

## WASTE MANAGEMENT AS A TOOL TO PRESERVE THE SENSITIVE ECOSYSTEM OF THE AL- BAHA REGION IN SAUDI ARABIA

Mahmoud T. Mohamed\*, Naief A. Aldossary, Abdulaziz A. Alzahrani, Jamal K. Alghamdi

Department of Architecture, Faculty of Engineering, Al-Baha University, P.O.Box (1988), Saudi Arabia

\*Correspondence: [mtarek@bu.edu.sa](mailto:mtarek@bu.edu.sa)

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### ABSTRACT

Interest in waste management and recycling, together with the effective and wise use of energy and water was progressively increased in Saudi Arabia to achieve sustainability and wildlife conservation in its sensitive ecosystems. The establishment of integrated waste management systems in economically and environmentally promising areas is of great attention.

This work is aiming at reviewing the various methods and practices undertaken in developing countries in waste management and the rational and effective use of energy and water in sensitive ecosystem areas.

Exploring the distinctive environmental elements of the Al-Baha region as one of the most important sensitive regions of the Kingdom was performed to identify undertaken waste disposal methods and their negative effects.

.Several extended practices and scenarios were proposed to support effective management in maintaining the ecological balance in sensitive ecosystems.

**KEYWORDS:** waste management, recycling, wildlife conservation, sensitive ecosystems, ecological balance.

### إدارة النفايات كأداة للحفاظ على النظام البيئي الحساس في منطقة الباحة في المملكة العربية السعودية

محمود طارق محمد حماد\*، نايف علي الدوسري، عبد العزيز الزهراني، جمال خالد الغامدي

قسم العمارة، كلية الهندسة، جامعة الباحة (1988)، المملكة العربية السعودية

\*البريد الإلكتروني للباحث الرئيسي: [mtarek@bu.edu.sa](mailto:mtarek@bu.edu.sa)

### المخلص

ازداد الاهتمام بإدارة النفايات وإعادة التدوير، جنباً إلى جنب مع الاستخدام الفعال والحكيم للطاقة والمياه في المملكة العربية السعودية لتحقيق الاستدامة والحفاظ على الحياة الفطرية في أنظمتها البيئية الحساسة. إن إنشاء أنظمة متكاملة لإدارة النفايات في المناطق الريفية اقتصادياً وبيئياً يحظى باهتمام كبير. يهدف هذا العمل إلى مراجعة مختلف الأساليب والممارسات المتبعة في البلدان النامية في إدارة النفايات والاستخدام الرشيد والفعال للطاقة والمياه في مناطق النظم البيئية الحساسة. كما يسلط الضوء على العناصر البيئية المميزة لمنطقة الباحة كواحدة من أهم المناطق الحساسة في المملكة للتعرف على طرق التخلص من النفايات المتبعة وآثارها السلبية.

تم اقتراح العديد من الممارسات والسيناريوهات الموسعة لدعم الإدارة الفعالة في الحفاظ على التوازن البيئي في النظم البيئية الحساسة وخاصة منطقة الباحة بما يحفظ مكوناتها البيئية ويؤهلها لجذب السياحة البيئية.

**الكلمات المفتاحية:** إدارة النفايات، إعادة التدوير، الحفاظ على الحياة الفطرية، النظم البيئية الحساسة، التوازن البيئي.

## 1. INTRODUCTION

Managing and treating waste resulting from human activities in urban environments play an effective role in preserving natural resources and ecological balance, and in protecting the environment and wildlife from degradation and pollution. Undoubtedly, poor waste management carries great risks, and it is in citizens' interests to care about waste management. Solid waste management involves teamwork and includes various professional fields, such as civil, mechanical, and chemical engineering, transportation, land use planning, and economics. The nature of the community also affects the quantity and quality of the waste it produces, and rich societies have more waste than poor ones.

Al-Baha region is considered one of the most important regions of the Kingdom, due to its environmental characteristics and diversity in vegetation and wildlife. However, it was affected by urban development. Changes have been brought by modern civilization, consequently, had negative waste effects on the natural environment, and tourism resources because it contributes to wasting vegetation and destroying the ecosystem. This requires concerted efforts and the authorities' cooperation to develop an integrated waste management system that maintains environmental balance, is economically feasible, and contributes to building an information base that can be used to develop indicators and determine its costs and benefits.

### 1.1. Objectives of the study

The objectives of the study can be summarised as follows:

- Highlighting recent trends and guiding principles of solid waste management at sensitive ecosystems, to achieve sustainability and wildlife conservation.
- Reviewing the Kingdom's strategies for waste management and recycling in its various regions, and reviewing also some successful international experiences in the solid waste managing field.
- A survey on the Al-Baha ecosystem, as well as their institutions' policies in managing the negative effects of waste to develop a proposal guideline framework for solid waste management integrated with its sensitive ecosystem.

### 1.2. Research Importance

It reveals various methods and guidelines in waste management and treatment methods in sensitive ecosystems. It also highlights the effective and vital role of preserving natural resources and protecting the ecological balance from deterioration. This research also discusses waste management and treatment methods caused by urban extension and tourism activity in Al-Baha, one of the most important and distinguished sensitive ecosystems in Saudi Arabia. The results of this research will help decision-makers in developing an integrated waste management plan that is economically and ecologically feasible. Furthermore, it qualifies it for eco-tourism and makes it an eco-tourism attraction in the region.

### 1.3. Research Methodology

For the previous objectives, the research followed the inductive, descriptive, and analytical approach by studying and discussing the theoretical trends in waste management in sensitive ecosystems and principles related to recycling issues, in addition to reducing waste production, rational and effective use of energy and water, these literature followed by Applied and analytical study to Al Baha sensitive ecosystem, and concluded by developing proposed guidelines of solid waste management.

## **2. STRATEGIES FOR MANAGING AND RECYCLING WASTE IN SENSITIVE ECOSYSTEMS**

### **2.1. Sensitive ecosystems areas**

In general, areas with sensitive ecosystems take the state's first attention; these protected areas are often declared nationally, and sometimes even globally.

These areas are dedicated to nature and cultural heritage conservation, and the area's biodiversity preservation. Establishing such areas is one of the methods used to preserve these natural ecosystems and the cultural heritage associated with them (Ceballos Lascurain, H., 1996).

### **2.2. Waste/waste prevention strategy**

When planning to establish facilities, there must be a complete strategy to deal with solid waste and, as far as possible, prevent its appearance. A rational policy to prevent waste requires reconfiguring everything in the facility to be reused or returned to the environment through the process of biodegradation (Janeen, Tang. 2004).

In any development process that relies on the use of resources, there will be two main sources of solid waste: materials purchased and used by facilities and materials brought by residents to the facility. The following strategies for preventing waste apply to both sources, although different methods will be needed to apply these strategies:

- a. Use non-toxic products and reduce waste.
- b. Mixing or anaerobic digestion of biodegradable waste.
- c. Reusing materials on site or collecting materials for recycling off-site.

## **3. NEGATIVE EFFECTS OF WASTE**

Experience has shown that there is no completely safe method of waste disposal, as all forms of waste negatively impact the ecosystem, public health, and the local economy. The only way to avoid ecological damage from waste is to prevent the creation and generation of such waste in the first place. Pollution prevention requires a change in the activities practice in order to eliminate the causes of the problem; this does not mean doing without these activities but working differently.

Increasing population activities as a result of urbanization represents one of the most important effects on the ecosystem, as it represents the main form of human intervention in nature, as shown in Fig. 1. Of course, this expansion creates a lot of waste that seriously impacts public health, wildlife, and the ecosystem (Abdul Karim Abdul Aziz, Muhammad Adel Abrek. 2018).



**Fig. 1: Urbanization Affects the Ecosystem**  
Source: (Abdul Karim Abdul Aziz, Muhammad Adel Abrek. 2018)

### **3.1. Negative effects on the ecosystem:**

- Pollution, as waste contains many toxic chemicals that may be mixed with the ecosystem, leading to pollution.
- Reducing biodiversity, as waste needs to be buried in landfills, and this is the reason for the elimination of many forests and wild lands that contain wildlife.
- The disposal of vegetation cover in order to create landfills for waste leads to the emergence of insects and harmful animals.
- Threatening the animal's lives, as some light wastes such as plastic bags pose a real threat to the organism's lives, by swallowing them.
- Incorrect waste disposal methods, such as incineration, lead to the emission of fumes that pollute the ecosystem.

