article 03 section07, page 05, issued 2013/07/25.
[102] Nonhazardous Waste Law Saudi Arabia, article 02, page 05, issued 2013/07/25.
[103] Nonhazardous Waste Law Saudi Arabia, article article2 section16, page 21, issued 2013/07/25.
[104] Nonhazardous Waste Law Saudi Arabia, article 25, page 31, issued 2013/07/25.

managed by the public sector.[105] Under the NSWL, the government checks the qualifications of companies engaged in the waste management industry and requires licenses and permits for all companies involved in waste management in the KSA. However, the requirements to obtain any license varies based on the type of activity that the company desires to practice.

NSWL stipulates the requirement of obtaining an operating license to manage waste materials, which can only be issued by the ministry of municipality and rural affairs.[106]

Further, NSWL stipulates those entities offering waste management services such as consultation, processing, and sorting which must also obtain licenses.[107] NSWL defines 'waste management consultation service as any study or consultation that is used to measure the environmental impacts associated with waste management"[108]. In addition, NSWL has limited the consultation services to the local certified practitioners.[109] For example, if a private contractor plans to build a landfill, he will need to obtain an environmental assessment report provided by a local certified consultant. NSWL defines waste sorting as" a process where NSW is separated into various elements which can be either manually or automatically to make it easier for treating, recycling or incarcerating the waste"[110]. For example, once NSW is received at the landfill, equipment separates plastic waste from the waste stream. NSWL defines waste processing as "the process of changing the character and composition of waste after clear sorting to reduce the amount of waste, prepare the waste for treatment, or recycling"[111]. For instance, in order to recycle plastic waste, the waste processor needs to squeeze plastic waste.

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[105] Nonhazardous Waste Law Saudi Arabia, article 15, page 17, issued 2013/07/25.
[106] Nonhazardous Waste Law Saudi Arabia, article 16, page 19, issued 2013/07/25.
[107] Nonhazardous Waste Law Saudi Arabia, article 15, page 17, issued 2013/07/25.
[108] Nonhazardous Waste Law Saudi Arabia, article 02 , definitions page 7, issued 2013/07/25.
[109] Nonhazardous Waste Law Saudi Arabia, article 03, page 7, issued 2013/07/25.
[110] Nonhazardous Waste Law Saudi Arabia, article 02, Definitions, page 7, issued 2013/07/25.
[111] Nonhazardous Waste Law Saudi Arabia, article 02, Definitions, page 7, issued 2013/07/25.

`To be issued with a license to take part in waste management activities in the KSA, the following requirements need to be met:

Present individual commercial ID

1- Present tax ID
2- Present the number of workers that are under sponsorship.
3- Prove to be taking part in three waste management projects.

However, even after being licensed to take part in waste management activities, the license can be revoked if there is a breach of the NSWL.[112]

3.2.2 Requirements in the Selection of Landfill Location

NSWL imposes requirements and conditions in the selection of landfill locations. The requirements are imposed to ensure public safety as well as to protect the environment. As such, the requirements and standards have regulated the establishment of landfills, landfills' ownership, and landfills' location.

First, the NSWL imposes standards and criteria to be followed when establishing a landfill. The landfill's entrance gate must be away from the exit gate. This standard aims at facilitating the access to the landfill and helps in minimizing congestion. Landfills must also be equipped with fans to help circulate the waste fumes. As such, landfills use fans to reduce the smell of organic waste. Moreover, landfills must be stationed at places far away from residential sites, commercial centers, and industrial areas.[113] This standard aims at protecting the public from air pollution that can be caused by waste management activities. For example, treating NSW can generate some harmful emissions such as methane emissions.[114] Finally, landfill areas

[112] Nonhazardous Waste Law Saudi Arabia, article 15, page 18, issued 2013/07/25.
[113]Nonhazardous Waste Law Saudi Arabia, article 18, page 23, issued 2013/07/25.
[114]EPA, Basic Information About Landfill Gas., 2020 ENVTL. PROTECTION ANANCY

must be owned by MOMRA. This is because public funds are used to support landfill operation. Through these requirements, the municipalities ensure that landfills are used for a long period of time. [115]

3.2.3 NSWL Stipulations on Penalties and Punishments:

NSWL formulates penalties and punishments for entities that violate the law, which governs NSW in the KSA. The penalties and punishments can be either fees or revocation of license based on the type of violation. There are several types of violations under NSWL, including misplacing waste, accumulating the waste, and changing the waste container's location.

First of all, there are two types of misplacing waste under NSWL. It is a violation to fail to place waste in designated containers. For example, if someone placed his trash bag next to his house door, it is considered a violation under NSWL. Secondly, changing the designated places of the waste containers to another is considered a violation. Meaning, transferring the garbage bin location from a commercial street to another residential area.[116]

Second, NSWL prohibits any form of waste accumulation or storage without a permit. This prohibition aims at protecting the ownership of waste, since all types of NSW are fully owned by the government. The government has the authority to decide whether or not to recycle or dispose of the waste. For example, if an individual is found taking plastic bottles, aluminum, scrap, glass or cans from the garbage cans to recycle it, this would be considered a violation of the government's property under NSWL. The main reason behind the ownership of waste is to combat the black market for waste, since there are some undocumented workers collecting and sorting the

[115] Nonhazardous Waste Law Saudi Arabia, article 18, page 23, issued 2013/07/25.
[116] Nonhazardous Waste Law Saudi Arabia, article 25, page 23, issued 2013/07/25.

waste. Afterward, these undocumented workers keep beneficial types of waste for themselves and then improperly dump the less beneficial types of waste. Therefore, the government has the mandate to own wastes that are received at landfill as well as wastes that are deposited in the garbage cans. Thus, no company or individual has the right to claim the ownership of wastes whether before or after the wastes are taken to respective landfills.

Finally, NSWL imposes punishments and penalties for violations. The penalties are set with the purpose of ensuring that all waste generators obey and follow the provisions set by NSWL and prevent improper handling of waste. The penalties vary based on the type of violation, for example, misplacing waste out of the waste container is punishable by up to $2,666, while altering the garbage can location is punishable up to $5,333. Thus, NSWL has imposed various types of punishments and penalties; therefore, waste generators adhere to the provisions mentioned above.[117]

3.2.4 NSW Transporters' Responsibilities:

NSWL regulates the transportation of NSW from the point of generation to the point of disposal.[118] The regulation also obligated waste transporters to dispose of the waste in the designated landfill. NSWL further obligates NSW transporters to collect the waste in sealed bags.[119]

NSWL makes NSW transporters responsible for the waste from the point of generation to the points of disposal. Since the waste is owned by the government, transporters are responsible for damages that may occur from the waste.[120] For example, if a waste transporter has collected

[117] Nonhazardous Waste Law Saudi Arabia, article 25, page 23, issued 2013/07/25.
[118] Nonhazardous Waste Law Saudi Arabia, article 1, page5, issued 2013/07/25.
[119] Nonhazardous Waste Law Saudi Arabia, article 5, page9, issued 2013/07/25.
[120] Nonhazardous Waste Law Saudi Arabia, article 21, page28, issued 2013/07/25.

the waste from the point of generation, he would be responsible before the government, if by any chance he spills any waste material on the road. Thus, waste transporters are fully responsible for the waste from the point of generation to the point of disposal.[121]

Second, NSWL obligates transporters to dispose of the waste in the designated landfill.[122]The main reason behind this obligation is to protect the environment from improper waste disposal. For example, if a waste transporter has disposed of the waste in the desert, he would be responsible before the government for any environmental damages.[123]

Thus, transporters have the responsibility to deliver the waste to the proper landfill.

Third, NSWL obligates waste transporters to collect the waste through sealed bags and place them in containers thereafter. The purpose of this provision revolves around facilitating waste disposal in the designated landfill.[124] For example, if a waste transporter wants to dispose of plastic waste at the landfill, he needs to make sure that waste materials are sealed and contained.[125]

3.2.5 The Requirements to Handle the Waste at the Landfill:

NSWL also imposes requirements and conditions on handling and treating NSW. These requirements include those governing the incineration process, administration process, waste sorting process, and waste treatment.

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[121]"Investigation on Trucks Transporting Waste Illegally ." Al-Madinah News, n.d.,,

[122] Nonhazardous Waste Law Saudi Arabia, article 21, page28, issued 2013/07/25.

[123]"Disposing of the Waste in the Desert Is Polluting the Environment ." *the Economy* May 9, 2009. https://www.aleqt.com/2009/05/01/article_36684.html.

[124]Nonhazardous Waste Law Saudi Arabia, article 21, page28, issued 2013/07/25.

[125]Alriyadh.Gov. "the Department of Cleanness Affairs ." n.d.https://clean.alriyadh.gov.sa/Pages/Landfill_definition.aspx.

First, NSWL defines waste incineration process as 'the combustion of NSW whether in controlled or open incineration facilities'[126]. Nonetheless, the KSA depends only upon open incineration as a method to treat NSW.[127]Under NSWL, there is only one requirement for the incineration process and that is - incineration must be done away from urban areas or locations where people reside.[128]

This method is not the most environmentally friendly method to treat waste as it results in a myriad of environmental harms including local air pollution.[129] More than 170,000 complaints have been raised about open burning of NSW on the KSA. The lack of standards of controlled incarnation in the treatment of NSW was the main complaint (Picture1-2).[130]

Second, NSWL sets out an administration process to be followed at the landfill. This process aims at facilitating the administrative operations at the landfill by identifying responsibilities that need to be followed by the management at the landfill. First, landfill management (MG) is responsible for documenting the types and volumes of NSW received at the landfill. This measurement helps in evaluating the landfill's needs. For example, if the management at the landfill needs more equipment to treat the waste, they need to document the volumes of waste their landfill is receiving.[131] Second, the MG is responsible for overseeing the operations conducted at their landfill.[132] Third, the MG is responsible for covering the waste

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[126] Nonhazardous Waste Law Saudi Arabia, article 1, page7, issued 2013/07/25.

[127]Okathjournal , waste incineration caused serious environmental damages at Jeddah City ,AbdulazizGzay, 2007 October

[128] Nonhazardous Waste Law Saudi Arabia, article 18, page23, issued 2013/07/25.

[129]Rory Bratcher, Recycling vs. Landfills or Incinerators, 2017 SCIENCING

[130]N.A. (2018b). Demands to establish environmental courts to receive environmental complains. *Alwatan*, https://www.alwatan.com.sa/ampArticle/374019

[131]The ministry of rural affairs has approved criteria to be used in waste management. (2016, May 28). The Economy, 1. https://www.aleqt.com/2016/05/28/article

[132] Nonhazardous Waste Law Saudi Arabia, article 18 , section 5 , page25, issued 2013/07/25.

containers at the landfill. These measurements aim at preventing the circulation of the NSW waste. For example, organic waste containers have the potential to release bad smells during rainy seasons; therefore, covering them would prevent the circulation of the bad smell.[133] Finally, MG is responsible for overseeing how workers assort the waste. This measurement aims at ensuring that the workers are separating the NSW properly since the KSA relies on manual waste sorting.[134]

Third, NSWL has set out standards and criteria to conduct waste sorting at the landfill. Generally, waste sorting can be manually or automatically sorted. However, in the KSA waste sorting is conducted manually.[135] There are; however, two standards that need to be followed in manual waste sorting. First, construction waste must be sorted separately, since some of the construction materials contain hazardous waste.[136] Second, all types of NSW must be collected in containers to be treated afterwards. The NSWL has been given full autonomy to MG to determine the method of treating waste materials that have been sorted out. They can opt to treat NSW using incineration or burying it under ground.[137] Both methods, incidentally, have increasing negative environmental impacts, due to the lack of recycling programs.[138]

[133]Okaz news, Waste containers smells circulated around AlsadiahVillage , Abdullah Mashor,2011 https://www.okaz.com.sa/article/393108

[134]Alethadnews ,Sorting the waste is a social responsibility ,2016 April9,

[135]Riyadh News, 130 Million Ton Is Generated Yearly In Saudi Arabia ,ebrahimshiban 2020, Https://www.alriyadh.com/1827815

[136] Nonhazardous Waste Law Saudi Arabia, article 23 , section 5 , page29, issued 2013/07/25.

[137] Nonhazardous Waste Law Saudi Arabia, article 21, page28, issued 2013/07/25.

[138]Ministry of rural affairs / Memo. (2005, June 7). Saudi Arabia Governmental News. https://www.spa.gov.sa/268123

3.2.6 NSWL Discussion:

Different countries have various laws against disposing of waste products carelessly as it leads to land, air, and water pollution.[139] The government of the KSA has also stipulated some basic laws against the unlawful disposal of NSW.[140] For instance, it has emphasized the licensing of waste management practices and the basic standards of a private contractor dealing with waste.[141] However, the law has failed to mention some of the important aspects that deal with eradicating waste and its impact on society. As such, this discussion demonstrates some of the key aspects that the NSWL has stipulated and some of the key aspects that it has failed to consider when dealing with NSW.

The NSWL has not provided any standards or criteria related to the separation of the garbage cans in order to dispose of them effectively. To elaborate, blue garbage bins are used to dispose of plastic wrappers and other non-biodegradable waste products. Yellow garbage cans are used to dispose of glass bottles and papers, while the black cans are used to dispose of household wastes. Through this process, waste generators have had a hard time sorting their waste.[142]

On the other hand, there are waste products that are not recycled and are improperly dumped into the Red and Arabian Sea. This then leads to the reduction of oxygen in the sea hence killing sea creatures (picture3).[143] Furthermore, dumping plastic waste into the sea

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[139]Dennis Finley, Pollution, National Geographic,www.nationalgeographic.org/encyclopedia/pollution//

[140]More Than 16 Milion Ton Of Waste Saudiarabia Is Generating Yearly. (2017). Sabaq News, 1.

