INVESTIGATION OF MUNICIPAL SOLID WASTE MANAGEMENT IN GCC STATES

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By
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ABSTRACT

This thesis investigated the municipal solid waste management in GCC states. An investigation of the GCC municipal solid waste legislation's was conducted and compared and some comments and proposed changes were pointed. The main issue of municipal solid waste management in GCC states is the absence of regional co-operation on government level. Therefore recycling and composting that could have a major role in the enhancement of the environment in the GCC states were examined and several actions that could be taken by the GCC government were proposed. The government's role in helping to increase the participation of the public in waste management activities was discussed. A regional recycling scheme was investigated and proposed including some financial aspects. Composting facilities in GCC states were investigated and especially composting as an alternative in Kuwait. Some recommendations on composting were presented. Investigation of construction and demolition waste recycling opportunity in Kuwait was examined.

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CHAPTER I

GULF CO-OPERATION COUNCIL (GCC)

1. GULF CO-OPERATION COUNCIL (GCC)

1.1 Background

On 4 February 1981, in Riyadh, Saudi Arabia, the leaders of the Arabian Gulf States established the formation of a new organisation to be known as the Gulf Co-operation Council (GCC), with the aim of strengthening relations and co-operation among the members. The GCC consists of six states, which are aligned on the western side of the Arabian Gulf. The states are:

- State of Kuwait
- Kingdom of Saudi Arabia
- United Arab Emirates (UAE)
- State of Qatar
- Sultanate of Oman
- State of Bahrain

These countries share a similar ideology, heritage, and culture, as well as similar political, social, and demographic structures. Table 1 provides general information on the GCC states, such as climate information, population statistics, and locations, and Appendix I presents a general map of the Gulf States. Each country is described in greater detail in Appendix II.

Table 1: General Information Summary on GCC

STATE INFORMATION	KINGDOM OF SAUDI ARABIA	STATE OF KUWAIT	STATE OF QATAR	UNITED ARAB EMIRATES	STATE OF BAHRAIN	SULTANATE OF OMAN
Area (Km2)	2,250,000	17,818	10,360	83,400	690.83	300,000
Population	12 Million	1.84 Million	0.3 Million	1.8 Million	0.431	2 Million
Climate	- Hot summer - Moderate - Cold winter varies according to region	- Hot summer sand - Sand storms -Pleasant winter	- Hot & Humid	- Hot & Humid	- Hot & Humid	- Hot Summer - Pleasant Winter(North) - Moderate all year around (South)
Economy	- Oil production - Agriculture	- Trading - Petroleum - Foreign Investment	- Oil Production - Natural Gas	- Trading - Petroleum - Natural Gas	- Trading - Petroleum	- Oil Production
Official Language	Arabic	Arabic	Arabic	Arabic	Arabic	Arabic
Religion	Islam	slam	Islam	Islam	Islam	Islam

SOURCE: The Encyclopaedia Americana Inter. Edition 1991 Vol. 27,14,20,24,23,3
Kingdom of Saudi Arabia, Ministry of Information, Information Affairs Interior Information. This is our Country 1992
Bahrain Chamber of Commerce & Industry Directory 1990-1991
Sultanate of Oman, Ministry of Commerce and Industry 1992
UAE, Ministry of Finance & Industry - Industrial Dept., Industrial Directory 1992

The GCC states have special relations and common characteristics that tie them together. Recent circumstances, such as the Iraqi invasion of Kuwait, displayed to the leaders and the people of the GCC the need for a serious unification process to be initiated at various levels.

It has become clear to the GCC members, through their different meetings on economic unification, that small-sized, isolated entities cannot expect to achieve progress individually. Therefore, co-ordination and integration between member states are the only routes for GCC development and prosperity. An article published by the (***Municipalities Magazine*1992**) asserted that "Today, the absolute theories of economic integration have been achieved, the academic conceptions have become more flexible in implementation, and we can see the experiences of the European Common Market in their endeavours to implement theMaastricht treaty. The article also pointed to the experiences of the GCC states in economic integration as being the most successful in modern times. This is due to the GCC's position of solidarity taken towards any outside intervention that may affect their common interests, e.g., financial, military, and declines in oil prices

Another article, by **(Nafie1992),** Managing Editor of the *Municipalities Magazine*, indicated that the GCC countries have distinctive economic characteristics that encourage them to co-ordinate and co-operate economically, financially, and technically to attain economic integration. These similarities are reflected in the Unified Economic Agreement (UEA) of 11 November 1981, reached only six months from the date of the establishment of the GCC. Some of the provisions of this agreement, which addresses the financial rights and relationships between the GCC states and their citizens, were only put into effect on 1 March 1983, Appendix III.

It is clear that the challenges facing the GCC area call for more integration, which will be a crucial element for a new economic age. It is a commonly held view that the world is a single economic entity; thus, separated economic existence is out of the question, especially in the case of the GCC states.

Individually the GCC states have a strong economic role and influence at both regional and international levels. Economic integration would strengthen the GCC states' position internationally in that they would form an economic block. The GCC's main objective is to enhance co-operation and achieve integration among the member states in all fields including the economy, finance, education, culture, society, health, defence, communications, passports, customs, movement of individuals and goods, and legal and judiciary affairs.

In reference to the monetary and the investment fields, several decisions and recommendations have been made by the GCC's Finance and Economic Co-operation Committee, including:

- Establishment of joint border customs centres.
- Establishment of a databank at the GCC Secretariat.
- Study of the feasibility of setting up a customs union.
- Unification of electricity, water, telephone, and telex charges, as well as of the prices of refined petroleum products.
- Study of fishing activities in the member states.
- Authorisation for GCC businessmen in any member state to market their products directly either through wholesale and retail dealers, to consumers.
- Authorisation for GCC citizens to own hotels and restaurants in any member state.

- Authorisation for pharmacists and craftsmen to practice their professions in any member state.
- Study of the insurance market in each member state.
- Preference to national products in government projects.

Moreover, the citizens of GCC member states have given particular attention to the development of trade exchange between the GCC states in order to facilitate business. The GCC states are also planning to implement a policy by which joint importation of necessary food and medication can be achieved. The GCC's Economy and Commerce Ministers, i.e., the respective ministers from the GCC member states, have already recommended the introduction of protective measures (i.e., economic and market) for local industries as well as the setting up of a re-insurance company.

The industry ministers in the member states, in a bid to formulate a unified industrial strategy, also urged encouragement for and the introduction of economic and market protective measures for local industries and unification of regulations governing the industrial sectors in the member states. The ministers also discussed the possibility of setting up an industrial fund and industrial training institutes, as well as upgrading similar existing funds and institutes. The ministers agreed to give preference to local industries within each of the GCC member states for government purchases.

1.2 GCC Co-operation for Protection of the Environment

During a meeting of GCC environmental experts regarding co-operation among the GCC states to protect the environment, the following recommendations were made:

- Forging of an anti-pollution strategy.
- Linkage of environmental planning to the overall development plan.
- Support for relevant institutions in the member states.
- Development of uniform specifications on pollution levels.
- Creation of environmental awareness through media and school curricula.
- Co-ordination of research on environmental problems.
- Establishment of an environmental committee to implement policies on environmental protection.

- Holding of periodic meetings of the environmental officials in the member states.
- Enhancement of co-operation in environmental first aid among the member states.
- Intensification of environmental first-aid training.
- Co-ordination of international relief aid for the environment.
- Exchange of experts among the various societies in the member states.
- Unification of attitudes at regional and world meetings.

A few steps have already been taken to ensure the awareness on the part of the people of the GCC of their valuable environment through meetings and conferences held in Kuwait, Dubai and Saudi Arabia. An example is the *First Annual Waste Management Conference* held in Dubai, UAE, on 24-25 September 1993.

The GCC states participated in both the *First* and *Second Euro-Arab Cities Conferences*, held in October 1988, in Morocco and in September 1994, in Spain, respectively. Both conferences received a great deal of attention from the GCC states, and as a result, most of the GCC states submitted several papers pertinent to the municipalities and their responsibilities in developing their cities and towns into modern entities. In both conferences, several recommendations were made, especially regarding the importance of communication between European and Arab cities through meetings and exchanging both scientific and practical experience.

In the *Second Euro-Arab Cities Conference*, a great deal of attention was given to the problem of waste management in the Arab cities. A very important conclusion was drawn; Arab cities have not yet produced strategies and plans to avoid the generation of more waste, and consequently, the formulation of such a waste management strategy is essential.

In early 1995, the Arab Ministers' Committee (i.e., the ministers from the GCC states who are responsible for environmental affairs) adopted the slogan *The Environment and the Economy* to represent their activities during 1995.

1.3 Systems Approach to Solid Waste Management in the GCC States

Solid waste management is at present independently performed in each GCC states with a general lack of co-operation. In addition, there are numerous interdependencies among the various solid waste management policies of the different municipalities in the GCC states. For example, there is no policy preventing the export of paper and carton waste out of Kuwait. At the same time, the UAE's policy is to encourage the import of paper and carton waste from Kuwait and other GCC states. This has created, in just a few years, a large market for paper and carton waste recycling and export in the UAE. The integration of solid waste management policies would influence the economic, industrial, environmental and public sectors. By accepting new, integrated, solid waste management policies, these sectors would develop and strengthen co-operation and co-ordination between the GCC states in various fields for the benefit, development and stability of their peoples. It is important to identify, analyse, select and implement the best possible policy or policies. These policies will be based on legal, socio-economic, environmental and technical factors. The trends in and impacts of the selected policies will influence the solid waste management conceptual framework.

Satisfactory decisions regarding solid waste management policies cannot be obtained by treating each factor, e.g., legal, socio-economic, environmental, and technical, as separate issue. Therefore and to achieve a best possible policy, these factors should be viewed as an interconnected system. In short, a systematic approach is essential to ensure that all of the legal, socio-economic, environmental and technical aspects of solid waste management policies are taken into consideration. Currently, such is not the case. Policies are set without feasibility studies or post-implementation evaluations.

1.4 Thesis Aim and Scope

Between 1980 and 1995, the author was extensively involved in waste management operations in the Municipality of Kuwait. During this period, the author was directly involved with municipal solid waste collection, transportation and disposal activities. As a technical consultant, the author gained specific experience in the planning, evaluation, and monitoring of municipal solid waste (MSW) practices carried out by the various departments in the Municipality of Kuwait. The author gained both theoretical and practical knowledge through training programs, courses and seminars that he attended. Moreover, the author was in charge of conducting field studies pertaining to MSW reclamation.

As a result, he realised that there was a need for a detailed investigation of MSW due the existing drawbacks in the waste management system not only in Kuwait but also in all the GCC member states. These systems and their drawbacks are described in detail in this thesis.

During the author's years with the Municipality of Kuwait, he submitted several proposals pertaining to various environmental issues. The proposals contained a variety of alternatives for the handling and treatment of MSW. Some of the proposals on waste management presented to the Municipality of Kuwait included construction and demolition (C&D) waste utilisation, national MSW recycling programmes, oil waste utilisation, and minimisation of city cleansing costs.

In this region of the world, city cleansing is defined as street cleaning and MSW collection. Studies calling for regional integration in the development of recycling programmes for recyclable MSW materials such as glass, paper, metal and oil were also presented to the Municipality of Kuwait. The author recommended that a joint venture between some of the GCC states be established with the objective of setting up a concrete and steel recycling project. The author was also in charge of performing the initial assessment study on the present landfill sites in Kuwait and worked on upgrading the environmental and technical features of the landfill sites allocated for MSW disposal.

The GCC states are geographically close and share many common traditions. Moreover, there is a growing interest of the members of the GCC states to implement the UEA **(Co-operation Council for the Arab Gulf States, 1988)**. (The Articles of the UEA and discussion are provided in Appendix 3.) Consequently, it is essential that the possibility of integration in the field of MSW management among the GCC states be examined. Also, since each GCC state already pays some attention to its waste management operations, the need to consolidate the GCC's efforts through joint action in the form of a regional co-operation plan for the recycling of recyclable materials, is of greater importance than ever.

The current waste management systems in the GCC states suffer from several defects. For instance, environmentally unsound waste disposal practices have been carried out for a long time. As a result, there is need for a modern and proper waste disposal system. Another defect is the lack of co-ordination and co-operation among the GCC states in the area of waste exchange, treatment and recycling. Such co-ordination and co-operation could result in greater development of the recycling industry in the GCC region. Furthermore, economies of scale could be gained from such co-operation, which would increase the availability of recyclable materials and improve recycling project profitability in this region. Other defects may pertain to MSW legislation, which needs to be updated. Because of these problems, the author believes the main research questions that need to be addressed in this thesis are:

- **What is the current legislation on MSW in the GCC, and what policies could improve the situation?**
- **What are the past and present waste management systems used in the GCC member states, and what should future developments be?**
- **What is the potential for minimisation and reuse of MSW in the GCC?**
- **Can recycling, as a modern waste management alternative, be implemented through a regional co-operative recycling program that includes all or most of the GCC member states?**
- **Is there any potential for the recycling of inert waste within each of the GCC member states?**

The aim of this thesis is to address the above questions through research projects that will provide a basis for creating a conceptual framework for MSW management in the GCC states with specific emphasis on the potential of regional co-operation. The research activities are summarised as follows:

- Studying the GCC municipalities' current organisations, legislation and responsibilities.
- Investigating the present MSW management schemes in the GCC states.
- Examining the potential for the GCC states to co-operate in the field of MSW recycling.
- Examining the potential of composting.
- Investigating the potential of inert waste utilisation.

This thesis will have eleven chapters in which the GCC's MSW management and operation are discussed from various angles. Chapter 1 contains the aim of the thesis, which is to construct a conceptual framework for MSW management in the GCC states. A description of the GCC and its member states is provided, and the co-operation of the GCC states in various fields is discussed.

Chapter 2 is a general review of earlier work regarding waste management in this region, and other important literature related to the objective of this thesis is presented.

Chapter 3 discusses the methodology employed in this study to obtain data. The difficulties encountered were numerous and somewhat peculiar to this region of the world. Thus, they will be explained as will the strategies employed to overcome them.

Chapter 4 discusses the organisations, legislation and responsibilities of the GCC states' municipalities. This chapter also includes some of the important research, and regional and international decisions pertaining to waste management.

Chapter 5 is a detailed description of the investigation of MSW management in the State of Kuwait, which was chosen as the base for this thesis owing to the unique circumstances of the Gulf War and other economic crises. Moreover, economically Kuwait's has always been the most robust of the GCC states and Middle Eastern Countries. In addition, this chapter contains several new pieces of empirical data on waste and its management.

Chapter 6 investigates MSW management practices in other GCC states. There is a description of the present MSW management schemes in selected major cities of the GCC states. Data on the quantities and characteristics of MSW in those cities are provided.

Chapter 7 examines MSW treatment techniques currently in operation in the GCC states.

Chapter 8 presents Kuwait's experience and future plans for managing its MSW through the application of composting as a valuable alternative method of MSW management and utilisation.

Chapter 9 contains data on recycling facilities located in some of the GCC states. A proposal for regional co-operation in the utilisation of MSW is presented. The economic aspects of such co-operation are discussed by means of a market study, and case studies of some existing recycling facilities in Kuwait are presented. A questionnaire is also presented that was designed to determine the attitudes of the students at Kuwait University toward aspects of recycling MSW.

Chapter 10 presents information on a major type of MSW, namely, C&D waste. General data on this type of waste generated in Kuwait are compiled and discussed.

Chapter 11 is the final chapter, and it covers the conclusions and recommendations of this thesis. It also provides suggestions for further research and studies related to MSW in the GCC.

This study deals with the formulation of a MSW management policy among the GCC states that will establish general co-operation among the GCC member states through the application of a MSW recycling operation in the Arabian Gulf region.

The study required data that was difficult to obtain, and was in fact, not available most of the time. Most of the cities covered in this study have undergone few systematic attempts to collect data on MSW. Those attempts that have been made have been directed at specific purposes and limited objectives. The GCC member states' municipalities do have some understanding and appreciation of the issues related to waste management operations, and as a result, some studies have been conducted. Yet none of these studies has tested the possibilities of regional co-operation. A major problem with these studies is the fact that most of them have accuracy problems with the data collected. Several agencies have conducted studies on behalf of the GCC municipalities in the field of waste management. Yet, the outcome of such studies has never mentioned the need for regional co-operation in recycling, composting, or incineration.

There are many difficulties in obtaining accurate data on MSW from the various municipalities in the GCC. The difficulty in obtaining the required information and the lack of access to these data were major issues of this study. One example of data inaccuracy is given here.

The Municipality of Kuwait's Cleansing Department cannot provide any accurate data on MSW management. When asked about the average number of trips made for construction waste per day before and after 1990, the Cleansing Department provided the following statement:

> Before 1990, the year of the invasion, the number of trips per day of construction waste was 700, and because of the size and volume of construction waste produced as a result of the war's destruction and demolition activities, the number of trips per day is 400. Which is an obvious increase in construction waste amounts' (Head of the

Landfill Section, Cleansing Department, Municipality of Kuwait, personal communication).

Even after confronting the Cleansing Department with such incorrect data, the officials did not provide any explanation for any of the apparent inaccuracies in their statement. Other instances of inaccuracy were clear when the Landfill Section was asked to provide information on the total area of the landfill sites and the amounts of MSW disposed of per year. Great variation in the information provided from the Cleansing Department, Technical Office and the Landfill Section was noted.

Similar problems with the accuracy of data were encountered in other GCC states, and by cross checking various studies and reports from several sources. Much of the data was left out of this thesis, as it was obviously invalid.

In this part of the world, it is extremely difficult to collect data from governmental offices on any subject. Such data are considered to be*work secrets*. Officials are also not confident of the data they may already have in their hands. Consequently, they do not want to be held responsible for providing inaccurate data about their own departments. Furthermore, contradictions in the data provided make collection extremely difficult and time-consuming for any researcher. As it is a researcher's objective to obtain as much accurate data as possible from the various sources, the data must be double- and sometimes triple-checked through personal meetings, site visits, and many possible and still legal means to confirm the accuracy of the data collected.

It is of great importance in this area of the New World Order to establish a Regional Data Centre. The General Secretariat of the GCC states has almost no data on waste in the different GCC cities. Few documents with general information about the GCC states' municipalities were found at the General Secretariat's headquarters in Riyadh, Saudi Arabia. The same can also be said of the Arab Towns' Organisation there where the lack of reports, studies, and/or recent data on waste quantities, methods of treatment, and municipalities' future plans for solid waste handling was also noted.

CHAPTER II

Methodology

2. Methodology

2.1 Background

This chapter deals with the various techniques used in the development of this thesis. Often researchers use single or multiple methods to conduct the different tasks of the research projects. The author was interested in applying more than one method in order to be able to accomplish the various tasks of the research projects. This interest is based on the need for using different methods due to complexity of executing the research tasks in this region. Several books were written on research methodology some of which are given below and which provided the author with general knowledge on research methodologies:

(Fox 1969) provided a comprehensive coverage of variety of research methods for use in social sciences and humanities ranging from content analysis to the experimental design model. This text is particularly good on practical aspects of carrying out research of this type.

(Struening & Guttentag 1975) provided a guide to research in the evaluation of social policy taking in many types of analysis and data collection methods particularly the experimental design model.

(Cohen & Nagel 1934) put a standard text on scientific method, which considered both experimental and observational studies and history.

(Glaser & Strauss 1967) a key reference for the student engaged in exploratory research. Distinguished by its insistence on the interaction between data gathering and theory development. Also contains novel ideas on data sources. It is an interesting text for all researchers making use of field observations.

(Howard & Sharp 1983), define research as:

> Seeking through methodical processes to add to one's own body of knowledge and, hopefully, to that of others, by the discovery of non-trivial facts and insights

A key word in their definition is methodical processes. The author of this thesis believes that not only these methodical processes are related to research objectives and data analysis, but also to the culture where data are being gathered.

While conducting the projects of this research the author faced several cultural, and political constraints.

It was difficult, and sometimes impossible, to carry out the projects of this research due to unavailable records on MSW. Moreover, when records were made available they were neither consistent nor easy to follow.

Time and efforts were invested heavily in the development of the research projects. In gathering, investigating and evaluating the actual data on MSW trips to each of the GCC states was made by the author. The travelling between the cities of the GCC states was a new experience to the author. In away many lessons were learned about the behaviour and attitude of the people in these cities regarding waste generation, source separation, recycling, composting, and disposal.

During the research it was very difficult to gain access to the required information on MSW. Official letters to be submitted to the municipalities officials indicating the purpose of the research and what will the data be used for in specific. In some cases the meetings and interview were not allowed with the landfill sites technical staff. In other cases municipalities officials at the landfill site confiscated the camera. That was due to bad experience with persons who claim that they were researchers and turned to be newspaper reporters that wished to publish the municipalities improper disposal operations.

2.2 Primary Sources for Data

In this part of the world you may reach your target in three ways in order to obtain data from primary sources. First, direct contact (interview)(**Gorden 1969**), with key persons on the subject you wish to investigate. Second, through mediators who facilitate the way for you to gain access to required information. Finally, through the use of questionnaire(**Moser & Kalton 1971**); and (**Berdie & Anderson 1974**); archival data (**Glaser & Strauss 1967**), and field observation (**Webb 1966**). These three ways are simple to talk about yet difficult to implement within the GCC states. The author of this thesis found that the use of a third party (the second way) is the most practical when dealing with GCC officials in order to obtain the required data. They tend to be more comfortable dealing with people they know and trust that they would not expose their improper handling of waste issues to public opinion.

The author also found that government officials were not interested in relatively long interviews where they have to take lots of care in answering questions. They are also so manipulative in declaring what they want the public to know not what the public wants to learn. Therefore they tend not to answer the questions proposed by the author neither direct nor through the use of questionnaire.

In most cases those officials lack the technical background on MSW issues. As a result they tend to pass the questions to other subordinates who have slightly better knowledge about MSW.

2.3 GCC General Secretariat

Since the author was dealing with GCC states, it was appropriate to contact the GCC General Secretariat in Riyadh as the first best location to collect data on municipal affairs. They have a department known as the municipalities department. Engineer Waleed Tawfiq is the Head of that department told the author that it is in general very difficult to get information on MSW from the GCC municipalities. He claimed that GCC municipalities showed, over the years, very low level of co-ordination, co-operation, and participation in the General Secretariat research projects. He even indicated that some of the GCC municipalities treat their information with great security as if it was military classified information.Tawfiq gave an example about his endless efforts in collecting the municipality organisation structure from the various GCC states, which resulted in little success. All municipalities did not answer Tawfiq letters' to the various GCC municipalities requesting data on MSW organisation structures or composition and quantities. He indicated that more co-operations between the municipalities of the GCC on one hand and between them and the GCC

Secretariat is required since the GCC Secretariat is looking forward to establish the municipal library. Tawfiq also indicated that requesting data of financial nature from the GCC municipalities is hard to obtain. He also felt that using questionnaires as data gathering tool was not successful.

2.4 Arab Cities Organization

Another organisation, which the author felt that could be of help in obtaining data on GCC municipalities was the Arab Cities Organisation located in Kuwait. The author met with several staff members from this organisation to gather the required data for this research. Each one of them had its own experience and knowledge about the GCC cities and their municipalities yet the information they presented were general. The Arab Cities Organisation has a library, which is also poor in its contents on municipal waste management information. The author met with the general manager, Wasel Mansour, who used to be a manager at Kuwait municipality during the 80s. He elaborated on the real issues facing the municipality in Kuwait and other GCC states.Mansour recommended that the author should travel to meet with officials from the various GCC municipalities in order to assess their current waste management scheme and to obtain studies and documents pertained to municipal waste.