### **3.2. Direct effects on public health systems:**

There is no completely safe way to dispose of waste. Thus, the only way to avoid ecological damage is to prevent its creation. Preventing pollution means changing the way activities are conducted to eliminate the source of the problem.

Water must also be treated to avoid infection, using chlorine or chlorine compounds; this treatment aims to ensure that there are no toxic organic organisms in the water (Ceballos Lascurain, H., 1996).

### **3.3. Indirect effects on public health systems:**

The negative effects on public health systems can be divided into:

#### **a) Negative effects of liquid waste disposal and wastewater disposal systems:**

The disposal of untreated or initially treated sewage products, whether in seawater or land water, leads to severe pollution of the environment, which in turn leads to the destruction of marine life. It also poisons the plant life on which marine organisms depend for their food.

#### **b) Negative effects resulting from the use of wastewater treatment systems:**

The negative effects here depend on the type of technology used and the efficiency of the resulting treatment. The solids are dumped, which creates unpleasant odours, pollutes the environment, and destroys the equilibrium of wildlife relationships.

c) Negative effects of solid waste disposal systems:

Solid waste is organic, biodegradable, or non-degradable waste that causes serious environmental damage if the appropriate disposal technology is not carefully considered.

**3.4. Waste disposal in tourist facilities takes several forms:**

- Waste disposal using regular landfill:

Waste is collected in an open area away from facilities. However, this method has several disadvantages, including air pollution and groundwater pollution.

- Disposal of waste through sanitary landfill:

Waste is backfilled in areas far from the facilities, either by backfilling using the trench method or via the sloping method, by backfilling on inclining layers and then covering them with a layer of earthen backfill.

- Disposal of waste by sea:

Waste is thrown into the sea after being compressed to increase its weight so that it will settle on the seafloor. However, this method is completely environmentally unacceptable, as it leads to severe damage to the marine environment (Wassim Chaabane, 2020).

- Waste disposal by incineration:

This method leads to negative effects on the environment, as burning leads to carbon dioxide emission, which causes thermal changes in the climate, and leads to serious health consequences, affecting the plant environment and public health.

**4. PREVENTING POLLUTION IN SENSITIVE ECOSYSTEMS.**

Preventing pollution in sensitive ecosystems associated with resources requires thinking carefully about the activities and services carried out in the facilities and planning these to produce the least amount of waste possible. The use of materials that later become waste is problematic; if the use of these materials is necessary, they must be remanufactured to make use of them (Ceballos Lascurain, H., 1997).

**4.1. Clear participation systems:**

It is possible to prevent waste by drawing attention to the cause of this problem rather than waiting for the problem occur and then trying to solve it. Clear participation systems require the informed participation of visitors, users, operators, and workers; if visitors participate in waste prevention, the facility will operate more environmentally friendly.

**4.2. Training and maintenance (awareness and education):**

Among the requirements for waste prevention are staff training, education of all users of the system, regular maintenance, and awareness of the cause of most waste problems – lack of attention (Hawkins, D.E., Ellenwood, M., Bittman, S; 1995).

### 4.3. Attitudes of visitors and hosts in tourist facilities (reducing waste by reducing consumption):

Waste prevention requires making changes to behaviour, which is contrary to the typical assumption that going on vacation means evasion of responsibilities. Promoting a sense of responsibility among visitors is an essential element of ecologically optimal development (Grzegorz Przydatek, 2019).

### 4.4. National legislation for waste disposal

Waste prevention in local communities requires legislative solutions as follows:

#### 4.4.1. Strengthening present national legislation:

This includes strengthening environmental standards and objectives, and ensuring that law enforcement agencies have the skills and resources to perform their duties.

#### 4.4.2. Monitoring and scientific research:

Monitoring and control systems are needed. Data on visitor numbers, length of stay and activities, combined with experiences and observations from local communities, are important for managing and anticipating waste removal and disposal requirements. Innovative technological research should also be supported to explore new methods applicable in mountain environments, such as waste-to-energy and composting. Applied and participatory research is also needed to understand better behaviors (Ministry of Agriculture, Forestry, Environment and Water Management, Austria, 2018).

#### 4.4.3. Strengthening community capabilities:

Plans are needed, which include avoidance/prevention (including concerning illegal dumping of waste), local capacities for use, recycling, reduction, treatment and disposal.

#### 4.4.4. Preparing waste management plans in case of disasters:

Mountainous areas are particularly vulnerable to earthquakes, landslides and floods, which cause massive amounts of waste. Immediate waste management plans are needed to reduce the spread of disease and reduce environmental impacts

## 5. GUIDELINES TO PREVENT SOLID WASTE IN SENSITIVE ECOSYSTEMS:

Typically, nothing should be brought in sensitive ecosystems associated with ecological resources unless it is biodegradable or recycled. This can be represented as shown in Fig. 2.

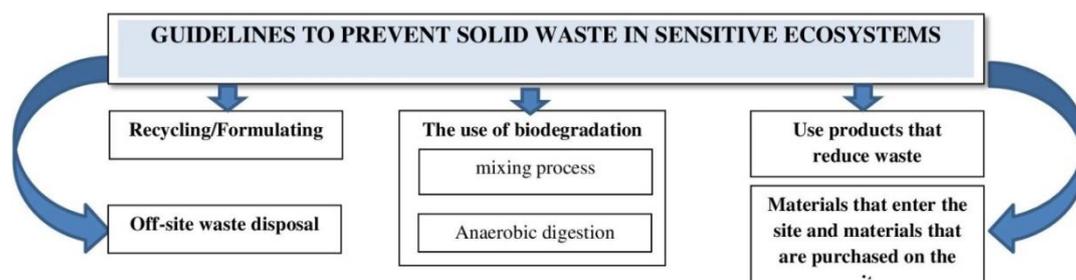


Fig. 2: Preventing Solid Waste Diagram  
Source: The Researcher

### **5.1. Using products that reduce waste**

A lot of the increase in the volume of waste comes from consumer used products and over-packaging. Thus, attention should be paid to wastes which become toxic after disposal, taking suitable measures to avoid using these materials. Locally produced goods that require the least amount of transport and the least storage capacity help to avoid packaging waste disposal (Ceballos Lascurain, H., 1997).

Two systems should be considered in regard to reducing product waste: biodegradation and reconstitution/manufacturing. Both the economy and technology are constantly changing, and the system chosen must be flexible and adaptable to market conditions (McKenzie, Dorothy; 1991).

### **5.2. Biodegradation**

In the biodegradation process, microorganisms break down the products of other organisms and then reintroduce them into the ecosystem (Ceballos Lascurain, H., 1997).

Biodegradable waste includes newspapers, magazines, papers, food scraps, tree leaves, wastewater solids, and dirt. There are two obvious conversion options: composting and anaerobic digestion, as follows:

#### **First: Mixing/Composting:**

Mixing/ composting is generally used to treat barn waste and dirt deposited in ponds. This organic waste requires mixing with other materials (chemical fertilisers) to achieve nutritional balance, which contributes to improving soil quality and reducing the volume of the original materials by 40–50%. However, the mixing process creates ammonia gas and carbon dioxide and releases unpleasant odours, thus it is necessary to filter the final product to remove bulky substances (Lyle, 1993).

#### **Second: Anaerobic digestion:**

Anaerobic digestion is used around the world for the treatment of animal excrement and human solid waste, as well as for the treatment of all types of solid wastes, such as wasted newsprint, green waste, and greenery waste. The wet fermentation process turns the waste into three by-products that can then be used; biogas, an organic fertiliser that is also useful in agriculture, and a liquid organic fertiliser consisting of a diluted fertiliser that can be used in the irrigation process.

### **5.3. Recycling/formulating**

No material is “waste” until it is thrown away; if it can be reused, it becomes a resource instead (Mackenzie, 1991). There are markets for recyclable materials, including aluminium, paper, glass, metal, and some types of plastic.