[141]Contractors Council, Technical Studies To Rescue Contractors. (2020). Al-waten, 1. Https://www.alwatan.com.sa/article

[142]E.m. (2019, June 29). Challenges Face GccIn Dealing With Nonhazardous Waste. Ecomena. Https://www.ecomena.org/gcc-waste-management

[143]Ibid

contributes negatively to climate change.[144] Subsequently, the sunlight and heat directed on the oceans result in releasing greenhouses from the plastic waste.[145] As such, the NSWL has filed in dealing with the matter of disposing of waste in the sea. This can be seen through their lack of taking legal action against the people who participate in such practices. The NSWL has failed to mention whether this action is legal or illegal; hence, the practice is carried out daily.[146]

Because the KSA is known for its cool deserts, most people like to camp in them. However, the deserts lack garbage disposals, and as such, the public tends to dispose of garbage wastes throughout the desert. It has been noted that NSWL has failed to regulate individual behaviors in the desert environment, although individuals' behaviors play essential role on environmental pollution.[147]Through the littering of waste in the desert, the desert has now become highly polluted with plastic waste, among other waste materials (picture4).[148]

Plastic waste bags are regularly used for disposing of waste products in the KSA. Although various countries have banned the use of plastic bags; have come up with green solutions for plastic bag disposals, the KSA continues to use plastic bags, which is difficult to diminish hence creating more plastic pollution in the country.[149]

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[144]Brooke Bauman, How Plastics Contribute To Climate Change, Yale Climate Change Connection (Aug. 20, 2019),yaleclimateconnections.org

[145]Plastic Waste And Climate Change - What's The Connection?, Australia Wwf (June 21, 2020), Https://www.wwf.org.aun

[146]Waste Is Polluting Arabic Gulf In Saudi Arabia. (2019). Okaz, Https://www.okaz.com.sa

[147]Katrina Fischer Kuh, Environmental Privacy Utah L. Rev. (2015) Available at: https://scholarlycommons.law.hofstra.edu/faculty_scholarship/910.<1-3>

[148]Disposing The Waste In The Deserts Causes Desert Pollution. (2009, May 1). Aleqtazdiah, 1, 1. Https://www.aleqt.com/2009/05/01/article

[149]Anjum, Muzammil, R. Miandad, M. Waqas, I. Ahmad, Z. O. A. Alafif, A. S. Aburiazaiza, M. A. E. Barakst, And T. Akhtar. "Solid Waste Management In Saudi Arabia." Applied Agriculture And Biotechnology 1 (2016): 13-26.

Finally, the garbage cans provided have no specific sizes that can be used. As such, different households use various sizes of waste products or containers. Some tend to use small garbage receptors causing an overflow of garbage into the streets; hence, disposing of it carelessly; littering the area or disposing of the waste products in the wrong places. As such, residential areas should be given sufficient size garbage bins that can accommodate all types of waste materials (picture 5-6).[150]

In summary, NSWL has failed to consider some of the key issues that affect the society and planet at large. Some of these aspects include the disposal of plastic wastes in deserts, insufficient garbage cans and poor recycling methods.

Conclusion

The NSWL governs the management of waste in the KSA and is responsible for ensuring that the provisions that govern waste management are adequately adhered to. There is a need for the KSA to adhere to the formulated laws and to ensure that waste is effectively collected, stored, and disposed of safely and suitably. NSWL plays a significant role in NSW disposal. They also dictate the requirements that private contractors must meet before managing waste in the municipality. Moreover, the law also outlines penalties to individuals who violate the provisions set to govern NSW in the KSA. Therefore, disposal of waste products is a collective role that calls for all citizens' responsibility and accountability.

[150]Saudi Citizens Are Frustrated From The Household Garbage Cans. (2006). Alriyadhoffical, 1. Https://www.alriyadh.com/125982

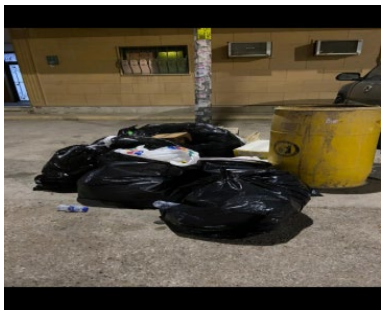
(Picture 1) During NSW open Incineration[151]

(Picture2) after NSW Incinerated [152]

(picture4) Desert waste
Aleqtsadiah Journal[153]

(picture3) Red Sea Waste 9
BBC News [154]

big size garbage
(Picture5 taken by the author)



small size garbage can
(Picture6 Taken by the author)

[151]Mohamed El-newehy, Plastic Waste Management 17 (1 Ed. 2016)

[152] Ibid

[153]Almaroqy, A. (2011, December 3). Alqtsadiah. Alqtsadiah News. Https://www.aleqt.com/2011/12/03/article_603582.html

[154]Ibid

3.2.7 Legal Authority in Charge of NSW Disposal in the KSA:

The Royal Decree No. 48M of August 8, 2013, bestowed the mandate of waste management to MOMRA. MOMRA responsibilities in managing NSW include administrative and financial functions.[155]

First, the administrative role of MOMRA includes the hiring of staff members that manage the landfill sites and determining the locations of the landfills. First, MOMRA is tasked with appointing staff members to serve at the landfill since the landfill is operated under MOMRA supervision. Meaning, when a labor worker desires to serve at the landfill, he needs to submit his resume to MOMRA. Secondly, under NSWL, MOMRA is responsible for determining the location of the landfill according to certain standards and its landfill location must be situated away from residential areas.[156]

Second, the financial role of MOMRA includes purchasing landfill locations, and compensating private contractors. Additionally, MOMRA is tasked with selecting the landfill location based on the standards stipulated under NSWL, since the landfill location is deemed as public property. Furthermore, MOMRA is responsible for compensating private contractors, since the services provided by the contractors are considered public services.[157]

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[155] Nonhazardous waste law, introductory, page 1, issued 2013/07/25.

[156] Alzahrani, M. (2019). The Differences Between The Ministry Of Municipality And Rural; Affairs And The Ministry Of Environmental Affairs. Okath News, 1. Https://www.okaz.com.sa/local/na/1710551

[157] Mubashir. (2020). The Ministry Of Municipality And Rural Affairs Signed Four Contracts To Improve The Waste Management In Saudi Arabia. Mubashr. Https://www.mubasher.info/news/3586145

Conclusion

In conclusion, MOMRA has administrative and financial responsibilities in managing NSW in the KSA. The administrative responsibilities include appointing workers to run the landfill sites and determining the landfill sites' location. Additionally, MOMRA has the responsibility of funding all activities related to the waste management field such as purchasing landfills sites and paying for private contractors.

3.3 SA Environmental Standards Used in Material Recovery and Recycling Material (ESR):

General Environmental Regulations and Rules (GERR) is one of the oldest environmental laws at the KSA. It was issued in 2001 based on Royal Decree No165/M. GERR has generally regulated various environmental areas. However, GERR has provided general standards to be used in material recovery and recycling material. These standards include defining the relevant authority to monitor the implementation of the standards, standards to employ technology to maintain a balance in natural resources, and standards to employ technology to maintain a balance in natural resources. This section, describes the environmental standards used in material recovery and recycling material (ESR), including identifying relevant authorities to monitor the implementation of the standards. It then explains the standards used to employ technology to maintain a balance in natural resources.

3.3.1 The Relevant Authority to Monitor the Implementation of the Standards:

Under GERR the meteorology and environmental presidency (PME) is responsible for monitoring the implementation of ESR and possesses authority to grant an exception from ESR

requirements to individual installations under specified circumstances. PME shall, upon request, assess environmental standards, the grounds for the proposal.[158] The PME should, for example, assess, without harming the environment, the method of disposing of NSW and methods used to decompose them. Based on the methods mentioned in the proposal, PME can decide whether to provide exceptions to ESR or not.

3.3.2 Standards to Employ Technology to Maintain a Balance in Natural Resources:

General Environmental Regulations and Rules (GERR) sets out the standard for implementing technologies for the recycling and reuse of waste management tools. The GERR notes that institutions must implement the technologies required and be consistent with the region or the regional environmental variables. Taking this norm into account, all organizations must streamline the use of technology in recycling and the recycling of resources. This norm is intended to eliminate the unintended risks of recycling. This norm seeks to ensure that resources are rationalized to expand the use of non-renewable resources.[159] However, GERR has not provided details on what type of technology can be used, how to eliminate risks of recycling, or how to expand the use of non-renewable resources. Due to the lack of details in this regulation, there is no active recycle program at the KSA so far.

Conclusion:

General Environmental Regulations and Rules (GERR) aims at regulating the waste recycling and material recovery. However, GERR has set out general standards and criteria to manage waste recycling and material recovery. Although these general standards were set to

[158]General Environmental Regulations and Rules for Implementation, article1,page 6, issued 15 October2001 .
[159]General Environmental Regulations and Rules for Implementation, article8,page8, issued 15 October2001

promote waste recycling and material recovery, they have not achieved their goal yet. Due to the superficiality in the GERR standards, the KSA does not have a clear process for recycling. As a result, the KSA waste management system lacks recycling programs.

3.4 Islamic Sharia Law:

Environmental protection is an integral aspect of Islam. According to the Quran, Muslims have been made stewards on Earth, which also enjoins the responsibility of Muslims to play a proactive role in environmental conservation. Muslims are repeatedly urged to reflect on the relationship with their surroundings and maintain an ecological balance.

In this section, the Sharia Law, for the protection of various aspects of waste management, will be discussed in the light of the Quran and, sayings of Prophet Muhammad and his companions. To start, the KSA's legal system is based on the Sharia law which is derived from the Quran and the traditions that are in tandem with the teachings of Prophet Mohammad. Therefore, any Environmental law that is made in the KSA must be aligned with the teachings, beliefs and practices of Sharia and when found to be in contrary, then it is null and void to the extent of that inconsistent. Similarly, where there is no law regulating waste management, Sharia law will be applied and where there is confusion between Sharia law and any of the environmental law enacted, then the provisions of Sharia law will prevail owing to its supremacy based on Sharia Law. There are four major points that touch on waste management. The four

major points are resource conservation, forbidding spreading corruption in the land, reduction of waste by encouraging living simple life, and cleanliness.

3.4.1 Resource Conservation:

The Islamic teachings towards the conservation of natural resources are based mainly on the prohibition of over-exploitation. The Holy Quran says: "It is He who has appointed you viceroys in the earth … that He may try you in what he has given you"[160].

"O children of Adam! … eat and drink: but waste not by excess, since Allah (God) does not love the waster"[161]. For example, the Prophet walked by his companion, Saad, who was washing for prayer, and said "What is this wastage, and then Saad responded?", and then Saad responded, "Is their wastage even in washing for prayer?", and then the Prophet Muhammad responded, "Yes, even if you are by a flowing river!"[162].

Resource conservation and waste management are interconnected to the extent that resource conservation focuses on managing the use of natural resources to maximize benefits for the current generation while protecting the ability to meet future generations' needs. The protection and rational exploitation of resources are both part of resource conservation in this instance. In an ironic twist, waste management can be considered a way of controlling how waste is disposed of. From beginning to end, waste management involves the activities and actions required to control waste materials. As a result, the process includes collection, transport, treatment, and disposal. The waste management process is accompanied by monitoring and regulation. From this understanding, the link between resource conservation and waste management can be seen.

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[160]The Holy Quran ,AlAnaam , verse 165.
[161]The Holy Quran, Alaraf , Verse 31.
[162]Ibn Majah Series, Sahih, Verse419.

3.4.2 Forbidden to Spread Corruption on the Land:

According to Islam, corruption of land is a broad category that applies to anything disturbing Earth's order and collective systems, making the lives of humans or living things unsustainable. The Quran says, "And do not desire corruption in the land. Indeed, God does not love corruptors"[163]. And in other verses, "Eat & drink from the provision of Allah and do not commit abuse on the earth, spreading corruption"[164].

The link between forbidding the spread of corruption on the land and waste management is that both contribute to resource conservation. Because neglecting the resource conservation principle would negatively impact the waste management field, which in return is considered spreading corruption on the land. For example, allowing people to use more than they need will increase waste, which is considered a form of spreading corruption. Thus, the failure in conserving resources is considered a form of corruption in Sharia Law.

3.4.3 Reduction of Waste by Encouragement to Live Simple Life:

Adopting a simple lifestyle is greatly stressed in Islam. For instance, it is mentioned in the Quran, “Do not be extravagant, surely Allah does not like extravagance”[165]. Reducing the consumption of different types of products can significantly reduce the amount of waste, which will positively impact the waste management. Prophet Muhammad ﷺ himself led a simple life and encouraged his companions to do the same, although he had all power to live in a life of abundance.

Therefore, people need to embrace sustainable living since it helps reduce individual and societal utilization of Earth's natural resources and the human ecological footprint. Thus, encouraging

[163]The Holy Quran, Alqassas, Verse77
[164]The Holy Quran, Alaraf, Verse31
[165]The Holy Quran,Alqassas, Verse 77.

people to live in such a manner helps conserve resources and reduce waste volume, hence, increasing the chances of managing waste materials effectively.