2.5 GCC Municipalities Interviews and Field Investigation

Consequently, the author arranged for trips to all GCC cities considered adequate for this research to conduct interviews and field investigations so to stand on the top of the waste management issues at each city. The author realised that it is important to seek the assistant of third party to introduce him to officials who he has not dealt with in the past. This methodology worked even better than going directly to meet with people who the author knew previously. Almost all GCC officials were conservative in their comments and answers. They also preferred to answer small number of questions. The author tried to ask them several questions yet he could not get all the answers. Even though the author used a non-directive way to bring certain subjects into the discussion the officials were again careful in their responses. Therefore; he found that the best way is to shortlist the important questions according to their answers. The author needs to indicate here that not every answer from some of the officials was correct or accurate. Therefore, a field investigation was conducted to compare the information received from the GCC municipalities. The author managed to take photographs of landfill sites, and collection vehicles during their operation mode. Almost every official met with the author indicated that they use sanitary landfill for the disposal of MSW. The actual situation is most of these landfills are insanitary landfill sites. A major problem with most of the GCC municipalities is related to policy implementation. Apparently the decision-maker at the municipalities are not aware of the delay of implementing their policies and decisions by the other levels of management. According to several general managers in GCC municipalities it is difficult to deal with the waste amounts generated on a daily basis. This is the usual excuse the author received from them. Also some of them indicate that budget constraints are limiting their ability to implement some of the policies which are vital for managing waste. An official in Kuwait said, "a sanitary landfill to be designed according to standards will cost a large sum of money". The author found that unacceptable especially when we compare the wealth of Kuwait to the wealth of other third world countries that is implementing sanitary landfill concept. Also they indicated that they are facing some political constraints when dealing with allocation of landfill sites or waste treatment plants.

2.6 Telephone Survey/Questionnaire

Another method used by the author was the telephone survey method. That was used to increase the response rate and to obtain a random sample of population in Kuwait. The telephone survey method was selected over the postal questionnaire due to poor postal service in this region and especially in Kuwait. Moreover, since the postal questionnaire method depends on how well the respondents understand the questions and how close their interpretations to the author interpretations this method was rejected. The conclusion about possible misinterpretations was gathered after conducting a pilot survey. The pilot survey indicated that the respondents would need the presence of the author to explain some detailed information as a background to the subject of the questionnaire. As a result the author decided to conduct a questionnaire survey at Kuwait University where he met with a sample of students from different classes who were attending an environmental class. Although a pilot survey was conducted prior to passing the questionnaire to the sample, some questions were raised during answer session. Those questions indicated to the author that he should not assume full understanding by the sample due to the unfamiliar terms, expressions, and logic behind those questions. The assumption that the sample level of education will be reflected in their answers was not fully true.

2.7 Field Observation

The author found that Field observation was an effective method for the research projects. Due to lack of information and statistics on MSW in the GCC states it was essential to observe the actual generation, collection, and disposal activities in order to draw actual conclusions. MSW quantities were investigated using a small representative sample of vehicles that arrived at the three main landfill sites in Kuwait. Collection of MSW performance was determined through field observation for the various cleansing companies operating in Kuwait. Several pictures were taken from different collection areas in Kuwait that indicated variation in labour performance. At the disposal sites in Kuwait an investigation of criteria compliance was conducted and an assessment of the level of operation was determined based on field observations.

Each of the GCC municipalities has a small collection of documents on MSW. Researchers may face several problems getting to such collections in the first place. Once you get the chance to examine such collections they usually do not express enough details and they tend to provide general information to basic readers. Reports and studies were hard to find since there was not a central location were such documents may be kept. Researchers need to go from section to section at the municipality to find some of the studies in possession of certain officials.

2.8 Secondary Sources for Data

As a secondary sources for data on MSW in the GCC states the author identified Journals, which are Municipalities Magazine and Middle East Environment. The only text book found on municipalities in the Middle East was the book published by the Arab Institute for Cities Development titled General Cleansing and Waste Disposal in the Arab Cities. This book which comes in two volumes discuss information provided by the GCC municipalities through a questionnaire survey. The data on GCC municipalities in this book are out dated and incomplete.

Computer databases containing statistics on MSW in the GCC do not exist. The GCC General Secretariat is intending to establish a database for that purpose. So far researchers have to bear with the unavailability of data on MSW in the GCC.

The author made use of computer spreadsheets to build a financial model for GCC regional recycling facility. The financial model was established based on waste materials availability, market prices and demand for recyclable materials within the GCC states. The model provided an insight to the potential benefits of recycling through regional co-operation scheme.

2.9 Case-Study

Another method used in this thesis was the case-studies method. The author presented five different case studies, which discussed the following subjects:

(1) Kuwait MSW management as an example for the GCC states.

(2) Oil recycling in Kuwait as potential alternative for other GCC states.

(3) Al-Qurain insanitary landfill, an example of negative impacts on the environment due to improper disposal.

(4) Composting experience in Kuwait and lessons to be learned by other GCC states.

(5) C&D waste recycling in Kuwait a model for other GCC states.

In general the author used several methodologies to accomplish the tasks of this research. The following table 2 demonstrates these methodologies not necessary in the same order they appear in the thesis.

Table 2: Various Methodologies Applied with examples and remarks on its applicability and effectiveness.

Methodology	Examples	Remarks on applicability and effectiveness
Literature review	Papers, books journals…etc.	Few literatures were available yet out dated or irrelevant
Interviews	Organisations, public and private	Using mediators is almost the best way for obtaining as much accurate data as possible.
Field investigation	MSW amounts and characteristics	Difficult to apply and requires authority's support yet extremely effective in obtaining unique data.
Survey Questionnaire Telephone	Kuwait University students, and general public	Some degree of difficulty in applying, and not so effective due to lack of co-operation
Case-study	Five different cases study.	Difficult to apply due to confidentiality yet high degree of effectiveness.
Environmental and Technical assessment	Landfill sites in Kuwait and compost plants in GCC	Difficult to apply due to travel constraint, technical background, confidentiality yet effective.
Financial Modelling	Regional recycling facility	Difficult to moderate due to lack of data yet highly effective.
Photographs	On-site activities in landfills & collection areas	Difficult to moderate depending on the location, very effective in conveying the message.
Personal communications	Municipality officials, environmental agencies	Difficult to moderate based on the position of the contact, highly effective in obtaining some data.

CHAPTER III

Literature review

3. LITERATURE REVIEW

This chapter reviews certain areas of literature, which are relevant to the main study although not directly about MSW management in the GCC. However, the studies that are reviewed help to put the current study into context with other work that has been done. It was very difficult to find papers or books written on solid waste management related to the GCC states.

The author searched for information on GCC municipal waste both locally and internationally, but the material found was not extensive.During visits to the United Kingdom (UK) and the United States of America (USA) between 1991 and 1995, the author conducted a number of searches through the environmental database systems linked to several educational institutions, such as the University of Stirling in Scotland, and the University of Dayton, the University of Cincinnati, the University of Miami and Ohio State University in the USA.

The objective was to find information related to waste management in the GCC states. Yet, not a single paper was found. Moreover, the author searched for data through institutions within the GCC states, such as the

Kuwait Institute for Scientific Research (KISR), Kuwait University, the GCC States' General Secretariat, and the Arab Cities Organisation, as well as in the archives of several journals and magazines. However, most of what has been published about waste management in the GCC states is limited and outdated information. Few papers and reports discuss current aspects of waste management in the GCC states. This lack of literature emphasises the need for the research programme covered in this thesis. The literature found is reported below on a country-by-country basis.

3.1 State of Kuwait

Between 1978 and 1979, the Municipality of Kuwait conducted a study on municipal waste management with the assistance of a Swedish consulting firm **(VBB 1979).** The study included estimates of the amounts of different kinds of waste contained in the total waste generated. These estimates were based on the number of trip-loads from the cleansing centres to the sanitary landfills. The average weight of a load was established from other deliveries to the compost plant. The total amount of domestic waste was estimated to be 700,000 tons per year for a total population of about 1.1 million people. The per capita waste generated was about 610 kg/y, and the level of waste ranged from 490 kg/y per capita for Kuwaiti areas to 740 kg/y per capita for non-Kuwaiti areas. The figure for non-Kuwaiti areas seems to be an overestimation, possibly for the following two reasons. First, the residents of the non-Kuwaiti areas are mostly low-income households. As a result, less consumption of foodstuff, newspapers, and packaging materials is expected, which should be reflected on the amounts of waste produced per household and per capita. Second, most of the non-Kuwaiti residents are foreign labourers who tend to be conservative in their spending habits, and who save a large portion of their income for future obligations in their home countries.

KISR performed a study in 1982 to estimate the amount of organic waste that can be converted into compost **(Allam 1982)**.According to KISR, the total amount of organic matter in the MSW stream was 1,470 t/d. The study took random samples MSW during a three-week period to obtain daily data on the types of trucks used and the number of truckloads of waste collected for each of the 46 districts in Kuwait.

Since the Municipality of Kuwait was in charge of MSW collection and disposal up until 1982, the year the waste management services were privatised, monthly records of the hauls made to the dumping sites were kept for evaluation. On the basis of an average of 3.5 t/haul (trip), the amount of MSW generated was estimated to be 2,275 t/d or 830,375 t/y. Although, the Municipality used an average of 3.5 t/haul in their calculations, the records included trucks with capacities far greater than this. The author discovered that the Municipality's records were based on visual observations of the trucks coming into the landfill sites rather than on the weighing of a sample of the trucks. This indicates that the estimation technique was rather primitive and scientifically questionable.

The Swedish consulting firm conducted a similar study in 1982 on samples collected from some areas in Kuwait **(VBB 1982).** The study estimated the daily generation of MSW in Kuwait in tons (Table 3.1).

TABLE 3.1: ESTIMATED DAILY MSW GENERATION

Year	1982	1985	1990	2000
Minimum	1,564	1,550	1,841	2,276
Maximum		1,840	2,276	2,890

In Table 3.1, one can see that in 1982, the maximum amount of MSW estimated by VBB was more realistic than the Municipality's study in 1982, which showed clear overestimation of the amounts of MSW generated in Kuwait (2,275 tons per day).

In 1984 and 1986, two handpicked samples were analysed by Vest Alpine of Austria **(Vest Alpine 1984/1986).** These studies of the average composition of MSW showed that food waste was the largest single component (44%), followed by paper (15%), cardboard and cartons (11%) and plastic (9%). The moisture content was estimated to be about 45% by weight with a carbon-to-nitrogen ratio (C:N) of 25:1. These data confirm that MSW is a readily compost material.

In 1986, the Municipality of Kuwait conducted another study on MSW in which a limited number of households were sampled **(AlKandary 1986).** The average amount of MSW generated was estimated to be 0.909 kg per capita. In the study, the daily refuse of 10 randomly selected households in each of 11 districts was weighed from 10 January to 11 August 1986. The study estimated the average waste generation rates of Kuwaiti and non-Kuwaiti residents to be 1.01 and 0.74 kg/d per capita, respectively.

This estimation by the Municipality was more acceptable in terms of its scientific basis and its logical outcome. The Kuwaiti MSW generation rate was more realistic than the generation rate mentioned in the Municipality's study in 1978-1979 **(VBB 1979).**

In 1988 the Industrial Investment Company **(IIC 1988)** of Kuwait conducted a detailed study on MSW in Kuwait. Their study was based on samples collected from 14 of 16 typical residential areas of Kuwait, with various social and economic structures. The designed sample covered a population of 900,068 persons. In general, the analysis indicated that the MSW generated in Kuwait is suitable for processing and conversion into a soil conditioner known as compost. Kuwait's MSW contains in excess of 60% by weight of organic matter, which may be separated out and further processed to produce compost. The inorganic materials seem to account for less than 30% of the total. The study pointed out that each cubic-metre box contained an average of 20-30 plastic household-refuse bags. It was therefore presumed those 25 bags per cubic metre constituted a reasonable average corresponding to a refuse density of 138.5 kg/m^3. Given an average weight of 5.45 kg/plastic bag, and taking into account that the average size of a Kuwaiti family is around five persons, the expected amount of domestic waste generated per capita is around 1.108 kg/d per capita. Based on these results, the total amount of MSW generated per day by the total population of 1,958,477 was calculated to be 2170 t/d. The IIC's figures on MSW generated in Kuwait are in agreement with the Swedish study conducted in 1982 **(VBB 1982)**, in which the amount of MSW generated in 1990 was estimated to be 2,276 t/d. The IIC study is by far the most scientifically prepared study, and its results seem to be both logical and accurate.

Recently, Kuwait University conducted a research project that successfully provided statistically accurate answers to a number of household-solid-waste-related questions **(Koushki 1995)**. A questionnaire survey indicated that a household in Kuwait generated on average a total of 8.4 kg/d of solid waste. The average family size used in the study of 6.14 persons, led to the determination of a rate per person of 1.37 kg/d of solid waste.

- Based on these rates, the total population of Kuwait (in 1995) generated nearly 2450 t/d of solid waste.
- The difference between the solid waste generation rates—the rate reported by the sample households—and the rate computed from

the landfill disposal data, amounted to less than 2%. Although, households estimated the quantity of their solid waste accurately, their estimation regarding the composition of daily solid waste, by type, i.e., foodstuff, 51.1% (1250 t); paper materials, 18.6% (455 t); plastic materials, 13.4% (330 t); metal/cans, 5% (120 t); glass, 4.5% (110 t), and finally, other, 7.5% (185 t), was grossly inaccurate.

- As expected, a number of household-related factors affected the daily quantity of solid waste generated by the family. These included family size, family car ownership, family income, age of the family head, education of the family head (to some extent), and the number of weekly family shopping trips.
- The fact that the education level of the family head was negatively associated with the daily quantity of the family's solid waste indicates that improving the general public's awareness concerning the problem of urban solid waste should be a high priority for the policy makers.
- A number of structured, yet simple cross-classification models have been developed to forecast the future quantity of urban solid waste for general planning analysis. These models require a minimum of data for the prediction of household solid waste. Work

is in progress towards the development of multiple regression models for a more accurate forecasting of the quantity of household solid waste generated.

- Periodic research is needed to update and modify the data regarding household solid waste in Kuwait.

3.2 Kingdom of Saudi Arabia

(Farsi & Hammouda 1981) presented a research paper on "Cleaning in Jeddah in the Present and Future" to the University of KingAbdul Aziz in Jeddah, Saudi Arabia and to the United Nations' University in Tokyo, Japan. The objective of the paper was to highlight the plans and programmes of the Municipality of Jeddah for a city cleansing system. The paper envisaged the conversion of the manual systems used in the past into fully mechanised systems in the near future. The mechanised systems, which include containers that can be mechanically discharged into rear-loading compactor trucks or directly at a transfer station, incinerators, or sanitary landfills, have already been adopted. In the author's opinion, a fully mechanised system may not be necessary in this region since the cost of labour to perform similar tasks manually is very low. A balance between mechanised and manual systems may be more applicable.

(Bajunaid & Hammouda 1982) presented a paper entitled "Controlled Refuse Disposal by Sanitary Landfill and Incinerators for Jeddah City" at the Fifth Annual Madison Conference of Applied Research and Practice on Municipal and Industrial Waste, which was organised by the University of Wisconsin Extension, Madison, Wisconsin, USA. The authors discussed the problems facing the Municipality of Jeddah due to waste disposal and mechanisation methods adopted in its sanitary landfill, which was established under the management and operation of an American Company. The authors also discussed the perpetration of waste prior to land disposal via transfer stations and incinerators. The controlled burial of waste at the sanitary landfill was also dealt with at length. The city of Jeddah produces about 1250 t/d of domestic and commercial refuses, requiring a sufficient amount of landfill space to handle the refuse. Incineration is used in combination with the landfill, and thus, reduces the volume of refuse significantly, sometimes up to 95%. The question that should be addressed by the municipalities in this region is what is the value added by using incineration as a waste management alternative, especially when considering the minimal energy gained from waste incineration coupled with the low energy cost in this region.

In 1982, the Municipality of Jeddah conducted a preliminary study on its efforts to develop and improve the system of disposing of all types of city waste and a physical analysis of the waste. This study revealed that waste from the city of Jeddah is a suitable and favourable organic source for composting. As such it can be reused for the benefit of the community in agricultural and environmental enhancement. Also in 1982, the Municipality of Jeddah conducted a feasibility study on waste composting in the city of Jeddah. The authors, Hammouda and Bajunaid, discussed alternative methods of waste disposal to replace the disposal of domestic and commercial wastes in (insanitary) landfills. The suitability of the city of Jeddah's waste for composting, waste composition, composting chemistry, waste sampling and technology were also discussed. This study provided guidelines for the selection of compost production as a disposal solution.

In 1983, John Wiley & Sons Inc. published a review in London, which was part of the book entitled *Metropolitan Waste Management in*

Developing Countries. The review described the plans of the Municipality of Jeddah, which has adopted fully mechanised systems for city cleansing and waste recycling of paper, plastic, glass and organic materials for the future. Currently the cleansing activities are well maintained, yet the recycling of MSW is still far behind and demands more co-operation between the public and the authority.

In 1983, a research paper entitled "Implementation Aspects of the City of Jeddah's Urbanisation", was submitted to the University of King Abdul Aziz in Saudi Arabia. The research team, Bajunaid, Hammouda and Gazzard, discussed the costs and benefits of the rapid urbanisation of the city of Jeddah. The paper described how in the process of urbanisation, the city of Jeddah has started to improve and develop refuse collection and disposal with the aid of modern mechanical equipment, vehicles and containers.

Middle East Environment published a review on Saudi Arabia in 1994. The review included a discussion of recycling in Saudi Arabia. It indicated that recycling might be one solution to some of the country's waste management problems. Moreover, Saudi Arabia's recent census put the population at about 17 million, most of whom reside in large urban centres, which makes recycling far more commercially viable than in any other GCC state. As a result Saudi Arabia is considered the largest market in the Gulf as far as environmental products and services are concerned.

(Alam 1997) conducted a study on waste management and recycle in the city of Jeddah. He indicated that MSW is collected through city contractors, private contractors and individual organisations. The average amount of MSW generated on a daily basis is about 4,000 tons. Alam pointed that the city of Jeddah will have the first recycling facility in the Kingdom of Saudi Arabia. A contract was awarded by the Ministry of Municipalities and Rural Affairs to a company called SADACA for environment to start a national programme. The author of this thesis believes that the implementations of this programme in Jeddah will be a corner stone for other national recycling programmes around the GCC states. Moreover it will help in providing a framework and plans for regional integration in recycling MSW.

(Kdo 1997) covered in his paper the importance of paper waste recycling in Saudi Arabia. He indicated that in Saudi Arabia there are two converters, which produce tissue papers and there are a few plants which produce cartons. He also emphasis that in Saudi Arabia only 30-40% of the total imported amounts of pulp, paper, and cardboard (648,000 tons in 1995) are being recycled while the remainder ends up in landfill sites. The author proposed a national recovery rate of 50% of the total amounts of the imported paper. This seems to be a high target to achieve in a ten-year time (by the year 2007) since Kdo's estimation of 30-40% current recovery rate is largely optimistic considering that a national recycling programme does not exist at this time.

(Ali & Hamdan 1997) conducted a study on recycling of lubricating oils in Saudi Arabia to estimate the amounts of waste oil that could be recycled. They described available processes for waste oil recycling which were developed by international firms such as Meinken of Germany, which is already being applied in some of the GCC states, Mohawk of the USA and Kinetic Technology International of the Netherlands. The study covered the economic aspects of waste oil recycling based on figures provided by both Meinken and Mohawk for a capacity of 50,000 tons per annum. A comparison between the two process economics revealed that Mohawk process appears to be more attractive than that ofMeinken. This is due to the expected high profit of the Mohawk process based on lower capital cost than that of the Meinken process. However, one must realise that for the Mohawk process to be profitable it should be tied with an existing refinery to obtain Hydrogen. If an independent hydrogen plant will be established the Mohawk process profit will drop significantly.

(Abu-Rizaiza & Al-Ghamdi 1995) conducted a study on the issues associated with waste collection during the Hajj period in Muna, which is a small valley located about 25 Km Southeast of Mekkah and where 1.5 million pilgrims spend five days in a camping area of about 6 Km^2. The study attempted to quantify the per capita generation of solid waste during the Hajj period (7^{th}-13^{th} of the month of Hajj according to the Islamic calendar) in Muna. The study results' indicated that the average daily generation of waste during that period was 2750.3 tons produced by 1,537,168 pilgrims and corresponds to 1.79 Kg per capita per day. Although this average per capita generation rate is considered high in comparison to the generation rate during normal periods, it is quite acceptable due to the extra activities performed by the pilgrims during that period. As a result more consumption of food and drinks would be normal behaviour and consequently more waste in the form of food left over and packaging materials would be expected. The study pointed out that plastic and food waste comprised over 80% of the total waste amounts. This is reasonable since large amounts of food, plastic plates, cups, and drinking water bottles are used heavily.

The moisture content was estimated to be 40%, which seems to be some what high knowing that the temperature ranges between 40-45C°during the pilgrimage period and since large amounts of waste were not collected directly after generation due to collection logistic problems a mentioned by the study. Therefore the high temperature and long period of exposure of waste to the hot air environment the moisture content may be much less than 40%.

(Al-Mogarri 1997) conducted a public opinion survey questionnaire with respect to the management of solid waste in Jubail, Saudi Arabia. The study aim was to determine the quality of services being provided, the level of services expected and the willingness of the people to participate in the waste reduction and recycling programs. In order to accomplish these objectives the city was divided into three areas for the comparison of socio-economic characteristics and indicators of waste management. The sample of 270 households was randomly selected from total households of

11329. The sample represents only 2% of the total households, which seem to be a small percentage that could have been increased to obtain a more balanced and accurate responses. The sample contained 86% Saudi nationals and only 4% from other nationalities. The survey outcome indicated that more than 75% of the households use plastic bags for waste disposal, and a large number of them put the bags at the door of the house. About 50% of the households dispose their waste in the morning and only 10-15% was not satisfied with the time of waste collection. People were more concerned about the waste being scattered in front of their houses than on the streets. More than 70% of the households have respond positively to segregate waste at home and the percentage has further increased with the offer to provide plastic bags. People are not particularly interested in taking their segregated waste to a centralised location for recycling. The quantity of waste generated has been found to be increasing with the increase in income level. The average per capita waste generation based on the sample survey has been found to be 1.01 kg/c/d. The municipal waste composition consists of more than 50% food waste. While the remainder being paper, cardboard, aluminium cans and other useful materials, which could be sold on the market if such material were recovered from the source of generation before getting polluted with food and liquid waste.

(Al-Saleh 1997) focused in his paper on how to reduce the generation of construction waste at their source in Saudi Arabia utilising the most practical and economical options to treat construction waste. He also discussed the concept of preplanning and the benefits of adapting such technique in reducing the volume of waste produced during construction activities. Al-saleh indicated that the construction industry in Saudi Arabia is under pressure to make fundamental changes in managing the waste that arise from its activities and particularly in examining closely the manner in which wastes from construction activities can be minimised. Al-Saleh, like the author, faced similar problem in finding data in the literature that could help in predicting the amount or the types of construction waste generated in the Kingdom of Saudi Arabia. Al-Saleh assumed that the amount of construction waste produced in the Kingdom of Saudi Arabia to be higher or in the same range of the United States which was estimated by **(Bossink 1994)** to be between 20%-29% of the solid waste stream.

(Hamid & Hussain 1997) conducted a study aiming at the assessment of the suitability of recycled plastics materials by incorporating various additives in recycle plastics. Blends of recycled plastics with virgin polyethylene were stabilised with recycle master batches and were exposed in outdoor weather of Dhahran, Saudi Arabia. Changes in mechanical properties and percent crystallinity were measured. The results showed that the stabilised blends possess good light stability and can be used for certain outdoor applications. The results of this study may be applied on GCC level where plastic products from stabilised recycle/virgin blends can be produced from locally available mixed polyethylene recycle material. Such studies should be encouraged by the municipalities in the GCC states in order to achieve positive results that may be suitable for this region.