The reconfiguration rate can be increased by purchasing products with existing markets where they can be sold, such as reconstituted materials. The possibility of reconfiguring any material depends on the price offered by the buyer, so material costs and shipping costs can change over time; however, if there is no option to reuse or reformat, the materials used in the facility must be reformulated, even at a net loss, rather than disposed of.

#### 5.4. Off-site waste disposal

If the waste prevention strategy is fully realised, a real but lesser amount of waste will remain, and all waste must be collected separately and disposed of off-site. Although the disposal of waste anywhere harms the environment, in any special environmental area, Particular care must be taken not to deposit this waste locally. Instead, it must be disposed of in a far location (Ceballos Lascrain, H., 1997).

#### 5.5. Materials brought to the site and materials purchased on site.

Visitors and guests typically bring various materials they consume to the visiting site and often leave behind their waste disposal problems. In addition, products purchased on-site and in the surrounding community can exacerbate this problem. These materials can contain toxic elements and are difficult to dispose of, and education is important in reducing these types of waste, both through written guidance about the importance of building facilities and various forms of education.

### 6. GUIDELINES FOR CONTROLLING LOCAL/INTERNAL LOSSES (WASTEWATER) IN NATURAL RESOURCES AREAS

These Guidelines for controlling local/internal losses could be presented as shown in Fig. 3.



Fig. 3: Controlling local/Internal losses (wastewater)  
Source: The Researcher

#### 6.1. Technical treatments (General trend)

Systems that feature control and monitoring devices should be used. It is necessary to maintain maintenance permanently. Typically, these systems are:

##### A. Dry toilets (mixed)

As shown in Fig. 4, mixed toilets consist of a large tank directly below the toilet. The waste enters the tank through a wide-diameter waterway that connects the tank to the toilet, and then decomposes in an environment rich in oxygen. This toilet works without water; however, solid materials (such as sawdust) are added to improve drainage and air circulation and save fuel. A small fan works to draw air into the vent pipe to ensure the appropriate amount of oxygen for the decomposition process and to avoid unpleasant odours. All of the internal components (such as pipes, baffles/beams, and rotating forks) work to strengthen the mixing process; the final mixture can be

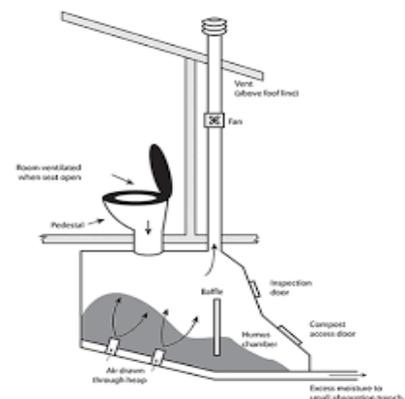


Fig. 4: Dry Toilets (mixed)  
Source: <https://www.google.com.sa>

removed from the lower surface of the tank approximately once a year to be used as a soil conditioner (Lyle, 1993).

### B. Pit latrines

A pit latrine, as shown in Fig. 5, is the most primitive method of human waste disposal, and is widely used worldwide in rural areas. It is not suitable to be used as a permanent solution for facilities erected in areas with natural resources, but it may suffice during the construction phase or the beginning of the operation process, and in remote camps.

In short, a dug or pit toilet is a simple hole in the ground where human excrement exists. To avoid bad odours and the spread of flies that appear in dug toilets, it is suggested to add an external vent pipe, painted black that comes straight out of the pit to create an upward current while preventing odours from entering the toilet compartment. It is not appropriate to use drainage basins dug in sandy soil close to water level (Ceballos Lascurain, H., 1997).

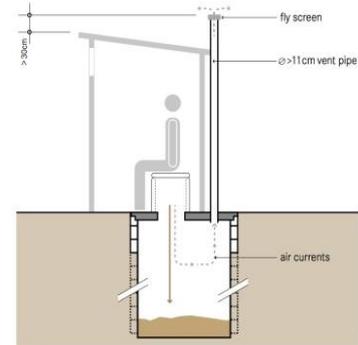


Fig. 5: Pit Latrines

Source: <https://www.google.com.sa>

### C. Anaerobic waste processing

Anaerobic waste treatment (sewage systems) uses microorganisms (bacteria) that live in wastewater. Anaerobic bacteria work in environments where oxygen is unavailable; complex reactions occur that cause unpleasant odours – these odours indicate the effective progression of anaerobic bacteria removal of process pollutants from the waste stream. As shown in Fig. 6, treated wastewater (water flow) is usually discharged into an underground system that passes the water flow through side sections in the soil it filters. Anaerobic waste treatment is inexpensive, not complicated to operate and maintain, and provides excellent quality water (Ceballos Lascurain, H., 1997).

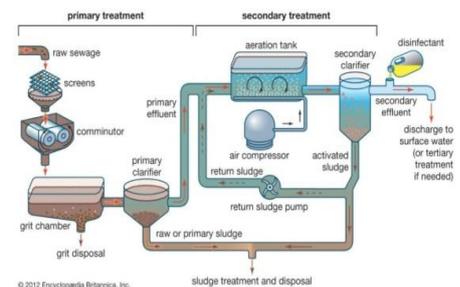


Fig. 6: Anaerobic Waste Treatment

Source: <https://www.google.com.sa>

### D. Pneumatic waste treatment

This treatment is also carried out by microorganisms (bacteria); however, the air in this system (aerobic treatment) flows to ensure the availability of free oxygen, and aerobic organisms work about twenty times faster than anaerobic organisms. Since this process is much faster, it consumes less time and requires a smaller processing area (Ceballos Lascurain, H., 1997).

Pneumatic treatment systems are suitable for all sizes of facilities located in eco-tourism venues, and because there are no unpleasant natural gas odours, this system can be placed near populated areas.

### 6.2. Alternative methods of disinfection

Traditionally, water from conventional treatment systems is disinfected using chlorine or its compounds before it is returned to the environment or reused. However, a side effect of this method is that chlorine or chlorine compounds are highly reactive and sometimes produce highly toxic

chemicals. Thus, according to many environmentalists, there is no justification for the use of chlorine and its compounds in the disinfection process.

Most public health laws call for the use of chlorine in disinfection. These laws must be changed to allow no disinfection, the use of other disinfectants, or the use of alternatives that allow chlorine removal after appropriate contact time.

## 7. GUIDE LINES FOR RECOVERING ENEREGY FROM WAST

Waste is currently the world's third largest source of renewable energy after solar and wind energy. It also contributes; together with biomass energy, to more than half of the renewable energy used globally (ISWA, 2006). Consequently, many countries around the world are researching and developing large-scale plans to separate and recycle waste or turn it into compost (Ogola et al., 2011).

### 7.1. Turning waste into fuel

The process of deriving fuel from waste is neither direct nor easy, and has several technical requirements to ensure that it is useful as an energy source for the end user, depending on its moisture content, and the form and quantity of available waste. The conversion process also involves the need for early coordination and follow-up with the source of the industrial material (industrial waste being waste from factories) for at least six months before starting the conversion process.

### 7.2. Multiple technologies for extracting energy from waste

There are many ways to extract energy from waste presented as shown in Fig. 7.

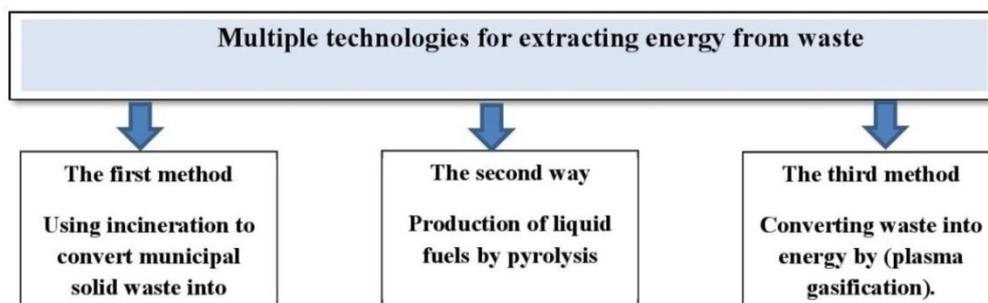


Fig. 7: Extract Energy from Waste.  
Source: The Researcher

The most important is burning organic materials such as waste to achieve “energy recovery” for later use in electricity production. For example, Fig. 8, shows a waste-energy plant operating in Ireland, where 20 households have electricity from dioxin residue (Tayel Al-Hassan, 2018).