3.4.4 Cleanliness:

When Abu Musa was sent to Al-Basra as the new governor, he addressed the people saying: "I was sent to you by 'Umar bin Al-Khattab to teach you the Book of your Lord [the Holy Quran], the Sunnah [of your Prophet], and to clean your streets"[166]. And in another narration, Abu Hurairah reported that the Messenger of Allah ﷺ forbade that a person relieves himself in a water source, on a path, in a place of shade, or in the burrow of a living creature. In another narration, Prophet Mohamed stated: "Beware of the three acts that cause you to be cursed: First, relieving yourselves in shaded places (that people utilize), in a walkway or in a watering place"[167].And in another narration Removing harmful things from the road is an act of charity (sadaqah)"[168]. It is evident in these values that Islam places a high value on the need to prevent pollution of critical resources and waste management. Therefore, Sharia law has emphasized the cleanliness principle, which cannot be achieved without a proper waste management system. Having a clean environment helps create a conducive place to dwell. Thus, cleanliness shows there is proper utilization of resources, which in return reduces the waste amount and enhances waste management.

In conclusion, the Sharia Law has encompassed and endorsed general principles such as resource conservation, and has forbidden the spread of corruption in the land. This reduces waste

[166]Amir Abdelzaher, Noha Abdel-mottaleb& Bader Al-issaAnd , The Islamic Environmental Health Guidebook 31 (2 Ed. 2011)
[167]Ghulam Rassol, Islam And Environmental Protection: A Fresh Perspective, 2021 Ecomena
[168]Ibid

by emphasizing cleanliness and encouraging people to live a simple life. These principles can be the starting point for a better waste management system at the KSA. They can be used in guiding individuals' behaviors and improving public awareness through the educational system.

3.5 Royal Decrees:

Royal decrees constitute another important authority that influences the development and implementation of NSW management in the KSA. A decree is a rule of law, defined as "an order given by king or queen"[169]. Royal decrees have no limitations in scope and there is no law that can be passed without backing it up with a royal decree issued by the king to enable the ministries and other governmental agencies adopt any law, royal decrees are the base of laws in the KSA, issued, amended, and abolished by the king. In addition to issuing and amending laws, royal Decrees are also the only way to appoint top government officials. Thus, royal decrees play an influential role in selecting qualified professionals to lead the waste management system to higher levels of effectiveness.

3.6 Basel Convention on the Control of Trans-Boundary Movement of Hazardous Wastes and their Disposal:

The KSA's management of waste also reflects its commitments under international agreements, most importantly the Basel Convention, parties. This section reviews the main objectives of the convention and its impacts on the KSA waste management. Basel Convention is a United Nations treaty signed on 22nd March 1989 in Basel, Switzerland, by189 parties

[169]Ibid

including the KSA and 53 signatories.[170] The main reason behind this convention was the transporting of hazardous and other types of waste from the developed world to the developing world.[171]

The Basel Convention imposes obligations to the party states that they ought to follow in managing their disposal waste. Upon becoming a Party to the Convention, the State is supposed to inform the Secretariat of the Conventions about what is considered hazardous under its national legislation. This should happen within six months, after ratification of the treaty. Therefore, the KSA was under obligation to submit to the Secretariat what it meant by waste disposal within the territorial waters of the KSA.[172]

Basel convention calls upon the State Parties to take the appropriate measures to ensure that the provisions in the Convention are met. This includes both the legal and administrative measures.[173] In response to this, the KSA has taken several measures that include establishment of The General Authority for Meteorology and Environmental Protection. This Authority is tasked to enact laws and regulations that touch on the issues of the environment. Additionally, there are environmental regulations that were created in 2001with the intention of regulating both the public and private institutions on matters relating to disposal of wastes. Although these regulations have touched on waste management standards, they lack many details that are essential to the waste management field. For example, the regulations have not touched on the

[170]Basel Convention Parties, Un Environment Programme (Mar. 29, 1989), /www.basel.intt

[171]Muthu S. Sundram, Basel Convention On Transboundary Movement Of Hazardous Wastes: Total Ban Amendment, 9 Pace Int'l L. Rev. 1 (1997) Available At: Https://digitalcommons.pace.edu/pilr/vol9 <7-8>

[172] Basel Convention on the control of transboundary movement of hazardous waste and their disposal , Article 3, page 13 .

[173]Basel Convention on the control of transboundary movement of hazardous waste and their disposal , Article 4, page 16 .

transportation of NSW. Not only that but also, the regulations have not listed penalties for the mismanagement of NSW. Therefore, GERR alone cannot be a reliable source to manage NSW in the KSA.

4.0 Chapter 4: Overview of the UAE Waste Management System:

This overview is imperative because it provides a background of waste management systems and describes the similarities between the KSA and the UAE. Through this chapter, it will be possible to clearly set out all practices that the waste management systems in the KSA and the UAE have in common and their effectiveness in the attainment of desired environmental outcomes. The chapter also provides an overview of the total volume of waste generated by the UAE, including the volume of construction and demolition wastes, commercial waste, agricultural waste, industrial waste, municipal waste, and other types of waste.

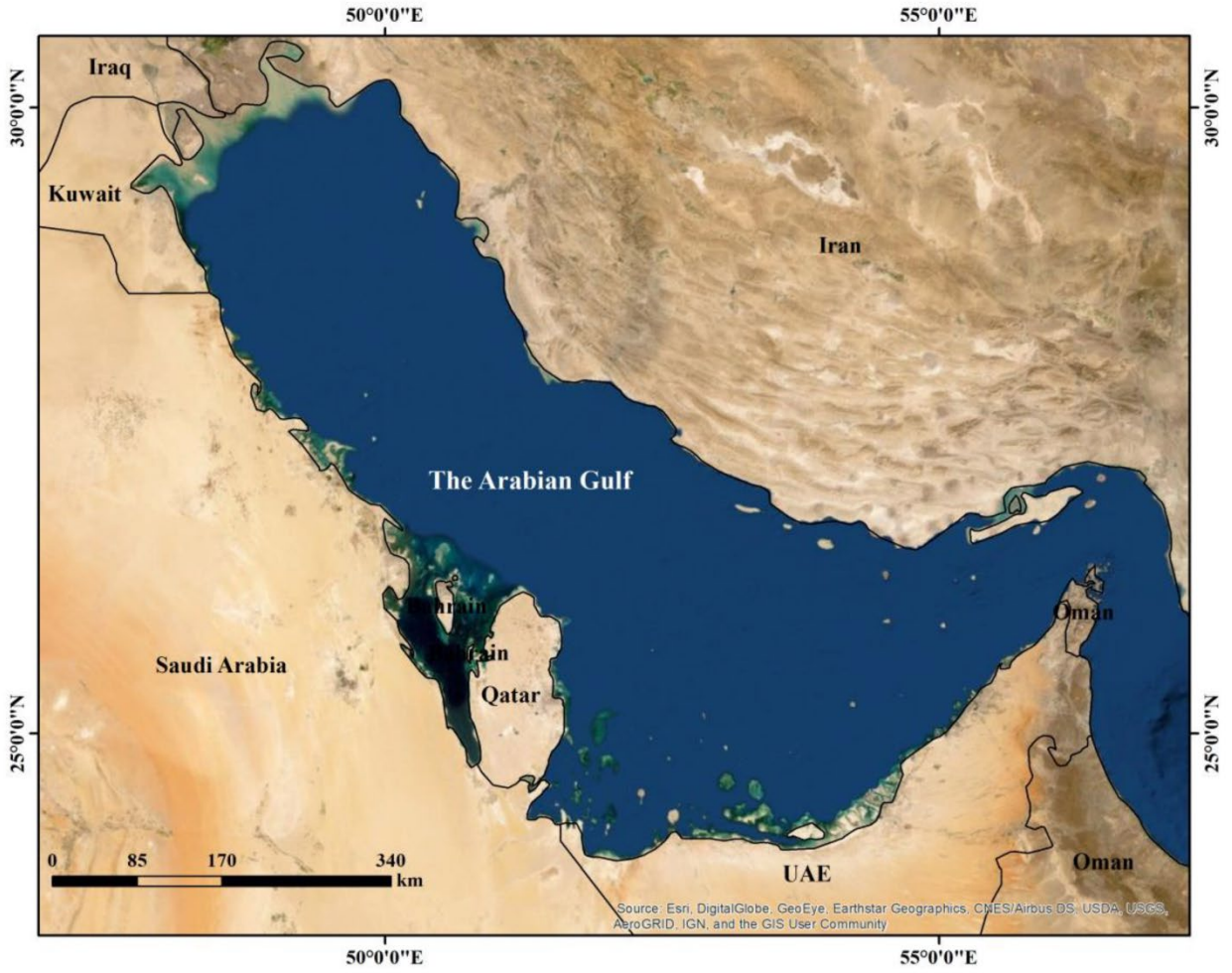
Additionally, an overview will lay out the standards and criteria used in waste management in the UAE. The standards that will be examined in the chapter include waste generation, waste transportation, waste treatment, and disposal. This chapter will further explain the role legal authorities have in ensuring adequate waste management practices in the UAE. Furthermore, the chapter will provide an overview of some of the most prominent policies and initiatives that have been adopted in the UAE for waste management system. Some of the initiatives and policies include converting waste into energy, converting wastes to compost, using smart garbage bins, and implementing comprehensive recycling programs. The policies and initiatives are responsible for ensuring that wastes are efficiently handled in a manner that is most beneficial to the environment. Finally, this chapter will conclude by providing a comprehensive analysis of similarities and differences between the waste management systems in the KSA and the UAE. The overview is crucial because it will highlight some of the practices and components that are effective in the waste handling systems in the two countries.

Background:

The KSA and the UAE are neighboring countries. They are both members of the Gulf Council Corporation and Arabic Council Countries.[174] Additionally, they share the same religion, traditions, language and history. In the political vein, they are both ruled by royal families. In an economical vein, they both rely on oil exports as a significant aspect of domestic revenue. Additionally, they are both considered developing countries. In the environmental vein, both countries share the same type of climate and soil.[175] Furthermore, they both have marine borders along the Arab Gulf (Picture1). Apart from these similarities, a comparative analysis of waste management systems in the two countries offers a methodological perspective from two similar yet different viewpoints; thus, offering a wider social perspective needed to trace and identify causal issues ailing the KSA's waste management system. Despite the impossibility of transferring outcomes from one legal system to another, this comparative analysis model identifies similar issues across the two countries from which recommendations on adjustments can be drawn to effectively help in the adjustment of waste management systems in the KSA.

[174]S.g.t.g.c.c. (2021). Member States Of Gulf Cooperation. Gulf Cooperation Council. Https://www.gcc-sg.org/en-us/aboutgcc/memberstates/pages/home.aspx

[175]I.M. (2020). Saudi Arabia vs. United Arab Emirates. Index Mundi. https://www.indexmundi.com/factbook/compare/saudi-arabia.united-arab-emirates



(Picture 1)[176]

Overview of the Volume of NSW at the UAE:

In 2010, the UAE launched a strategic objective of intensive waste management aimed at diverting more than 75% of waste from landfills by the end of 2021.[177] The goal of this overview is to analyze the volumes of non-hazardous waste produced in the UAE, since the development of this strategic objective – most specifically from 2012 to 2017. The volumes of waste generated in

[176]Mohamed Hereher , Assessment Of Climate Change Impacts On Sea Surface Temperatures And Sea Level Rise—the Arabian Gulf, Mdpi (Mar. 1, 2020), Https://www.mdpi.com/2225-1154/8/4/50/htm

[177]Mawed, M., Al Nuaimi, M. S., &kashawni, G. (2020). Construction And Demolition Waste Management In The UAEe: Application And Obstacles. International Journal, 18(70), 235-245.

this period are projected in the charts below and are composed of construction and demolition waste, agricultural waste, commercial and industrial waste, agricultural waste, municipal waste, and other waste compositions.

The volumes of construction and demolition waste in the UAE has fluctuated significantly over the years of focus, with the highest volume amount being recorded in 2012 (9,628,309 metric tons) and the lowest being recorded in 2015 (2,876,313 metric tons).[178] The UAE experienced a steady decrease in these volumes from 2012 to 2015 before the volumes shot up again in 2016. The steady decrease in volumes of construction and demolition waste between 2012 to 2015 can be attributed to waste reduction policies by the government aimed at conserving buildings that are already in existence rather than building new ones, adjusting the size of those being built, and considering adaptability of the buildings when constructing new ones to enable them to serve for a long time, the utilization of construction techniques that facilitate material reuse and disassembly, and encourage the employment of alternative framing designs and techniques.[179] There was a sharp increase in construction and demolition waste between 2015 (2,876,313 metric tons) to 2016 (4,532,379 metric tons). This can be attributed to growing urbanization and population in the country. According to the United Nations Population Division World Urbanization Prospects, the urbanization and population growth in the UAE increased significantly between 2015 to 2016 from 0.877% to 1.392%.[180] This can be the reason behind the increase in the construction and demolition waste over the two years since old building designs are being demolished and new buildings are

[178]Waste Statistics, "Statistics Center of Abu Dhabi, accessed July 11, 2019, https://www.scad.gov.ae/Release Documents/Waste Statistics_2018_Annual_Yearly_en_v1.pdf
[179]Abu-Dhabi Recycle Over 1,236,814 Tons Of Construction Waste, Alwattan, Https://alwatan.ae/?p=653325
[180]Urban Population Growth - United Emirates, THE WORLD BANK , https://data.worldbank.org/indicator/chart

being set up to cater to the increasing population.[181] This increase was then followed by a decrease between 2016 and 2017 (4,532,379 metric tons to 3,959,319 metric tons) which can be attributed to the C&D waste reduction measures already stated above coupled up with efforts of incorporating agreements that forbid excessive packaging and bringing of materials to places where construction is ongoing.

