SUSTAINABLE WASTE PLANNING AND MANAGEMENT FOR THE RESIDENTIAL SECTOR: A MULTI-RESIDENTIAL RECYCLING SYSTEM IN ALBAHA

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Abstract - The application of a waste recycling and management framework plan is a significant step in protecting the environment and investing in local waste. In addition, local citizens and responsible governmental sectors need to view the management and recycling of domestic waste as important in terms of environmental responsibility and investment. This paper examines the value of local waste in the Albaha region of Saudi Arabia and its influence on urban management. The population of Albaha city exceeds 412520 and the region is in urgent need of a recycling framework for the disposal of both its daily and annual waste, in order to protect the environment. This study analyses current levels of waste generation across the region, along with the existing disposal strategies, i.e. the use of landfill and incineration. The findings identify the lack of any precise knowledge concerning the amount of waste generated, as well as the ability to identify which materials are capable of being recycled and re-used. The use of landfill and/or incinerators is currently the only solution found in the infrastructure plan. This study therefore suggests the need for a Waste Recycle Framework (WRMF) to invest and manage local waste, including the recycling of metal and other recyclable materials. The study suggests a number of solutions for managing and recycling waste materials, including: (1) establishing specialised waste recycling companies; (2) managing waste separation through the use of coloured bins in residential sectors; (3) raising public awareness and implementing fines for littering. The study concludes by offering additional recommendations for both investors and the public.

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Index Terms - Waste planning, waste management, waste recycling, waste disposal.

I. INTRODUCTION

An effective approach to waste disposal is essential for the establishment of a waste management policy [1]. The management of waste, including disposal and recycling, forms an important aspect of urban sustainable planning strategies aimed at delivering economic benefits, while also meeting the required environmental criteria [2]. In developing countries, municipal solid waste is primarily made up of over 70% degradable materials, resulting in considerable amounts of greenhouse gas emissions from urban areas [3]. In particular, the increased generation of municipal solid waste containing high elements of organic waste, along with its unscientific disposal, leads to an increase in the emission of CO2 into the environment [3].The factors restraining the use of recycling have been identified by Conke (2018) [2]. In China, this results from a dramatic increase in population, along with rapid economic growth, climate change and environmental pollution[4]. Hence, waste recycling has been become one of the most important methods of addressing environmental requirements and participating in the economic system. In recent years, the Chinese government has begun to provide (and regulate) new resources from urban waste recycling, thus generating new materials from waste [4]. One viable choice for the management of solid waste concerns the generation of energy [5]. There is an urgent need to develop a sustainable approach to dealing with solid municipal waste in the Kingdom of Saudi Arabia, particularly within its suburbs[5]. Current municipal solid waste processing in Saudi Arabia consists of collecting waste materials and transferring them to landfill sites located on the outskirts of towns and cities[5]. Saudi Arabia is currently considering waste as an alternative means of renewable energy, capable of contributing to its energy demands, i.e. in the form of electricity [5]. The use of hoisting equipment is essential for collecting and transferring solid waste [6], however, this can expose operators to unhealthy working conditions[6]. Therefore, the key factor to achieving unattended operation is learning and practicing the effective use of solid waste carriers and management [6].

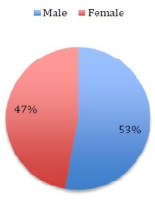
This paper is divided into four main categories, as outlined below.

(a) Statement of the problem.
(b) Research methodology.
(c) Waste disposal approach in Albaha.
(d) Solution strategies.
(e) Conclusion and recommendations.

II. STATEMENT OF THE PROBLEM

Table 3.1: Population pyramid in Saudi Arabia (2009)[7]

	Male	Female
0 to 4	14428	13379
5 to 9	16923	15537
10 to 14	19566	17804
15 to 19	22752	20338
20 to 24	22299	21768
25 to 29	23975	22714
30 to 34	22865	19678
35 to 39	19576	15521
40 to 44	15225	12373
45 to 49	13295	10227
50 to 54	8455	6818
55 to 59	5302	5112
60 to 64	4561	4351
65 to 69	3614	3298
70 to 74	2061	1919
75 to 79	1305	1226
80+	2157	1908
Total	412520	



Waste management is now a key global issue, due the current practice of most societies to dispose of recyclable materials, i.e. cans, glass and plastic. Human beings hold a responsibility towards the environment, including protection from the burning of fossils fuel and minimising CO2 emission rates. This has led to an urgent need to consider the implementation of waste management targets in the Albaha region. Waste generation can be become an issue in the absence of effective management and recycling, particularly in relation to the extraction of recyclable materials from solid and metal products. The employment of a recycling process as an aspect of waste disposal thus transforms such problems into a benefit for both the local economy and the environment. The Albaha region includes seven main towns, each of which has many other suburbs and villages across the region, as can be seen in Figure 2.1.