- The first method is to use incineration to convert municipal solid waste into energy, which is a relatively old method. However, one of the problems associated with household solid waste after it has been reduced to ash for electric power generation, is the number of pollutants that are emitted into the air through the chimney of the incinerator, which can cause serious environmental damage.

- The second method is the production of liquid fuels through pyrolysis, a process which is applied to plastic products from polymers that decompose to produce liquids similar to petroleum fuels.
- The third method is converting waste into energy by plasma gasification, as shown in Fig. 9. Gasification is a term used to refer to the conversion of a substance from a liquid or solid state to a gaseous state. For plasma, it is the fourth state of matter, after solid, liquid, and gas.



**Fig. 8: Ireland's first Operational Waste-to-Energy Plant Powering 20,000 Homes with Electricity from Waste**  
Source: (Tayel Al-Hassan, 2018)



**Fig. 9: Plasma Gasification Chamber**  
Source: (Tayel Al-Hassan, 2018)

## **8. WASTE MANAGEMENT STRATEGIES IN SAUDI ARABIA**

The Kingdom continually seeks sustainable solutions to manage waste and turn it into valuable resources. Thus, it has created solutions for the comprehensive treatment of municipal solid waste, including material recovery facilities that allow the possibility of sorting and extracting recyclable materials, in addition to composting processes during which organic waste is converted into nutrient-rich compost. Waste that cannot be processed is converted into an energy source.

The Kingdom has also established systems for recycling construction and demolition waste to divert it from landfill, as well as a municipal waste management system taking into global account regulations and international standards, developed in collaboration with the Gulf countries.

The Ministry of Municipal and Rural Affairs is the main foundation responsible for managing waste in the Kingdom of Saudi Arabia. Other foundations work in the waste management field, such as the Ministries of Industry and Health.

The Supreme Committee for Environmental Protection in the Kingdom prepared a comprehensive strategy for waste management in the Kingdom, which includes developing the current methods, and technologies for collecting, transporting, and recycling waste, and finding facilities for waste treatment. (Ministry of Environment Water & Agriculture. 2021).

The strategy has been divided into five main axes to match all environmental issues for managing waste in sustainable ways in the Kingdom, including:

- a. Organization and management.
- b. Collecting, transporting, and recycling waste.
- c. Waste treatment and final disposal.
- d. Economic feasibility, costs, and partnership with the private sector.
- e. Awareness and training.

The strategy also included an executive program based on the five axes (the executive program for the waste management system issued by Royal Decree No. (M/3) dated 5/1/1443 AH), and it stems from the priorities and issues that face the Kingdom. (Bureau of experts at the council of ministers. 2021).

The Kingdom has also established a system for managing municipal solid waste, taking into account global regulations and international standards, and developing sustainable solutions for managing waste and converting it into valuable resources.

It also created systems for recycling construction and demolition waste to divert it from landfills lands around the cities while extracting high-quality rubble to be used in construction projects throughout the Kingdom.

The strategy emphasized the importance of defining responsibilities among the concerned authorities to prepare regulations on how to benefit from these wastes and to consider them as primary resources.

The strategy also stresses the importance of private sector participation in investing in this vital sector, supporting companies to provide infrastructure for waste treatment, and facilitating procedures, in addition to the importance of educating society about the diversity of waste materials, through awareness curricula programs. (MINISTRY OF ENVIRONMENT WATER & AGRICULTURE. 2021).

## **9. INTERNATIONAL EXPERIENCES IN WASTE MANAGEMENT.**

Burning this waste to produce energy is a successful project on an economic and environmental level, because it achieves more than one goal at the same time. It contributes to solving the waste problem and reduces the imported energy bill in non-oil-producing countries, provides job opportunities, raises the level of hygiene and improves the level of public health in the city.

Technologies for converting municipal waste generated by cities, farms and food industries into energy are the best way to reduce the volume of waste, thus reducing the areas used for landfilling

this waste. For example, waste needs more than 25 years to decompose in sanitary landfills, while it can turn into ash of a much smaller size within hours or into liquids, gases and solids that are used as clean fuel.

### 9.1. Japan

Japan currently leads the world in waste management; it converts a percentage of it into energy from the total waste emitted from its cities. Until 1950, there was a lot of “waste that could be recycled,” roughly from 8.91 million tons in 1960 to 43.94 million tons in 1980. In order to treat waste, the amount of which had increased almost 5 times in 20 years, municipalities across the country invested large amounts of taxes and construction of waste incinerators. And it had to build a structure for waste collection, perhaps the most famous of which is in the town of Kamikatsu, where food waste processing machines are issued from homes, as shown in Fig. 10, and set up recycling companies that manufacture products using recycled resources as raw materials: <https://www.nippon.com/ar/views/gu900038>.



Fig. 10: Handling food waste from households in Kamikatsu, Japan Japanese cedar sawdust found in the area is used to breed microorganisms that break down the food waste. Source: <https://www.nippon.com/ar/ncommon/contents/views/156027/156027.jpg>

### 9.2. Germany

About 22 years ago, Germany actually started implementing the waste separation system. Many considered this decision as a "green revolution", the goal was initially to filter reusable materials so that they would not be buried or burned, due to the risks that threaten the soil and water sources, and also to preserve the climate.

This implementation turned into an industry that generates about four billion euros annually for the German economy, and into a renewable source of energy, reference: <https://p.dw.com/p/17tue>.

Waste is diverted at a waste collection station in Bonn. It is a giant station containing complexes, a waste incinerator, and an electric generator. as shown in Fig. 11. The idea is to obtain energy by exploiting the heat resulting from combustion to generate energy.



**Fig. 11: The SWP waste collection and incineration plant in Bonn, Germany**  
Source: <https://p.dw.com/p/17tue>

The waste is collected by trucks in a closed complex 12 meters underground. Many people also come in their own cars to throw away the rubbish that does not fit, such as old electronic devices. This waste is then transported by two cranes operated from the wheelhouse at the top of the complex to three large furnaces for incineration.

Where ten tons of waste are burned every hour, and this heat is used to heat the water that will produce steam to generate electricity.” Also, “the ash and sediment remaining after the burning process are converted into another type of cement that is used in paving the streets.”

The energy extracted from waste cannot be a substitute for oil, gas, or even nuclear energy, which is expected to be phased out in Germany by 2020 in the wake of fears of an environmental catastrophe like the one that occurred in Fukushima, Japan.

But the problem lies in the fact that the quantities of waste are constantly decreasing due to recycling, but it generates electricity for about 20,000 homes, and we provide about 10,000 homes with heating. (Bahloul, L. Halimi, S. 2019).

Experimental projects exist in Arab countries such as Saudi Arabia, the United Arab Emirates, Egypt, and Jordan. However, waste-to-energy projects are still in the construction phase. In addition, many Arab countries suffer from the phenomenon of indiscriminate dumping, and "sanitary" incinerators are currently used in most of these countries to burn medical waste only.

### **9.3. Jordan**

There is an experiment is being implemented now in Jordan, called participatory digestion between sludge (materials resulting from wastewater treatment) and food residues in anaerobic bioreactors to produce methane gas.

Recent studies reveal that Jordan suffers from the bad effects of climate change in terms of low rainfall, drought, and desertification. In order to find a suitable solution to the sludge problem, Jordan is implementing a pilot project to reduce the carbon footprint of sludge processing, hence considering the use of sludge primarily as an energy source.

Co-digestion of the sludge with other organic waste sources is also being considered, it is also expected to use quantities of household organic beside the sludge. For this, the Prince Faisal Center

at Mutah University carried out the technical and research aspects through the bioreactor's design, installation and experimental operation for co-digestion between sludge and leftovers. (Al-Hassan, Tayel. 2018).