The industrial and commercial waste has experienced a gradual increase across the years, with the only decrease experienced between 2015 and 2016 – a decrease from 3,306,644 metric tons to 2,692,768 metric tons. Over the years, the UAE has been spearheading the embracement of new technology from autonomous vehicles to data analytics and artificial intelligence, offering organizations, especially startups, the opportunity to grow and innovate if on fertile grounds.[182] Additionally, the UAE's vast oil reserves together with its sovereign wealth funds have strategically positioned it as a center of commerce and industry in the Middle East[183]

Also, government initiatives such as revenue-generating measures and extensive economic restraints, such as, reforms on energy prices and subsidies, including prioritization of the expansion of revenues of non-oil tax and capital spending, has augmented the country's industrial and economic activities for years.[184] Ultimately, these activities have led to increased production of industrial and commercial waste as the charts depict.

The UAE has also experienced a fluctuation in agricultural waste over the years with the highest volume being realized in 2013 (999,239 metric tons) and the lowest volume being realized

[181]Construction Code, UNITED EMIRATES

[182]Mawed, M., Al Nuaimi, M. S., &Kashawni, G. (2020). Construction and demolition waste management in the UAE: Application and obstacles. *International Journal*, (237-240) *18*(70), 235-245.

[183]Ibid

[184]SmarhMahmood , United Emirates intends to diversify its revenues ,ALKLEEJ (Aug. 21, 2016), https://www.alkhaleej.ae

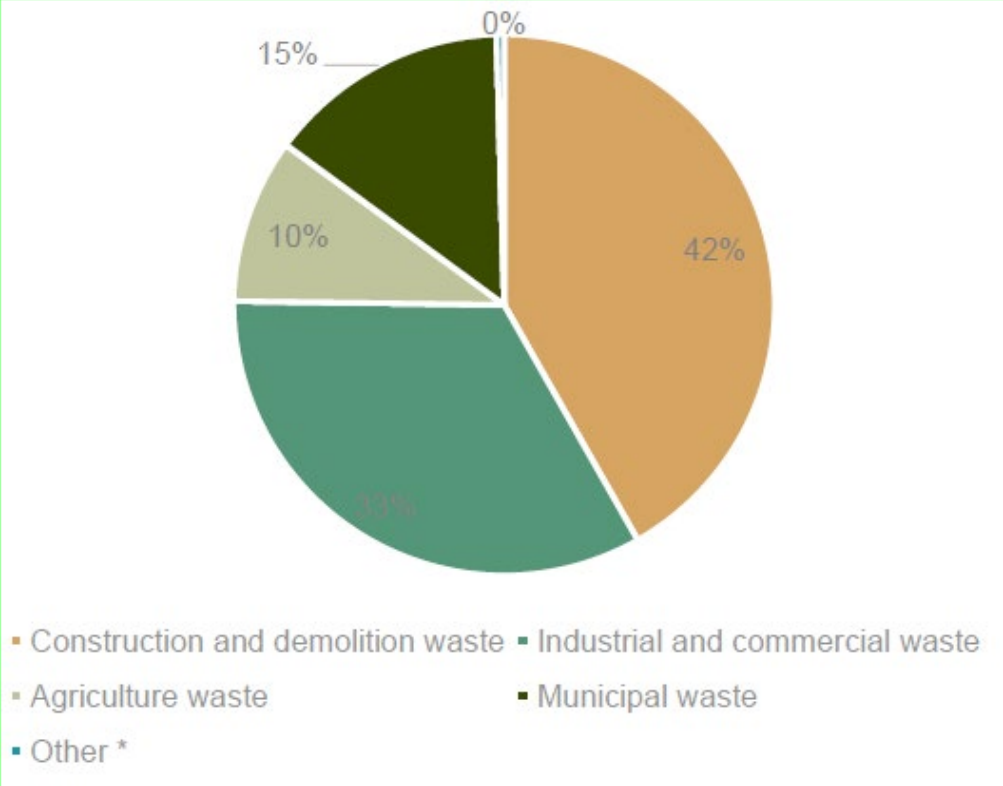
in 2015 (493,106 metric tons). However, it is important to note that the volumes of agricultural waste are generally low compared to the industrial and commercial waste; construction and demolition waste across the years of interest. This low volume in comparison to other wastes can be attributed to the fact that the UAE has an arid climate characterized by low rainfall, high temperature, poor soil, and lack of natural waterways providing minimal opportunities for agriculture and subsequent agricultural waste generation.[185] The municipal waste volumes in the country have also experienced periodic fluctuations over the years with the highest volume being recorded in 2015 (1,678,983 metric tons) and the lowest volume being recorded in 2012 (1,272,668 metric tons). The municipal waste in the UAE is generated from commercial, domestic, and construction activities by individuals and is collected and treated by various the UAE municipalities. It is important to note that the municipal waste volume in the country significantly reduced from 2015 to 2017 due to increased rates of municipal waste recycling and the incorporation of new technologies to improve waste separation and collection across major cities.[186]

[185]Arab Monetary Fund (), Https://www.amf.org.ae/en/arabic_economic_database

[186]Over 1200 Tons Of Waste Is Sorted Every Day At United Emirates. (2020, February 3). Albyan. Https://www.albayan.ae/across-the-uae/news-and-reports/2020-02-04-

(Tons)

Source	2012	2013	2014	2015	2016	2017
Total	**12,705,902**	**11,762,602**	**9,918,590**	**8,420,998**	**9,598,969**	**9,477,037**
Construction and demolition waste	**9,628,309**	**7,692,921**	**4,419,665**	**2,876,313**	**4,532,379**	**3,959,319**
C & D waste	5,721,367	2,767,342	1,723,497	2,042,883	2,580,913	2,589,660
C & D mixed waste	3,906,942	4,925,579	2,696,168	833,430	1,951,465	1,369,659
Industrial and commercial waste	**804,174**	**1,305,556**	**3,312,125**	**3,306,644**	**2,692,768**	**3,169,212**
Agriculture waste	**898,258**	**999,239**	**561,991**	**493,106**	**745,644**	**933,505**
General agriculture waste	305,749	339,078	320,689	380,465	503,001	567,992
Mixed agriculture and Animal waste	592,509	660,161	241,302	112,641	242,643	365,513
Municipal waste	**1,272,668**	**1,528,093**	**1,466,590**	**1,678,983**	**1,561,680**	**1,372,140**
Households, streets, and public gardens waste	1,059,219	1,234,336	1,298,955	1,420,323	1,397,292	1,194,208
Bulky waste	213,449	293,757	167,635	258,660	164,387	177,932
Other*	**102,493**	**236,793**	**158,219**	**65,952**	**66,499**	**42,861**



Source: (Waste, Statistics, 2019).

Conclusion

The decreasing volumes of construction and demolition waste in the UAE can be attributed to increased government regulations and the adoption of new construction measures. Moreover, the increase in industrial and commercial waste is attributed to the establishment of the UAE as Middle East's leading commercial and industrial country; hence, increasing commercial and industrial activities. The low volumes of agricultural waste can be due to the poor climatic condition in the UAE that does not support agriculture, while the fluctuation in municipal wastes can be attributed to changing municipal waste management approaches adopted by different cities.

4.1 Standards and Criteria Related to the Waste Management System at the UAE:

The UAE's non-hazardous waste law (NSWLU) was issued no2018, which is made up of 38 articles.[187] The different articles within the law set out the different waste generation guidelines (WGG), with article 5 of the law setting out the liability of the waste generators, supplies, and establishments.[188] Article 8 contains guidelines on disposal of waste, as well as waste generators obligations to sort their wastes before disposal.[189] Also, article 20 of the law provides guidelines on the transportation of waste with relevant entities tasked with the responsibility of transporting waste obligated to do so in line with the rules and conditions set by the implementing regulation of individual emirates.[190] Also, article 14 of the law provides

[187] United Emirates Nonhazardous Waste Law.2018
[188] United Emirates Nonhazardous Waste Law. Article 5. 2005
[189] United Emirates Nonhazardous Waste Law. Article 08. 2005
[190] United Emirates Nonhazardous Waste Law. Article 20. 2005

guidelines on various criteria related to construction and demolition waste with a competent authority tasked with the management of construction waste according to source separation standards.[191] Other articles include rehabilitation of unhealthy landfills (article 21), penalties (article 27), and waste recycling or reuse (article 7).[192]A detailed analysis of the standards and criteria the law sets for waste management in the UAE is provided in subsequent paragraphs

4.1.1 Standards and Criteria Related to Waste Generation at the UAE:

Instead of issuing detailed standards and criteria to regulate the behaviors of Waste Generation (WG) at NSWL, the UAE referred to Waste Generators Guidelines (WGG) as a reference to govern WG behaviors. Since modifying the law takes a whole set of steps and procedures, the UAE has chosen to list the standards and criteria separately under WGG, so they can be modified and updated easily. In particular, UAE is experiencing rapid urbanization increase, so addressing WG behaviors separately would help to keep the standards and criteria up with the rapid increase.[193] WGG standards and criteria touch on waste sorting and waste services fees.

First, WGG obligates WG to sort their waste before disposing of it in garbage bins, so they can be efficiently treated at the designated landfills. Therefore, the Ministry of Climate Change and Environmental Affairs (MCCEA) has obligated waste management services providers (WMSP) to supply all residential commercial areas with different types of garbage bins, so WG can fulfill their obligations based on WWG.

The garbage bins in the UAE are categorized into different types, so they can accommodate the different types of waste generated by WG. There are garbage bins to accommodate the cans,

[191] United Emirates Nonhazardous Waste Law. Article 14. 2005
[192] United Emirates Nonhazardous Waste Law. Article 21,27,07. 2005
[193]Minstery of Climate and Environment , Waste Generatrors Guidelines , (2013).

bottles, plastic, paper, and organic waste. Each type of waste is treated differently, once they reach the designated landfills. For example, once plastic waste reaches the designated landfill, recycling corporations are required to collect and treat it. Additionally, once organic waste reaches the designated landfills, waste management corporations such as Bee'ah Company are required to collect and treat it.

However, the volume of waste received at the designated landfills is beyond the capacity of the corporations. Therefore, in efforts to reduce the volumes of NSW, the UAE has imposed fees on NSW, with generators having to pay varying amounts depending on the volume generated. For instance, residential waste generators are required to pay a fee of 80 Dirham while the fee for industrial and commercial waste varies depending on the volume of waste and the waste management service provider.[194]

Second, the WGG have imposed specific standards and criteria to be followed by the commercial sector. First, business owners must supply their working places with appropriate garbage cans which can accommodate the type of waste they are generating. For example, offices are required to allocate garbage cans that can accommodate the papers disposed of by their employees. The reason behind this requirement is to sort the waste at the generation point, so the concerned bodies can treat the waste efficiently, once it reaches the landfills. Furthermore, the WGG require restaurants and coffee shops operators to monitor their garbage bins. This requirement aims to avoid the negative impacts that may occur, in case the garbage bins get full. For example, the garbage bins in Egypt are the places where cats and dogs gather to eat leftover food, which is often disposed of by restaurants and coffee shops. Not only that, they are also

[194]Waste Disposal Fees. (2018, March 17). Khleeg new. https://alkhaleejonline.net

places where bad smells circulate.[195]Additionally, WGG has obligated the restaurants and coffee shops operators (RCF) to contact charity organizations to collect leftovers. Otherwise, RCF will be subject to pay extra fees for the extra volume of waste disposed of at their garbage bins. This requirement aims at keeping the volume of waste generated out of RCF to the minimum level. Thus, WGG has set a whole set of requirements to mitigate the negative impacts that can result from improper use and management of RCF garbage bins.

Third, GGW has imposed standards and criteria related to construction companies. These standards and criteria aim at regulating the generation of demolition and construction waste. GGW has linked the validity of the license for the construction companies with the efficiency of managing the construction and demolition waste (CDW). To further illustrate, the volume of the CDW is monitored by the municipality branches. In case the concerned authority found that a construction company mismanaged their CDW, they would revoke its commercial license. Therefore, the construction companies in the UAE are wisely using the construction materials in their projects. Additionally, they send the CDW to recycle centers, so they can use them again in other projects. Thus, GGW aims at reducing the volume of demolition and construction waste as well as encouraging its reuse.[196]

4.1.2 Standards and Criteria Related to the Transportation of Waste in the UAE:

Waste transportation is the movement of waste over specific areas by tankers, trains, barges, trucks, or other means.[197] The process of transporting waste is pivotal to any waste

[195] United Nations Environment Programme. (2017, December 17). Bad smell is circulating Cairo , The capital of Egypt. UNEP. https://www.unep.org/ar/alakhbar-walqss/alqst/alrayht-alkryht-fy-mdynt-alqahrt

[196]Ibid

[197]Waste, Transportation of | Encyclopedia.com. (n.d.). Https://Encyclopedia.Com. https://www.encyclopedia.com/environment/educational-magazines/waste-transportation

management system since it ensures that waste is disposed of in proper locations and prevents illegal dumping.[198] Even more, effective transportation ensures that disposal is timely to avoid any nuisance conditions caused by the accumulation of waste. Moreover, an effective transportation system ensures safe movement of waste from generation to disposal point. Due to this importance, the UAE has given a lot of attention to the transportation of NSW. As such, UAE has not only limited waste transporters mission in collecting and transporting NSW, it has also made them responsible for second degree waste sorting.[199] Therefore, the standards and criteria related to waste transportation touches on the transportation and sorting of waste.