(Tariq & AL-Hazmi 1997) conducted a study on the current trends and technology in plastic recycling in the GCC region. The study indicated that in the GCC region the prospect of plastic recycling is very promising as more awareness is growing. This is due to the establishment of new plastic manufacturing plants within the GCC region, which consequently will tend to increase the production/consumption ratio of plastics. The author believes that this is an optimistic view, which could be achieved to a certain extent only if the GCC states put into affect legislation that will encourage plastics recycling programs. The authors suggested that in order to accomplish good recycling program an integrated policy should be adopted by the GCC states. And a strong material recovery facilities base should be developed through out the GCC states by the private sector to make the plastic recycling more economical right at the source generating points. Tariq & Al-Hazmi believe that the most promising opportunity for recycling of plastics in the GCC region is perhaps recycling of PET bottles. An example of that promising opportunity was given on Saudi Arabia where 40,000 tons per year of PET bottles are being produced and that a demand for 35,000 tons per year of polyester fibre for a carpet manufacturer already exist. This may not be possible to achieve in every GCC states since secured demand for PET bottles may not exist.

3.3 The UAE

(Ward 1993) submitted a paper on waste management in the Middle East at the First Annual Waste Management Conference in Dubai, UAE. The paper presented a general view of a region with many significantly different local constraints and problems, and more specifically, of one set of approaches in Dubai where Ward was reasonably certain of the issues. He argued that the first problem of waste is that there is no universally accepted set of definitions of waste terminology. Moreover, data and regulations often cannot be translated to different regions. He also indicated that the generation of waste in Arabian Gulf region is generally high by international norms. For example, Dubai's generation rate of 710 kg/person/y is in the high group (which has a typical generation rate greater than 500 kg/person/y), which is due to the high consumer-spending rate, lack of recycling programmes and low level of community environmental awareness. In these regards, Dubai should be typical of other GCC states. Ward pointed out that the waste management programmes currently in place in the region concentrate on collection and disposal and are only now beginning to embrace the concept of strategic waste management (i.e., waste reduction, efficient waste collection, education and environmentally sound waste disposal). He believes that the GCC states are generally expected to have similar waste compositions as Western countries. The author of this thesis disagrees with this last expectation, since the GCC countries will always have significant cultural differences that will be reflected in the composition of their waste. (See Chapter 4 for further clarification.)

(Middle East Environment **1993)** published the UAE annual review, which discussed several related waste management issues. According to the Municipality of Dubai's officials, Dubai, as is also the case in other emirates and GCC states, has to contend with the fact, that by handling all its waste internally it is unable to achieve the economies of scale that are taken for granted in more densely populated regions of the world. The distances between the cities of the Gulf impose major constraints upon the development of economically viable waste management facilities, and this is compounded by restrictions on the Trans-boundary movement of waste. The problem is that unless environmental legislation and waste management facilities develop at the same pace in every adjoining state, it is difficult to control the movement of waste, and proper management in one state may be threatened by the diversion of wastes to lower cost disposal routes elsewhere.

(Middle East Environment **1993)** published an article on the recycling sector in the GCC states. The article argued that recycling is gaining

ground despite obstacles. One major obstacle is that the viability of recycling projects appears to be based chiefly on a lack of confidence in the continuity of supply of the relevant waste stream. This, in turn, is attributed partly to a lack of support from government or municipal authorities, and partly to the belief that the population at large is not sufficiently committed to recycling to permit the actual implementation of any such programme. Another concern is the stability of the market for recycled products. The article pointed out that a UAE aluminium production facility prides itself on adhering to the principle that waste should be treated or disposed of in its country of origin. If this principle were adhered to in the GCC states and exports of recyclable were banned, recycling industries in the region would become both secure and more numerous. By the same token, however, if successful local recycling facilities were denied access to foreign scrap material markets, the current recycling ventures might be undermined. What should be taken into account are the amounts of recyclable materials that may end up at landfill sites if export restrictions are applied. In 1993, a paper company in the UAE exported around 40,000 t of waste paper, at a value of around US$6.5 million, from the Gulf to India. This indicates that there is enough paper waste to cover the demand of the local and export markets.

The Municipality of Abu Dhabi issued a report **(Al Gubaisi 1993)** on the types and quantities of MSW generated within its confines (Table 3.2).

TABLE 3.2: ABU-DHABI MSW COMPOSITION

Material	**Percentage**	**Quantity (t)**
Paper	15	165
Plastic	7	77
Glass	3	33
Sand	5	55
Non-ferrous metals	1	11
Ferrous metals	5	55
Food	45	495
Textile	5	55
Wood	7	77
Miscellaneous	7	77
Total	**100**	**1100**

About 700 t of the 1100 t of MSW collected daily are disposed of after the separation and reclamation of recyclable materials. The other 400 t are taken to the Abu Dhabi Compost Plant for the production of different types of compost. The report described Abu Dhabi's future plans with regard to waste management, which include the following:

- The construction of an additional production unit at Abu Dhabi's Compost Plant.
- The construction of a new landfill site.
- The construction of a hazardous waste incineration facility.
- The construction of a main transfer station.

As of 1997, none of the above tasks had been completely implemented.

3.4 State of Qatar

(Anwari 1997) conducted a general study on Qatar MSW by looking at Doha city. The study highlighted the collection, transfer, separation, and disposal activities of MSW in Doha. The study also covered information on the types, composition and generation rate of MSW in Doha. Anwari indicated that in 1986 the daily amount of MSW collected in Doha was 280 tons. This amount was increased to 440 tons per day in 1996, which corresponds to 60% increase within 10 years time. However during the same period, the population was increased from 270,000 to 338,000 which only corresponds to 25% increase. This is clearly indicates that an increase in population will increase the MSW generation. In 1996 the total weight of MSW collected in Doha was 159,613 tons compared with 162,598 tons in 1995 and 162,111 tons in 1994. Based on the above data, the average generation rate of MSW in Doha is 1.30 Kg/c/d.

3.5 Sultanate of Oman

In 1984, the Municipality of Dhofar also called Salalh conducted a study on the best alternatives available for solid waste disposal within its limits. The study concentrated on the present and possible future techniques to be applied for the benefit of environmental health. The study provided information on the quantities of MSW generated and collected by the Municipality of Dhofar.

(Middle East Environment **1994)** pointed out that recycling had not yet made much of an impact in Oman, and that studies indicated that there was limited potential for commercial recycling ventures. This may be due to the size of the population of Oman, which is a major constraint, while the low density of that population and the rugged topography of the country mean that for all intents and purposes, a significant proportion of the potential recyclable material is inaccessible.

According to a recent study by the Municipality of Muscat, the rate of municipal solid waste generated per capita per day is almost 1.2 Kg. of domestic waste. Considering that the total number of population is

405,000 people. Therefore, the total amount of domestic waste generated per day is about 486 tons, which is about 177,390 tons per year. Moreover, the Municipality of Muscat conducted a study 5, October 1993 upon which a sample of 176.5 Kg of domestic waste was collected and analysed to obtain the percentages of the waste components. The following table 3.3 presents the findings of the Municipality of Muscat:

Table 3.3: MUSCAT MSW COMPOSITION – 1993

Components	Weight (Kg)	%
Vegetables & Fruits (50 mm)	27.1	15.2
Vegetables & Fruits (10-50 mm)	43.6	24.4
Vegetables & Fruits (10 mm)	15	8.4
Paper & Carton	31.2	17.5
Glass	17.7	9.9
Iron	9.0	5.0
Aluminium	1.1	0.6
Plastic LDP	9.3	5.2
Plastic HDP	6.8	3.8
Leather & Rubber	.01	0.0
Bones, meat, Fish (10mm)	1.1	0.6
Fibres	1.7	1.0
Ceramics & stones (10mm)	1.1	.6
Baby Diapers	11.8	0.0
TOTAL	**176.5**	**100%**

3.6 State of Bahrain

The Environmental Health Department of the Central Municipal Council conducted two separate studies in 1987 and 1989, on the physical composition and characteristics of solid waste in Bahrain. Samples were taken from different districts with varied social and economic standards. The available data on the constituents showed that organic matter constituted about 53% by weight, paper and cardboard about 16%, metals and tin 5%, textiles 2.5%, plastic 14% and glass 7%.

(Al-Sayigh 1993) presented a paper at the First Annual Waste Management Conference in Dubai, the UAE. The author discussed the development of an efficient and cost-effective system for collecting, transporting and storing, and disposing of household and commercial wastes in Bahrain. He pointed out that the principal problems hindering the progress of the waste management system were mainly of a financial nature.

(*Middle East Environment* 1993) published "Bahrain's Waste Management Annual Review." The review indicated that the total domestic waste generated in Bahrain on a daily basis was around 600 tons.

To put this into a global context, Bahrain's daily per capita figure is 1200 grams, while Europeans generate 750 grams and Americans 500 grams (ibid.). (In this author's opinion, the figure on American waste generation per capita per day is rather low and does not correspond to other studies that will be mentioned later in this thesis.) The review asserted that MSW management has become a major issue at both national and regional levels in the Gulf, and that there is growing recognition that regional co-ordination is needed to identify and install the most appropriate technology for separation, recycling, composting and residue incineration of domestic waste. The review pointed out the fact that the concept of recycling is not yet firmly established in Bahrain in particular and in the GCC states in general, and the private sector is reluctant to invest in this new sector. The review indicated that the existing separation and incineration facilities in the region are inadequate both in terms of scale and efficiency. According to the Environmental Health Directorate's officials, two alternatives have been under consideration: composting and direct incineration.

3.7General

The following articles are not all directly related to the GCC, yet they do raise relevant issues and questions about MSW management.

(Hamoda 1997) conducted a study on the performance of composting plants in Arab countries. He emphasised that there is a growing market for soil conditioners such as compost in the Arab world where many countries are committed to land reclamation. Among the compost plants he evaluated their current practices were some of the GCC compost plants. These plants are Abu Dhabi, Alain, and Sharjah in UAE, Doha in Qatar, and Muscat in Oman. The evaluation was based on plant design (physical treatment and biological treatment), operating method (control of physical treatment and control of fermentation), and determining the degree of maturation. The following tables 3.4 and 3.5 show the operating and performance data on some compost plants in GCC states and properties of compost produced in two plants in UAE respectively.

TABLE 3.4: OPERATING AND PERFORMANCE DATA ON SOME GCC COMPOST PLANTS

State	City	Process type	Date of operation	Design through Put	Actual through Put	Rejects as % of input	Performance factor Actual/design x 100
UAE	Abu Dhabi	Hammermill Drum & Windrow	1977 1st stage, 1979 2nd stage	165 450	 350-400	40	57-65
UAE	Al-Ain	Hammermill Drum & Windrow, grinding screening aerated bed	1978 1st stage, 1986 2nd stage	150 275	125 115	40 45	83 42
UAE	Sharjah	Shredder Drum & Windrow	1978 1986 major modification	150 150	100 200	40 38	67 133
Qatar	Doha	Hammermill, Drum & Windrow	1975 1st stage, 1983 2nd stage	165 150	130 130	40-43	79 87
Oman	Muscat	Grinder, Drum & aerated cell	1982	150	110	NA	73

Table 3.5: Properties of Compost in Abu Dhabi and Al-Ain Plants

Parameter	Abu Dhabi	Al-Ain
Moisture content (% by weight)	25-30	25-35
Organic content (% by weight)	70-75	65
Nitrogen (% by weight)	1.5	0.5-1.5
Phosphorus (% by weight)	0.5	0.7
Potassium (% by weight)	0.6	0.6
C/N ratio	15	15-20
pH range	6.5-7.5	7.0-8.5

(Gur 1997) although Gur's paper on Health Aspects of Solid and Hazardous Waste Management covered primarily the practice of the WHO member states in the Eastern Mediterranean Region, several important points that were mentioned could be relevant to the GCC states. Gur mentioned that co-disposal of medical waste with MSW is a general practice in many of the WHO member states in the Eastern Mediterranean Region. Thus, the solid waste of these countries is likely to contain highly infectious clinical waste from hospitals. That was the same practice within the GCC states until recently when medical waste incineration became mandatory. The author agrees with Gur that to many countries of the Mediterranean region as well as other developing countries scavenging is a form of recycling of MSW yet with very high health risks to those who are involved. However, the GCC states do not face the scavenging issue as much as other developing countries do. This is due to the high standards of living of almost the whole GCC states population.

In the journal the *OECD Observer*, **(Yakowitz 1993)** asserted that of the approximately 45 million tons of metal consumed annually in the Organisation for Economic Co-operation and Development (OECD) countries, nearly 1/3 comes from recovery operations in scrap and residues. Recovery operations, applied to wastes destined for environmentally sound processing, lead to resource recovery, reclamation, recycling, direct reuse, or alternative uses. This processing included the collection, storage, transport, and treatment of wastes in accordance with safety standards for workers and requirements of environmental protection and preservation, and also the adequate disposal of any further wastes arising from the recovery operations themselves. The goal of public policy is to try to minimise potential harm to humans and the environment from recovery while allowing for opportunities to increase the quantity of waste treated instead of sending it immediately for final disposal. OECD member governments have taken decisive steps to insure that this goal is fully met.

The Arab Urban Development Institute **(AUDI 1986)** conducted a study on cleansing and methods of waste disposal in Arab cities. The study identified the legislation, economics, and progress of the solid waste management operations of 276 Arab cities in 18 Arab states. Most of the cities co-operated in answering the questionnaire put out by AUDI; however, the GCC cities declined to provide answers to many questions, in spite of the fact that the answers to the questions, which were believed to be direct and simple, were readily available in the cities' records. This study, which gathered data on the characteristics of the MSW in the different cities, revealed that there was great variation in domestic waste generation per capita between the GCC cities and the other Arab cities covered in this study. The GCC cities generated more MSW than any other Arab city, basically due to their wealth. The State of Bahrain was considered to have generated the most waste per capita, estimated at about 1330 grams/day, while the lowest amount generated per capita, estimated at 730 grams/day, was the Sultanate of Oman. The average amount generated per capita in the GCC states was estimated to be about 1.111

grams/day. The study declined to give any specific percentages for the different categories of solid waste in cities in the GCC states.

A techno-economic study of re-refining waste lubricating oils in the Arabian Gulf countries **(Al-Ahmad & Al-Mutaz, 1991)** indicated that waste motor lubricating oil in the Arabian Gulf countries can be re-refined by three processes: chemical treatment to remove metals from the used oil; physical treatment through flash distillation, fractionation, or thin-film evaporation; and solvent extraction. An economic evaluation was presented comparing the yield and investment costs of the various re-refining processes and determined that sulphuric-acid-clay treatment, propane extraction, distillation/hydrotreating, and solvent extraction were the most common commercial methods available.

(Khan & Burnet 1989) used various socio-economic factors and levels of industrialisation to forecast the volumes and composition of solid waste generated in 28 cities world-wide. Multiple linear regression analysis of the effect of these factors on the paper, metal, food, and glass recovery components of waste indicated that persons per dwelling, climate, and income were the most important factors influencing the percentages of the four components. The percentage of paper in waste was directly related to and affected by income levels. Food and glass components in waste were most affected by the dwelling occupancy rate.

(Gordon 1977) presents a comprehensive review of all the significant data available in each field of solid waste management and waste processing systems. Special problems of managing wastes from industry, agriculture and forestry are dealt with in detail. Tables of quality specifications for recycled material are provided in the context of resources and energy recovery. The technologies of separation and energy aspects of reclamation are described. The book provides guidance in estimating the present and future generation rates of solid waste management systems. The most remarkable feature of the book is that it presents a brief history of solid waste management. This book is designed as a handbook for quick reference as well as for background reading on solid waste management.

(Henstock 1983) presents a collection of essays contributed by experts on the economic, technical and environmental factors relating to disposal and recovery of MSW. MSW is explained as a general term used for urban waste, which includes mixed refuse, and commercial, institutional, industrial, and other bulky wastes. The incineration process is described as a means of achieving maximum volume reduction of MSW. The predominant method of waste disposal in the UK is sanitary landfill. In West Germany and Switzerland, also over 60% of domestic and commercial waste end in landfills. The disposal method is often dependent on the cost and availability of landfill sites. The subject of refuse separation is discussed from numerous points of view, such as source separation, and recovery as materials or as energy. The disposal and treatment options for hazardous waste are briefly considered. The export of western waste management skills to developing countries is also discussed. This book provides realistic and valuable information on the topic of municipal waste management.

(Wilson 1981) deals with the problem of waste management by presenting a system approach to the problem of planning for waste management. The comparative evaluation of alternative technologies on the two important criteria of economics and the conservation of resources is also presented in detail. International data on the types and quantities of waste generated, the composition of household waste and the current use of technologies for municipal waste disposal are given. The book discusses the state of the art in waste management technology, as seen in the early 1980s. The technologies appropriate to the management of potentially hazardous waste are examined briefly. The art of collecting quantitative information on the technologies is especially emphasised in this book.

The OECD (1981) reviews the experiences of its members in the implementation of economic instruments, user charges, product charges, deposit systems and financial assistance, in solid waste management policy. It summarises the role and application of economic instruments in different policy spheres. It provides information on waste material exchanges operated by member countries of the OECD. This report is based on case studies contributed by the member countries. The Waste Management Policy Group of the OECD's Environmental Committee prepared this report.

(Steiner & Hannes 1997) conducted a survey on MSW composting in the Arabian region that was published in *Bio-cycle*. The report discussed the status of several composting facilities including their locations, suppliers of main components, operations and throughput. The authors confirmed this author's view on the issue of differences in attitude towards waste and waste handling between the public in the Arabian region and the public in Central Europe. In Steiner and Hannes' (1997, p.53) own words:

> In this region, one is generally not concerned with waste to the extent people are in Central Europe. The thought of waste separation in the household as is currently common practice (e.g., in Germany) generally causes nothing more than shaking heads. Thus, the input material for existing and proposed composting facilities will remain mixed waste.

The authors also made a valid point regarding the construction of compost plants functioning as fertiliser plants in the Arabian region, whereby the revenues from product sales equal or exceed the processing costs. In industrialised countries, environmental considerations usually lead to the construction of waste treatment facilities, whereas this is a completely irrelevant consideration in the Arabian region. Table 3.6 represents a list of the MSW composting plants in the Arabian region.

TABLE 3.6: MSW Composting Plants in the Arab World

Country	Location	Supplier of Main Components	Commencement of Operation	Throughput (t/d)
Egypt	Alexandria	N/A	N/A	200
	Damietta	Buhler	1985	160
	Giza	N/A	N/A	150
	Cairo	Buhler	N/A	200
Iran	Isfahan	Buhler	1987	500
Qatar	Doha	Buhler	1977-84	300
Kuwait	Kuwait City	Daneco	1995	700
Oman	Muscat	OTV(France)	1985	*
Saudi Arabia	Yanbu	Buhler	1984	*
Syria	Damascus	Buhler	1988	700
UAE	Abu Dhabi	Buhler	1976-79	600
	Al-Ain	Voest	1986	450
	Sharjah	Daneco	1978	450
	Dubai	Daneco, Voest	1968	400
	Fujaira	Daneco	1986	150
	Ajman	Daneco	1986	150

* Not operational
N/A = Not available

3.8 Recent Examples of International literature from UK, Europe, and USA

(O'Riordan 1999) text "Environmental Science for Environmental Management" demonstrates how the use of environmental science, can create an effective approach to environmental management on different spatial scales. Following the Rio Conference and meetings on population, social justice, women, urban settlement and oceans, civil society has increasingly promoted the cause of a more radical agenda, ranging from rights to know, fair trade, social empowerment, social justice and civil rights for the oppressed, as well as novel forms of accounting and auditing.

This text is set in the context of a changing environmentalism and a challenged science. It builds on the popularity and applicability of the first edition. Four entirely new chapters have been included on environmental politics, Population and the role of GIS in environmentalism. It continually makes the case for inter-disciplinarily and has contributions from authors with backgrounds in Geography, Biology, Chemistry and Geology. Moreover it covers policy issues in depth and looks at global issues as well as the management of regional and local resource allocation questions. Furthermore it provides numerous case examples from all over the world. It contains an interesting chapter on waste management, which represents data on landfill taxes in Europe and MSW generation rates in several countries including Turkey and Iran. It also presents two important Directives issued by EC in recent years namely the Landfill Directive and the Packaging Directive. The author of this thesis recommends the chapter on waste management to be examined not only by the GCC municipalities' officials but also by other environmental authorities in the region. For the purpose of comparing data between GCC and EC on waste generation, Directives, and other related issues this book can play a guide.

(SEPA 1999) the Scottish Environmental Protection Agency has produced its final draft for the National Waste Strategy for Scotland. The strategy called for the implementation of the waste management hierarchy which includes waste prevention and or reduction at the source, reuse of all possible items, materials recycling, energy recovery from incineration or landfill gases, and finally sanitary disposal. The draft pointed to the important role of SEPA in the implementation of the strategy through its regulatory powers to implement the environmental and human health objectives of its strategy. The strategy calls on all members of the society to play an active role in the implementation of its objectives and targets. The author of this thesis invites the GCC municipalities to learn from SEPA national waste strategy and tailor a similar strategy, which will be based on general similar objectives and targets. Although there are some similarities between waste practices in Scotland and the GCC there are also few significant differences. One of the main similarities is the current landfill utilisation in both regions where landfill is the primary disposal route for waste arising taking over 90% of waste. A major difference is the potential utilisation of the landfill gas (methane) in the UK, which amounts to 1.8 - 2 million tonnes per annum as a source of energy, something which has no justifiable economic value within the GCC states due to the inexpensive alternative source for energy namely oil. The GCC municipalities can use SEPA national waste strategy as a guide for when they decide to have a regional waste management strategy.

United States Environmental Protection Agency. "Characterisation of Municipal Solid Waste in the United States: 1997 Update". EPA530-R-98-007.

This US EPA report describes the national municipal solid waste (MSW) stream. The report characterises the national solid waste stream for 1997. It also discusses trends and highlights changes that have occurred over the years, both in the types of wastes generated and in the ways they are managed. Although the report does not specifically address local and regional variations in the waste stream, the data in the report can be used to develop approximate estimates of MSW generation and composition in defined areas. This report contained data on:

- Total MSW generation, recovery, and discards from 1960 to 1997.
- The per capita generation and discard rates, materials (e.g., paper, glass, metals, and plastic) that comprise MSW, as well as products (e.g., durable and non-durable goods, containers, and packaging) found in the waste stream.
- Aggregate data on the infrastructure for MSW management, including estimates of the number of Kerbside recycling programs, drop-off centres, materials recovery facilities, and composting programs in the United States.

- Trends in MSW management from 1960 to 1997, including source reduction, recovery for recycling (including composting), and disposal via combustion and landfill.
- Projections of MSW generation to the year 2005.

The report showed that in 1997, 217 million tons of MSW were generated in the U.S., or 4.4 pounds per person per day. Paper and yard trimmings account for over 51 percent of total generation. Of the total of 217 million tons of MSW generated, 28 percent was recycled, up from 10 percent in 1980 and 16 percent in 1990. The 217 million tons of municipal solid waste (MSW) generated in 1997 was nearly 8 million tons more than in 1996, when MSW generation was 209 million tons. Historically, the increase in waste generation has been correlated with increased economic activity, and moderated by decreases in waste generation caused by source reduction activities such as backyard composting and leaving grass trimmings on the lawn. On a per capita basis, increased recycling offset half of the increase in total MSW generation. Between 1996 and 1997, almost all product categories increased in tonnage. This correlates with increased per capita consumer expenditures. The exceptions were glass and yard trimmings. Paper and paperboard products made up the largest percentage of all the materials in MSW, increasing by 4.2 million tons to 83.8 million tons, or 38.6 percent of total generation, in 1997. This increase was due to a rebound in newsprint production, and more production of printing and writing papers, container board (corrugated boxes), box board, and tissue paper. Yard trimmings comprised the second largest material category, estimated at 27.7 million tons, or 12.8 percent of total generation, in 1997. This compared to 35.0 million tons (17.1 percent of total generation) in 1990. This decline is largely due to state legislation affecting yard trimmings disposal in landfills, and due to source reduction measures such as backyard composting and leaving grass trimmings on the yard. From 1996 to 1997, the per capita generation of yard trimmings decreased by only 0.2 million tons. Recycling (including composting) recovered 28 percent (61 million tons) of MSW in 1997, up from 27 percent (57 million tons) in 1996. It should be noted that data shown here for years prior to 1997 have been adjusted by EPA to reflect the latest revisions to the data and methodology, and therefore may differ slightly from the same measure reported in previous updates.