The preliminary results were as follows:

Disposing of sludge accumulated inside the purification plants, which was the source of a major health and environmental problem.

Reducing the amount of solid waste by up to 40% through the use of food leftovers from restaurants and homes and can be expanded later by taking leftovers from nearby residential communities and restaurants.

Reducing the carbon footprint by 50% through:

- Reducing the proportion of carbon dioxide emitted from the decomposition of sludge and food residues.
- Reducing the number of fossil fuels needed to transport leftovers to landfills.
- Reducing the consumption of fossil fuels required for electricity to operate the purification plant by relying on the gas produced from the co-digestion process.

#### **9.4. The United Arab of Emirates**

In the United Arab Emirates, the importance of solid waste is increasing, as an integral part of the environment. The state has developed a strategy for waste recycling and focused on organic waste, paper, cardboard, plastic, and metal products, in order to reduce the volume of waste, which is rapidly increasing, and to benefit from it. Directly as raw materials or through economic and environmental products, instead of burying them, the UAE seeks to establish appropriate facilities, to sort waste and food residues, to safely dispose purposes, and to recycle some of their components through some recycling projects. (Bahloul, L. Halimi, S. 2019).

- Establishing an integrated waste treatment project includes collecting and sorting that waste
- Establishing a project to construct a new healthy landfill site according to modern standards and international specifications operated with a backfilling cells system, which is equipped with insulating materials to prevent any leakage into the ground, it also equipped with a collecting harmful gases system resulting from waste to be used in power generation
- Establishing facilities and centers for solid waste treatment, including stations and units for collecting and sorting household waste.
- Establishing an organic fertilizer factory, in addition to developing and treating used tires and construction and demolition waste.

## **10. THE IMPACT OF WASTE MANAGEMENT ON ECOSYSTEM AND WILDLIFE OF AL-BAHA**

### **10.1. General description of Al-Baha**

- Al-Baha is a mountainous area located in the southwest of the Kingdom of Saudi Arabia.
- The most important characteristic of the region is the Sarawat mountain range, which makes the average height of the mountainous region in Shafa (2000 m) above sea level.

- The region has a historical character, as it has been inhabited since ancient times. Its population is currently 378000.
- A unique urban style and traditional villages characterize the Al-Baha region.
- The economy depends mainly on the services sector in the cities. The agricultural sector is in decline due to the lack of arable land.

## 10.2. Location

The Al-Baha region is located in the southwest of the Kingdom of Saudi Arabia and is bordered to the north and west by the Makkah Al-Mukarramah region, and by the Asir region to the south and east. The regional capital, Al-Baha, is located 220 km south of Taif and 265 km north of Abha, occupying an area of 10,960 km<sup>2</sup>. It is the smallest administrative region in the Kingdom in terms of area, representing just 0.6% of the Kingdom's total area (Al-Baha Tourism Development Strategy, 2000), as shown in Fig. 12.

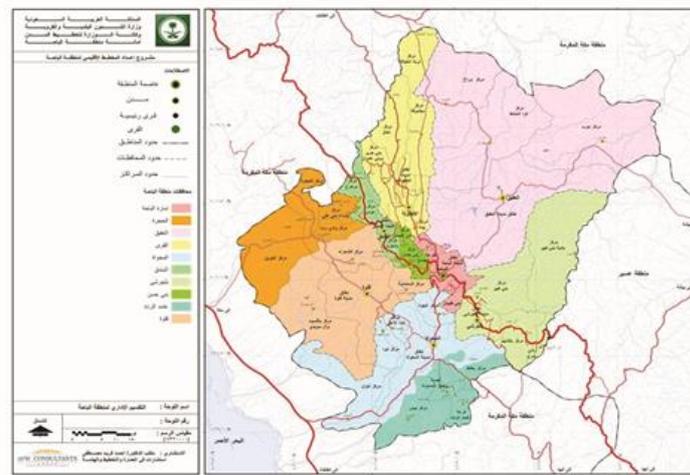


Fig. 12: The Al-Baha region and the borders of the centers and governorates  
Source: Ministry of Municipal Affairs, 1429

## 10.3. Ecosystem of Al-Baha

The ecosystem of Al-Baha, especially the natural ecology, is the most important element for living organisms, and any impact on the ecology consequently affects all life within it. The following subjects will review the ecological characteristics of the region that could be negatively affected or damaged by waste.

### 10.3.1. The natural ecology:

The Al-Baha region is one of the most important and prominent tourist areas in the Kingdom, due to its forests and landscapes with strategic locations. The region's tourist strip extends across the Sarawat mountain range near the small villages, which have expanded rapidly to keep pace with the urban development of the Kingdom in recent decades. as shown in Fig. 13, the Raghadan Forest is one of the most important tourist attractions in the region. The forest is in the north-western part of Al-Baha, about 5 km from the city centre. It is characterised by dense trees and is considered one of the most beautiful forests due to its natural characteristics in the country.

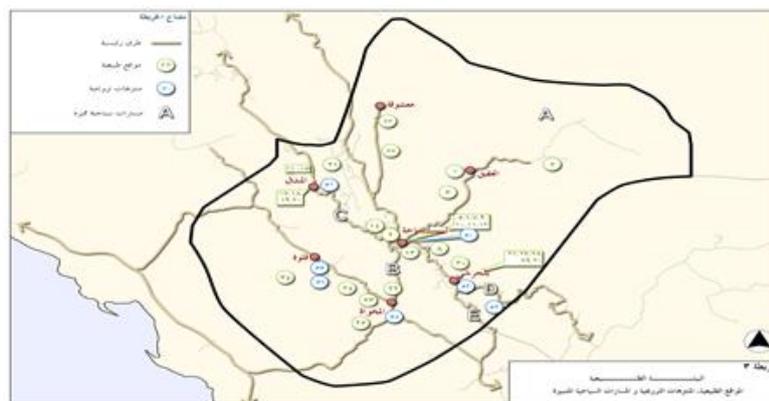


**Fig. 13: The Raghadan Forest is one of the most important natural environmental components in the Al-Baha region**  
Source: Saudi Tourism Guide, 2018.

The Shahba Forest is located in the north-eastern part of the region, and is characterised by its dense trees. The Sukran Forest is located in Baljurashi, 53 km south of Al-Baha, and is crossed by the main road between Al-Baha and Abha. The Zarqa Forest is one of the forests adjacent to the city of Al-Baha, located a kilometre north of the city along the Raghadan Forest Road. (Saudi Tourism Guide, 2018).

### 10.3.2. The culture and the heritage:

- Archaeological and historical sites include ancient mines and some sites that represent the pre- and post-Islamic period, as shown in Fig. 14.
- Roads of historical importance, such as the Elephant Road and other trade routes.
- Heritage villages: most of which have been abandoned and are surrounded by modern urban developments, as shown in Fig. 15.
- Museums: a new museum has been built in Al-Baha, displaying many historical artefacts.



**Fig. 14: Natural sites and parks in the Al-Baha region**  
Source: Tourism development strategy in Al-Baha region, 2000.



**Fig. 15: The traditional village of the Ain, a famous heritage village in Al-Baha**  
Source: Saudi Tourism Guide, 2018.

#### **10.4. The built environment in Al-Baha**

It is currently difficult to determine the boundaries of the city centre of Al-Baha, as shown in Fig. 16. To address this necessitates the cooperation of a team of relevant government agencies, focused on reconsidering aspects of urban planning, design, regulations, and controls for urban and city development (Al-Baha Tourism Development Strategy, 2000).



**Fig. 16: Showing the center of Al Baha city**  
Source: Saudi Tourism Guide, 2018.

## **11. WASTE GENERATION AND ITS NEGATIVE EFFECTS ON ECOSYSTEM**

There are two main sources of waste generation that have negative effects on the Al-Baha ecosystem, Tourism activities, and increasing urbanization, so strict development plans, standards, systems, and regulations must be placed to evaluate ecosystem waste management. In the case of the Al-Baha region, which offers a unique ecosystem as a tourist product, the plans must also

contain an administrative review system as a whole, knowing if the system can ensure a high quality level in reducing and recycling waste.