First, waste transporters are required to obtain a license from the municipality branch to practice the transportation of waste. To obtain a waste transportation license, prospective waste transporters must satisfy a series of requirements. Waste transporters need to first prove that they have enough skillful workforce to handle the waste transportation. Next, waste transporters need prove that they have equipped their trucks with the necessary tools to ensure the safety and efficiency of the waste transportation such as fire extinguishers.[200] Additionally, UNSWL requires that all trucks used in the transportation of waste must be equipped with GBS tracking system, so the municipality branches can track the transportation of waste, as well as prevent the improper dumping of waste.[201]

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[198] Hani, D. (2020, September 22). waste collecting and sorting at Dubai. Albyan. https://www.albayan.ae/across-the-uae/news-and-reports/2018-03-14-1.3210327

[199]Second degree waste sorting is" a process where waste transporters double check waste generators waste sorting. in case, waste generators did not sort their waste properly, waste transporters are required to file report against waste generators as well as sorting the waste properly before reaching the designated landfills.

[200] United Emirates Nonhazardous Waste Law,2005, Article07, page07, United Emirates

[201]United Emirates Nonhazardous Waste Law,2005, Article06, page73, United Emirates

Second, WGG has obligated waste transporters to launch sorting centers. These centers are responsible for double checking the sorting of waste conducted by waste generators. In case a sorting center finds waste that has not been sorted properly, they must follow certain procedures. First, they need to locate the address of the unsorted waste. Secondly, they need to fill out a report and submit it to the municipality branch, so they can issue a penalty against the waste generator.[202] Thus, besides transporting NSW, waste transporters are required to make sure that waste generators have sorted their waste properly.

4.1.3 Waste Disposal and Treatment in the UAE:

The UAE has various methods of waste treatment, which varies based on the available means to treat waste as well as the type of waste. The methods used to treat waste at the landfills includes: recycling, converting waste to compost, converting waste to energy, waste incineration, and land disposal at designated landfills.

With respect to treating waste through recycling, the Ministry of Climate Change and Environmental Affairs obligates municipality branches to create partnership with the private sector- not only to recycle the waste, but also to advertise and support the usage of the recycled products.[203] Organic waste, for example, is converted to compost and then delivered to farmers at very low cost, so farmers can rely on the recycled food waste and use it as a compost, instead of purchasing the compost from the markets.[204]

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[202]Nonhazardous Waste Law,2005, Article06, page73, United Emirates

[203]Dubai City. (2015). The Ministry Of Climate Change And Environmental Affairs Is Engaging With The Private Sector To Manage The Waste .albayan. Published. Https://www.albayan.ae/across-the-uae/news-and-reports/2015-10-05-1.2473803

[204]Rajab, H. (2020, November 25). Launching A Station To Convert Waste To Compost At The Capital City In United Emirates. Wam. Https://www.wam.ae/ar/details/1395302889882

Second, with respect to converting waste to energy, the UAE has taken many steps to diminish the quantity of the waste buried at the landfills. Therefore, the UAE has launched stations at the landfill locations, to convert a portion of the waste stream to energy. This has led the UAE to impose some restrictions on the types of waste converted to energy. The restrictions prevent the conversion of all types of wood waste, waste produced out of the oil industry, and animals' bodies into energy. The reason for these restrictions is to make the conversion of waste to energy more efficient and safer.[205]

Third, some waste that cannot be converted to energy or compost, such as wood waste, waste made from the oil industry, and animal bodies, is treated using a controlled burning method.[206] Under controlled burning, better known as incineration, waste is burned at extremely high temperatures (1800-2200 degrees Fahrenheit) in oxygenated combustion chambers.[207] When the waste reaches such high temperatures, it is completely combusted, leaving nothing but ash and gases behind.

Finally, any remaining waste is buried at landfills. This method is listed as the last method to treat waste in the UAE, in the event there is no other method to treat waste at the landfills.[208] In addition, the UAE has imposed particular standards and criteria for landfill disposal. First, the landfills' structure must meet certain requirements. The land must be

[205]Nsirat, A. (2007). Types Of Waste Cannot Be Recycled. Albyan. Published. Https://www.albayan.ae/across-the-uae/2007-06-23-1.774896

[206]Ministry Of Climate Change And Environmental Affairs. (2012). Unified Guidelines [e-book]. In For The Waste Management At United Emirates (P. 08).

[207]Gemma.alexander. (2022, January 24). How Waste Incineration Works. Earth911. Https://earth911.com/business-policy/how-incineration-works

[208]Aleynalekhbaria. (2021). Converting The Waste From Burden To Benefit. Https://al-ain.com/article/uae-innovative-initiatives-convert-waste-economic. Https://al-ain.com/article/uae-innovative-initiatives-convert-waste-economic

equipped with tools which separate the leachate of waste from the waste after burying the waste at the landfills. The leachate and gases resulting from the waste must be treated separately. For example, gases produced during waste decomposition are collected by flares and blowers or vacuums. In this system, gases are collected and directed to a central processing facility.[209] Landfill locations must be surrounded with trees to mitigate the negative environmental impacts that can be caused by treating the waste at the landfills. Landfills operators are required to provide their workers with courses and training in the waste management field. The courses and training aim at providing the workers with the most updated knowledge related to the waste management, so they can perform their work at the landfills efficiently. Last but not least, each landfill must have a reception center. The reason behind this requirement is to check the types and quantities of the waste received at the landfills.[210] Thus, the UAE has implemented various methods of waste treatment designed to effectively reduce waste volume; identify, sort, transport, and safely and efficiently dispose of different waste streams.

4.1.4 Legal Authorities Governing Waste Management in the UAE:

The UAE is one of the largest producers of waste per capita; the average person generates approximately 2.2 KG of NSW every day.[211] It also faces challenges in managing NSW as a result of the significantly high temperatures the region experiences throughout the year and limited landfill space. As a result, part of the UAE national agenda for 2021 is to achieve 75% treatment of its domestic NSW. To achieve this goal, the UAE has established collaboration with

[209]Recycling Economic Information (Rei) Report, Envtl. Protection Anancy
[210]Nonhazardous Waste Law,2005, Article09, page76, United Emirates
[211]Alessa, T. (2015). The Amount Of Waste Generated By The Arabic World. 7iber. Published. Https://www.albayan.ae/across-the-uae/2007-06-23-1.774896

the private sector for better effectiveness in waste management. In this section, we will explore the legal authorities in charge of the management of waste in the UAE.

Many municipalities spend a large amount of money on NSW management yet collecting and disposing of it still remains a problem. As a result, many governments opt to privatize waste collection.[212] However, the UAE government has fully privatized its waste management system. The region has established a holistic approach through a partnership between private corporations and the government for the management of NSW. Through this partnership, the private sector plays a key role in the monitoring and operation of the industry. The privatization of the system is based on specific reasons. First, the UAE governmental sector is suffering due to bureaucracy. The bureaucracy has led to delays in implementing waste management plans in the past and has also made decision-making slow, making the sector rigid to trends and new opportunities.[213] Another problem that necessitated the privatization of the sector was the limited capabilities of the UAE government to handle NSW effectively. This was further compounded by the region's weak education system which did not equip governmental employees with adequate knowledge in the environmental field.[214]

By privatizing the waste management sector, the UAE has significantly benefited from foreign experiences. The private sector conducts all operations and monitoring of the UAE waste management system. Essentially, the sector is independent in its efforts to manage waste. Alongside the distribution of garbage bins, waste collection, and waste treatment in landfills, the

[212]Benjamin Bolaane& Emmanuel Isaac, Privatization Of Solid Waste Collection Services: Lessons From Gaborone, 2014 Res.gate<2>
[213]Sinem Cengiz, Progress In The Middle East Held Hostage By Bureaucracy, 2020 Lse
[214]Alswafi, M. (2007). The Need To Reform The Educational System At United Emirates. United Emirates Center For The Research And Strategic Planning. Published.
Https://www.ecssr.ae/reports_analysis

private sector conducts development research. It identifies and implements the best waste management strategies based on trends. To achieve these goals, these corporations are managed by boards, which oversee operations without direct interference from the government. The only roles that the government plays in the sector are regulation and supervision.[215]Moreover, through the partnership, the UAE government is creating a suitable environment for the private companies in the industry to succeed. The government is not only licensing more private companies to enhance competition, but it is also attracting foreign investor companies through the formulation of favorable policies. Stiff competition has proven to have a direct impact on the quality of services in a sector and innovation.[216] For instance, in the Middle East, the UAE is the only country with corporations that recycle tires and paper through recycling.[217] The favorable business environment has also increased the number of waste management corporations in the region. Currently, the region has eighty-four private waste management companies.[218]

The privatization of the UAE's waste management system has significantly improved waste management needs in the country. Through the partnership between the private sector and the government, a favorable corporate environment has been created in the country for more corporations to join and operate in the waste management sector. As more corporations join the sector, competition has intensified leading to stiff competition that has a direct impact on the

[215]Hani, F. (2018). Public And Private Sector Have Signed An Agreement To Launch The Biggest Station To Convert Waste To Energy .albyan. Published. Https://www.albayan.ae/ /2018-01-30-1.3173690
[216]Municipal Affairs At Dubai. (2021). Dubai Has Come Up With A Collection Of Procedures To Boost The Sustainability. Albyan. Published. Https://www.albayan.ae/uae/news/2021-08-04-1.4220513
[217]Albyan, United Emirates has Expanded its RecyclingManufactory,2020, https://www.albayan.ae/across-the-uae/news-and-reports/2020-11-18-1
[218]Al Serkal, M. (2018, October 29). New Waste Management System Launched In Dubai. Gulf News. Published. Https://gulfnews.com/uae/environment/new-waste-management-system-launched-in-dubai-1.1207168

quality of services in a sector and innovation. Through the partnership, the UAE is closer to achieving its national agenda for 2021; to achieve 75% treatment of its domestic NSW.

4.2 Initiatives and Policies Adopted in the Waste Management Field:

In a bid to realize its waste management agenda and objectives of implementing a sustainable and a competitive waste management system, the UAE through partnership with the private sector has adopted plenty of strategic policies and initiatives to develop its waste management system.[219] Subsequently, the most prominent policies and initiatives are waste to energy technology, converting waste to combusting, smart garbage bins, and recycling programs.

4.2.1 Waste to Energy Technology (WET):

Waste to Energy Technology (WET) is a technology that has proven its benefits to the UAE cities. The technology manages to clear waste material and wastewater using water treatment procedures under the guidance of professionals. Technology has also managed to prove its effectiveness by producing reliable energy from the treatment of wastage.

Among the Gulf Corporation Countries (GCC), the UAE is considered the first country to use WET in waste treatment. In the UAE's major cities, the ministry of climate change and environmental affairs, MCCEA, has started building facilities to recover energy from waste.[220] Built on 100,000 square meters, the Abu Dhabi facility is considered the largest plant in the

[219]United Emirates Initiatives To Convert The Waste From A Burden To An Economical Source. (2021, April .Albyan. Https://www.albayan.ae/economy/uae/2021-04-04-1.4132374

[220]Bloomberg, United Emirates Has Successfully Built The Biggest Station To Generate Energy Out Of Waste, 2021, July 29). Al-khlige News. Published. Https://www.alkhaleej.ae/2021-07-29/

UAE. This facility generates up to 100 MW.[221] The second-largest facility in the country is the Dubai facility, which recovers the energy from the waste. The facility was established in the second quarter of 2020 and is built on 7-5 hectares. The Dubai facility aims at treating approximately 2,000 tons of waste daily, and it generates 60MW of energy. Sharjah facility is the third-largest plant in the UAE that recovers energy from waste. The plan was established in 2007 and is built on 8,500 square meters. Additionally, the plant functions to recover energy to manufacture the compost of waste.[222]

WET aims at burning NSW at 2500 degrees- a temperature that assists in reducing the size of the waste by 90 percent. Nevertheless, the treatment of waste through WET involves different steps. The process starts with garbage trucks dumping the waste into the tipping hill. The waste is picked up using cranes and then deposited into combustion chambers. It is at this facility where the burning of waste generates heat, which then turns into the water in the boiler. The heat in the boiler converts the water into steam which forces a turbine to spin and produce electricity.[223]

In conclusion, the treatment of waste through WET technology can assist in the production of electricity and reduce waste. In addition, the UAE will be able to substantially reduce the amount of waste reaching landfills, ultimately curbing the release of greenhouse gases. Moreover, due to its use of pollution control equipment, this process is environmentally friendly and sustainable.

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[221]The Ministry Of Climate Change And Environmental Affairs. (2017). Convert Waste To Energy. Https://u.ae/ar-ae/information-and-services/environment-and-energy/water-and-energy/types-of-energy-sources/waste-to-energy-

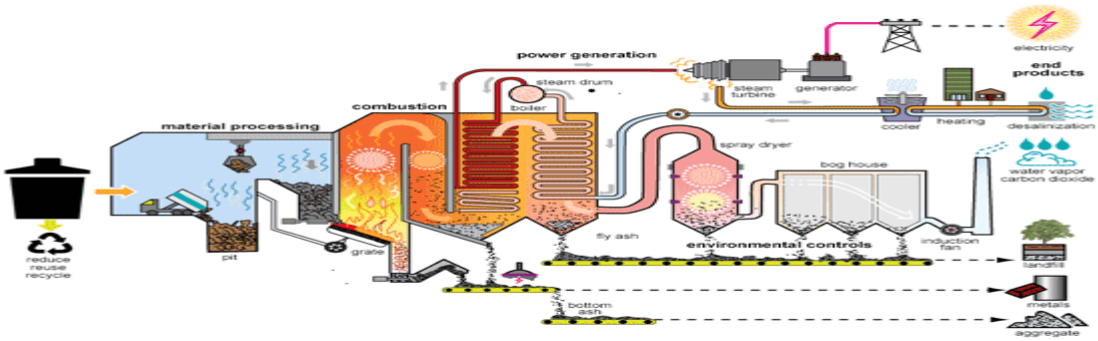
[222]Ibid

[223]Waste to Energy Facility, SPOKANECITY , https://my.spokanecity.org/solidwaste/waste-to-energy/

Waste to Energy Station at UAE[224]

Private sector announces the establishment of largest waste to energy facility in Middle East [225].