There were nearly 9,000 Kerbside recycling programs in the United States in 1997, as well as more than 12,000 drop-off centres for recyclable.

About 380 materials recovery facilities helped process the recyclable collected. About 3,500 yard-trimmings composting programs were reported, up from about 2,300 reported in 1996. Recovery of paper and paperboard reached 42 percent (35 million tons) in 1997, accounting for more than half of the total MSW recovered. With greater generation of paper, more was available for recycling. In addition, 11.5 million tons of yard trimmings were recovered for composting in 1997, accounting for the second largest fraction of total recovery. The percentage of yard trimmings composted (41 percent) has more than doubled since 1992. This is due to increased numbers of yard trimming facilities, more material being handled at facilities, and bans of yard trimmings from landfills by 22 states. From 1996 to 1997, however, composting increased by just one million tons, suggesting that much of the impact of the states' ban of yard trimmings from landfills had already taken place. The per capita discard rate (after recovery for recycling, including composting) was 3.2 pounds per person per day in 1997, up from 3.1 pounds per person per day in 1996. Landfills managed 55 percent of MSW generated (120 million tons), about the same percentage as in 1996. Combustion facilities managed 17 percent (37 million tons) of total MSW generated, about the same as in 1996.

The waste generation figure of 217 million tons per year in 1997 is an increase of nearly 8 million tons from 1996, when MSW generation was 209 million tons. Looking at the longer-term trend, generation increased steadily from 88 million tons in 1960 to 214 million tons in 1994. Generation decreased slightly in 1995 and 1996, then increased again in 1997. Increases in waste generation since 1960 have been correlated with increased economic activity as measured by gross domestic product and personal consumption expenditures. The waste generation has been limited by source reduction activities such as an increase in yard trimmings being composted on-site, and more grass trimmings being left on lawns.

The decrease in waste generation in 1995 was due in large part to decreases in yard trimmings. This continued in 1996, and was supported by paper and paperboard generation decreases in 1996 as well. In 1997, generation of paper and paperboard increased by 4.2 million tons, compared to 1996, accounting for about half of the increase in waste generation over the last year. The per capita MSW generation rate for 1997 was 4.4 pounds per person per day, compared to 4.3 pounds per person per day in 1996. The longer term trend shows that the per capita waste generation rate increased from 2.7 pounds per person per day in

1960 to 4.5 pounds per person per day in 1990—decreasing to 4.4 in 1995, 4.3 in 1996, then rising again to 4.4 in 1997. Again, these changes are correlated with economic activity, but limited by source reduction. The per capita waste generation increase from 1996 to 1997 would have been even higher had no source reduction activities taken place. From 1996 to 1997 the recycling rate increased from 27 percent to 28 percent. This compares to a 10 percent recycling rate in 1980 and a 16 percent rate in 1990. Although the rate of growth of recycling, including composting is not as high as it was in the early 1990s, the tonnage of material recycled and composted has continued to grow, as has the per capita recycling rate. From 1996 to 1997 the per capita MSW generation rate, which is strongly correlated with economic activity, increased by 0.12 pounds per person per day. Half of this (0.06 pounds per person per day) went to increase recycling and half of this (0.06 pounds per person per day) went to increased disposal. In the 1960s and early 1970s, a large percentage of MSW was burned. Through the mid-1980s, incineration declined considerably and landfills became more difficult to site. MSW generation continued to rise, however, while materials recovery rates increased slowly. As a result, the burden on the nation's landfills grew dramatically. Although there are now less municipal solid waste landfills, their average size has increased and capacity at the national level does not appear to be a problem. Regional dislocations do, however, sometimes occur. As recovery rates have increased, while combustion remained relatively constant, the percentage of MSW discarded to landfills has steadily decreased.

United States Environmental Protection Agency. "Municipal Solid Waste Source Reduction: A snapshot of States Initiatives". EPA530-R-98-017..

This EPA report shows that over the past few years, the United States has made significant progress in diverting municipal solid waste (MSW) from landfills and combustion facilities. In 1996, 27 percent of MSW was recovered, exceeding the national goal of 25 percent set by the U.S. Environmental Protection Agency (EPA). States have played an integral role in helping the nation to achieve this goal through a variety of MSW management practices, including recycling, composting, and source reduction. Source reduction (also called waste prevention) has come to be recognised as a common sense approach with significant potential to use resources efficiently, save money, and reduce waste. Consequently, the benefits of source reduction are prompting an increasing number of states to move beyond traditional waste management programs and find new options for waste reduction initiatives. These initiatives emphasise creating less waste in the first place as opposed to simply diverting waste from disposal.

Since the late 1980s, many states have demonstrated initiative by instituting a number of innovative source reduction policies, such as mandating reduction goals and planning requirements, legislating disposal bans, and implementing extensive education and outreach campaigns. Source reduction remains a top priority for EPA's solid waste management program, and states will continue to play a crucial role in assisting the Agency to meet its current goal of freezing U.S. per capita waste generation at 1990 levels. Municipal Solid Waste Source Reduction: A Snapshot of State Initiatives features a number of successful and innovative state programs. It also catalogues publications and resources related to source reduction. EPA took this snapshot to get a picture of state initiatives, to share successful activities and strategies, and help foster effective source reduction programs nation-wide. This snap-shot is specifically focused on MSW; state activities geared to the source reduction of hazardous, toxic, or industrial wastes are not addressed in this document. Furthermore, this document highlights state source reduction activities in effect as of the fall of 1997.

EPA hopes this information inspires states to take additional actions and enhance existing programs. EPA also encourages states to communicate and partner with each other to share program-specific details when establishing new source reduction programs. This snapshot reveals state initiatives in five main areas related to source reduction. Reduction Planning, through goal setting and research, State In House Programs, implemented within state governments, Residential Programs, within the homes of the residents, Commercial Programs, in business and industrial workplaces, and Support for Local Governments, through financial and technical assistance. State efforts strive to alter individual behaviour through educational and technical assistance programs and also serve the important function of providing financial support for local source reduction activities. Key findings of this report include the following:

- Most states are active in source reduction. Almost all states (47 states) undertake some type of source reduction activity.
- A number of states have demonstrated significant commitment to source reduction. Ten states—California, Colorado, Connecticut,

Maine, Massachusetts, Minnesota, New York, Rhode Island, Tennessee, and Texas— took a comprehensive approach by adopting a wide array of source reduction activities. These states enacted source reduction efforts across all five of the main areas outlined earlier. In addition, six of these states go a step further by establishing a specific state wide source reduction goal.

- Many states focus on commercial programs. With 39 of the 47 states reporting programs, it appears that a primary focus is on the commercial sector. Most commercial sector programs educate the business community about finding ways to reduce waste generation and reuse products.
- Half of the states support residential programs. Twenty-three states actively educate residents and foster source reduction in the residential sector. The most popular efforts include backyard composting and consumer purchasing education campaigns.
- In-house programs and support for local source reduction activities garner equal support. Twenty-seven states promote and implement in-house source reduction programs, and 28 assist local governments in implementing source reduction efforts. State in-house programs generally focus on procurement and office policies stressing source

reduction. Support for local source reduction tends to consist of grant financing and technical assistance programs.

United States Environmental Protection Agency. "Cutting the Waste Stream into Half". EPA530-R-99-013.

The Institute for Local Self-Reliance (ILSR), in co-operation with the United States Environmental Protection Agency (EPA), created the Waste Reduction Record-Setters project. The goal of the project is to identify successful waste reduction programs in communities, businesses, and other organisations and to encourage their replication. This report features 18 communities with record setting residential or municipal solid waste (MSW) reduction levels. This report examines the policies and strategies used to reach high diversion levels; it does not include an in-depth discussion of materials markets. Seventeen of the communities profiled are diverting between 40% and 65% of their residential waste streams from disposal. Six are diverting between 43% and 56% of their municipal solid waste streams (residential plus commercial/institutional waste). This report is divided into six main sections. The introduction explains the methodology used to identify and document record-setting waste reduction programs. The second section, "Keys to Residential Program Success," discusses residential waste reduction program features and characteristics common to many of the record-setters. The next section, "Keys to Institutional/Commercial Program Success," presents program features and characteristics common to institutional and commercial waste (ICW) reduction programs in those communities achieving high diversion in this sector. The "Keys to Cost-Effectiveness" section presents methods for determining whether community waste reduction programs are cost-effective and evaluates each of the featured communities in these terms. The "Tips for Replication" section presents tips supplied by community contacts that may help other communities achieve high waste reduction levels. Finally, the sixth section includes in-depth profiles of the 18 communities and their waste reduction efforts. The conductors of this report chose the communities profiled based on a number of factors: waste reduction level, community size and type, program diversity, geographical balance, and willingness and ability to provide data.

(Public Works 1999): "Designing A-Rate Structure for Pay as you throw". p.28-32. May 1999.

This article discuss the design of a rate structure for Pay as you throw program (PAYT) which charges residents for trash collection based on how much waste they throw away. PAYT (also called variable-rate or unit-based pricing) continuously reminds and financially motivates people to reduce waste.

PAYT programs is widely implemented in the United States (over 20 million persons in 4,000 communities are participating) while averaging waste reductions of 14 to 27 percent. Also, according to a recent Institute for Local Self Reliance (Washington, D.C.) study, PAYT achieves high recycling rates when combines with comprehensive recycling programs.

Planners and local officials need information on how to determine the appropriate price to charge residents for each unit of garbage collected, a process called rate structure design. EPA reviewed the rate structure design methods used by various communities and developed this article. Janice Canterbury an Environmental Specialist with the Municipal Waste Reduction Branch of the Environmental Protection Agency, Washington, D.C. The writer explains the key elements communities commonly considered in setting their PAYT rates. In general, solid waste planners follow one of three methods when choosing a community's rate structure: drawing from comparable communities, building from community data, and analysing full MSW costs.

Various products are available from EPA to inform communities about the experience of pioneering PAYT programs. The Pay-As-You-Throw Tool Kit includes detailed guidebooks, an extensive workbook, and a videotape to help solid waste decision makers learn more about PAYT and to plan and implement their own program. Another important resource for communities is Pay-As-You-Throw Success Stories, a collection of testimonials by various PAYT municipalities. To learn more about these free products and tools contact the PAYT Help-line at 888 EPA-PAYT (372-7298). You also can access most of these items online through the PAYT Web site at www.epa.gov/payt. More detailed information on analysing MSW costs is provided in EPA's *Full Cost Accounting for Municipal Solid Waste Management: A Hand-book, (EPA530-R-95-041),* September 1997, available from the RCRA Hotline at (800) 424-9346. Also, visit EPA's Full Cost Accounting Web site at www.epa.gov/fca.

United States Environmental Protection Agency Solid Waste and Emergency Response Office of Solid Waste (5305W). "Recycling for Our Future". Reusable News, fall 1999. EPA530-N-99-009.

The third annual America Recycles Day (ARD) took place on November 15, 1999, with EPA serving as a "premier sponsor" of the event. The theme was "For Our Children's Future...Buy Recycled Today", which emphasises the importance of buying recycled-content products and recycling in order to conserve resources for future generations. The national recycling rate continues to rise from 16% in 1990 to 28% in 1997, according to EPA's new report, Characterisation of Municipal Solid Waste in the United States: 1998 Update. This increase reflects the continued growth of recycling and composting programs across the country. Successful source reduction programs from backyard composting helped to offset the total amount of garbage generated nation wide. Similarly GCC states need to sponsor regional events with theme such as "GCC waste continues... solutions in demand". A true presentation of the current conditions of waste recycling, reduction, and composting need to be shared among the GCC states in order to develop a regional target rates plan. GCC authorities need to share the actual figures on recycling rates and work together toward a better enhancement plan of the current status.

United States Environmental Protection Agency. "Characterisation of building-related Construction and Demolition Debris in the United States". Municipal and Industrial Solid Waste Division Office of Solid Waste. EPA530-R-98-010.

The purpose of this report is to characterise the quantity and composition of building-related construction and demolition (C&D) debris generated in the United States, and to summarise the waste management practices for this waste stream. The focus of this report is on building-related wastes, including construction, demolition, and renovation of residential and non-residential buildings. Road and bridge debris, land clearing debris, etc. are not covered in detail in this report. They are, however, discussed briefly. The methodology used for this study combines national Census Bureau data on construction industry activities with point source waste assessment data (i.e., waste sampling and weighing at a variety of construction and demolition sites) to estimate the amount of building-related C&D debris produced nationally. It is important to recognise that this is a first attempt to use this methodology. It is expected that as the trend towards better characterisation of C&D sites continues and more communities record their C&D debris quantities and compositions, the national estimates as developed in this report can be tested and modified accordingly.

Currently, the limited point source waste assessment data may be a source of considerable uncertainty in the analysis. Since the method developed here makes use of readily available Census Bureau data on national C&D activity, (e.g., construction and demolition permits and construction value) the methodology should be well suited for periodic updating. Waste assessment results should change very slowly over time because construction materials used and building construction practices remain relatively constant from year to year. Composition of waste from demolished buildings, which have been built over a range of years, should change even more slowly. The report produced the following estimates for the building-Related C&D Debris Generation:

• A 136 million tons of building-related C&D debris were generated in 1996.

• The per capita generation rate in 1996 was 2.8 pounds per person per day.

• 43% of the waste (58 million tons per year) is generated from residential sources and 57% (78 million tons per year) is from non-residential sources.

• Building demolitions account for 48% of the waste stream, or 65 million tons per year; renovations account for 44%, or 60 million tons per year; and 8%, or 11 million tons per year, is generated at construction sites.

The composition of C&D debris is highly variable and depends critically on the type of activity where sampling is done. Whereas wood is typically the largest component of waste material generated at construction and renovation sites (as suppose to concrete in the GCC region), concrete is commonly the largest component of building demolition debris. Road, Bridge, and Land Clearing Debris Road, bridge, and land clearing wastes represent a major portion of total C&D debris, and some of the materials produced are managed by the same processors and landfills that manage building-related wastes. A methodology was not developed in the scope of this project to estimate these wastes. Point source waste assessment data were not available for these projects. The most common management practice for C&D debris is landfilling, including C&D landfills, MSW landfills, and unpermitted sites. An estimated 35 to 45 percent was discarded in C&D landfills in 1996. An estimated 30 to 40 percent of C&D debris is managed on-site, at MSW landfills, or at unpermitted landfills. Within the GCC states unpermitted landfills are known as uncontrolled landfills. There is not enough data to show the GCC amounts of C&D in uncontrolled landfills however it is estimated that in Kuwait only there is about 1.1 million tons per year of C&D waste disposed off at uncontrolled landfills.

In the US there are about 1,900 active C&D landfills which is more than the number of landfills within the GCC collectively. It is estimated that 20%-30% of building-related C&D debris was recovered for processing and recycling in 1996. Unfortunately the GCC still unprepared for C&D waste recovery. As the region becomes more developed the need for C&D waste recovery for processing and recycling will show its importance eventually. The only question is then at what cost are the GCC states going to clear the existing sites from C&D waste. There are about 3,500 operating facilities that process C&D debris materials in the United States which, can be learned from by GCC states authorities and transfer such experience to the region. A major difference in selective demolition operations between the US and GCC is the intensive labour requirement which is less expensive within the GCC than in the US. Metals have the highest recycling rates among the materials recovered from C&D sites. This even more true within the GCC since mostif not all the buildings and roads are made of concrete and steel bar.

(Coggins 1995) presented a paper to the Colloquium on prospects of Material Recycling in the GCC Region. The paper title is "Waste Management in the United Kingdom: Current issues, Problems and Policy Options".

The paper provided an overview of waste management in the U.K. in the mid-1990's, with an emphasis on the dynamic interplay of political, industrial, social and environmental pressures on waste generation through to disposal. The paper focused on household, commercial and industrial waste streams. The author gives toward the end of his paper which included definition of waste, waste hierarchy, recycling options, managing waste (The Draft National Waste Strategy), and regulation and market instruments a valuable number of key lessons for the GCC region which he listed as follow:

*Know your waste, and establish a realistic and usable waste data management system,

*Such policies should be flexible, integrated and reflect the dynamics of waste generation,

*Plan for household, commercial and industrial waste, and consider the importance of other waste streams such as sewage sludge, *Recognise, and implement, waste management policies based on the waste hierarchy,

*Establish realistic and integrated national policies for waste management,

*Local circumstances must be taken into account, together with the operational scale of waste management options,

*Consider how best to integrate public services and private sector involvement,

*Remember the importance of publicity and education, and work with local communities and industry,

*Evaluate the roles of regulatory and market-based instruments, and how alternative waste management options can be compared, monitored and evaluated,

*With recycling programmes ensure that suitable markets exist,

This paper has touched on the core of the waste management dilemma in the GCC states. Authorities in this region should pay careful attention to the many recommendations made by the author. One very important issue the author pointed out and this author tend to agree fully with is that there is a cost for achieving sustainable development objectives and the sooner the GCC region realise that the less expensive it may become.

(Hempen 1998) prepared a report for the European Environmental Bureau on Training Materials on waste management. The report discusses the development of European Union waste policy principles, approaches and legislative measures. It addresses the various waste-Directives adopted by the European Union. The first Directive issued in 1975 and amended in 1991 is known as Waste Framework Directive. It stated that "the essential objective of all provisions relating to waste disposal must be the protection of human health and the environment against harmful effects caused by the collection, transport, treatment, storage and tipping of waste". This is very similar to the GCC states laws on waste. However the European Union framework Directive has shifted from the remedial approach to the prevention approach even though a hierarchy of waste management options was not part of the 1975 original Directive. In the case of the GCC the concentration in their waste legislation was toward the treatment focus option and not prevention. The author of this thesis recommendation to the current GCC waste legislation is to include the prevention option and introduce the polluter pays principle in order to maintain better control of waste management activities. The report point out the announcement made by the European Commission regarding the preparation of a common waste management strategy which had been demanded since mid eighties by the European Parliament. Similarly the GCC Secretariat General should explore the potential of creating a single GCC waste act and consequently a common strategy on waste management. The report also discuss the packaging Directive, the landfill Directive, theMaastricht Treaty, the Amsterdam Treaty and other related waste directive issues and views. The report is an excellent review and it could lighten GCC waste management officials.

(Coggins 1996) published a paper titled “Changing Waste Management Structure, Issues and Problems: a Case Study of London, UK” in the Journal of Waste Management and Resource Recovery, Vol. 2, No. 4, pp.163-175.

This paper discusses the changes in waste management in London over the last 20 years. The author pointed out that the administrative changes involved reorganisation of local government in the UK led to changes in the way local services are provided and funded. More involvement from the private sector in waste management is apparent in the UK. This is indicated by a 22% share of the total value of the first generation of Compulsory competitive tendering (CCT) contracts for waste collection had been won by the private sector. The Environmental Protection Act of

1990 extended CCT to cover waste disposal also. A similarity between UK landfills and most of the GCC landfills is that both are originally were quarries used over the years and consequently they were obvious locations for waste disposal. According to this paper no further plants for mixed household waste were built after 1970 due to problems over quality control and lack of markets. On the contrary the GCC states have increased their composting plants numbers and capacities since early 1970's and up until recently. However the same problem over quality control does exist in the GCC. As to the lack of markets issue within the GCC the local produced of compost suffer the competition from imported compost into the major market, which is the government agricultural programmes. For example in Kuwait two composting plants (public and private) are currently abandoned due to both quality and lack of local markets. The author of this thesis believes that the local government in Kuwait should encourage and support the local producers of compost in order to benefit from the diversion of large quantities of waste from its landfill sites and accomplish the green of open areas environmental programme. Moreover since the civic amenity sites are playing an important role as recycling centres in the UK the current landfill sites operated by local authorities within the GCC should step in the same direction of the civic amenity sites and become a national recycling centres. This will lead to a future regional recycling centre and will work as an initial step toward further regional co-operation. Private sector may also play an important role in the management and operation of such sites. Recycling rates in the UK are as low as 5% of household waste however the educated implementation of kerbside collection programmes will result in higher recycling rates. A target of 25% is rather high but doable in countries such as the UK and the US however this may not be the case in the GCC since awareness and education programmes need to be established first in order to generate interest from both government and private entities. Later in this thesis a 15% assumed recycling rate for the GCC states is considered in developing a financial model for regional recycling programme (see chapter 9 for more details). The author agrees with the paper's view on the disability of local authorities to provide markets for paper, glass and other recyclable materials. And thus the private sector is more capable to conduct recycling programmes and deal with fluctuating markets conditions. The paper mentioned, as an example, the recycling rates achieved by a number of London boroughs. Richmond upon Thames in outer London had a recycling rate for glass and paper well above the national average at 30% and 36% respectively. Richmond introduced a new concept in waste management to the UK, which was taken after the Netherlands concept to reduce household energy consumption. Waste reduction has been an important target of Richmond's waste management objectives. GCC cities would benefit form such experience of cities such as Richmond, Sutton and Camden of the UK in the field of recycling and waste minimisation. Moreover GCC cities can learn from UK cities the Best Practicable Environmental Option for waste collection, treatment and disposal. In this author opinion the recycling incentives and penalties table shown below is worth studied by GCC authorities, municipalities, in order to draw ideas and suggestions that can be part of their recycling strategies or better be their unified waste management strategy.

Recycling Incentives & Penalties

Incentives		Polluter Pays
*Tradable Permits *Tax Incentives *Investment Allowances	Production	*Min. % of Recyclable Materials *Product Levies/Bans *Input Material Levels/Taxes *Excess Packaging Levies/Bans
*Differential VAT *Deposits *Eco-Labelling	Consumption	*Deposits *Green Dot Levy *Dual Stock *Trade Description Act
*Diversion Credit *Rateable Value adjustment for Drop-off sites	Collection	*Mandatory Recycling *Direct Charges/Local Taxes *Mandatory Retail Drop-off Sites *True Costs of Collection
*Diversion Credit *Tradable Permits	Disposal	*Direct Charges *Surcharge on Recyclables *Landfill Levy *NIMBY *True Costs of Landfill
*Recycling Credit *Investment Allowances *Redemption Systems *Mandatory Purchasing *Hole-In-The-Wall Processing *Rateable Value Adjustments	Recycling	*Re-Definition of Waste *Higher Prices for Recyclables *Ban on Landfilling Recyclables *Recycling Targets & Penalties

Source: Environmental Resources Limited 1992.

(Watts & Probert 1999) conducted a survey on the city and county of Swansea, UK. Three areas were selected based on their affluence with West Cross being the most effluent area followed by Morriston and Llansamlet. The survey examine aspects of recycling behaviour in terms of the materials recycled, the length and frequency of participation in both kerbside and bring bank recycling for the purpose of modelling the supply. The influence of the socio-demographic variables on the level of public participation in recycling and the identification of differences due to facilitating factors such as storage space was examined by the survey. The University of Wales Swansea in conjunction with the Swansea Environmental Centre and the city and county of Swansea have designed the survey and distributed among the schools in each of the three areas. Statistical Analysis was performed on the survey returns using Cross Tab and Chi-square analyses. The analysis indicated that there is an obvious differential in the reported levels of participation in recycling across three socio-demographically-distinct areas of Swansea, which may be in part due to the facilitating social factors. The survey went even further step to examine the possible relation between recycling behaviour and 'green consumerisum'. There is an indication from the survey that a relationship between 'green consumerism' and recycling behaviour. The author of this thesis is currently preparing for a similar survey in co-operation with Kuwait University, Kuwait Municipality, and Public Environmental Authority. The objective is to determine the level of future recycling participation and thus a forecast model will be developed.