The area lacks a waste disposal system, septic tanks, and groundwater sources; this significantly impacts the Al-Baha region's attractiveness and its consideration of it as a distinguished tourist destination. The system currently used for collecting and disposing of solid waste is not effective in cleaning urban areas and their surroundings of waste. Dumping waste on roads and at tourist sites must also be addressed.

Forest parks lack general waste management due to visitor numbers; this leads to a decrease in the value and quality of the ecological characteristics and its surroundings.

In case to protect the distinctive urban character of the mountainous region and its authentic customs, the various traditional residence sites, and the general appearance of the nature of the region from visual distortion, it needs to study the resources and systems related to the development management and control of its effects.

### 11.1. Touristic General Waste

Visiting forests, amusement park, trekking, and shopping are the most popular tourist activities in the Al Baha region. These activities generate a great amount of waste, as the following **Table 1**.

**Table. 1: Entertainment activities and the Percentage of tourists who practice them in Al-Baha region.**  
Source: (The General Authority for Tourism and Antiquities. 2018)

Activity	The percentage of tourists
<b>Entertainment</b>	
Visit a forest	95%
Picnic in the countryside	27%
Picnic in an urban area	11%
Cultural event/festival	26%
Amusement park	49%
Public garden	41%
Zoo	1%
<b>View the landscape</b>	
Heritage village	16%
Religious site	13%
Historic/artistic site	11%
Geological features	6%
Museum/gallery	3%
<b>Shopping</b>	
Shopping centre	72%
Summer market	61%
<b>Sports</b>	
Events	10%
Individual sports	6%

For instance, Raghadan Park, which is located north of the Al-Baha region and is considered one of the five largest forests in the Al-Baha region, with an area of about 600,000 square meters, which varies between gardens for families, amusement parks, theatre, waterfalls, and shopping places. It is clear that the number of visiting tourists is increasing, which has some negative effects

on the environment and wildlife in the park. However, there are bins for garbage disposal in the park, which are then emptied into abandoned landfills in the park.

Recently, the municipality implemented a waste disposal project based on automatic waste collection; to be a perfect alternative to open boxes.

Garbage is collected and transported via a network of underground channels, and this mechanism keeps roads and streets neat and clean, as shown in Fig. 17.



Fig. 17: Waste disposal project based on automatic waste collection  
Source: <https://sabq.org/saudia/regions/ctsgde-3>

## 11.2. Commercial and Domestic General Waste

Municipal waste generated in recent years is increasing and mainly due to the increasing urbanization, which has negatively affected the Al Baha ecosystem. Many small villages and scattered and isolated buildings have appeared throughout the region, especially in sites with distinctive and unique environmental characteristics along Wadi Qub, such as the villages of Raghadan, Al Tawila, Al Jadiyah, and Bani Saad, as shown in Fig. 18. This random growth has resulted in various kinds of sewage and waste, which negatively affects natural resources, vegetation cover, public service supplies, roads, and infrastructure. Many mountain sites with distinct natural characteristics have also been converted into housing schemes and apartment buildings, and the resulting waste dumps have spread along the mountain terraces. As shown in Fig. 19, the forests in the city of Al-Baha have also been affected by urban expansion, with the southern parts of Raghadan Forest and Shahba Forest impacted by modern projects and buildings.



**Fig. 18: Increasing urbanization in Al Baha region**  
Source: <https://earth.google.com/>



**Fig. 19: Urban encroachment on the forests in Al-Baha**  
Source: The General Authority for Tourism and Antiquities. 2018.

## 12. ECOLOGICAL CONSIDERATIONS AND THEIR RELATIONSHIP TO WASTE DISPOSAL SYSTEMS:

In the case of the Al-Baha region, which provides a sensitive ecosystem as a tourist product, there must be a strategy for determining the ecological impacts resulting from tourism that bring about changes in the region. There must also be a review of the administrative system as a whole, to establish whether the system can guarantee a high level of quality in waste minimisation and recycling.

In general, the area lacks a waste disposal system and septic tanks for groundwater sources. This has a significant impact on the attractiveness of the Al-Baha region and its consideration as a distinctive tourist destination. The system for solid waste collection and disposal currently in use is ineffective for clearing urban and surrounding areas of waste. The issue of littering on roads and tourist sites must also be addressed.

Forest parks lack public waste management, due to visitor numbers. This leads to a decrease in the value and quality of the ecological characteristics and its surroundings.

To protect the distinctive urban character of the mountainous region, its authentic customs, the various traditional places of residence, and the general appearance of the region (being free from visual distortion of nature), it is necessary to study the resources and regulations related to development management and control of its effects.

### 13. WASTE TREATMENT IN AL-BAHA

The municipality of Al Baha City has the implementation responsibility for cleaning the tourist waste and the domestic urbanization waste, which relies on the city's available capabilities or the local contractors. Daily household and commercial waste production in Al-Baha is approximately 500 tonnes. In addition, there are around 400 tonnes produced by demolition and construction work. The area has a main landfill site on Al-Aqiq Road, but this has no systems for collecting leachate and gases. Previously, it was located far enough from the urban area, but it is now close to residential neighbourhoods, and waste is dumped to a height of 19 metres. The large landfill site is located east of Al-Baha city, on an area of 1.5 square kilometres, and it is almost full. An adjacent site has been chosen as an extension to it. The landfill requires the collection of gases after their emission, in addition to collecting the resulting wastewater and not polluting the groundwater. It is beneficial to recycle waste efficiently and economically.

A constant problem is the outbreak of fires in landfill, the release of flames, and the emission of fumes, as shown in Fig. 20.

The current landfill has existed for several decades close to residential neighbourhoods and several main sites, the most important of which are King Saud Airport, the air gate to the Al-Baha region, and the University City in Al-Baha.



**Fig. 20: Rising smoke in the sky east of Al-Baha city**  
Source: researcher

There is a healthy engineering landfill project in Wadi Rakh in the Al-Baha region of the Al-Aqiq Governorate, it is 40% completed. It is required for landfills to be outside the city, and their orientation at residential communities should be against the direction of the prevailing winds. One of the most important areas of the Al-Baha region is the Nakhla centre, particularly its northern view. It is considered one of the most beautiful tourist sites in the Al-Baha region. It is also one of

the largest valleys that feed the Wadi Al-Adra dam and water well projects; thus, landfill there can cause negative health effects, spread epidemics and diseases, pollute and destroy the environment, and create visual distortion for travellers, residents, and tourists. The Palm Valley site is shown in Fig. 21.



**Fig. 21: Landfills in the Palm Valley pose health risks and create environmental pollution.**  
Source: researcher.

## **14. WASTE MANAGEMENT APPROACHES AT AL BAHA REGION.**

### **14.1. Developing a waste management plan**

Developing a plan for solid waste management in Al Baha region must be discussed by stakeholders as well as community participation. Objectives must be set for the waste management program; as shown in Fig. 22, these objectives could be summarized as follows:

- 1- Environment: by preserving natural and cultural resources.
- 2- Health: By providing a clean environment to protect human health.
- 3- Efficiency: To use resources efficiently and cost-effectively.
- 4- The local economy: To stimulate tourism and provide job opportunities.
- 5- Participating systems: Encouraging work with stakeholders and local communities.
- 6- Awareness: Training, and support for educational and research activities.
- 7- Culture: Preserving local culture (heritage, traditions, religion, and art).
- 8- Appropriate technology: To use appropriate technology for local conditions.