[224]Launching A Facility To Convert Waste To Energy. (2019, June 2). Almostaqbal. Https://mostaqbal.ae.
[225]Hani, F. (2020, September 23). Biggest Facility To Recover The Energy Out Of The Waste. Albyan. Https://www.albayan.ae/across-the-uae/news-and-reports/2018-01-30-1.3173690



Mechanism of waste to energy technology[226]

4.2.2 Converting Waste to Composting:

Composting converts organic wastes into compost. Most organic wastes emanate from households and comprise a significant percentage of every country's total waste.

Composting is a natural process used to decompose and recycle organic material into compost, which can be used to increase the soil's humus content. The various materials that can be composted include fruits, vegetables, eggshells, grains, coffee filters, unbleached paper napkins, as well as other types of organic wastes.[227]

In the UAE, there are three significant plants used to decompose wastes and attain compost. Annually, compost is produced by the three plants is 70,000, thus significantly reducing organic wastes while improving the soil's humus content. The three plants play a crucial role in improving the environment; commercial and agricultural level through their contribution to improved soil fertility. Environmentally, the compost that comes out of the process helps improve soil fertility, reducing the need for using artificial fertilizers and chemicals to improve

[226]How Waste-To-Energy Plants Work,, USA ENERGY INFORMATION ADMINISTRATION, https://www.eia.gov/energyexplained/biomass/waste-to-energy-in-depth.php (Nov. 22, 2021)
[227]Mark Risse& Britt Faucette, FOOD WASTE COMPOSTING: Institutional and Industrial Applications, U. GA. <1-3>.

the soil's productivity. This is in addition to the role that the plants have played in the reduction of waste volumes received at various landfills across the country.[228]

The plants have proven to be sustainable because they have contributed to meeting the needs of local businesses and have reduced the need for the UAE to import chemical compost. They have also been pivotal in improving the UAE food security because farmers no longer have to import chemical compost to meet their agricultural requirements. Inadvertently, making the plants beneficial to the UAE on an environmental, commercial, and agricultural levels, which makes this type of waste handling ideal for dealing with organic wastes within the country and beyond.[229]

In conclusion, composting is an efficient way of handling organic wastes because it benefits the environment and improves individuals' economic well-being. The compost that results from the process plays a vital role in improving soil fertility, protecting the environment from the adverse effects of chemical compost, and improving the economy. Considering these benefits of composting, the UAE supports and encourages the adoption of composting through imposing customs on the importation of compost, a move that is aimed at encouraging local farmers to purchase the local compost made of waste in the UAE since it is affordable. This also creates a market for locally made compost; hence, creating a financial incentive for people to adopt composting.[230]

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[228]Icba. (2017). Converting Waste To Compost In The United Emirates. Agriculture For Tomorrow. Published. Https://www.biosaline.org/ar/news/2017-06-11-6174

[229]Abu-dhabi Factory For Compost. (2014). Selling The Compost Produced Out Of Waste At Low Prices For Local Farmers. Alethd. Published. Https://www.alittihad.ae/article.

[230]Ali, A. (2020, January 14). United Emirates Succeed In Producing High Quality Combust. Wam.ae. Https://wam.ae/ar/details/1395302816035

4.2.3 Smart Garbage Bins:

For effective waste management, there is a need to ensure that recyclable and non-recyclable wastes are separated. This section examines the design of smart garbage bins and their effectiveness in waste management. The section highlights how the UAE is adopting the use of smart garbage bins in its major cities and some of the perceived benefits it will have on the country.

The use of smart garbage bins is one of the latest technologies used in the field of waste management. The smart garbage bins utilize sensors that send alerts to the waste collection center once filled with garbage. This makes it easy for the waste collection centers to collect the garbage immediately to avoid overflow of wastes into the immediate environment.[231]The smart garbage bins have two compartments, each playing a unique role in managing the disposed wastes. One of the compartments is specially designed to receive and handle recyclable wastes, while the other compartment receives all non-hazardous wastes that cannot be recycled.

In 2019, the Ministry of Climate Change and Environmental Affairs (MOCCE) announced strategic plans aimed at replacing regular garbage bins with smart garbage bins to ensure that wastes are handled more efficiently. According to the strategic plan, the country will supply the major cities with 200 smart garbage bins quarterly to ensure that all major cities have access to smart garbage bins. According to the Ministry of Environmental and Climate Affairs, the plan is expected to reduce the amount of wastes that end up in landfills by at least 75%. This is attributed to the role the plan will play in increasing the amount of wastes that get recycled in the country. Therefore, the smart garbage bins have many beneficial impacts on the

[231] Waste collection centers are ‘’the concerned authority which oversights the operations related to waste transportation’’.

environmental wellbeing of the UAE and significantly contribute to the attainment of the country's goals for sustainable waste management.[232] Thus, the use of smart garbage bins will provide many benefits to the UAE by ensuring that wastes are handled more sustainably and in a way that contributes to the attainment of desired environmental conditions.

In conclusion, smart garbage bins have compartments that separate recyclable wastes from those that cannot be recycled, making it easier for waste to be handled more sustainably. The UAE's strategic plan to increase the use of smart garbage bins in its major cities will significantly reduce waste that ends up in landfills by increasing recycling.

Smart garbage bins in UAE

Adoption of Recycling Programs:

The UAE has struggled with waste for a long time, and they have strived to set up recycling schemes that will help them treat almost all types of waste collected.[233]

[232]Naem, W. (2019). 230 Smart Garbage Bins In Dubai. Albyan Environmental News. Published. Https://www.albayan.ae/across-the-uae/news-and-reports/2019-10-01-1.3662831

[233]Aljesmi, A. (2007, August 25). lack of landfills Spaces at Dubai is a Source of Threat. Albayan Environmental News. https://www.albayan.ae/across-the-uae/2007-08-25-1.783715

Recycling is described as the procedure of changing waste products into new products and materials. Recycling procedures stand out as the most popular technique to handle waste because of the benefits achieved from the programs.[234] One of the benefits is it lowers environmental contamination as recycling halts the generation of new products. For example, recycling metallic containers protects the environment in various ways. For one, it aids in lowering the generation of new metallic containers by discouraging people from discarding metallic in landfills. Second, recycling schemes safeguard the environment. Each year hundreds of trees are used in paper manufacturing. Therefore, paper recycling is a great initiative to protect trees and keep forests at equilibrium. Third, recycling schemes help in reducing the effects of climate change since tending to the trash at the waste grounds emits dangerous gases such as carbon dioxide and methane. Fourth, recycling conserves raw materials and natural resources; reduces the amount of NSW that must be disposed of at landfills, thus, conserving landfill space, which minimizes greenhouse gas emissions during waste composition. It also has many economic benefits and is efficient. For example, rather than plastics being disposed of in landfills, recycling allows these plastics to be melted down and remodeled into fresh packaging materials. This provides companies with a convenient and sustainable way to acquire packaging material rather than remaking them from scratch - a process that consumes new resources and raw materials.[235] Fifth, the recycling schemes can reduce the number of waste grounds since the amount of trash being deposited at the waste grounds is reduced due to the effective

[234]Adel, A. (2020, December 30). What Is Recycling And How Can Properly Implemented. Arabianic. Https://www.arabiainc.com/2020/10/30/

[235]Zafar, S. (2020, July 1). Recycling Benefits. Ecomena. Https://www.ecomena.org/recycling-ar/

implementation of recycling schemes. Sixth, the recycling schemes create employment since the implementation of the entire process requires labor to gather and recycle the waste material.[236]

The UAE has heavily invested in growing recycling schemes. Its government has developed several types of recycling facilities to handle various types of waste. First, the UAE launched the MRF facility to recycle waste generated out of residential areas. It is termed one of the biggest recycling facilities in the Middle East, as it can recycle over 600,000 tons of waste. Second, the UAE has built a construction and demolition facility to recycle all kinds of waste from construction sites making it the first of its kind in the Middle East. It can recycle 500,000 tons of construction litter and makes it applicable in the construction profession. Third, the UAE has launched the TRF facility to recycle tires. This facility can recycle up to 3 million tires annually and generate usable rubber out of the treated tires. There are various means of using the rubber. The rubber generated out of the treated tires can be used in the construction of sports courts and can also be used in generating artificial turf. The MRC's fourth project is the recycling of metal and iron waste. MRC is fitted with modern tools for cutting old vehicles and scraps, which is then cut and made applicable in the industrial field. Thus, the UAE has a wide range of recycling schemes and facilities that can treat various kinds of waste.[237]

In conclusion, recycling is a new concept in the UAE which helps to maintain a cleaner environment while protecting natural resources. Recycling has also helped to save on huge costs that are used in the production of new materials. The UAE has taken the recycling concept to a whole new level where they have set up many recycling schemes and facilities that can recycle various types of waste including residential, construction, metal and iron waste. As mentioned

[236]Lotfy, S. (2021, August 2). Benefits Can Be Obtained From Recycling. Edarabia News. Https://www.edarabia.com/ar/4

[237]Social Affairs. (2020). Bee'ah For Recycling Services. Bee'ah. Https://beeah.ae/ar/beeah-tadweer

previously, in 2019, MOCCE announced strategic plans aimed at replacing regular garbage bins with smart garbage bins to ensure that wastes are handled more efficiently. These are just some of the policies used by the country to facilitate effective waste management.

4.3 Comparison Analysis Between the UAE and the KSA:

This section compares approaches to waste management in the UAE and the KSA with consideration to different dimensions. Previous sections of the paper provide an overview of existing laws and regulations on the management of non-hazardous waste in the KSA including GULM, NSWL, Royal decrees, and Sharia laws. On the other hand, a comprehensive overview of waste management in the UAE is also provided including the NSWLU, its standards, and initiatives adopted in the waste management field. Therefore, this section of comparative analysis not only provides valuable information about each issue but also underlines how the KSA can adjust and improve its waste management approach by borrowing a leaf from the UAE.

In terms of similarities, first, both countries have similar waste profiles, waste generation dynamics, and waste generation challenges as well as similar political, social, geographic, and economic contexts that provide the backdrop for the development and implementation of waste management approaches. Additionally, the two countries are facing a rapid increase in population and urbanization. This increase in urbanization and population can be attributed to the sharp increase in national births, improved health services, and a continuous influx of expatriates profiting from the expanding entrepreneurial opportunities in the two countries. Second, they are both considered developing countries. Over the past two decades, the two countries have recorded sustainable growth in the fields of trade, economy, communications and investment, tourism, technology, infrastructure, and social development.[229] They have also demonstrated impressive

growth in gender equality and the economic and political empowerment of women.[229] Third, both countries largely rely on oil export. Energy and oil are certainly a very significant sector of the world. As a mainstay to the economy, oil and petroleum exports account for close to 30% of the total gross domestic product in the UAE and 50% in the KSA.[238] Fourth and last, both countries play a leading role in the Middle East. With developed and steady economies together with stable leadership, the two countries act as important economic, social, and political centers in the Middle East.[239] Thus, these similarities, coupled with the cultural and social synchrony existing between the two countries, illustrate that they can learn and benefit from each other's waste management system.

While the UAE and the KSA have certain similarities in their approaches to waste management, the two countries also have significant differences as well. These differences range from the division of authority and responsibility between the private sector and the government when it comes to waste management; the strategies associated with the sorting of waste; the standards and criteria that guide the evaluation of waste transporters; the disposal of waste in water bodies; the sources of funds; the incorporation of technology in waste management systems; the adoption of recycling; the waste treatment approaches; and guidelines associated with fees chargeable to waste generators. These significant differences are discussed in greater details in the subsequent paragraphs

In terms of differences, first, the waste management system in KSA is operated by the private sector and monitored by the public sector. Under the NSWL in the KSA, the government

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[238]OPEC (2021), https://www.opec.org/opec_web/en/about_us/169.htm

[239]Hani Findakly, Defusing Saudi Arabia-UAE Tensions Through Economic Rebalancing, Atlantic Council (Sept. 13, 2021), Https://www.atlanticcouncil.org/blogs/menasource/defusing-saudi-arabia-uae-tensions-through-economic-rebalancing/

is mandated with the responsibility of regulating and supervising waste management systems throughout the country. Through its ministry of municipality and rural affairs, the KSA government hires and supervises contractors to run waste management affairs throughout the country. In contrast, the waste management system in the UAE is operated and monitored by the private sector with the government only acting as a watchdog.[240] In the UAE, the central government issues all regulations regarding waste management. Moreover, it has devolved its responsibility to municipality branches, giving them the mandate to oversee waste management services conducted by private players across the UAE.[241] Moreover, the UAE has all its waste management activities funded by the individuals and corporations that benefit from the waste management services.[242]Since these private players benefit from waste management schemes, they are agile enough and have the financial capability to address any waste management issues that may arise on a real-time basis. For example, waste management corporations are entitled to charge waste generators with monthly fees as an exchange to collect and transport their waste to the designated landfills. These fees are subject to be increased, based on the volume of waste disposed of by waste generators.