(Jones, Nesaratnam, & Porteous 1999) conducted a study on the factors affecting the rate of generation of household glass waste in the UK. It is estimated that 22% of glass waste generated by the households in the UK is currently recycled (European Glass Container Federation 1997). The study indicated that higher income households have a greater potential to generate wine bottles as glass waste. The mean quantity of glass waste collected from households was found to increase non-linearly with household size, the rate of increase declining with increasing household size. The glass waste generation rates are correlated with the proportion of professional and managerial worker households present in wards. There is an indication of greater use of bottle banks sites by professional and managerial worker households. Within the GCC States the bottle bank concept is rather old and well known however it has never been applied properly. Bottle bank sites are out of site and hard to get to them and in most cases they are not clearly marked as bottle banks. What would be interesting is to have a market study for the potential uses of recycled glass waste and consequently both the municipalities and the private sector would make a more educated decision. The main objective should be to increase the participation rate and to encourage the participants to segregate the different colours glass waste into white, green, and brown. A more recent observation within the GCC cities is related to the reduction in the usage of glass containers and bottles versus the increase in the usage of plastic containers and bottle. The author anticipates more implementation of plastic products within the GCC, as more down stream petrochemical projects are in existence already and soon m ore to be developed.

DETR (1999) the Department of the Environment, Transport and the Regions produced a draft waste strategy for England and Wales: A way with Waste. In part one the strategy elaborate the Government's foresight the sustainable waste management in England and Wales over the next 20 years. The strategy provides (a) Overview of waste policy (b) Outline the scale of the task facing the DETR (c) The tools that can assist in facing the challenge (d) The details of the actions stakeholders need to take in the next five years to meet the vision and targets set by the Department of the Environment, Transport and the Regions. In Part two, which is a complement to part one, several important data were provided. The strategy in part two offered (a) data on the nature and quantity of waste arising as a benchmark for reviewing progress against the targets described in part one. (For example the Government has set a goal of recovering 45% of municipal waste by 2010 and of recycling or composting 30% of household waste by the same date. However to meet these goals, it will be important to achieve the existing targets of 40% recovery and 25% recycling or composting by the year 2005. This seems to be a hard goal to achieve in view of the current waste quantities' growth rate of around 3% annually. In 1997/98 around 27 million tonnes of waste was produced with just 8% being recycled or composted and 6% having energy recovered from it). (b) Detailed background to many of the policies described in part one. (d) Describe the progress made since the last waste strategy was published in 1995. (e) Set out arrangements for a number of specific waste stream, including packaging waste and special waste. (f) Describe the current facilities for managing waste in England and Wales. In general the draft waste strategy for England and Wales indicated the importance of the collective efforts of all stakeholders - government, regulators, waste producers and waste processors - in achieving the vision set out in part one of the strategy, which will need to be concentrated on more sustainable waste management solutions such as waste reduction, re-use, recycling, composting and energy recovery. Consequently, in general the strategy calls on the stakeholders to understand the scale of the waste problem in term of how much is being produced as a nation and to understand what system exist for dealing with waste sustainable. There is a wealth of information in this draft waste strategy which can be of great use by the various departments in the GCC states responsible for producing waste strategies. The strategy can be used as an example and for comparison purposes especially in the area of waste targets, goals and policies that are required for waste sustainable management in the region. The benefit for GCC states is that there is no need to invent the wheel when there are such extensive amount of work that has been done in this field. However the author of this thesis suggest that GCC states should be comparing (growth, goals, and targets figures) with those of the England and Wales for guidance in drawing their own waste strategy. For more information it is suggested to visit the site of DETR (www.detr.gov.uk).

DETR (1999) Report of The Market Development Group. This is the report to Ministers for the Environment on the Group's work and its conclusions.

The group was set up by the Department of the Environment, Transport and the Regions (DETR) to consider a key element in promoting more sustainable forms of waste management, namely the development and expansion of markets for recyclable materials. A similar Group should be established within the GCC and it is highly recommended that the GCC secretariat in Riyadh take charge of the set up of the group. The group's terms of reference were:

- to investigate the barriers to expanding the markets for recycled goods;
- to develop proposals to help overcome these barriers; and

- to make recommendations, as appropriate, to central and local government, industry, and the community sector.

This work focused on municipal solid waste, and in particular on the five materials that comprises the bulk of the non-organic household waste stream: glass, paper, plastics, steel and aluminium. For the GCC recyclable materials the author of this thesis presented a financial model which included the potential amounts ofrecyclables such as paper, glass, plastics, and aluminium (see chapter 9 for more details). The group comprised representatives from central and local Government, the waste and reprocessing industry including compliance schemes and materials organisations, and the community sector.

The Group's report emphasised that the situation facing waste management in the UK is extremely serious, and will require a step change in behaviour and practice. SEPA (1999) strategy indicated that in 1998, 3.3 million tonnes of packaging waste were recovered but this will have to reach over 5 million tonnes in 2001 to meet the packaging Directive recovery target. If the UK is to meet present and future international obligations and deliver its domestic environmental policy objectives, then a significant and sizeable expansion in the outlets for recycled materials is essential in order to secure the required increase in recycling activity. The Group recognised that this would be a long term process, and argued strongly therefore for urgent and immediate action. The author believes that in the case of the GCC states, it is even more urgent and an immediate action by all states in this aspect is required.

The Group concluded that, along with measures to develop and expand further the existing markets for recyclable materials (which, whilst valuable, will not on their own be sufficient to meet this challenge), a new, more radical approach is needed. This approach should set out to identify and develop a broad range of new, more diverse, and higher value uses for recyclable materials in sectors outside those that produced the material. The work could be taken forward in the first instance through support from existing relevant grant schemes and best practice programmes, expanded as necessary. The Group felt, however, that there was also a need for a national focus to this activity, perhaps through a new, proactive national body that would give it a high profile and stimulate further research and development.

The Market Development Group recommended the following actions in key areas, which are listed here based on its priority:

(1) Identify and develop new markets for recycled goods and materials.

(2) Promote demand for recycled goods and materials through consideration of the introduction of economic instruments and through public procurement policy.

(3) Take action to stabilise the markets for recycled materials and reduce price volatility.

(4) Develop improved quality in and standards for recycled goods and materials.

(5) Promote better understanding of the potential uses of recycled materials and the importance of designing for recyclability.

(6) Stimulate research and development into improved reprocessing technology for recyclate.

(7) Take specific action to correct the colour imbalance in glass recycling.

These recommendations can be utilised by the GCC states in order to form and achieve national and regional co-operation and integration in recycling of waste materials from municipal waste.

Similar to the Group's work, which fell into two parts GCC can apply the followings: (1) Consider the position relating to each of the different materials markets, and the specific factors that apply there. (2) Examine more general issues, such as consumer awareness, public procurement and quality, and the measures that could be used across a range of materials to stimulate demand.

The Group identified barriers facing the waste recyclable materials. For example in the case of glass, the Group identified the inconsistent quality of cullet as one barrier to increased recycling, but felt that the key barrier was the colour imbalance - the discrepancy caused by the large amount of green glass imported into the UK and clear glass exported. Solutions proposed included a reduction in imports of green glass and the development of alternative applications for green cullet.

For paper, the Group noted the steady, often rapid growth in world-wide demand for recycled paper, but considered there was still scope in respect of some paper products for a further increase in recycled fibre content. These included the printings and writings market, corrugated box packaging and pharmaceuticals packaging (folding box board). The major barrier to increased use of recyclable was the now outdated, but still persisting, perception that recycled paper is inferior in quality. The

Group also recognised that the production capacity limit at UK mills was relevant.

The Group found that the plastics industry was in general more diverse and fragmented than the other main recycling industries. The main barrier to increased recycling was the lack of sustained competitive pricing, compared both with virgin polymer and with recyclable from commercial and industrial sources. The Group proposed a number of ways forward, such as price guarantees, index linking of prices and economic instruments. A resistance to the use of recyclable coupled with the sub-optimal technology and skills base of the UK plastics recycling industry were also seen as main long-term barriers. The Group recommended these be overcome through promotion of the opportunities for using recycled material and the development and dissemination of innovative recycling processes.

Finally, in both the steel and aluminium markets, the Group found that the main barrier to increased recycling was the quantity (and, for aluminium, the quality) of metal collected. There did not appear to be any failures in demand for either metal, and the issue was rather a need to increase collection rates, which fell outside the remit of the Group. In the case of the metals industry, there appeared to be no obvious benefit to tackling the demand side of the equation.

More generally, the Group considered the main weakness, which hampered the development of recyclable markets to be their inherent instability and the volatile price movements that occur.

The Group consequently identified the major issues as:

(1) The quality of waste materials supplied for reprocessing.
(2) The discriminatory nature of some product specifications (or the absence of any specifications where new applications were concerned).
(3) The lack of consumer awareness and poor public perception about recycled goods and materials.

Also important is the fact that recyclable from household waste has to compete both with virgin raw materials and with material sourced from commercial and industrial waste, which is generally cheaper to recycle.

The Group also noted that the recycling industry was characterised by a large number of small and medium sized enterprises (SMEs), who are less able to take a longer term approach than larger companies (and are therefore more vulnerable to market instability), and amongst whom there are greater problems of disseminating information, for example about good practice, quality standards or new technologies.

The Group identified a range of measures to address these issues, including mechanisms to provide price guarantees, the promotion of partnership and risk-sharing amongst the stakeholders in the supply chain, leading to the development of longer-term contracts rather than spot prices, and a possible futures market forrecyclables. It also proposed that the eco-design message should be more widely promoted, that industry representative bodies should develop model specifications, and that good practice guidance for the reprocessing of waste materials should be developed. Greater emphasis on environmental considerations in public procurement decisions - both in local and central government - and in the purchasing policies of large organisations, was also seen as vital.

Finally, the Group considered the use of economic instruments to stimulate demand for recyclate, and contributed to a separate study on this subject, being undertaken by ECOTEC Research and Consulting on behalf of the DETR. (The results of this research will be published shortly.) However, the Group recognised the potential complexity of introducing generic measures for a range of different materials, and the need to take into account the global nature of many markets.

The author of this thesis believes in the importance of the existence of such group in the GCC. Also believes in the need to further study the barriers facing the waste recyclable materials markets and technologies and the future applications of recyclable materials into new products industries, which are in demand this region, the GCC, but also other regions of the world.

DETR (1998) consultation paper on a Revised UK strategy, Sustainable Development: Opportunities for Change. DETR in this paper intends to review and revise the national Sustainable Development strategy published in 1994. It is worth mentioning that the UK was among the first countries to prepare such strategy. UK insists on building a modern and fair Britain with sustainable economic growth, a strong economy (innovative and efficient) and a healthy environment to pass on to its future generations. 'Sustainable development' is a phrase that has become widely used in recent years, particularly during and since the Earth Summit in Rio de Janeiro in 1992. *Sustainable development* is a new and integrated way of thinking about choices right across Government, and throughout society, so that everyone can share in the highest quality of life now, without passing on a poorer world to the next generation. It is an approach, which seeks to find solutions, rather than emphasise conflicts; to build a decent society for all our people in, which each citizen has a stake; to move forward, rather than look to the past.

This consultation paper:

- sets out the Government's vision of sustainable development, and the steps to put it into practice;
- explores what further action might be taken, by each of member of the society, to achieve sustainable development; and
- Poses some questions, on which comments and suggestions are invited.

DETR (1999) strategy for sustainable development for the UK: A better Quality of Life.

The Strategy for sustainable development has four main aims. These are:

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- prudent use of natural resources; and
- Maintenance of high and stable levels of economic growth and employment.

For the UK, priorities for the future are:

- more investment in people and equipment for a competitive economy;
- reducing the level of social exclusion;
- promoting a transport system which provides choice, and also minimises environmental harm and reduces congestion;
- improving the larger towns and cities to make them better places to live and work;
- directing development and promoting agricultural practices to protect and enhance the countryside and wildlife;
- improving energy efficiency and tackling waste;

- Working with others to achieve sustainable development internationally.

The author of this thesis believes that the same priorities can be applicable for the future of the GCC states. It has been noticed recently that the GCC states become more involved in the objectives and implementations of the sustainable development policies. Recently the GCC states approved the interconnect project which calls for a regional electricity grid in order to minimise the loss in energy and to increase the integrated benefits among the GCC states.

UK Government policy will take account of ten guiding principles as follow:

- putting people at the centre;
- taking a long term perspective;
- taking account of costs and benefits;
- creating an open and supportive economic system;
- combating poverty and social exclusion;
- respecting environmental limits;
- the precautionary principle;

- using scientific knowledge;
- transparency, information, participation and access to justice;
- Making the polluter pay.

Within the GCC states the most difficult guiding principles to be applied are making the polluter pay and respecting environmental limits. This is due to the non-existence, in some GCC states, of the proper enforcement of the legislation as it is going to be mentioned later in the thesis.

The strategy has developed a way of measuring progress by a system of indicators. Headline indicators identify the key issues relating to quality of life. These headline indicators shall be publish every year along with report on DETR sustainable development actions and forward plans. The strategy describes measures to build sustainable development into policies and decisions, in Government and across society. Also it looks at how to create a sustainable economy with less impact on the environment. And discusses how they plan to support better communities for people to live and work in. It describes the strategy to protect our environment and natural resources, both for their own sake and for the contribution they make to their economic vitality. Sustainable development is very much an international issue and the strategy deals with international co-operation.

Finally the strategy looks briefly at the progress made in the past, the priorities for the immediate future and how they shall report on the result of their actions. *A better quality of life* provides a national focus from which local and regional action can also follow. DETR have set a target for all local authorities to prepare local sustainable development strategies by the year 2000 and hope to have sustainable development frameworks for each English region by the end of 2000. This is remarkable achievement by the UK government, which should be followed by other GCC states.

The Government cannot do the job alone. We need to work together, forging partnerships with business, local authorities and voluntary groups. There are many initiatives where industry and local communities are already making a difference. Within the GCC the lack of public awareness and government enforcement of legislation hinder the co-operation between the various sectors in the economy. GCC states need to start as soon as possible and learn form the UK experience in preparing both national and regional sustainable development strategy to ensure a better position for its societies among the leaders of this world especially in view of the globalisation and the world trade organisation objectives.

CHAPTER IV

GCC municipalities: Organisations, legislation and responsibilities

4. GCC MUNICIPALITIES: ORGANIZATION, LEGISLATION AND RESPONSIBILITIES

4.1 Background Needs

Presently, the solid waste management operations of the GCC member states do not reflect the economic progress that has been taking place throughout the GCC states. Although, the GCC member states are well known world-wide for their wealth as a result of oil production, marketing, and diversified reinvestment of oil returns, there is a lack of political will to develop an environmental strategy with relation to MSW.

According to the head of the Environmental Protection and Safety Section of the Dubai Municipality **(Ward, 1993)**, many common features impact waste management in Middle Eastern countries including:

- A harsh prevailing environment in which ecosystems are already under considerable stress.
- Pressure due to high rates of development.
- Poorly developed regulatory and waste management infrastructures
- Communities typically poorly informed about waste and environmental issues.

Moreover the use of land for solid waste disposal in the GCC states is becoming a significant issue since the demand for land is increasing as a result of the growing number of households, and expanding commercial and industrial areas. This is a major feature that is common to these states. Most of the GCC cities are continuously expanding, which in turn is causing a rapid increase in the amount of waste produced.

In this region, where six of the richest countries in the world are located, the decisions made in selecting waste treatment alternatives are obviously poor **(Arab Institute for Cities' Development 1986)**. Moreover, the legislation is out-dated and matches neither the present nor the future conditions.

The proportion of organic matter in the MSW in the GCC states makes up between 40 and 50% of the waste's total composition. Other items such as paper, cardboard, metals, glass and plastics constitute 30 to 40%. Wood and miscellaneous items form the remainder (Arab Institute for Cities' Development, 1986). Most of the GCC states' proposed methods of waste treatment are considered to be very expensive due to the complexity of the equipment required for classification, separation, recycling, and composting. It is important that the GCC states develop a strategy for waste management that includes the best possible alternative or alternatives for solid waste management. As a result, both the high cost and environmental damage will be reduced.

It is very important that data on waste disposal methods in the GCC states be collected in order to analyse, compare, and identify the implications for environmental health and economic feasibility of these methods, and to establish better practices. The experience of other countries is a major source of practical data on the best alternatives available. Such information is essential in a region where information is rarely collected in an organised manner.

The suitable selection of solid waste treatment alternatives will create a chance for the private sector to enter and invest in the market for recyclable materials with confidence. Recycling and composting are of great importance in this region since the GCC states import almost every item sold on the market. Also, the need to green large areas of desert land is a major reason for composting. However, the level of imports makes the concept of waste minimisation difficult to develop.

To develop a strong base of co-operation among the GCC states in the field of waste recycling and reuse, it is essential to govern the technical and financial aspects of possible agreements through the unification of their legislation. In this thesis, MSW is to be covered; yet the greatest attention is to be given to household waste (including waste generated from commercial entities) since this is the kind of waste that contains the greatest amount of valuable recyclable materials. Moreover, the high content of organic matter in such waste makes it very important due to the need for compost material in this region.

4.2 Legislation and Responsibilities of the GCC Municipalities

The subject of MSW receives a great deal of attention in the different municipalities in the GCC member states. The main reason for their concern is the direct relationship between the daily services provided by the municipalities, and the public and environmental health in their states. To show the GCC municipalities' interest in cleansing operations, in general, and in the handling and treatment of their MSW, in particular, it is helpful to review the regulations applied to waste management by the local authorities in each of the GCC states. Table **4.1** presents the responsibilities of each of the GCC member states' authorities involved in the implementation of legislation concerned with cleaning up the environment and handling MSW.

In general, environmental cleanliness is the direct responsibility of the municipalities in the GCC states, as is MSW disposal and/or treatment. However, the collection of MSW is a responsibility that is shared between the municipalities and the general public in terms of the co-operation needed to accomplish such operations. Thus, private national and international cleansing companies are involved in MSW collection and disposal. Appendix IV gives a brief description of the legislation regarding solid waste management in each of the GCC states.

Table 4.1: A comparison of the GCC states' Waste Management Legislation

STATE	YEAR PASSED	AUTHORITY	RESPONSIBILITIES										
			Preventing disposal in open areas burning & Scavenging	Selection of proper landfill	Daily waste collection transportation disposal	Inspection	Issuing violations	Free of charge disposal	Disposal of hazardous materials special waste	Assigning Contractors	Preventing Environmental Pollution	Protection of Public Health	Remarks
Kingdom of Saudi Arabia	1939	City & Municipalities Council	x	x	x	x	X	x	Prohibits	x	x	x	
State of Kuwait	1972	Kuwait Municipality	x	x	All except Quantities Produced by *	Public & Official involvement	X	x	Prohibits	x	x	x	
State of Qatar	1974	Municipal & Towns Affairs Municipality Council	x	x	All except quantities placed in one cubic meter container	Police Involvement	X	x	x	-	x	x	Charges for waste collection
State of Bahrain	1975	Central Municipal Council	x	x	x	x	X	x	x	-	x	x	
Sultanate of Oman	1977	Muscat Municipality	x	x	x	x	X	x	x	-	x	x	
United Arab Emirates	1961	Municipality of Dubai	x	x	x	x	X	x	x	x	x	x	

x : Applied
- : Not Applied

* Hotels, factories, major residential or commercial complexes and co-operatives.

Referring again to Table 4.1, the following can be observed:

- All municipalities emphasise the importance of protecting the environment from waste pollution.
- Solid waste management in the GCC states is the direct responsibility of the municipalities, whether directly performed, or completely or partially subcontracted to private contractors.
- The waste management systems direct the public to abide by the rules for handling and disposing of waste in specified locations.
- These systems prohibit any individual from disposing of waste in public areas and especially in the given country's water resources.
- Contractors are obligated to deposit waste at facilities specified by the municipality; normally, such facilities are landfill sites.
- Most of these systems specify the penalties and fines levied against those who do not abide by the laws.
- The laws specify those persons having the authority to issue tickets and official warnings for violations.
- Most of the GCC states collect and dispose of MSW free of charge.

In spite of the emphasis given to the importance of maintaining a clean and healthy environment, the legal systems of the GCC states fail to address the importance of encouraging research in the various aspects of waste management operations. Also, these systems fail to acknowledge the roles that source separation and recycling play in the development of the various industries that produce products from recycled materials. They also fail to involve the public in any part of the waste management operation in a constructive way. Public participation is a vital factor in any legislative amendment.

The author believes that it is important to unite the legal systems of the GCC states for the benefit of this region if unification of GCC waste management legislation is to take place. Such unification would first require that legislation be updated to avoid any reduction in current standards of waste management. Then, the most effective legislation, in terms of both its short-term and long-term impact on the region as a whole, should be chosen.

In general, the most essential requirements in any MSW management scheme are clear policies. However, in this region, i.e., the GCC area, clear MSW management policies are lacking. This lack can be demonstrated by:

- The lack of up-to-date legislation regarding MSW management.
- The unresolved debate over incineration vs. landfill.
- The focus on disposal rather than a complete, integrated, waste management scheme; there is much discussion on methods of disposal but little on the need to minimise and recycle waste.

(Khuraibet 1997) presented a paper on the potential role of policy impact assessment in formulating sound solid waste management policy for Kuwait at the workshop on solid waste management in Kuwait.Khuraibet proposed an approach to assess policies by combining of environmental impact assessment (EIA) and policy analysis (PA). He concluded that EIA & PA are very similar in approach and perception both are effective approaches in dealing with issues of significance to environment and humans well being. They act as early warning systems by identifying issues of concern, predicting and assessing their magnitude and suggest mitigation measures for them. The emerging process, policy assessment seems sound and effective when applied to formulate a waste management policy. GCC municipality officials are encouraged to take a look at this approach, as it seems to be an effective tool in identifying, analysing, assessing and selecting waste management methods.

Several researchers, for example **(Barlone & Bernstein 1993)**, have suggested appropriate policies and strategies for waste management in industrialising countries. Also **(Al-Attar 1989)**, submitted M.Sc. thesis to the University of Aberdeen, Scotland on Solid and Semi-Solid Waste management in Kuwait, the potential role of Environmental Impact Assessment. These researchers ideas may provide useful comparisons.

In the following section we will be looking into the waste management organisation within each of the GCC Municipalities.