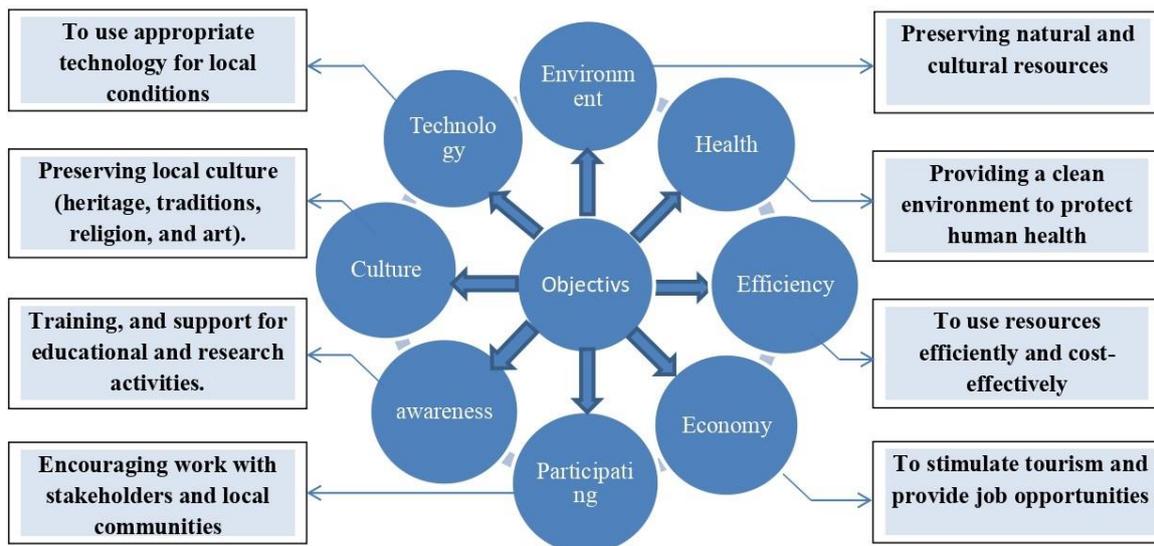


Fig. 22: Waste management plan  
Source: researcher.

### 14.2. Waste management framework

Proposed Treatment guidelines compatible with the sensitive ecosystem areas should be followed, such as technologies that reuse local waste, and non-biodegradable waste that is collected and disposed of off-site, as shown in Fig. 23.

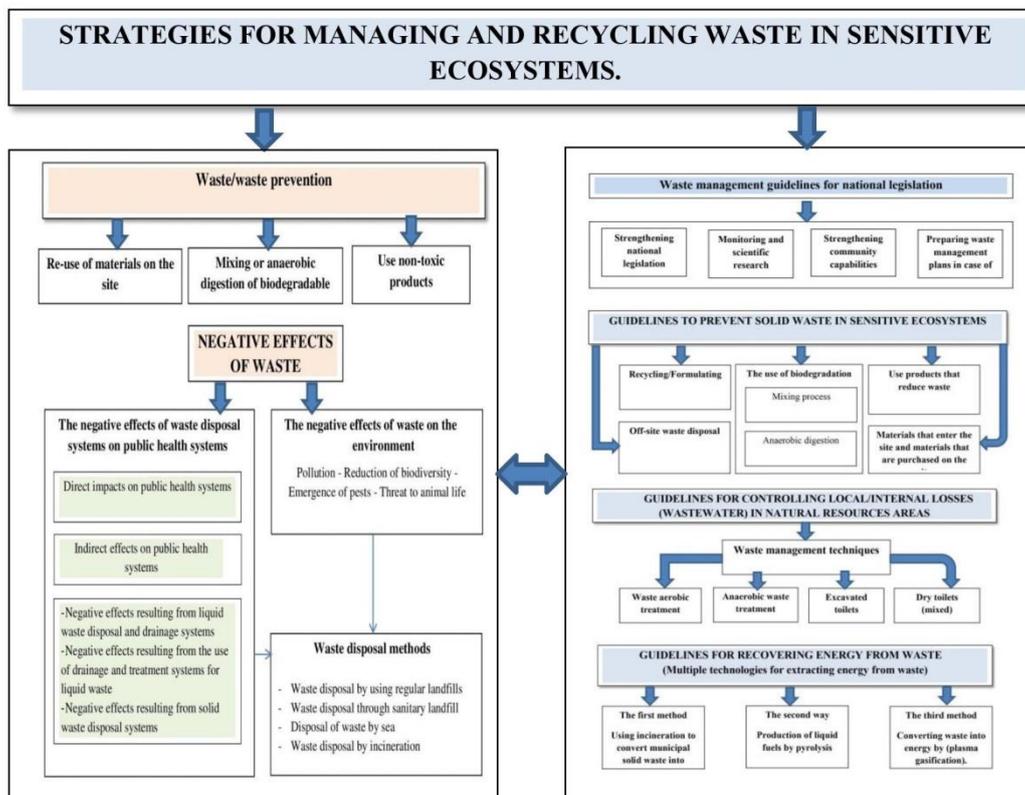


Fig. 23: Waste management Guidelines and technologies framework  
Source: researcher.

### 14.3. Waste Management Priority

The waste management process generated can be organized according to its nature, composition, and quantity and this process can be arranged in a hierarchical sequence as shown in Fig. 24.

Avoiding and reducing waste is of particular importance due to the great environmental impact of this waste, and the potentially harmful consequences for human health. Where hazardous waste cannot be avoided, emphasis must be placed on regulation, not only in setting standards for treatment and disposal but also in ensuring safe and responsible reuse and recycling.

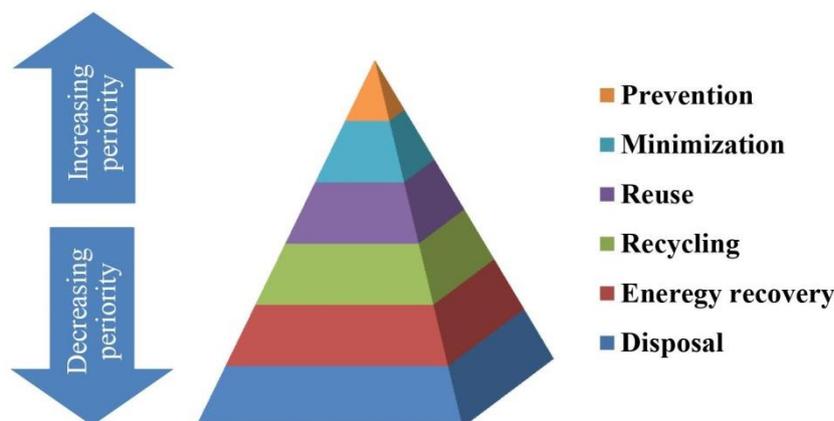


Fig. 24: The Waste management Hierarchy  
Source: researcher.

## SUMMARY AND CONCLUSIONS

The recycling of waste contributes greatly to achieving social balance. On other hand contribute to protecting and preserving the ecosystem from pollution risks and achieving economic resources. Therefore, the principles and guidelines discussed in the study to prevent solid waste are considered among the important environmental issues that must be followed, especially in sensitive ecosystems. In a way that achieves ecological balance, raises productivity, and creates a new economic horizon.

It is also clear that the recycling of waste using scientific treatment methods and advanced technology for recycling are the sustainable ecological management priorities that developed countries seek to achieve. This was clear by presenting their world-leading experiences in the waste management and recycling field.

The results also indicated that despite Saudi Arabia have established waste regulations; to create awareness of hazardous waste management; however, there is a need for an effective practice plan of safe management to be applied in sensitive ecosystems, such as the Al Baha ecosystem.

The results also indicated that there are serious attempts and projects concerning managing waste in Al-Baha parks using appropriate technological means, coordinated between the municipality and the private companies, also the urbanization and the increase in tourism activities had a negative effect on agricultural areas and vegetation in forests. Table 2, summarizes the negative effects of increasing urbanization and touristic activities on the ecosystem of the Al-Baha region. (Walid Al-Zamel, Abdullah Al-Qarni, 2019).

**Table. 2: The negative effects of increasing urbanization and touristic activities on the ecosystem of the Al-Baha region. Source: researcher.**

<b>The negative effects of urbanization</b>	<b>The negative effects of touristic activities</b>
The impact of urban extension on the ecosystem of natural areas, including forests, valleys, open areas, and farms located in valleys or on mountain terraces.	The volume of waste generated by residential schemes that are created at the expense of natural areas has increased.
Random Urbanization that extend in all directions horizontally negatively affected farms and virgin natural areas.	Deterioration of the natural ecosystem, due to sewage, domestic, medical and industrial waste, burial sites and/or drainage of the built environment, affecting valleys and dams and thus surface and groundwater.
Urbanization threatens ecotourism attractions, and its negative effects extend to social and economic conditions.	The volume of waste resulting from tourism activities in the region, especially parks and forests, has increased and its negative effects on the ecosystem
The unplanned urbanization led to the deterioration of the urban and architectural character of the region, due to the inconsistency of modern buildings with the traditional architectural character of the historical buildings of the region and the emergence of problems related to corrupt views and visual interruption.	Many forests and wild lands, which contain wild life, have been eliminated, and pests have widely spread.