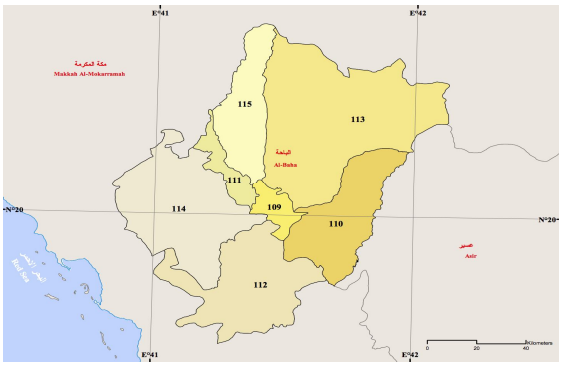


Figure 2.1: Map of the Albaha region

Despite the region's natural resources, there remains a need to focus on the challenge of waste management and disposal, including investment. Alongside the environmental and economical requirements, waste generation should be managed in a way that contributes to the region's income while also protecting the environment. The only waste disposal facilities currently available in the region are a waste incinerator and a landfill site located on the main road between Albaha and Alaqiq, which have led to increasing CO2 emission rates. Albaha city is one of only thirteen regions in Saudi Arabia whose population exceed 412520 (table 3.1) [7], which leads to a potential for the generation of energy from waste materials.

According to [5], there has been an increase in the generation of waste since 2012, which is projected to exceed 3,500 tonnes in Jeddah by 2032. Such waste materials contain energy that, with efficient management, can, as noted above, be exploited for the benefit of the local population.

III. RESEARCH METHODOLOGY

This study examines current waste disposal methods, in order to draw up a sustainable solution for recycling and investment in the Albaha region. It is first necessary to identify the amount of annual waste generated in Albaha in relation to its size of population, as well as undertaking an analysis of its current approaches towards waste disposal. This research employed a qualitative approach to address the following research questions:

RQ1: What is the amount of annual waste in Albaha, based on the number of families and residential unites?

RQ2: What is the current approach towards waste disposal and recycling in Albaha, and what is its impact on the local environment?

RQ3: What are the strategies capable of being applied to find a solution for waste investment and recycling, taking into account the impact on the local economy and environment?

In order to answer these questions, the researcher undertook a site visit, followed by interviews with relevant personnel. The physical survey involved a diagnostic approach to current landfill sites and waste disposal incinerators located across Albaha. The interviews were undertaken with decision makers at the municipality of Albaha, in order to analyse future plans for the management of waste, including alleviating its impact in the urban local environment. In addition, they aimed to identify suitable strategies to create sustainable urban solutions for waste management in accordance with the topography, demands and challenges of Albaha. The analysis of the findings of the survey and the interviews identified solutions for managing and controlling waste, as well as the recycling of solid and reusable waste. One suggestion is for waste management companies to be established to ensure waste can become a valuable source of local income.

IV. WASTE DISPOSAL APPROACH IN ALBAHA

The environmental and economic challenges facing waste disposal in Albaha have resulted from an increase in population, including from the tourism industry and the development of the university at the region. The prediction of the amount of solid waste created is an important target for sustainable requirements in term of its future management [8]. The challenges faced by developing countries include the collection and gathering of data related to waste and the maintenance of accurate records [8]. The generation and production of solid waste is generally related to social, economic and demographic factors [8], although these are subject to change in response to economic and population growth [8]. The most common approach towards waste disposal is to transmit all rubbish to a waste site for incinerators and/or landfill with the latter being the most frequently employed. As noted above, an allocated landfill site accepting all forms of waste is located on the main road between Albaha and Alaqiq. For details see figures 4.1 and 4.2, below.



Figure 4.1: Landfill process in Albaha



Figure 4.2: landfill process in Albaha

The concept of smart city criteria is the provision of new opportunities for waste disposal and management [9]. There is a need for the collection of waste from residential units to be managed and timed in accordance with the number of areas and neighbourhoods. Albaha city contains over 1000 litter bins, distributed across the city, which are emptied daily and taken to the waste site located to the east of Albaha city. This includes food, recyclable waste (i.e. paper and card), as well as steel and wood.