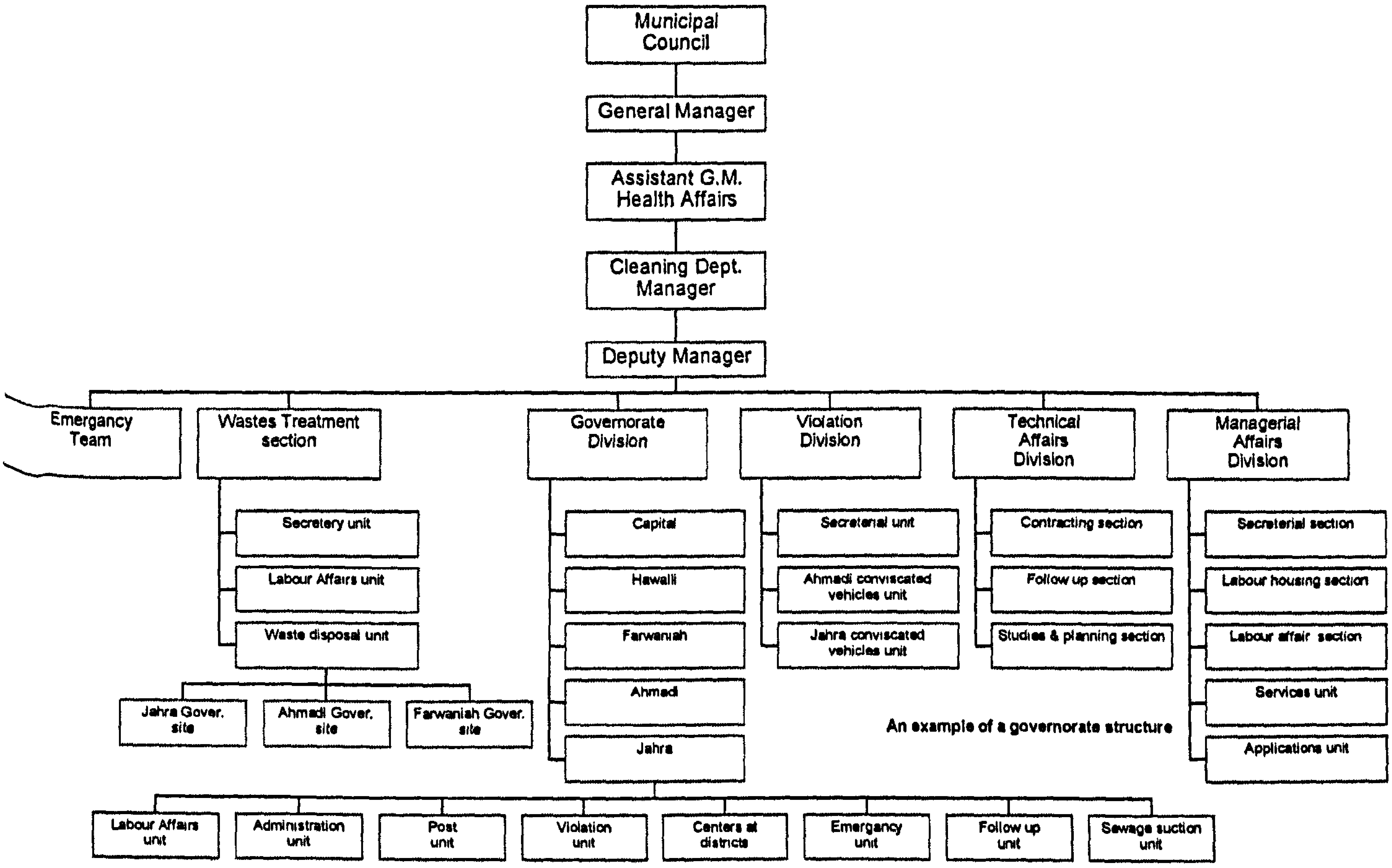
4.2.1 Municipality of Kuwait, State of Kuwait

The Cleansing Department for Service Affairs (hereafter referred to as the Cleansing Department) takes responsibility for MSW management in the Municipality of Kuwait. The Assistant General Manager heads the Cleansing Department, and a department manager and his deputy conduct the follow-up implementation of the upper management's decisions and policies (Fig. 4.1).

The Cleansing Department employs about 2000 people with different technical and managerial backgrounds, and several services are provided by the various sections of the Cleansing Department. The main service provided is the free-of-charge collection of MSW generated from the households in all areas of Kuwait.

The collection operation for MSW is a major task and definitely demands large financial resources. The organisation of the Cleansing Department is based on the idea of the decentralisation of authority. As a result, it has several sections that carry out the required tasks.

Figure 4.1: Kuwait Municipal Solid Waste Organisation Chart



Looking at the organisation chart for the Cleansing Department in Fig. 4.1, one can see that all of the various authorities have equal status. Each local authority takes care of several areas assigned it by the Technical Affairs Division through its Contracting Section. The Contracting Section divides up the different areas of Kuwait and forms groups of districts, which then constitute the territory covered by a given contract.

Each local authority has several Cleansing Centres, and each Centre is responsible for the management of the cleansing operations conducted within its designated boundaries, as presented in the cleansing contract. Each group of districts is subcontracted to a cleansing company for the performance of the required operations of waste collection, street sweeping, and other related cleansing activities.

The Waste Treatment Section controls the operation and management of several landfill sites, and thus is responsible for the disposal and treatment of the MSW. A contracting company actually disposes of the MSW and performs all activities inside the several landfill sites with the help of heavy equipment specifically contracted for such purposes. The Waste Treatment Section inspects the operations in all the landfill sites on a daily basis.

The Cleansing Department conducts its contracting; planning, studies and operations follow-up through the Technical Affairs Division. Other managerial affairs, such as secretarial work, and labour housing and affairs, are the responsibility of the Managerial Affairs Division.

The Cleansing Department is also responsible for the collection of scrap vehicles. Two locations, one to the north and one to the south of Kuwait city are allocated for storing such vehicles for further handling by the scrap-metal companies.

There is also an emergency team that has several pieces of both heavy and light equipment, as well as labourers and supervisors.

The organisation of the Cleansing Department has gone through several changes since it was established; the most recent changes are shown in the present chart (Fig. 4.1). One of the strengths in this chart is the ability each division has to take decisions as required by the situations that they may face without the need for approval from the upper management, unless there is a need for variation orders to be issued to the cleansing companies. During the author's meetings with the different divisions and sections of the Cleansing Department, he noticed that there was a lack of communication between, for example, the local authority responsible for the Capital

Governorate and the Technical Affairs Division. Data, which should be collected on a regular basis on waste amounts generated from the several cleansing centres within the Capital Local Authority, are not collected appropriately, proper records of any such data are not maintained, and any data that is collected is not communicated to the Technical Affairs Division. As a result, the required input for short-term and long-term studies is affected.

4.2.2 Secretariat of the City of Jeddah, Kingdom of Saudi Arabia

The organisational structure of the Secretariat of the City of Jeddah has certain distinctive features, which can be summarised as follows and presented in figure 4.2:

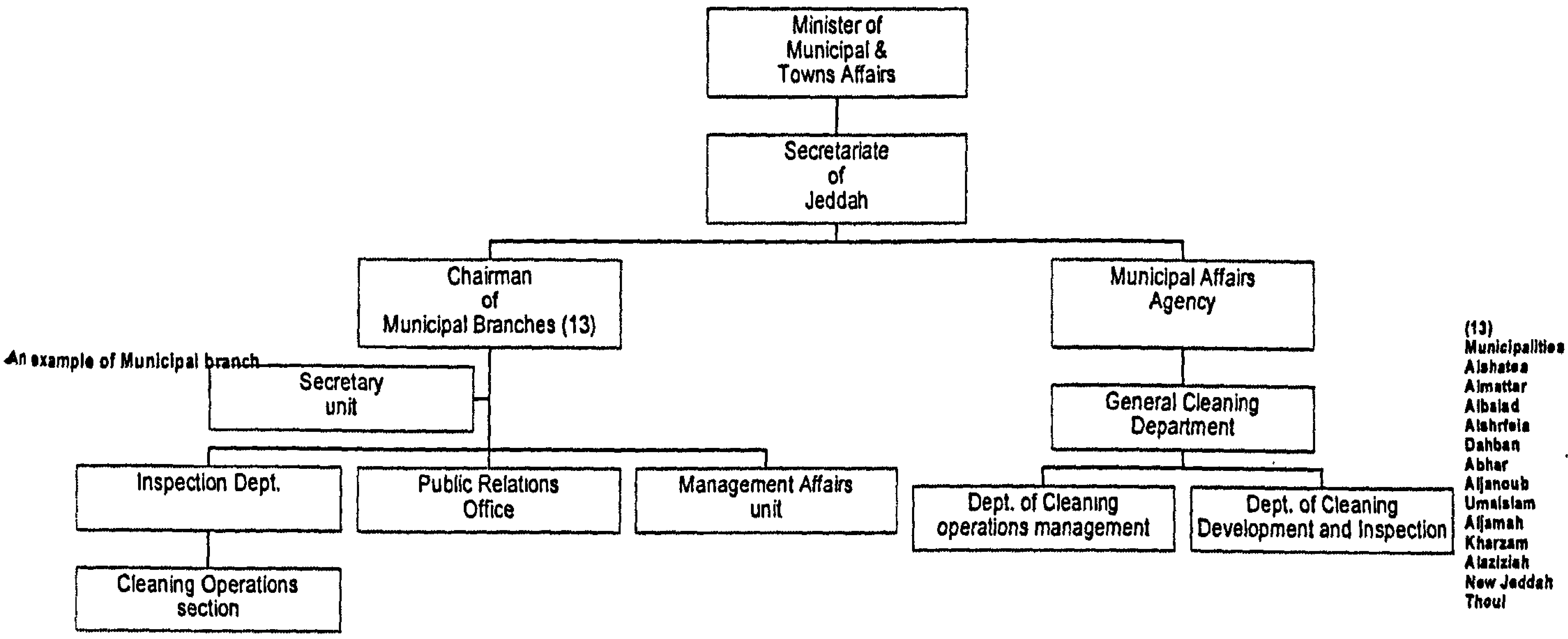
- Similar units are gathered under a single category.
- The Secretariat's Office has consultancy offices.
- New sets of departments, which are required for the current and future development of the city, are constantly being developed.
- Departments that are similar in terms of the activities they perform are united under the supervision of a single manager.
- A control unit manages the vehicles used by the city's staff.
- The unnecessary renting of buildings by several departments has been eliminated, and the cost of rental property that can be used for

city projects has been reduced.

- A detailed study of the manpower requirements was conducted in order to maximise the use of the city's staff. As a result, new criteria were initiated for employment in which more control was given to those responsible for hiring and placing staff to ensure that employees having the appropriate qualifications and experience are placed in suitable positions and are given fitting responsibilities.
- Another study of manpower requirements was specifically conducted for the foreign (i.e., non-Saudi) labour force who have been a burden on the city's Secretariat due to the large salaries and benefits they receive, and their unacceptable performance and productivity levels. As a result, several labourers were dismissed and replaced with national (i.e., Saudi) labourers.

- The Secretariat has transferred several of the technical staff from the control departments to the municipal branches and vice-versa to better fulfil the needs of each department and elevate productivity levels.

- **Figure 4.2: Jeddah Municipal Solid Waste Organisation Chart**



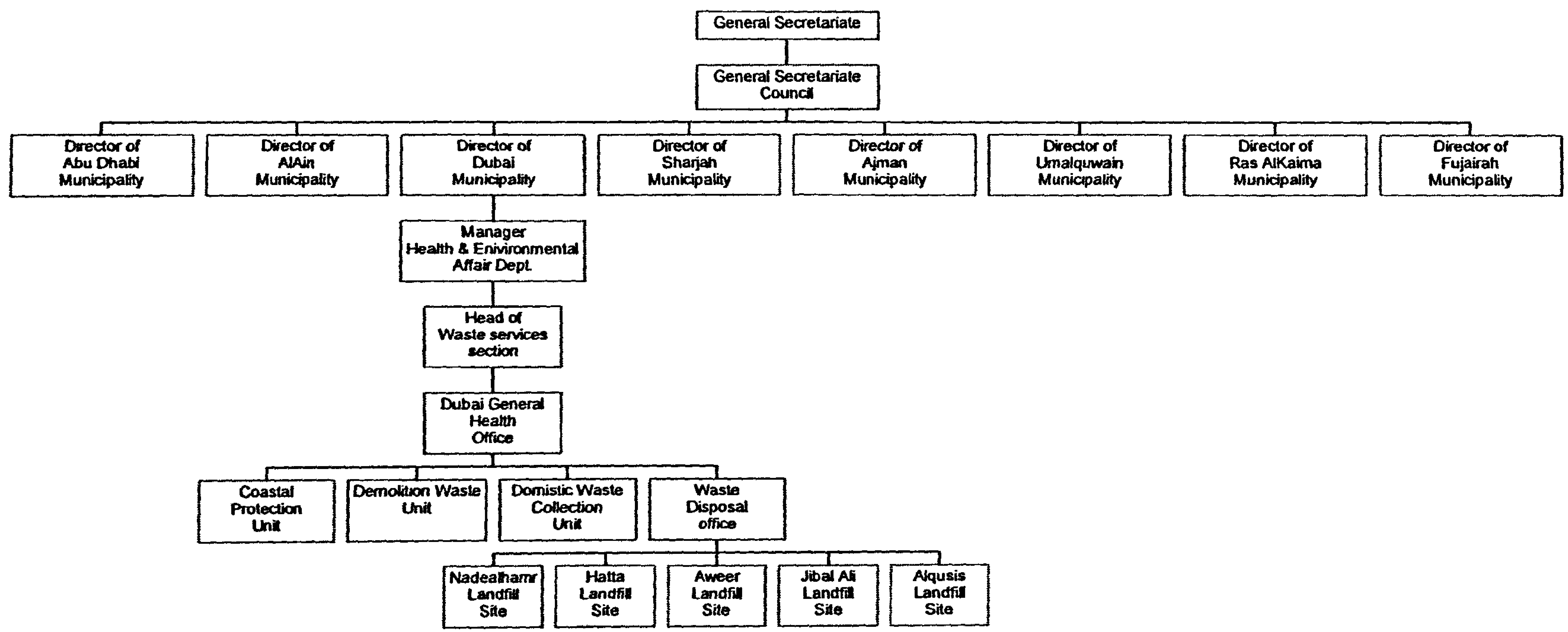
4.2.3 Municipality of Dubai, UAE

The responsibility for MSW management is carried out by the Health Department for Environmental Affairs, and specifically by the Waste Services Section, which (i.e., the waste services section) is considered to be the main co-ordinator between the top and bottom management of the Municipality (Fig. 4.3).

The Waste Services Section controls 15 offices, each of which is called a General Health Office. These offices are distributed in six areas. Six of the General Health Offices are located in Deira, five are located in the Dubai area, and one is located in each of the Awear, Hatta, Alasily and Jabil Ali areas. The Waste Services Section plans, designs, and implements all aspects of waste management, city cleansing and city beautification. Moreover, the Waste Services Section provides the required manpower and equipment for the 15 General Health Offices. The Waste Services Section provides to the general public and to government institutions free plastic bags.

Each of the General Health Offices has several units. The main unit handles all MSW generated by residential, commercial and industrial areas within its defined boundaries. This is in addition to collecting the wastewater from areas where a sewer network has not yet been constructed. It is estimated that about 30,000 gal/d of wastewater are collected.

Figure 4.3: Dubai Municipal Solid Waste Organisation Chart



A Demolition Unit collects all C&D waste generated in the residential, commercial and industrial areas. The removal of demolition waste resulting from private building violations of the construction regulations is also the duty of the Demolition Unit.

A well-equipped unit called the Coastal Protection Unit protects the coastal area from contamination and pollutants. Monitoring the shipping activities, which produce various types of wastes to be collected, is the Coastal Protection Unit's continual follow-up operation. The removal of sunken ships and boats, and skimming of engine oil from the water's surface are other major tasks performed by the Coastal Protection Unit.

The Waste Disposal Unit monitors the operation of waste disposal at the various landfill sites and monitors the progress of the disposal plans as well as performance levels. There is also a workshop where all the equipment, which is used in waste landfill can be repaired or serviced; this is also the responsibility of the Waste Disposal Unit.

The Waste Services Section employs the inspectors and controllers required to monitor and to follow up on the implementation of Decree Number 28/85, which addresses the cleansing activities of the Emirate of Dubai. The inspectors and controllers have the authority to ticket those who violate the decree. In addition, the inspectors and controllers, as part of their duties, report any required repairs needed in the city, such as damaged traffic lights, footpaths or sewage lines.

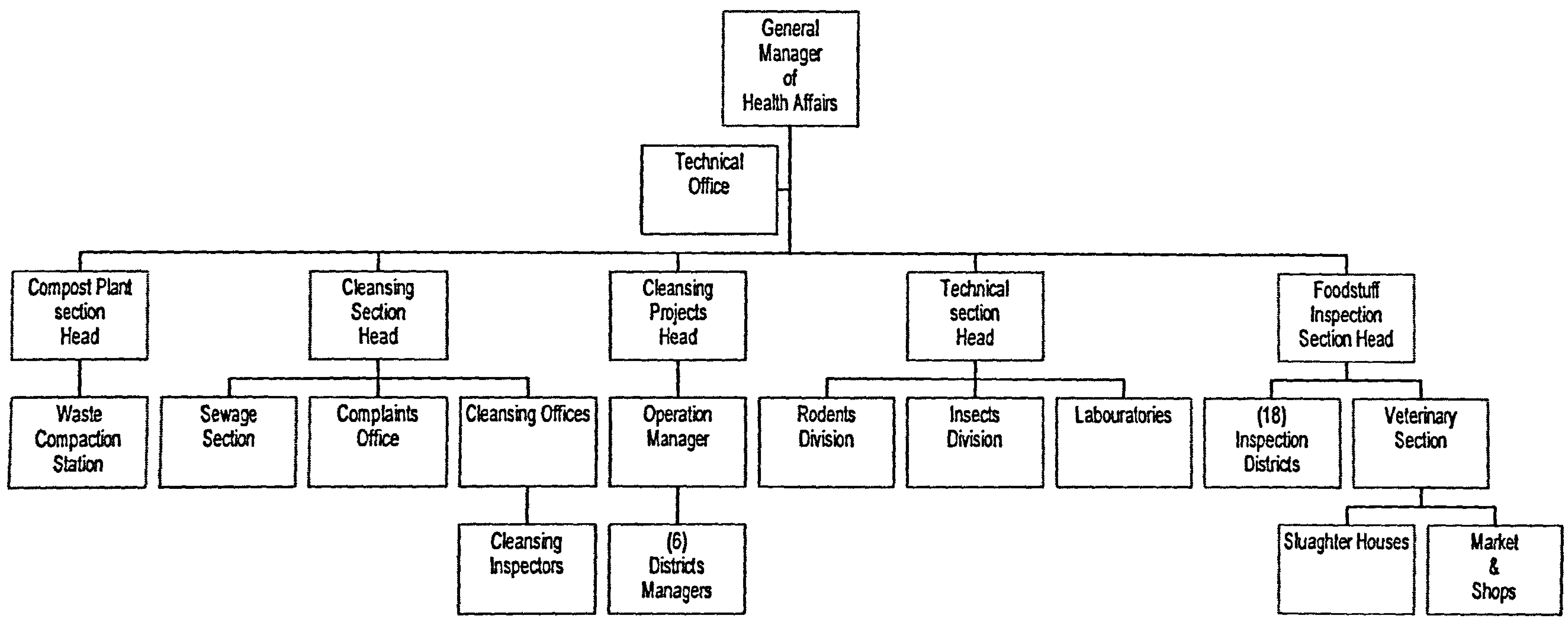
4.2.4 Municipality of Doha, State of Qatar

The Municipality of Doha carries out the responsibilities of General City cleansing. The Health Affairs Department is headed by the Municipality's Deputy General Manager, and is in charge of such responsibilities including waste collection, transportation and disposal (Fig. 4.4).

MSW management activities are performed through six district managers who are responsible for following up on the performance and level of accomplishment of their staff. The system of waste management in the Municipality of Doha is based on a decentralised scheme. The city is divided into six districts with each District Manager having full responsibility for and being fully in charge of taking proper actions and determining the best possible alternatives to be applied within his district in co-operation and harmony with the other districts in the city of Doha.

Each district is divided into smaller communities (called centres) in which an Assistant to the District Manager has the responsibility for performing and following up on assigned tasks such as MSW collection and disposal. In each Municipality Centre, machines and equipment for the cleansing operations are stored for daily use.

Figure 4.4: Doha Municipal Solid Waste Organisation Chart



An example of the equipment that is both required and available is shown in Table 4.2.

TABLE 4.2: COMPARISION OF REQUIRED AND AVAILABLE EQUIPMENT

Item	Availability	Requirement
Compaction Vehicles	67	50 (35 18-m^3 & 15 16-m^3)
Mechanised Sweepers	20	20
Trailer-Trucks	40	44
Sewage Trucks	23	23
Vehicles for Labour Transportation	10	10
Follow-up Vehicles	4	4

Source: Doha Municipality, Health Affairs Department (1993).

Within the management scheme of the Municipality of Doha's organisation, there is an Advisory Unit that provides consultations on the various aspects of the waste management operations. A German consulting firm (P.C. Berlin) manages this unit. A major accomplishment of this firm has been the transformation of the centralised waste management system into a decentralised system. Moreover, they determined the actual manpower staffing requirements, which resulted in more appropriate employment levels than were assumed before, and as a result, increased the quality of the manpower performance.

The Compost Plant Section is mainly responsible for managing, monitoring and operating the Compost Plant in which the reuse of the Municipality's MSW, which has been collected and transported, is accomplished.

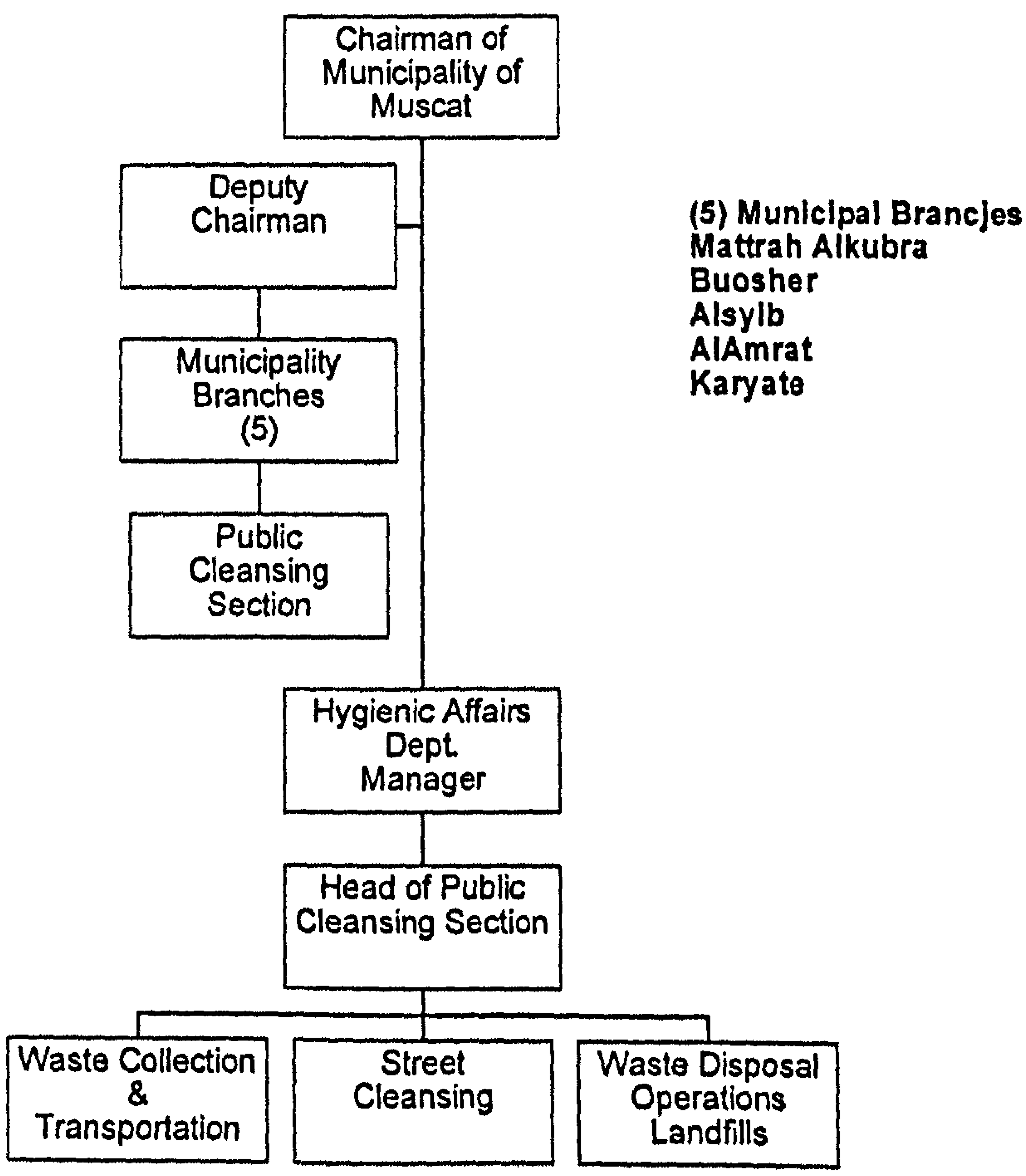
4.2.5 Muscat Municipality, Sultanate of Oman

In Muscat, waste management is handled through a decentralised system. There are several branches, each of which has a Public Hygiene Department. Such a department is responsible for several activities concerned with city cleansing, including rodent and insect extermination, foodstuff inspection and public health and safety licensing. A separate section, with a section head, is responsible for each type of activity (Fig. 4.5).