Second, the waste management system in the KSA has not incorporated sorting of waste before disposal in its strategies.[243] This means that hazardous and non-hazardous wastes are

[240]Golf News. (2021, September 3). An Oversight Center To Oversight The Waste Management Activities At United Emirates. Golf News. Https://www.alkhaleej.ae/2021-09-04/

[241]Integrated Waste Management In UAE, National Committee On Sustainable Development Goals (), Https://integrated-waste-management-fcsa.hub.arcgis.com//

[242]Daker Elrabay'a& Valentina Marchenko, Identifying the Full Cost to Landfill Municipal Solid Waste by Incorporating Emissions Impact and Land Development Lost Opportunity: Case Study, Sharjah-UAE, 2021 RES.GATE <33-37>l

[243]Labib, O., Manaf, L., Hamzah Sharaai, A., & Mohamad Zaid, S. S. (2021). Moderating Effects on Residents' Willingness in Waste Sorting to Improve Waste Handling in Dammam City, Saudi Arabia. *Recycling*, *6*(2), 24

disposed of together. For example, organic waste along with plastic, construction, health, and electronic waste is disposed of in the same garbage bins. While the country has NSWL, and ESR, each of these laws regulates a given activity that touches on the collection, transportation, treatment and disposal of waste materials within or outside the territory of the KSA but does not incorporate sorting strategies that must be adhered to. In contrast, the UAE waste management system has incorporated sorting strategies where waste is sorted before being disposed of. For example, the UAE authority mandates waste management corporations to supply residential and commercial areas with different types of garbage bins. This allows for easy sorting of waste at the generation point.[244]

Third, although the KSA's waste management system has set up certain criteria and standards for waste transporters during the process of moving waste, it has not addressed the improper disposal of waste by the transporters. For this reason, transported waste ends up polluting the environment and causing health effects on the community around the disposal areas.[245]

In contrast, the UAE has mandated waste transporters to equip their trucks with a GPS system which enables the concerned authorities to detect and track cases of improper waste disposal. This makes it easier to locate and punish irresponsible transporters.

Fourth, the waste management system in the KSA has given a blind eye to the illegal disposal of waste in the ocean. This has increased the levels of ocean water pollution, subsequently affecting marine life. With a poor waste disposal strategy, most of the waste disposed of at landfills end up carried downstream to water bodies including the red sea and the

[244]United News. (2021, June 11). Sorting Waste From The Point Of Generation. Https://www.alittihad.ae/news

[245]Eiman, M. (2021, March 10). Waste Transporters' Workers Are Improperly Disposing Of Their Waste In Residential Areas. Almarsad News. Https://al-marsd.com/

Arabian Gulf.[246]In contrast, the UAE waste management system has placed the responsibility of monitoring the illegal dumping of waste in the ocean on the Marine Security Forces. The Marine Security Forces also monitors the disposal of hydrocarbons and heavy metals into marine environments.[247]

Fifth, the waste system in the KSA is managed using an outdated method without the incorporation of technology. For example, the incineration of waste in the KSA is conducted through the open burning method. Also, most of the waste in the KSA ends up buried in landfills without any recycling and reuse frameworks in place. While in the UAE, there are environmental research centers that have been created to research the modernization of waste management using technology. For instance, the UAE utilizes smart garbage bins to facilitate the sorting of waste at the generation point within its major cities.

Sixth, the KSA's waste management system suffers from the absence of recycling programs. While most of the hazardous waste and non-hazardous waste in landfills across the KSA can be recycled, very minimal effort has been put in by the authorities to facilitate the recycling of these wastes. Recycling is yet at its initial stage in the KSA even though attention over the issue is increasing globally. In contrast, the UAE's waste management system has comprehensive recycling programs which facilitate the recycling of different waste types. Hence, apart from reducing the amount of waste dumped in the landfills, these programs also make waste beneficial.

[246]Al Jazeera. (2016, April 20). Scholars Have Warned The High Level Of Pollution In Gulf Canal As Well As The Red Sea. Al-jazzira News. Https://www.aljazeera.net/news/reports.
[247]Albayan, D. (2021, November 24). Dubai Police Department offers a Diploma in Marine Life Protection. Albyan News. https://www.albayan.ae/uae/news/2021-11-24-1.4306654

In fact, the UAE is constantly looking for ways to embrace key initiatives and projects that will impact waste management in a positive way.[248]

Seventh, is the treatment of waste in the KSA which is limited to burying and incinerating. In contrast, the waste management system in the UAE has many more methods of treating and handling waste such as converting waste to energy, recycling programs, and converting the waste to compost. All these methods provide environmentally friendly alternatives to handling waste.

Eighth, the KSA does not charge additional fees to individuals and corporations for waste management. As a result, the absence of fees has lowered their sense of responsibility when it comes to managing their waste. On the contrary, the UAE, corporations and individuals pay for the waste management services offered by the private sector. An extra fee is also charged on those who exceed the permissible volume of waste. This creates a sense of responsibility among the people and corporations when it comes to waste management.

Thus, while the two countries have certain features in common, the UAE has a more developed waste management system with better performance in handling waste. As the KSA seeks to improve its waste management, innovations in the UAE provide an example of feasible legal, policy and technological approaches.

[248]Musabah, A. (2018, March 23). 6 Stations for Recycling Various Types of Waste at United Emirates. United Emirates News. https://www.emaratalyoum.com/local-section/other/2018-04-23-1.1092382

5.0 Chapter 5: Conclusion and Recommendations:

5.1 Conclusion

In conclusion, the waste management system in the KSA is in urgent need of re-examination and reform. Even though the KSA is assiduously working on several projects to enhance waste management across its cities, it still operates an inefficient and outdated waste management system that lacks the incorporation of modern technology. Moreover, the existing regulations and laws have proven to be ineffective when it comes to handling the current challenging field of waste management. Nearly 29 million people reside in the KSA, and more than 76% of this population residing in the urban areas, the KSA needs to revise its waste management regulations and laws since the existing ones have proved inadequate in handling inappropriate waste disposal trends such as the dumping of waste in the seas and the deserts. Furthermore, the need to review the existing regulations is necessary to help identify specific corporate and individual responsibilities when it comes to waste management, which has not been addressed in the current regulations. Apart from a review of the existing regulations and laws, the KSA can benchmark from its neighbor- the UAE, which has one of the most advanced and integrated waste management systems in the Middle East. The UAE is also similar to the KSA when it comes to culture, language, soil, political system, and climate, making it the most suitable candidate to benchmark from. The United Nations Sustainable Development Goals (UNSDGs) specifically emphasize that the lack of an effective waste management system is a twin threat because of increased global warming and loss of resources. Inspired by this, the UAE has incorporated technology in its waste management system to better manage NSW. Moreover, the UAE is continuously seeking to adopt vital projects and initiatives that positively impact the

management of waste. Initiatives and policies such as the conversion of waste to resources and energy, the use of smart garbage bins, new technologies, and improved waste collection and separation systems have helped the UAE not only reduce its waste volumes but also control the movement and treatment of hazardous waste. Due to economic activities and population growth, the waste quantities in the UAE have significantly increased over the last decade. However, the country has been able to effectively manage this waste through a well-coordinated legal system that has set detailed regulations of individual behaviors, roles, and responsibilities when it comes to the handling and disposal of waste. For a long time, waste generation and management in the Middle East has been seen as simply worthless waste. Increasingly, however, through the frameworks of the circular economy, it has become clear to entrepreneurial companies and governments alike that there is value in waste. Not only are there huge reductions in CO2 emissions and operational cost savings to be realized from the implementation of an improved waste management system, but there are also commercial opportunities in waste management. Recent advancements in technology around recycling and managing waste, combined with the lucrative opportunities linked to certain streams of waste have made the UAE privatize its waste management sector. With private sector players more agile and better positioned than the state to quickly operate and construct advanced facilities of waste management, the UAE has been able to effectively manage waste. Considering all these initiatives and policies adopted by the UAE together with its detailed legal system and the associated success in waste management, the KSA can borrow and develop a better framework for managing its NSW.

5.2 Recommendation for Strengthening the KSA Management of NSW Informed by a Comparative Assessment of NSW in the UAE:

The following recommendations are made based on the comparative assessment presented in this research:

5.2.1 Reducing the Volume of Organic Waste:

Since the volume of organic waste is higher than the average global rate, the KSA should focus on reducing the volume of organic waste. There are several ways to reduce the volume of organic waste. First, imposing fees on major organic waste generators such as restaurants and hotels. These fees can be implemented to incentivize these major organic waste generators to reduce the volumes of organic waste. Second, converting organic waste to compost can also serve to reduce the amount of organic waste. Composting is a simpler process that can be used to treat large volumes of organic waste in cities with better land access. Additionally, the KSA can also invest in treatment technology. One of the most common mechanisms of processing organic waste through technology is anaerobic digestion, which involves organic waste being broken down into biogas for biofertilizer in a sealed, oxygen-free chamber.[249] Thus, while these initiatives will help reduce the volume of organic waste in the KSA, some of them present an opportunity for the waste to be useful.

[249]M.w.Sadik&H.m. El Shae, Recycling Of Agriculture And Animal Farm Wastes Into Compost Using Compost Activator In Saudi Arabia, 2010 Envtl. Application & Sci. <397-401>

5.2.2 Imposing Standards and Criteria Aim at Reducing the Volume of Plastic Waste:

Our daily lives have become increasingly reliant on plastic. It exists almost everywhere. cosmetic ingredients, product packaging, mobile phones, textiles, etc. Its widespread presence may make it difficult for some to give it up.[250] Therefore, the threat posed by plastics to the environment calls for significant reduction in its use considering its non-biodegradable nature.

However, the KSA should enact strict laws that require plastic manufacturers to accept responsibility for their waste and halt the construction of new plastic-making facilities in order to promote plastic alternatives. Furthermore, the KSA can impose high taxes on plastic imports and exports and charge less taxes on alternatives such as wood, cotton, and paper to encourage the move away from plastics. Additionally, the KSA should adopt policies that help to decrease the use of unnecessary single-use plastics such as plastic straws and disposable plastic cutlery. Moreover, the KSA needs to adopt policies that support the re-use of existing plastics. Encouraging enterprises that are working towards providing plastic alternatives is also another viable solution.

In summary, despite the widespread use of plastic waste, the KSA can mitigate them through adopting effective policies. The policies include imposing restrictions on the manufacturer of plastic materials, imposing taxes on the importation and exportation of plastic materials, imposing policies that contribute to decreasing the unnecessary single-use plastics, and imposing policies that support the reuse of existing plastics.

[250]Javeriya Siddiqui & Govind Pandey, A Review Of Plastic Waste Management Strategies, 2013 Int'l Res. J. Env't Sci.<84-86>

5.2.3 Encouraging the Privatization in the Waste Management Industry:

With more than 15 million tons of NSW generated annually, the KSA has one of the leading per capita rubbish creation rates globally and currently only recycles close to 10% of the generated waste.[251]Modern technology around waste management and recycling, as well as the financial benefits associated with waste management, has led to a growing trend of private companies to get involved with waste management.[252] In most cases, the private sector is more flexible than the public sector, which allows them to build and operate advanced waste management facilities more quickly. Keeping this in mind, the privatization of NSW management activities seems to be a suitable solution for some of the challenges of NSW management experienced by the KSA. In contrast to the public sector, the private sector is more efficient and effective in delivering services.[253]

Although the privatization of NSW management seems to be the solution to the waste management challenges in the KSA, this approach has its shortcomings which need to be addressed and considered. First and foremost, privatization could lead to increased corruption.[254]For example, nepotism in contract offers often occurs in private organizations where formal laws aren't enforced properly.[255] As a result, the competitive environment is likely to be negatively affected in the KSA, especially medium and small-sized enterprises. With the privatization of NSW management, the KSA will also be exposed to monopolistic risk,

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[251]Nizami, A. (2019, December 15). Recycling In Saudi Arabia. Ecomena. Https://www.ecomena.org/recycling-saudi-arabia-ar/

[252]R. (2021, April 23). Recycling Companies Initiatives. Bayut.sa. Https://www.bayut.sa.

[253]Shaker, M. (2010). The Environmental Impacts Resulted Out Of Privatization, (151-156).

[254]Jack M. Beerman, Privatization And Political Accountability, 28 Fordham Urban L.j.<1522-1524> (2001)

[255]Ahmad Aqeel, Privatization Is the Last Option, LUSAIL (Jan. 26, 2020), https://lusailnews.net/knowledgegate/opinion/26/07/2020/%D8%A7%.

especially in areas where city governments lack the regulatory capacity to manage competition.[256]Although the impacts of privatization are not always positive, the move is likely to increase competition, efficiency, service quality, and employment within the waste management sector of the KSA, hence, a move that needs to be adopted.