In order to be able to reuse any recyclable materials, this waste needs to be stored and managed, and a framework developed for waste collection. In order to reduce costs, there is a need to resolve issues of transportation, accompanied by the careful location of waste collection points. A large number of studies have confirmed that the positioning of waste collection points plays a significant role in minimising cost. A study was conducted by [10] into regulating the transferral of waste to a disposal site which focused on: (a) the collection points of waste; (b) the additional costs involved in transmitting such waste from the collection points to the disposal site; and (c) waste transportation management by companies [10]. The study established the need to identify the relationship between waste transportation and cost (along with the regulator's profile), in order to support the conclusions reached by the relevant decision makers [10]. In addition, the researchers highlighted that, when the regulator requires specialised companies to be fully responsible for the cost of waste transference, the most efficient collection points are those located in a city centre[10].

V. SOLUTION STRATEGIES

It is essential to identify appropriate strategies for addressing waste management, recycling and disposal, in order to attract local investment and fulfil local environmental responsibilities. The current approach of transferring all waste to landfill sites or incinerators across the region results in an increase in CO2 emissions, and thus the strategies and solutions must commence from the waste generators' 'residential unit'.

➢ Colourful recycled rubbish bins

The management of waste thus needs to start with the consumer. Households generate various different types of waste on a daily basis, which determines how these should be stored, including: (1) food and liquid waste; (2) solid rubbish; (3) organic waste; (4) hazardous waste; and (5) recyclable waste. Recycling appropriate waste materials into new and useful products is an essential process for town planning and management.

The separation process is a pre-step undertaken by firms managing and collecting waste materials from the collection points and taking them to a landfill site. Hence, in order to facilitate the division of waste, each house needs to have rubbish bins of differing colours, as seen in Figure 5.1, below. There are a large number of common recyclable materials, i.e. papers, cans, glass and plastic.



Figure 5.1: Colourful recycling waste bins

There is no standard use of specific colours for separating waste materials, as each country has its

own local standard [11]. This depends on waste generation and the daily amount of recyclable waste materials capable of being reused, as can be seen in Table 5.1.

Table 5.1: Standard colours for recycling bins in four different countries [11]

	Australia (Standards)	New Zealand (Standards)	United Kingdom (No formal standards but common colours below)	United States (No formal standards but common colours below)
General Waste	*Red*	*Red*	*Black or Grey*	*Black*
Mixed Recycling (Commingled)	*Yellow*	*Yellow*	*Blue*	*Blue*
Food Waste	*Burgundy*	*Lime Green* (Food Waste & Combined Food/Garden)	*Brown*	*Green*
Garden Waste/ Organics	*Lime Green*	*Dark Green* (Garden Waste only)	*Brown*	*Green*
Paper/Card	*Blue*	*Grey*	*N/A or not known* (Would probably go into Mixed Recycling)	*N/A or not known* (Would probably go into Mixed Recycling)
Glass	*N/A* (Would go into Mixed Recycing)	*Blue*	*N/A or not known* (Would probably go into Mixed Recycling)	*N/A or not known* (Would probably go into Mixed Recycling)

It would therefore be a simple matter to establish a local standard for waste separation within residential sectors in Albaha. This could be achieved by the Ministry of municipality allocating three colours relating to different kinds of waste, rather than providing one large rubbish bin for each neighbourhood. The benefit of such coloured bins is that each can be linked to a registered residential unit, with the householder responsible for managing their own waste and separating out the types of waste materials generated. At the same time, this enables the appropriate rubbish trucks to be allocated to collect recyclable materials and transport them to an allocated site or to recycling companies for the generation of new products.

➢ **Public awareness**

It is essential to ensure the cooperation of the public for the success of waste management and urban development [12, 13]. Waste management and recycling systems should therefore involve all households in the undertaking of conservation and the recycling of solid waste. This can take place during the initial sorting of waste at the residential unit. Solid waste (including paper, bottles and other metal elements) are important raw materials capable of being recycled and reused for the same, or separate, purposes. One of the challenges in waste management concerns the sorting process employed at the waste site, however manual waste sorting can be simplified when waste is placed in specific coloured rubbish bins. It is important to increase public awareness regarding the benefits of a waste management and recycling system, both in terms of the environment and the local economy. Many citizens fail to consider the disposal of their waste, thus creating difficulties for the sorting process in the city's waste disposal sites. This creates a negative solution through excessive use of landfill and/or burning (i.e. incinerators), thus increasing CO2 emission rates. Town centres demand a high level of energy, particularly in the form of electricity, and these are also areas of rapid urban growth and development, generating large amounts of solid waste [14]. One form of waste disposal is the incinerator approach that produces ash in municipal treatment facilities, resulting in environmental pollution [15]. As waste management needs to start from the level of the consumer and each member of a household, it is important to raise awareness of the issue by means of awareness programmes, run by public media schools, public places works and official media. These should include highlighting the benefits of recycling and the responsibility of each citizen, in order to increase a positive approach to recycling over time.