The head of the Public Cleansing Section is responsible for waste management operations, which include street cleaning, waste collection and transportation, and management of the Municipality's landfill site. The head of the Public Cleansing Section reports to the Hygienic Affairs Department

Manager, who handles all the planning and decisions. In order to ease cleansing operations, each municipality branch is divided into four-six districts. Each district has a supervisor who follows up on the cleansing activities in his district by dividing his district into sub-districts and appointing an inspector whose responsibility is to supervise the labourers and their work.

Figure 4.5: Muscat Municipal Solid Waste Organisation Chart



There are five municipality branches within the city of Muscat. The Deputy Chairman of the Municipality of Muscat is directly responsible for the general supervision of the work of the Municipality's branches. Within each branch there is a Cleansing Section which is responsible for all cleansing activities conducted by the Municipality. Waste is collected using rear-loading compactor trucks and open-trucks.

In February of 1992, the Municipality of Muscat began night-time collection of MSW for the first time. Officials in the Municipality of Muscat prefer this scheduling of waste collection since it has several advantages over the old waste collection scheduling, which was during the daytime. Waste collection during the night-time saves money, increases labour productivity, and takes less time. This is due to the much lighter traffic at night, which decreases the consumption of gas per vehicle (compactor-truck) and thus saves money; and the cooler temperatures, which help labourers to perform better than in the hot day-time temperatures, and thus increases productivity. The lighter traffic and increased productivity also combine to reduce the time required to complete collection and transportation of the waste, and thus improve efficiency. The work at night has no significant effect on the wage rate per worker.

4.2.6 Bahrain Central Municipal Council

Bahrain population has increased in the last twenty years with an average annual rate of 3.8%. Consequently domestic waste generated per capita has increased, as residents became more prosperous. The end result is a progressive damage to the current mechanical and financial resources besides the sever shortage of landfill space. The central Municipal Council (CMC) will have to be prepared to maintain the current service levels in the future taking into account the current financial difficulties in funding the services. As a result CMC is considering a major reorganisation of the existing operational procedures and rationalisation of the organisation and management structure.

Bahrain like the rest of the GCC states had traditional local government, which has evolved around villages have led to the present organisation structure of twelve independent Municipalities varying considerably in population and geographical area.

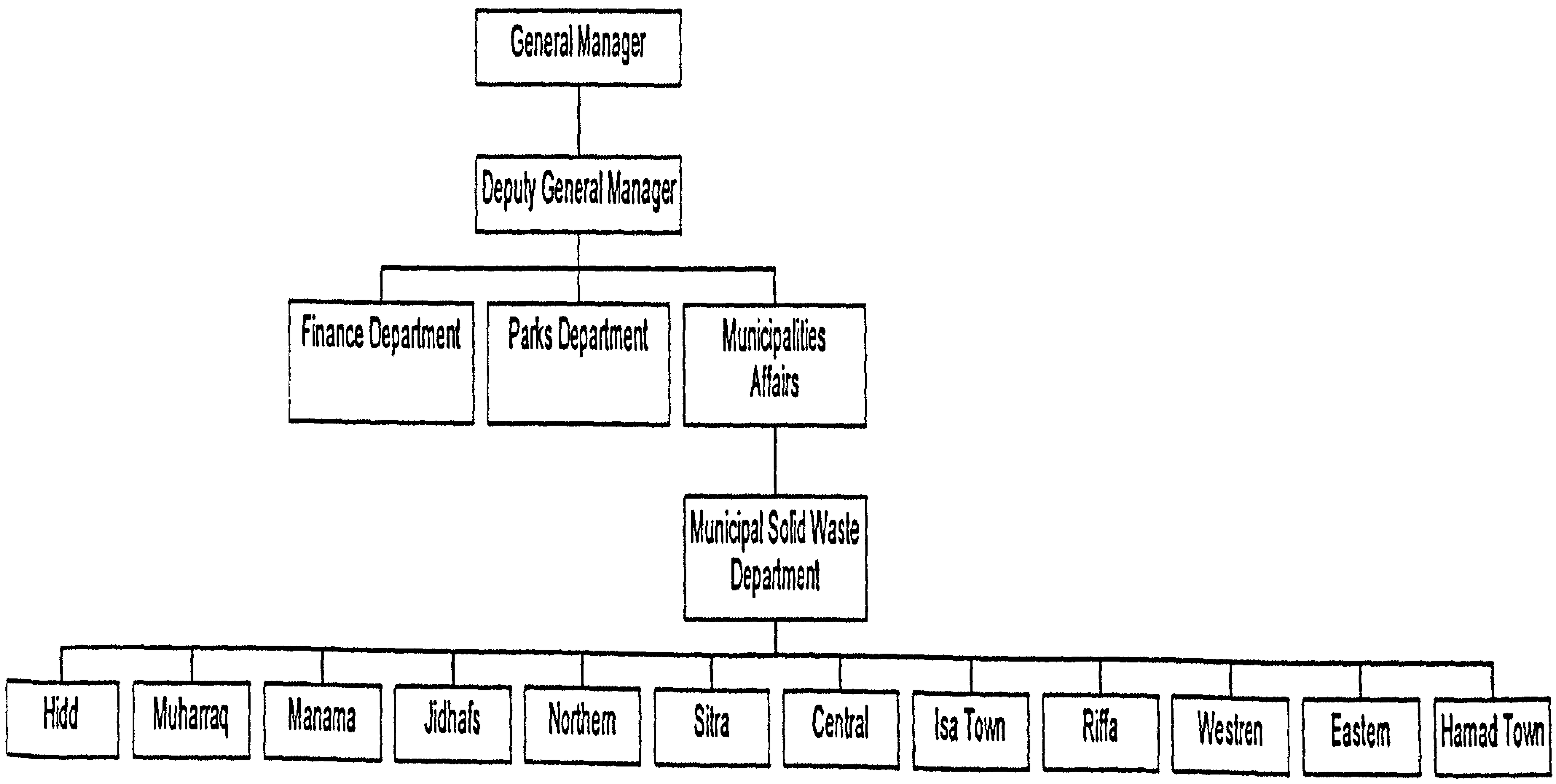
Bahrain has a fleet of 450 vehicles, 50% of which are over agreed replacement age. Two hundred and fifty are used to provide the main cleansing services; refuse collection and refuse disposal, street cleansing, and septic tank emptying. Inconsistent funding from the Ministry of Finance has constrained the implementation of a vehicle substitute programme based upon the economical life of each type of vehicle and has resulted in higher maintenance costs, more breakdowns and longer downtime periods.

In many instances the laws and regulations are sufficient but the aspiration and enthusiasm to implement them does not exist. Inadequate legislation or the non-implementation of suitable laws leads to unsystematic waste dumping, use of unsuitable waste receptacles, litter and uncovered loads in open areas. Even when offenders are caught inadequate fines or reluctance to collect non-paid fines only goes to disparage the problems **(Al Sayigh 1993).**

The current waste management operations, labour and equipment are affected by weather conditions, which are excessive heat, humidity and salinity. The current landfill sites, which are known as the quarry area, will be out of use within 10 to 15 years **(Latoh 1998).**

The current organisational structure of the Central Municipal Council of Bahrain is formed of twelve independent Municipalities, which provide the same cleansing services. It is envisioned that these authorities would be reorganised into two separate Directorates; one to provide all cleansing services and the other to manage the remaining municipal affairs. Many of the twelve municipalities' assets will be let or sold with few left for mobilisation and public liaison as part of the new centralised services administration. Based on this reorganisation scheme fewer management and supervisory levels would be utilised. Consequently more realistic and economical manpower to supervisor ratio would be implemented. Furthermore eliminating duplication of work and introducing more modern technical equipment and computers would reduce manpower. Figure 4.6 shows the current MSW organisational structure for Bahrain Central Municipal Council.

Figure 4.6: Bahrain Central Municipal Council MSW Organisational Structure



4.3 Discussion of the Organisation of the GCC Municipalities

The organisation of each of the GCC municipalities presented earlier shares with each of the other GCC municipalities a great number of basic features. These features may be summarised as follows:

- Simple, traditional, functional organisational structures have several functional managers reporting to one general manager of the waste department.
- City cleansing, and MSW collection and disposal are considered major functions of the waste department.
- Functional managers are dependent entirely upon their general managers for the performance of waste management operations; thus, should a given general manager be deficient in any way, the co-ordination of serious problems across functions becomes difficult because functional managers must clear all decisions through their general managers.

Generally these structures seem to work despite their weaknesses. However, more co-ordination between the managers at the different levels of the waste management structure is essential since MSW activities are performed within a decentralised scheme in which the managers of the districts are responsible for planning, budgeting, and monitoring the waste management operations.

CHAPTER V

Municipal Solid Waste in Kuwait (Case Study)

5. CASE STUDY: MSW IN KUWAIT

Kuwait is a rapidly growing modern state with a population of less than two million and a high return from oil exports. The population enjoys a high standard of living. Although MSW collection is considered acceptable, the Municipality of Kuwait performs poorly in all other areas of waste management. Recycling programmes are neither promoted by the local municipalities nor given any attention by the public who are busy with issues other than waste.

The Kuwaiti, as opposed to the non-Kuwaiti, population participates minimally in the development of legislation on MSW management. Although there is an elected Municipal Council that represents the various districts of Kuwait, the waste issue in Kuwait comprises a combination of both environmental and political questions, which involve the Municipality's decision makers, members of the Municipal Council, and members of the National Assembly (i.e., Kuwait's parliamentary body). The Municipality of Kuwait has always been in charge of municipal affairs in Kuwait. Other bodies, such as the Environmental Protection Department of the Ministry of Health, the Environmental Protection Council (EPC) (now the Environment Protection Authority) and KISR, have all had lesser roles in formulating such decisions.

The Municipality rarely consults the EPC (El-Baroudi et al., 1984) or KISR (Masud et al., 1987) on waste management issues. Waste issues, such as improper waste disposal and the absence of waste recycling programmes, remain unresolved even after recommendations have been approved by the Municipal Council.

In 1992, residents of the Jeleeb Al Shuyoukh residential area objected to the improper waste management operations taking place at the Jeleeb Al Shuyoukh landfill site. Such public reaction and the growing concern of the society towards improper disposal operations are positive indications of the need for effective environmental systems. The Cleansing Department of the Municipality of Kuwait is responsible for the management and operation of landfills in Kuwait. Since 1980, the Municipality of Kuwait has used the Jeleeb Al Shuyoukh landfill site for MSW disposal. This landfill was insanitary, and as a result, it was a health hazard and had a negative impact on the environment.

In general, an overview of the present MSW management in Kuwait indicates the existence of various deficiencies. These deficiencies are either directly or indirectly related to solid waste management operations, which include the collection, transportation, disposal and treatment of MSW. This chapter investigates the present solid waste management system's drawbacks and recommends corrective action, which if adopted by the Municipality of Kuwait would guide subsequent amendments in waste management operations.

5.1 Effect of Population on Solid Waste Management for Kuwait

It is essential for waste management, from a strategic planning viewpoint that the potential increase in population is forecasted through to the year 2020. National census data and Kuwait's Master Plan Review (KMPR - 1993) are the sources for this projection. The recent population growth between 1985 and 1995 is shown in Table 5.1.

TABLE 5.1: POPULATION FROM 1985 TO 1995

NATIONAL POPULATION GROWTH 1985 - 1995				
Year	**Kuwaiti**	**Non-Kuwaiti**	**Total**	**Kuwaiti Percentage**
1985	474082	1245659	1719741	27.6
1986	495401	1306144	1801545	27.5
1987	516719	1367900	1884619	27.4
1988	538036	1430926	1968962	27.3
1989	559355	1495223	2054578	27.2
1990	580674	1560791	2141465	27.1
1991	603411	-	-	-
1992	626150	796049	1422199	44.0
1993	648883	811970	1460853	44.4
1994	671344	948742	1620086	41.4
1995	694356	996179	1690535	41.1

Source: Ministry of Planning, 1995.

Table 5.1 shows that the percentage of the Kuwaiti population in the total population decreased as the non-Kuwaiti population increased rapidly up until 1990. Due to Iraq's invasion of Kuwait, the population structure of Kuwait has changed. After the liberation of Kuwait, the number of non-Kuwaitis decreased by almost 50%. The total population of Kuwait reached 1.4 million in 1992, the first year after the liberation of Kuwait. The percentage of Kuwaiti population was low, about 45% of the total population. It is extremely difficult to determine an exact figure for the future non-Kuwaiti population because of the continuous changes in the population's residency status, which is due to the unpredictable policy of the government of Kuwait regarding the granting of entry visas to foreigners.

The government of Kuwait encourages the increase of its Kuwaiti population through various financial incentives. Kuwaiti males receive KD 4,000 from the government as financial support when they get married to Kuwaiti females. Also the married couple gets KD 70,000 as a soft loan for housing repayable in monthly instalments of about KD 120. Consequently, the number of Kuwaitis is likely to increase through the year 2020.

The authors of the KMPR indicated that the total population, both Kuwaiti and non-Kuwaiti, is strongly influenced by two factors. The first factor is the level of total employment and the second is the number of dependants accompanying immigrant workers. Imported labour is needed to overcome the shortage in the Kuwaiti labour force since there are more jobs in the state than the Kuwait labour force can fill.

Table 5.2 shows the population projections for 1992-2020. In this table, the author introduced an adjustment factor to the non-Kuwaiti population projections to balance the Kuwaiti population and the non-Kuwaiti population at 50% shares of the total population.

Table 5.2: KUWAIT'S POPULATION PROJECTION (1992 - 2020)

YEAR	KUWAITI 3.79%	NON-KUWAITI 2.50%	TOTAL	% OF KUWAITI	% OF NON-KUWAITI
1992	602010	747990	1350000	0.445933	0.554067
1993	624826	766690	1391516	0.449026	0.550974
1994	648507	785857	1434364	0.452122	0.547878
1995	673086	805503	1478589	0.455222	0.544778
1996	698596	825641	1524236	0.458325	0.541675
1997	725072	846282	1571354	0.461431	0.538569
1998	752553	867439	1619992	0.464541	0.535459
1999	781074	889125	1670199	0.467653	0.532347
2000	810677	911353	1722030	0.470768	0.529232
2001	841402	934137	1775539	0.473885	0.526115
2002	873291	957490	1830781	0.477004	0.522996
2003	906388	981428	1887816	0.480125	0.519875
2004	940741	1005963	1946704	0.483248	0.516752
2005	976395	1031112	2007507	0.486372	0.513628
2006	1013400	1056890	2070290	0.489497	0.510503
2007	1051808	1083313	2135120	0.492622	0.507378
2008	1091671	1110395	2202067	0.495749	0.504251
2009	1133046	1138155	2271201	0.498875	0.501125
2010	1175988	1166609	2342597	0.502002	0.497998
2011	1220558	1195774	2416332	0.505128	0.494872
2012	1266817	1225669	2492486	0.508255	0.491745
2013	1314830	1256310	2571140	0.511380	0.488620
2014	1364662	1287718	2652380	0.514505	0.485495
2015	1416382	1319911	2736293	0.517628	0.482372
2016	1470063	1352909	2822972	0.520750	0.479250
2017	1525779	1386732	2912510	0.523871	0.476129
2018	1583606	1421400	3005005	0.526989	0.473011
2019	1643624	1456935	3100559	0.530106	0.469894
2020	1705918	1493358	3199276	0.533220	0.466780

Source: Author estimation.

This factor represents the objectives and the expected results of implementation of the Kuwaiti government's policies aimed at the minimisation of the non-Kuwaiti population in Kuwait. It would be helpful if the authorities would establish a strategic plan covering labour-force requirements for the next 20 years. Such a strategic plan would help in estimating the future rates of MSW generation. Consequently, effective planning and forecasting could be achieved. The development of the Kuwaiti labour force through organised professional training programmes would partially eliminate the need for such a high level of foreign labour, as is currently required.

5.2 Historical Developments in MSW Management in Kuwait

According to Decree Number 2111, issued in November 1977, waste collection was allowed to be performed on a contractual basis by private contractors on behalf of various concerns, such as hotels, co-operatives and high-rise building complexes. In 1979, the cleansing services of the Municipality of Kuwait were evaluated by VBB of Sweden, and the resulting recommendations were presented to the Municipality. The most important recommendation was to assign the waste collection in some areas to local contractors. Subsequently, in 1980, waste collection in the

Salmiyah area was contracted to the Al-Mulla Company and Browing Ferries Ltd (BFI). Similar arrangements were gradually applied to other areas. Currently, private contractors collect approximately 100% of the total domestic solid waste in Kuwait on behalf of the Municipality of Kuwait and other bodies.

MSW management was reassessed by Vest Alpine in 1984 and 1986; the use of MSW disposal alternatives and treatment, such as recycling and composting, was recommended. After 1984, numerous attempts were made by the Municipality of Kuwait to identify the best possible alternative for MSW recovery. This occurred in collaboration with various national and international enterprises. KISR conducted several studies on MSW between 1980 and 1990. In 1988, the Municipality of Kuwait required the Industrial Investment Company (IIC) to conduct feasibility study on converting MSW into compost through a composting facility at a total project cost of about KD 10 million. The recommendation of the feasibility study was that the government set up a composting plant as soon as possible. However, due to budget constraints and the project's lack of financial viability, the government delayed the project. The Municipality of Kuwait had established a pilot composting plant in theSulaibiya area in the late sixties in collaboration with a French company. Due to the unavailability of spare parts, which were needed for some of the mechanical equipment in the plant, the pilot plant was abandoned. The Agriculture Projects Company, on behalf of the Public Authority for Agricultural Affairs and Fisheries Resources (PAAAFR), restarted the Sulaibiya composting pilot plant in 1992. This was only for a short time, about 6 months; yet, no success was achieved due to the lack of professional operators, and the pilot plant was once again abandoned. In 1988, the Municipality of Kuwait transferred ownership of the plant to IIC; yet, the plant is still not operational.

Recently, the Municipality of Kuwait established an Environmental Affairs Department (EAD) within the Municipality's organisational structure. Young, educated, enthusiastic Kuwaiti engineers, who provide consultancy, environmental assessment, project evaluation and other services related to environmental issues, currently manage the EAD. The new EAD is an active unit that has great potential for producing high-quality investigative studies, which will assist in future decisions pertaining to MSW treatment, conversion and disposal.

For the last 12 years, the Municipality of Kuwait has conducted a range of studies on MSW management; yet, firm decisions on the implementation of the recommendations of these studies seem to be impossible to make due to the following:

- The complete lack of knowledge and expertise on the part of the decision-makers as to important aspects of waste management.
- The absence of and/or opposition to public participation in the ongoing waste management practices of the Municipality of Kuwait.

An example that demonstrates the lack of expertise of the waste management decision-makers is the absence of any surveys to determine the actual cost of waste management operations such as waste collection and waste disposal. Another example is the misuse of landfill sites by the Municipality's contractors, who fear no consequences for using improper disposal methods because of poor monitoring by the Municipality.

5.3 Kuwait's MSW Collection System

A successful MSW collection system is based on the careful selection and co-ordination of containers used by the various facilities, such as households, commercial businesses, industries and institutions, for initial waste disposal. The selection of containers can be affected by several factors, such as accessibility, frequency of collection, distance from collection points to collection vehicles and type of waste to be collected. Although MSW in Kuwait is collected, for the most part, by the manual emptying of waste containers (usually 240-liter containers), industrial, commercial and certain residential waste collection points are handled mechanically, usually with containers of 1 m^3 or greater capacity. MSW collection in Kuwait is carried out completely under the direct supervision of the Cleansing Department of the Municipality of Kuwait. An exception is large apartment buildings, which are responsible for the collection, transportation, and disposal of their own waste.

MSW collection is performed on a daily basis six days a week starting at 5:00 in the morning and ending at 12:00 noon. This schedule is required by the prevalent hot weather conditions in Kuwait. When monitoring the collection trucks arriving at the landfill sites, it was noted that no truck arrived at any of the landfill sites later than 12:30 p.m. This is due to the Municipality's regulations on the waste collection timetable and schedule control. Also, since collection is carried out by private contractors, it is in their own best interest to enter the collection area as early as possible in the morning and leave as early as possible to avoid the afternoon rush hour, which normally begins at 1:00 p.m.

Since 1978, the Municipality has required the use of black plastic bags by all domestic waste generators. In early 1980, a 240-l waste container was distributed to each household. As a result, the waste collection operation is much tidier and easier than it had been previously. In the past, waste collection was a major issue due to the lack of co-operation of the households with the Municipality's waste collection team. Waste used to be placed on the sides of the streets directly on the pavement and was usually not bagged. Currently, with a few exceptions in some collection areas, most of the collection areas comply by using black plastic bags and placing their waste in the containers provided. The containers are provided by the Municipality free of charge through the private contractors as part of a contractual agreement signed with the Municipality. Currently, most collections of MSW are made using compaction vehicles, although open trucks are used on a very limited scale. The Municipality's total number of rear-loading compaction vehicles is 245 at present. In addition, there are about 15% more compaction trucks, which are operated by private contractors on behalf of parties other than the Municipality of Kuwait. According to the Municipality's requirements, the 18-m^3 rear-loading compaction vehicle is the most commonly used in Kuwait. According to the Al-Mulla Cleaning Company's Operations Manager, Mr. Mohammad Mountaser (personal communication, 1991), it is estimated that an 18-m^3 compaction vehicle serves on average, 10,000 persons. Consequently with a total population estimate of about 1.4 million, the total number of compaction vehicles required is 140. This estimation indicates that the size of the Municipality's present collection (i.e., 245 such compaction vehicles) seems excessive for the provision of effective daily waste collection. It also indicates that the Municipality's collection system, which is completely based on the use of compaction vehicles, inflates the total cost of the collection contract. Generally the compaction vehicles make two trips each day for six days each week. The collection crew of each compaction vehicle numbers between 3 and 5 including a driver. The major issue with the collection crew is their careless behaviour during waste collection. Usually, the crew leaves loose waste behind at the collection points creating unsightly and insanitary conditions. The use of suitable containers and stricter control of the collection crews would significantly reduce such problems.

5.4 Field Investigation

To verify the estimations of Mr. Mountaser, the author conducted a field investigation at the Sulaibiyah landfill, which receives MSW from the southwestern Al Jahra area. MSW arriving from residential, commercial and industrial areas at the Sulayibiah landfill was weighed between 11 and 16 November 1991, and provided the basis for the estimation of MSW generated in the Al Jahra area in Kuwait. The results of the weighing are presented in Table **5.3**.

TABLE 5.3: MSW WEIGHINGS OF AL JAHRA AREA

Day of the Week	Date (d/m/y)	Total Weight (t/d)	Total No. of Trips/d	Total No. of Truck per Day
Saturday	11/11/91	150.640	23	19
Sunday	12/11/91	175.100	30	20
Monday	13/11/91	153.780	30	19
Tuesday	14/11/91	172.480	32	20
Wednesday	15/11/91	188.220	31	20
Thursday	16/11/91	175.880	32	23
Total		**1016.100**	**178**	**121**
Average		**169.350**	**30**	**20**

Source: Author estimation.