Additionally, municipal budgets can also save significantly on waste management when waste management is privatized. Competitor-driven NSW services help cut costs since private companies can spread investment, procurement, and environmental protection costs across multiple sites. Furthermore, privatizing waste management significantly lowers financial risks since the private sector has greater capabilities and experience when it comes to managing and assuming risks in an unstable market. Privatizing waste management can also make quick decisions since they are not hindered by governmental bureaucracies.[257] By borrowing a leaf from the UAE, the KSA can adopt a contract privatization model where the government contracts private companies to take care of the NSW management in the country through a competitive process to determine the best option. In the UAE, privatization is seen as a vital engine for infrastructure streamlining and wealth distribution. Therefore, the national and emirate waste management committees prepare request for proposals (RFP) for waste management projects and call upon all interested investors to express their interest in writing before a competitive pre-qualification process.[258] By doing so, the country has been able to partner with the best players in the private sector in its waste management initiatives ultimately guaranteeing its maximum

[256]Abduallh Al- Ribdi, A. (2017, January 17). Challenges Caused Out Of Privatization At Saudi Arabia. Economics. Https://www.aleqt.com/2017/01/18/article_1122641.html

[257]Abdulhamed Ghanim, A. (2019, May 1). the Benefits of privatizing Cleanliness Related Services. Alraiah. https://www.raya.com.

[258]United Emirates Governmental Services Page. (N.d.). Process Need To Be Followed To Contract With Governmental Sector At Uae. United Emirates Governmental Page. Https://u.ae/ar-ae/information-and-services/business/government-tendering-and-awarding

performance. An example of this is the Bee'ah Company in the Emirate of Sharjah, which has been able to improve waste separation, collection, and recycling activities in the UAE.[259] Through the adoption of a contract privatization model, the KSA can set expected standards for interested private players and monitor their performance over time. Thus, this will help the country achieve maximum value and effective waste management from privatization. In summary, formal private sector participation in waste management has the potential to positively impact waste management initiatives in the KSA.

5.2.4 Re-regulating Construction and Demolition Waste:

First, it would be very helpful if the KSA imposes much stricter standards to regulate the construction waste produced out of the projects. For example, if an entity is found mismanaging construction waste, it should be subject to penalties and in some cases license revocation. The KSA can introduce a clause under its waste management laws that detail the penalties against acts of prohibited littering and dumping of waste in undesignated areas. These penalties can range from financial fines depending on the type and volume of waste, days of community service, or even imprisonment. The clause can also detail punishments to organizations such as a withdrawal of their operating license. Second, the KSA should encourage the reuse of construction and demolition waste in other projects. The reuse of construction waste can be encouraged through creation of policies that allow for minimal to no levies on the purchase of recycled construction materials. This move will encourage most builders to use recycled materials, since they provide a cheaper alternative to the purchase of unused materials. Also, the policy can require construction demolition companies to ensure that they rescue a given

[259]Bee'ah Is The Biggest Environmental Company In Middle East. (2013). Arabic Gate. Https://www.arch-news.net.

percentage of materials from the demolition – say 60% - for recycling purposes. This step would help to reduce the volume of construction and demolition waste received at the municipal landfills.

Additionally, the KSA can define certain construction and demolition commodities to be reused in new construction. This measurement would help to decrease the use of virgin materials, which would ultimately help in source reduction. In addition to source reduction, deconstruction for reuse is another option apart from source reduction that reduces C&D waste. Deconstruction for reuse is the process of dismantling constructions in order to recycle or reuse components.[260] By doing so, it maximizes material recovery, preserve resources by reusing them, and divert demolition debris that would otherwise be disposed of. Using deconstruction for reuse makes construction waste more valuable, because it can be recycled. Deconstruction for reuse can be encouraged through passing a policy that requires deconstruction companies across the country to rescue a given percentage of materials from every deconstruction work they undertake. Any company that fails to adhere to the set percentage can be punished through fines. Also, the policy can require all deconstruction companies to get the approval of government authorities before and after undertaking any demolition activities since this will help assess the recycling percentage achieved. In short, when carrying out deconstruction, various components can be salvaged for recycling which is a practice that significantly reduces the amount of C&D waste in the process.

[260]Sustainable Management Of Construction And Demolition Materials, Environmental Protection Agency , Https://www.epa.gov/smm/sustainable-management-construction-and-demolition-materials

5.2.5 Sorting NSW Before Reaching the Designated Landfills:

Sorting the waste properly plays an essential role in the treatment of waste. It is much easier to treat and benefit from properly sorted wasted than mixed and improperly sorted waste. However, sorting NSW required unilateral [individual effort and dedication by involved parties] efforts whether at the governmental level or individual level.[261] MOMRA needs to supply residential, commercial, and industrial areas with different types of garbage bins. This measurement would help waste generators to properly sort their waste. Additionally, this measurement would help in monitoring the volume of waste at the generation point, as well as penalizing those who improperly sort their waste. Sorting waste at the source also ensures that recyclable waste is not dumped into landfills. This reduces the consumption of space in the landfills and the emission of greenhouse gases from the recyclable waste. Once sorting has been done, recyclable waste can be sent directly to the recycling depot to be put to valuable use without reaching the landfills. Moreover, it is important to sort waste for public health and environmental reasons. Especially since hazardous wastes can cause long term health and environmental problems; therefore, they must be disposed of safely and correctly without mixing with the NSW.[262] In brief, sorting waste at the source not only helps in monitoring generated waste volumes, but it also simplifies the subsequent processes of recycling together by reducing associated health and environmental impacts.

[261]Al-khlij. (2019, August 28). Sorting Waste Materials Challenges And Benefits. Https://www.alkhaleej.ae

[262]Noor Alowan, N. (2019, September 3). The Future Treasure Is Going To Be The Waste. Noon Post. Https://www.noonpost.com/content/20081

5.2.6 Improve Public Awareness Regarding Basic Concepts Related to the Waste Management Field:

Since individuals play an essential role in generating and sorting waste, the Ministry of Educational Affairs should work on improving public awareness. This can be achieved by providing general education and awareness about waste management to school age children. The background education should explain the impacts of waste on the environment. These public outreach programs would help build on the Islamic view that the environmental challenges being faced are an indicator of an ethical and moral crisis, hence, the only way to deal with these challenges is by taking up individual responsibilities on matters of waste management across the KSA.[263] Since the Islamic discourse offers a sense of optimism and hope about the possibility of attaining harmony between nature and humans, these public awareness initiatives would help people rethink their waste management strategies and gravitate towards positive waste handling and management. Additionally, the background education should provide the youth with essential knowledge regarding waste sorting and its impacts not only on the waste management system but also in their future. With social media infiltrating every aspect of today's life, the government can also leverage the use of social media sites by creating short pop-up adverts with waste management content. The national authority, in collaboration with the local authorities, can also come up with initiatives such as 'waste management awareness day' where people come together in parks and social facilities to gain more knowledge about waste management.

By spreading waste management awareness, we can encourage a more active and sustainable mindset in society. Moreover, awareness is an effective way to make waste

[263]Odeh Al-jayyousi, How Islam Can Represent A Model For Environmental Stewardship, Un Environment Programme , Https://www.unep.org/news-and-stories/story/how-islam-can-represent-model-environmental-stewardship

management a visible reality and popularize behavior patterns aimed at managing waste. Above all, the public needs to be convinced of the importance and potential of waste management, something that can only be achieved when they are made aware of it.[264]

5.2.7 Imposing Strict Regulations to Ensure the Separation of Medical Waste from NSW Stream Received at the Municipal Landfills:

This measurement is going to significantly improve the waste management system as well as the environmental condition, since medical waste contains some hazardous waste which can cause negative impacts on the environment, especially if it is buried along with NSW.

Improper disposal and treatment of medical waste poses serious hazards of secondary transmission of diseases due to exposure to infectious agents among the general community. Moreover, open incineration and burning without adequate control of pollution exposes the surrounding community to toxic contaminants in ash and air emissions. Other hazards include radiation burns and pollution/poisoning through pharmaceutical products' release. According to World Health Organization (WHO), medical waste can be classified into infectious, pathological, chemicals, sharps, genotoxic, pharmaceuticals, and radioactive. Traditionally transported medical waste always finds its way into landfills mixed up with other non-hazardous waste materials. This leaches out harmful substances into the land, water, and air. Most of these substances have a long half-life, so they break down only after many years. During this period, the potency of contamination is increased with the addition of more waste. Unfortunately, one does not need to work in the waste removal or medical field to be at risk when medical waste is improperly disposed

[264]Ethad News, & Mohamed Al-ameen, A. (2016, April 8). Sorting The Waste Materials Is Social Responsibility Which Result A Beneficial Impact On The Environment, Economic, And Public Health. Etihad News. Https://www.alittihad.ae/article.

of. This risk can only be reduced or eliminated if there is proper separation of medical waste from non-hazardous waste at landfills.[265]Consequently, proper handling and disposal of medical waste not only helps improve waste management, but it also protects the community and every aspect of the environment.

Medical waste also has a significant impact on the environment if not well disposed of. The burning of this waste releases many hazardous compounds and gases into the atmosphere, including furans and dioxins, hydrochloric acid and toxic metals such as cadmium, lead, and mercury. Large amounts of carbon dioxide are also released into the atmosphere during this process, triggering climate change.[266] Considering their long half-life, medical wastes can stay in the soil for a long time, releasing toxic compounds that affect the soil composition and life. Leaked toxins can also find their way into water bodies causing contamination and affecting marine life.[267] For this reason, organizations should strive to adopt environmentally friendly medical waste disposal practices which include autoclaving – the destruction of toxic microorganisms before disposal; incineration – this is only after the waste has been reviewed and determined as safe to burn; and microwaving – the complete shredding of medical waste. Therefore, medical waste should be disposed of without harming the environment since any harm caused to the environment ultimately threatens life and sustainability.

[265]Health-care Waste, World Health Organization (Feb. 8, 2018), Https://www.who.int/news-room/fact-sheets/detail/health-care-waste
[266]The Causes Of Climate Change, Nasa Global Climate Change , Https://climate.nasa.gov/causes.
[267]Health-care Waste, World Health Organization , Https://www.who.int/news-room/fact-sheets/detail/health-care-waste

5.2.8 Adopting the Controlled Burning Methods:

the KSA would greatly benefit by switching to controlled burning, due to the negative environmental impacts caused by the open burning of waste. Incineration is one of the most common forms of controlled burning where waste is burned under high temperatures in chambers. This form of controlled burning is also referred to as thermal treatment. The waste is converted into flue gas, ashes, and heat. Most of the ash consists of inorganic waste, which can be used to make fertilizer. In some countries such as Japan, the heat generated is used in the production of electricity.[268] Controlled burning can greatly reduce the amount of waste and dependence on landfills. Moreover, while landfills emit pollutants such as dioxin, nitrogen oxides, hydrocarbon organic compounds, and methane, incineration filters these contaminants before they are released into the atmosphere, thus reducing air pollution. Additionally, it is also possible to locate incineration plants near cities and towns. This is advantageous because it means waste does not have to be moved long distances for dumping purposes. Consequently, the cost of transportation is reduced substantially, and the savings can be used to fund other projects. Unlike landfills, incineration chambers reduce the unpleasant odors since waste is burned in controlled environments and reduces significant air pollution.[269] In short, while controlled burning does not completely get rid of landfills, it significantly decreases the quantity of non-hazardous wastes in the landfills together with their related environmental effects, converting the waste into useful recycled products.

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[268]Tomohiro Tabata, T., &Peii Tsai, P. (2016). Heat Supply From Municipal Solid Waste Incineration Plants In Japan: Current Situation And Future Challenges. National Library Of Medicine. Https://pubmed.ncbi.nlm.nih.gov/26628053/

[269]What Is Waste Incineration?, Conserve Energy For Future, Https://www.conserve-energy-future.com/advantages-and-disadvantages-incineration.php

5.2.9 Establishing a Comprehensive Recycling Program:

the KSA can establish a comprehensive recycling program (RCP) that covers not only the major cities but also smaller cities. The country can come up with waste generator guidelines – by borrowing a leaf from the UAE – to help govern waste generation. These guidelines will lay out the responsibilities of each player, such as sorting, and plans on how to work together to achieve effective recycling of waste. For effective recycling, there is also a need to have an effective sorting framework at source to enable for a comprehensive effective waste management. To make this a reality, the KSA can model after the UAE by categorizing garbage bins to dispose of and sort different types of waste. With this, recycling activities will be more effortless and possible, since individual waste will be managed sufficiently once it reaches the designated landfills.

The KSA can also integrate waste to energy technologies (WET) to help in the effective management of waste. This technology uses water treatment procedures to convert waste into reliable energy sources. Currently, the UAE has managed to effectively implement the technology and is in the process of coming up with more WET facilities to help intensify the recycling of waste across the country, an initiative that the KSA can effectively emulate.

Consequently, recycling programs can benefit from a new and improved waste management system, which will also sustain the environment. First, RCP would help by decreasing the need for raw materials to manufacture new products. Moreover, it would help in reducing the volume of waste received at the municipal landfills. Furthermore, it would help in mitigating the negative environmental impacts resulting from untreated NSW.[270] Additionally, RCP have the potential to positively impact the economy of the KSA not only through the enhancement of the nation's GDP from gross annual sales of recycled products but also through the creation of

[270]Environmental Benefits of Recycling, Continuing Effort St. Louis-Jefferson

employment opportunities in the recycling-based manufacturing industry. Finally, the depletion of natural resources and filling of landfills is happening at an increasing rate. The current global system of consumption, production, and disposal has been unsustainable. The reduction of waste produced and reusing the existing waste, therefore, helps create a sustainable planet for generations to come.[271] In conclusion, comprehensive recycling programs help enhance waste management initiatives and ultimately have a positive impact on every aspect of society.

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[271]David Biddle, Recycling for Profit: The New Green Business Frontier, Harvard Business Review, https://hbr.org/1993/11/recycling-for-profit-the-new-green-business-frontier

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