According to preceding discussion, the Al-Baha region faces many ecological problems requiring immediate attention for an effective waste management system. Therefore, a framework was proposed for a set of guiding risks for hazardous waste management that is compatible with the Al-Baha ecosystem, where waste can be collected, transported, treated, and disposed of safely and effectively in order to reduce the ecosystem impacts while simultaneously improving the economic and social impacts on society.

## RECOMMENDATIONS

Through the above, the following recommendations can be presented:

- Saudi Arabia has established waste regulations; to create awareness of hazardous waste management; however, there is a need for regulations and instructions specific to a sensitive ecosystem as well. Effective practice of safe management still needs to be applied in those areas.
- A regional plan for the Al-Baha region must be implemented to respect available natural resources and potentials, achieve ecological balance, and create housing plans that are compatible with current and future conditions and preserve the natural ecosystem.
- Ecological controls must be developed to control sewage waste in the valleys located within the urban blocs at Al Baha to prevent pollution resulting from it and limit its extension to the main valleys, with separating borders that protect natural forests and wildlife.
- The simple way to solve the waste problem is education, leading to increased ecological awareness, as well as planning solutions in accordance with ecological development aspects.
- Behaviours that lead to waste reduction or elimination, smart policies and legal instruments should be promoted.
- Innovative technological research should be supported to explore new methods applicable in mountainous environments such as waste-to-energy and composting.
- Waste management plans should also be prepared in the event of disasters before they occur and the efficient use of scarce resources both during and after dangerous events.

- In order to avoid the direct and indirect negative effects of urban expansion in Al-Baha, development must be concentrated in sites suitable for planning and not suitable for agricultural development, such as the eastern part of the region.
- Setting legislations for urban expansion, which is considered one of the main sources of waste generation at the expense of the natural environment in Al Baha, especially for the western part of the Shafa region, and linking the northeastern part of the city of Al-Aqiq with the city of Al-Aqiq. Al-Mandaq and Atola, linking the southeastern part with the main road extending from Baljurashi to the city.
- There must be an optimal exploitation of the sensitive ecosystems that are characterized by natural resources, wildlife, and the touristic potential areas, as well as the Sarawat mountain range, which passes through major cities such as Taif, Al-Baha, and Abha.
- Controls must be implemented to control sewage waste in valleys in Al Baha region located within urban blocks to prevent waste generated and spread to the main valleys, with building directives and controls that protect natural forests, especially surrounding forests close to urban blocks, such as Raghadan, and Shahba forest.

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## REFERENCES

- [1] Abdul Karim Abdul Aziz, Muhammad Adel Abrek. (2018), The Impact of Urban Sprawl on Agricultural Lands in the City of Tobruk, and its environs during the period from 2011-2017. *Journal of the College of Education, University of Tobruk*. Volume 8, Issue 12, November 2018, pages 182–208.
- [2] Ahmed Al-Jarallah. (2000). Civilizational development and its impact on oases in the Kingdom of Saudi Arabia. *Scientific Journal of King Faisal University*, 4 (12), pp. 73-82.
- [3] Al-Hassan, Tayel. (2018). From waste to fuel (Environmental solutions and alternative energy), , issued by Alqafilah Magazine, Saudi Aramco, Saudi Arabian Oil co. No. 90.pp, 53-57.
- [4] Bahloul, L. Halimi, S. (2019). Solid waste recycling in order to activate the dimensions of sustainable development - offering international experiences, *Journal of Economics and Human Development*, (10.3.PP. 491-504).
- [5] Bureau of experts at the council of ministers, Kingdom of Saudi Arabia, (2021).Municipal Solid Waste Management System, Royal Decree No. (M/48) dated 9/17/1434, ( pp. 1–25).
- [6] Ceballos Lascurain, H. (1996). *Tourism, Eco-tourism, and Protected Areas*. Gland, Switzerland: IUCN Publications, 5 (10), pp. 34-45.
- [7] Ceballos Lascurain, H. (1997). *Concept Report: Eco lodge Development in Desert and Coastal Zones*. EST Project. Washington D.C. USAID Publications, 124, 320–336.
- [8] Grzegorz Przydatek, (2019). Waste Management in Selected National Parks – A. *Journal of Ecological Engineering Review*. Volume 20, Issue 4, April 2019, pages 14–22.
- [9] Hawkins, D.E., Epler Wood, M., and Bittman, S. (Eds), (1995). *The Eco lodge Source Book for Planners and Developers*. Washington, D.C. The Eco-tourism Society (TES), (pp. 22–48).
- [10] Janeen, Tang. (2004). a case study of a hotel solid waste management program in bali, indonesia. A thesis presented to the University of Waterloo. Green Design. England. Laurence King Ltd, 162, 30–54.

- [11] Lectures of the training course in solid waste management - Institute of Housing Studies in the Netherlands in cooperation with the Housing Research Centre in Cairo - 19/2 to 2/3/2005. (pp. 26–34).
- [12] Lyle, J.T. (1993). *Regenerative Design for Sustainable Development*. New York: John Wiley and Sons, (pp. 27–83).
- [13] Ministry of Agriculture, Forestry, Environment and Water Management. (2018). An overview of waste management in mountainous areas sources and solutions. *Austria*, 3(1), 345–464.
- [14] Ministry of Environment Water & Agriculture. (2021). The executive regulations of the waste management system, issued by Royal Decree No. (M/3 .5/1/1443 AH), ( pp. 1–16).
- [15] Mohamed Abdel-Baqi Ibrahim. (2018 AD), *The Need for Solid Waste Management in New Cities in Egypt*. Cairo. Centre for Planning and Architectural Studies, 7 (18), pp. 36-48.
- [16] Saleh Al-Hathloul (1419). *urban development*. Riyadh: Dar Al-Sahn, 8 (5), pp. 75-81.
- [17] Saleh bin Ali Al-Hathlou. (2002). *The Arab Islamic city, the impact of legislation on the formation of the urban structure*. the Center for the Study of the Built Environment (CSBE), (Issue April 22, pp. 1–20).
- [18] *Saudi Arabia's Vision 2030. The National Transformation Programme. (2016 - 2020)*. Retrieved from Vision of the Kingdom [http://vision2030.gov.sa/ar/ntp: 2030 Saudi Arabia](http://vision2030.gov.sa/ar/ntp:2030), (pp. 1–24).
- [19] Tayel, Al-Hassan, (2018), *From Waste to Fuel, Environmental Solutions and Alternative Energy*, Jordan, *Al-Qafilah Magazine*, 6 (23), pp. 40-49
- [20] The General Authority for Tourism and Antiquities. (2000). *Tourism development strategy in the Al-Baha region*, (pp. 1–46).
- [21] The General Authority for Tourism and Antiquities. (2018). *Saudi Tourism Guide*. (pp. 1–9).
- [22] Walid, S, Al-Zamil. Abdullah, A, Al-Qarni. (2019). *The impact of urban extension on the natural environment in the Al-Baha region in the Kingdom of Saudi Arabia*. Riyadh. Princess Noura University, 15(1), 465–489.
- [23] Wassim Chaabane, (2020). *Solid waste management in tourism destinations in tunisia: diagnostic and improvement approaches*. A thesis For the Degree of doctor presented to the Academic Board of Rostock University, Faculty of Agriculture and Environmental Sciences.

### Websites

- [24] <https://p.dw.com/p/17tue>
- [25] <https://www.nippon.com/ar/views/gu900038/>
- [26] <https://pulpit.alwatanvoice.com/articles/2011/01/27/219130.html>
- [27] <https://earth.google.com/>
- [28] <https://sabq.org/saudia/regions/ctsgde-3>