➢ **Establishing solid waste recycling companies**

Solid waste management plays a significant role in creating a sustainable urban environment [16-18]. The efficient management of solid waste improves both the quality of life and urban development, due to its positive impact on the environment, as well as the social conditions and the economy in countries in which urbanisation is rapidly developing [16]. As noted above, all waste materials in Albaha are currently transmitted from household bins to the incinerators and/or landfill sites. However, there are many opportunities for specified companies to manage and recycle the metals elements and materials separated out from the general waste, thus creating local industries and developing the local economy.

The General authority of statistics (2015) [19] has stated that waste generation per capita in Saudi

Arabia is 1.22 kg in 2015. This has been calculated by divided the annual waste by the population number. The annual waste produced in Albaha is illustrated in Table 5.2, below.

Table 5.2: Annual waste generation prediction in Albaha[19]

Population of Albaha	Waste generation per capita (kg)	Waste generation (kg)
412520	1.22	503,274.4

It would be possible for companies to be established in the spacious area around Albaha city, where they can be located outside the urban growth boundary. Companies could specialise in recycling the steel and wood and plastic waste capable of being reused in the local production industry. In addition, there should be consideration of the needs of existing local industries, so encouraging the development of appropriate recycled resources for use in such companies. Consumer products include a wide use of plastic. The plastics industry faces a number of challenges in relation to the recovery and recycling process to reduce waste materials [20]. A study was conducted by [20] to evaluate strategies with a positive impact on recycling companies and plastic production to recycle and recover solid plastic waste [20]. The research investigated fifteen recycling companies producing plastic in Zambia[20], highlighting the environmental and economic impact of the employment of waste recycling companies to reduce the degree of solid waste. The results indicated that recycling companies can achieve economic, social and environmental benefits [20].

➢ **Fines for littering**

There is a major link between public awareness, responsibility and local policies. As noted above, responsibility for the protection of the environment starts with the consumer, followed by the relevant governmental sectors (i.e. the municipality) and companies managing waste disposal. A policy of imposing fines for littering could be applied, with the income accrued invested in increasing levels of waste recycling and disposal. A study was undertaken by [21] to investigate public support, organisational capacity and education to address the issue of littering. This focussed on two separate case studies: (a) Singapore and (b) the Japanese city of Yokohama [21]. These studies highlighted that littering offenses and waste generation has increased in Singapore but markedly decreased in Japan [21]. The researchers found that public norms and organisations shaping the environment in the cleaning process employed in Singapore resulted in a considerable annual cost [21]. On the other hand, waste is valued in Japan, with a large number of volunteers playing a significant role in its removal, an activity viewed as being productive [21]. This public participation in waste removal results in a far lower cost related to waste than that found in Singapore [21].

Finally, fines for littering can be directly related to public awareness and responsibility. As previously noted, each householder can manage his/her own waste by dividing waste materials on the basis of coloured bins, with specific bins being allocated for recyclable materials, which can then be transferred to companies using them to produce new products rather than employing raw materials. Public places (including schools, parks and streets) also need to be monitored and managed to ensure that all waste materials are placed in the correct bin. The imposition of fines for littering will ensure public cooperation, with such fines also being invested in the waste disposal industry.

CONCLUSION AND RECOMMENDATIONS

This study has investigated the current approach towards the management and disposal of waste in the Albaha region of Saudi Arabia, highlighting how waste can become a natural resource rather than impacting negatively on the environment. Site visits and interviews with a company managing waste disposal examined the current approach to waste disposal, along with location of landfill sites and the amount of the waste generated in Albaha. In addition, the waste generation per capita in Albaha was estimated in relation to the size of the local population. This indicates that the landfill process is the main method currently employed for waste disposal following the sorting and collection of metals, wood and steel. Moreover, the results highlight the opportunities resulting from the increased urban grown in Albaha for investment in waste recycling. The study offers the following recommendations:

- To establish a specialised company for waste recycling in the Albaha region.
- To establish local regulations, including fines for littering, to minimise the misuse of waste, in particular metals and other recyclable wastes
- To employ media schools and universities to run campaigns to increase public awareness.
- To replace the existing mixed waste bins with coloured bins to divide and store waste material from consumers.
- To separate out both organic and hazard materials, which should be allocated a specific landfill site, located at a considerable distance from urban growth.

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