Note: Total number of trips per day is different from total number of trucks per since some trucks conducted more than one trip per day.

5.4.1 Analysis of Findings

5.4.1.1 Input

- On average, 20 collection trucks arrive at the landfill per day.
- On average, 30 trips are made per day.
- On average, 169 tons/day of MSW is collected from the Al Jahra area.

5.4.1.2 Given

The number of trucks available for the collection of such an amount is equal to 28 rear-loading waste collection trucks, according to the Municipality's records.

5.4.1.3 Assumptions

- The average load per trip is about 5.708 tons. This is considered to be a light load for a truck with a capacity of 18 m^3; the normal practical load for an 18- m^3 truck is 7 tons/trip.
- The minimum number of trips per truck per day should not be less than 2.

5.4.1.4 Results

- The number of trucks required for the collection of the 169 tons of MSW produced each day, if the first assumption is true, is equal to 24 trucks per day. Yet, if the second assumption is applied, the number of trucks required per day should be divided by a maximum of 2 trips per truck per day or a minimum of 1.5 trips per truck per day, which results in 12 and 16 trips, respectively.
- The number of trucks required by the Al Jahra MSW collection contract is less than the number required or assigned by the Municipality, i.e.,28 rear-loading trucks.
- The difference between the number of trucks required and the number needed, if translated into a monetary value, clearly shows the contract's inflation.
- The total cost of the contract is KD 2,818,800. Collection constitutes 80% of the contract's cost, i.e., KD 2,255,040, assuming the use of 28 trucks plus crews. The calculations suggest that the contract can be

carried out with 16 trucks plus crews. Thus, the collection cost is reduced to 16/28 of the current collection cost of KD 2,255,040, which amounts to KD 1,288,594.

- As a result, the total reduction in the value of the contract would then be:

KD 2,255,040 – 1,288,590 = KD 966,450

This means that roughly KD 1 million is currently extra profit for the contractor. The real value of the contract should be:

KD 2,818,800 – 966,450 = KD 1,852,350

5.4.1.5 Conclusion

This field investigation indicates that the decisions regarding the number of collection vehicles used was not based on fieldwork. Such analyses would give the decision-makers more realistic figures to be considered in designing a waste management scheme for MSW collection. Since 1980, when the Municipality first contracted with private contractors for MSW collection, the role of the Municipality's fleet has declined gradually as more collection areas have been assigned to the private sector through 3 years contracts. In 1992, 4 years contracts were signed with 12 private companies for the collection of MSW. The annual number of trip-loads made by the Municipality's fleet between 1982 and 1992, and the corresponding quantities of waste collected per day and per year are given in Table **5.4**. The data in this table point to the declining role of the Municipality's fleet in the collection of solid waste over that 10 year period.

TABLE 5.4: ANNUAL NUMBER OF TRIP-LOADS MADE BY THE MUNICIPALITY OF KUWAIT'S FLEET BETWEEN 1982 AND 1992

Year	No. of Trips/year	Waste (ton/year)	Waste (ton/day)
1982	194,603	778,412	2132.64
1983	132,748	530,992	1454.77
1984	106,709	426,836	1169.41
1985	93,782	375,128	1027.75
1986	67,312	269,248	737.666
1987	46,452	185,808	509.063
1988	38,241	152,964	419.079
1989	28,355	113,420	310.740
1990–1992	0	0	0

Source: Municipality of Kuwait, 1992. Personal communication.

According to the Municipality's records, the use of private contractors for waste collection services has reduced the cost of such services. These records show that the number of crewmembers has been reduced, the number of engine breakdowns has decreased, the level of service has increased, and efficiency and tidiness have improved. However, evidence presented earlier in this section, particularly regarding vehicle numbers and tidiness, suggest that these claims may be open to question.

5.4.2 Collection Costs

The waste collection operation is often the most costly component of the local waste management systems. The cost of MSW collection is rapidly growing for various reasons, such as the development of new residential, commercial, and industrial areas, which in turn cause an increase in the population, who consequently generate greater amounts of MSW due to their activities. Therefore, the cost of MSW collection and transfer to disposal facilities away from populated areas is increased due to the increase in the number of transportation vehicles required, as well as the increased distance to the landfill sites. Also the increase in the cost of manufacturing, and consequently, the increase in the selling price, of waste collection equipment, such as mechanised waste collection vehicles, is another reason for the rapidly growing cost of waste collection. Moreover the very high collection frequency practised by the Municipality of Kuwait contributes to the cost of its waste collection contracts.

The Municipality of Kuwait's MSW is collected by private contractors. The Municipality sets the terms of reference, and the contractors submit bids for the collection and transportation of the MSW. The Municipality awards contracts to the contractor offering the best price; according to Municipality's officials, the lowest price offered is the one selected. As a result, the Municipality signs an agreement with the selected contractor to cover a specific area, which usually includes several residential districts and some commercial districts, for a specific period of time.

The Municipality of Kuwait prefers this type of subcontracted collection system over performing the waste collection on its own, since the former provides competition among the bidders, which increases the waste collection system's efficiency, and decreases the strain on the municipal budget. Yet, some disadvantages are being experienced with the subcontracted collection system, such as the increased duties involved in overseeing the contractor's work requiring an increased number of inspectors. There is also a need to arrange for a quick response in the case of unexpected, serious financial difficulties and/or contract problems that the subcontractor might encounter and interfere with the progress of the waste collection services. The frequency of collection is a major constraint in any of the Municipality's subcontract agreements. Due to the high rate of waste generation per capita, the waste being collected by the subcontractors in the assigned areas is in many cases more than what the storage can accommodate. Larger containers are required in this case, and public education and awareness are needed to ensure that the tasks of source separation and reuse are performed instead of just disposal. Moreover, from an environmental health viewpoint, waste cannot be stored for a long period of time in the containers provided due to the high temperatures in the summer time, which enhance the rapid biodegradation of the MSW and cause bad odours. The collection of waste is therefore performed on a daily basis. This is a major factor in increasing the cost of the collection and transportation of MSW in Kuwait. More frequent collection is generally more costly. Also, many collection points, both residential and commercial, have limited storage space for the initial disposal of waste, which requires even more frequent collection. Since the state was under a new contract for waste collection at the time of this field investigation, it would have been very difficult to change the types of containers used, i.e., 240-liter capacity; therefore; the containers continued to be used for the next 4 years (i.e., until 1996). In general, the frequency of collection depends on the demographics of the collection areas.

To show the rapid increase, in some cases unexplained, of waste collection costs; a general financial comparison between the 1985 contract and the 1989 contract for the Hawalli, Nugra, and Jabriya districts, which are considered to be blends of residential and commercial properties, was prepared. The cost of these contracts included only the cost of collection, since the cost of disposal of MSW by the Municipality's subcontractors is free of charge. Table 5.5 shows the differences between the two contracts.

TABLE 5.5: COMPARISON OF WASTE COLLECTION CONTRACTS, 1985 AND 1989

Year	1985 (KD)	1989 (KD)
Total Cost per Month	48,449	68,477
Number of Containers (6-m$^{3)}$	297	55
Number of Containers (240-l)	2997	3500
Number of Rear Loaders (16-m$^{3)}$	-	13
Number of Rear-Loaders (18-m$^{3)}$	17	-
Number of Labourers	220	107
Waste Generated (t/d)	272	182
Cost (KD) Conversion (KD 1. = US$ 3.5		

Source: Kuwait Municipality/Personal communication.

The cost per ton was estimated for both contracts. It was about KD 6.0/ton in 1985 and about KD 12.5/ton in 1989. Although in 1989, the contract districts had more buildings, more residents, longer routes, and more stops, less waste generated, and less vehicle capacity in service, the total cost per month was much higher, over 35% higher, than the 1985 contract cost. In a meeting with Mr. Reada Osman, the General Manager of the cleansing company that performed the services in these districts during 1985 and 1989, some of the reasons for the differences in the contracts' total cost per month were as follows:

- The importation of new labourers from Asia to conduct the services, which involved transportation costs which was higher in 1989 than in 1985.
- The new terms of labour-benefits and conditions imposed by the Municipality pertaining to the level and quality of accommodations, as a result, increased the cost since several changes had to be made. In the past, more than 200 labourers were housed in a camp that contained barracks and utilities. The new terms required better accommodations and periodic medical examinations.
- The insistence of the Municipality that new collection vehicles be obtained before the start of the new contract period increased the cost of waste collection because of the manufacturer's high cost for the new collection vehicles. The vehicles from the previous contract became the contractor's property upon completion of the contract. These conditions were verified with the Municipality's officials.

An idea was also circulating among the Municipality's top management related to cutting the cost of waste collection gradually. The idea was to have more than one company invest in constructing, operating, and managing composting plants, and consequently, haul the MSW on their own to their composting plants at no charge to the Municipality. The companies owning these composting plants would benefit from selling the recyclable materials and their compost product.

5.4.3 Types of Waste in Kuwait

5.4.3.1 MSW

The term *municipal solid waste* (MSW) refers to non-hazardous solid waste that has been discarded, wasted or thrown away by a community including households, commercial establishments, institutions, light industrial processes, agricultural authorities, and slaughterhouses. The term*domestic waste* is widely used to describe household waste, which encompasses food, plastics, glass, paper, cartons, and bones, wood and metal. Bulky waste, such as old furniture, television sets, boilers and refrigerators, requires special handling. Thus, a special collection programme is required based on specific times for collection during the week and/or via an on-call service with which residents file a telephone request for the collection of such types of wastes. In Kuwait, MSW is usually defined as waste generated from households, commercial and public establishments, schools and hospitals (excluding pathogenic wastes). In this thesis, the term MSW is used to describe domestic waste, also called household waste, as well as a waste that is similar in nature but originates from commercial and public establishments. Industrial solid waste is not considered part of MSW since it forms an ensuing health hazard, and requires different methods of collection and disposal.

5.4.3.2 Market Waste

Market waste is generated from the main markets in Kuwait's metropolitan district. Markets (also called *souks*) for animals, fruit and vegetables, fish and meat exist in various areas but mainly in Shuwaikh and Fahaheel. Recently, the Municipality of Kuwait invited some of the qualified companies specialising in *souk* development to invest in the construction, operation, management and maintenance of two modern *souks* in the Jahra and Hawalli districts.

The present markets, i.e., in Al Jahra, Hawallii and the *souks* in the Kuwait metropolitan district, produce major quantities of certain types of wastes such as paper, cartons, and plastic, and minor amounts of metal and glass. The quantity of fruit, vegetable, fish and meat waste generated on a daily basis is estimated to be around 35 tons, which implies a yearly waste collection of about 12,800 tons. Such waste is collected by the Municipality's contractors. From the animal market, the Municipality collects dead animals and cattle waste in open lorries. This kind of waste is usually deposited underneath the domestic waste at the various landfill sites.

5.4.3.3 Hotel and Supermarket Waste

Waste generated from hotels and supermarkets is collected and transported by private contractors. The constituents of this type of waste are mainly paper, cartons, and wood. Most of the hotels and supermarkets use stationary compaction units to minimise the cost of transportation. The quantity of compacted, shredded carton waste arrived daily at the landfill sites is estimated to be about 5.5-11 tons. It is expected that the amount of carton and paper waste packaging materials will increase in the next few years. This is due to an increase in the quantities of various goods imported through supermarkets, *souks*, and commercial business.

5.4.3.4.1.1 Industrial Waste

The industrial waste list includes a wide variety of materials such as, chemicals, gases, car batteries, and medicines. In general, the industrial waste produced in Kuwait is not recycled or reused except for spent vehicle oil, which is recycled by the Gulf Lubricating Oil Company. This company's production of recycled oil is about 15,000 tons/year.

The Municipality of Kuwait's laws state that industrial waste producers should handle the collection and transportation of their wastes to the assigned landfill sites themselves. In Kuwait, there are four industrial areas: Shuaiba, Mina Abdullah, Shuwaikh, and Subhan. The MSW contractors only collect waste from the Shuwaikh and Subhan industrial areas since their locations are close to the residential collection areas assigned by the Municipality's contract. The EPC and the Municipality of Kuwait requested that the producers of hazardous industrial waste present a report for approval on the type and quantity of their waste before disposal. Approval also covers the means of handling and disposing of such hazardous waste. Currently, many producers do not fully comply with the laws. They dispose of their hazardous industrial waste in the Municipality's landfill sites. The landfill staff lacks the knowledge, equipment and experience required for the identification of the various types of waste. Some of the industrial waste that is being disposed of at the Municipality's landfill site has possible negative effects on the environment and public health. The lack of capabilities on the part of the landfill staff gives the waste producers the opportunity to dispose of their waste without worrying about bearing the extra cost of further waste treatment prior to disposal.

According to the Municipality of Kuwait, waste from hospital operating rooms is received with other waste at the landfill sites. This problem has been reported to officials of the Ministry of Public Health (MPH) several times. Non-dangerous hospital waste has no effect on either the environment or public health, and thus can be dumped right along with domestic waste.

The MPH uses incineration units in each hospital to handle hazardous and infectious hospital waste. These incineration units are old and are not efficiently operated. A central incineration plant to treat hospital waste generated in Kuwait is under study by the MPH. The requirements of the incineration plant were determined by a committee of various members of the government, such as KISR, EPC, Kuwait municipality, and Kuwait University.

During the last 10 years, no attempts have been made to compile an industrial inventory so that an understanding of the issues associated with industrial waste could be achieved. The Hazardous Waste Section of the EPC presented a study that included a general overview of industrial waste, and its quantities, types, and possibilities for reuse. Currently, this study is being reassessed by the EPC's Hazardous Waste Section. The main objective of the reassessment is to obtain a better understanding of the problems and the possible reuse of the industrial waste in view of the current changes in the industrial and commercial sectors in Kuwait.

5.4.3.5 Slaughterhouse Waste

Waste generated from slaughterhouses in Kuwait contains animal blood, intestines, hides and carcasses. The Municipality has special tankers that transport the blood to the landfill sites where it is sprayed over compacted domestic waste and then covered with several layers of sand.

An estimated 45,000 gallons/day of blood is collected on a daily basis. The Kuwait Protein Company used to use animal blood waste in the production of protein. This was stopped after a short time due to financial constraints associated with the high costs of transportation and physical treatment of blood. The physical treatment involves a separation process required to separate the blood from a mixture of blood and water prior to protein production.

The other components of the slaughterhouse waste, including such things as intestines, hides, and carcasses, are collected in open trucks. The Municipality's contractors transport about 15 trip-loads/day. The Kuwait Tannery Company is a local company that handles animal hides transported to its plant from slaughterhouses located in Shuwaikh and Fahaheel. The Kuwait Tannery Company has been in business for more than 10 years.

The Company pays between KD 0.5 and 1.5/hide depending on the quality and conditions of the cut of the animal hides.

The privatisation of the slaughterhouses in Kuwait has now been completed. The Municipality of Kuwait has selected qualified investors to set up two new slaughterhouses after demolishing the old ones. The capital investment ranges from KD 2 to 12 million per slaughterhouse. Environmental protection measures, such waste and wastewater treatment, are being considered by the Municipality as responsibilities of the new slaughterhouses.

5.4.3.6 Sewage Sludge

Sewage sludge consists mainly of human and household waste. Sources of this waste are residential and commercial areas. Waste from these areas is treated at three sewage treatment plants in Ardiya, Rikka and Al Jahra. The treatment plants design flows are 153,000, 96,000 and 60,000 m^3/day respectively. Human waste generated from the industrial areas has to be treated by the producer before discharge into the sewer network.

5.4.3.7 Other Waste

In 1982, VBB of Sweden presented the Municipality of Kuwait with a proposal for the establishment of a solid waste reclamation centre. The centre would handle wastes such as scrap vehicles, metal scrap, steel and fibreglass water tanks, and spent oil. The Municipality of Kuwait collects scrap vehicles, junked household appliances, steel water tanks and drums on a daily basis. Scrap vehicles are transported to the AlJahra area to a site called Amgarah, which is managed by the Kuwait Metal Collecting and Shredding Company (KMCSCO). Currently, the number of stockpiled scrap vehicles is estimated to be about 1 million. The shredding of scrap vehicles by KMCSCO started at the beginning of 1993. The company plans to sell the shredded metal from scrap vehicles to major international companies. Since KMCSCO pays the Municipality only KD 1 for each scrap vehicle, it is in the company's best interest to stockpile as many scrap vehicles as possible until the price of scrap metal increases to a more desirable level. The company does not pay for the transportation of the scrap vehicles to its site since the Municipality of Kuwait transports them through its contractors.

5.5 Amounts and Composition of Kuwait's MSW

5.5.1 Estimation for the Municipality of Kuwait

In 1992, the Municipality of Kuwait estimated the total amount of MSW generated by the approximately 1.4 million people residing within Kuwait's metropolitan district to be 3000 tons/day. This corresponds to a generation rate of 2.22 kg/person/day. The Municipality's estimation was based on inaccurate data obtained from the operators of the landfill sites. The inaccuracy of the data was due to the lack of actual information on the numbers, types, and weights of compactors and trucks that arrive at the landfill sites. The Cleansing Department of the Municipality of Kuwait provided the data shown in Table 5.6, which presents a poor estimation of the amounts of MSW generated in Kuwait. The estimation was based on the numbers of trip-loads of MSW collected during 1992, at the various landfill sites. These landfill sites receive Kuwait's MSW on a daily basis. The assumed weight of each trip-load was considered to be 5 tons, but since these landfill sites are not equipped withweigh-bridge, it is difficult to determine the weights of the trip-loads accurately. The management of these sites may be improved by using simple devices such as portable weighing scales, which can determine the weights of the truckloads. The Municipality's estimation is rather primitive, and the techniques used are inaccurate. Such data can mislead the waste management decision-makers and, consequently, cause many complications in future developments in the waste management strategy.

TABLE 5.6: ESTIMATED MSW AMOUNTS FOR 1992

Landfill Site	Amount (t/y)
Jeleeb Al Shuyoukh	730,000
Sulaibiya	146,000
Mina Abdullah	292,000
Total	**1,168,000**

Source: Cleansing Department- Kuwait Municipality, 1992.

In 1988, the Municipality of Kuwait sponsored a study on the characteristics and utilisation of MSW. The study, conducted by the IIC, indicated that the total weight of MSW generated in 1988 was 2,100 tons/day. It also indicated that 1.108 kg of waste was generated per person per day. A comparison of that to the 2.0 kg/person/day generated in the USA indicates that there is a need to investigate the reasons for such differences between the two rates. The author believes that this difference is due to the high level of daily activities and consumption in the USA, namely; the large amounts of paper waste. Waste composition and generation varies among the Middle Eastern countries, European countries and the USA. Holmes (1992) indicated that Quantities of waste are invariably lower in developing countries because of lower prosperity and consumption as well as extensive scavenging by beggars and the very poor. Densities of waste are much higher because of paper, plastics, glass, and packaging materials and hence a much greater concentration ofputrescible matter. However, this is not likely to be the case in Kuwait since the level of prosperity and consumption is higher than in usual developing countries. Moreover, recent changes in the life-style in Kuwait to a more western style put Kuwait among the developed countries in term of the type of waste generated.

Previous studies conducted by various national and international organisations on the waste generation rate as it pertains to Kuwait are presented in Table 5.7, which summarises the main points in those studies on waste management between 1974 and 1992.

TABLE 5.7: SUMMARY OF STUDYIES CONDUCTED ON MSW WITH DIFFERENT METHODOLOGIES

ORGANISATION	YEAR	METHODOLOGY	TOTAL MSW AMOUNTS IN TONS		POPULATION	MSW GENERATION PER PERSON	
			PER YEAR	PER DAY		KG/YR	KG/DAY
KUWAIT MUNICIPALITY	74	WEIGHING TRIP-LOADS AT LANDFILL SITES AN AVERAGE OF 3 TONS/TRIP-LOAD WAS CONSIDERED	1.171.200	3209	960.000	445	1.22
VBB	78-79	BASED ON NUMBER OF TRIP-LOADS FROM SPECIFIC SOURCES ARRIVED AT LANDFILL SITES	700.000	1918	1.100.000	636	1.743
KUWAIT MUNICIPALITY	78	BASED ON AVERAGE TRIP-LOAD OF 3.5 TONS	830.375	2275	1.000.000	155	2.068
KISR	82	BASED ON A RANDOUM SAMPLE OF TRIP-LOADS, DATA COLLECTED FOR 3 WEEKS INCLUDED TYPES &NO. OF TRUCKS USED	536.550	1470	1.473.500	364	0.998
VBB	83	BASED ON THE NUMBER OF TRIP-LOADS ARRIVED TO LANDFILLS	671.785	1841	1.490.000	451	1.235
KUWAIT MUNICIPALITY	86	BASED ON 10 RANDOM HOUSEHOLDS FROM 11 DISTRICTS FOR ONE MONTH	547.445	1500	1.797.772	305	.834
IIC	88	ESTIMATED AVERAGE LOADS OF MSW CONTRACTORS' COLLECTION VEHICLES	792.050	2170	1.958.477	404	1.108
THESIS (author estimation)	92	A)WEIGHING MSW VEHICLES AT LANDFILLS B) AVERAGE NO. OF LOAD/ CONTRACTOR	675.648 786.575	1851 2155	1.350.000 1.350.000	500 583	1.371 1,596

The lack of information on many aspects of the MSW management process in Kuwait creates tremendous problems in obtaining the accurate and dependable data required for understanding the waste dilemma in Kuwait. Such obstacles limit anyone in ascertaining the future extent of the planning processes for waste management in Kuwait. The absence of records on the MSW quantities generated in Kuwait, numbers of truck-loads, types of vehicles used, etc., makes it difficult to establish any semblance of accurate estimations for the future using statistical methods. The Landfill Section in the Municipality of Kuwait has provided data on MSW amounts; yet the unscientific methods used to determine those amounts are unacceptable. The Municipality obtains its MSW values by multiplying the total number of trucks arriving at the landfill sites by the average load-weight per truck. This must be incorrect since it is impossible to determine the average load-weight visually, i.e., by just taking a look at the truck, and the landfill sites are not equipped with scales. Such visual estimation is an improper technique that is, however, staunchly used by the Landfill Section's technical staff. Rather, techniques based on scientific methods should be used to determine the MSW quantities under realistic assumptions. **Rushbrook & Ball (1988)** present clear guidelines for doing this correctly.

5.5.2 Techniques Used in This Thesis to Estimate MSW Quantities

The first technique required a random sampling of collection vehicles after completion of a full collection cycle in various areas. Given the number of compaction vehicles operated by each Municipality contractor and its average weight, which was obtained by weighing a sample of the trucks (access to this data was based on the author's personal relationships with the Municipality of Kuwait's contractors), the author determined that the total MSW collected by the Municipality of Kuwait's contractors, plus an additional 15% (obtained from the contractors' records) for waste amounts collected by private contractors on behalf of parties other than the Municipality, was about 2,155 tons/day. Consequently, the rate of waste generated per person per day was 1.5 kg.

The second technique involved the use of a small sample of truck-loads arriving at the three landfill sites: Jeleeb Al Shuyoukh, Mina Abdullah and Sulaibiya. An estimation of MSW quantities was made using the limited, representative sample size technique with the improvements added by Rushbrook and Ball (1988).

In order to obtain a more accurate accounting of the amount of MSW collected by private contractors, who operate on behalf of the Municipality of Kuwait, a weighing process was conducted at the three landfill sites, Jeleeb Al Shuyoukh, Mina Abdullah and Sulaibiya. Each landfill site was investigated for a period of one week in order to collect the required information on the number and weight of the collection vehicles arriving daily between 6:00 a.m. and 6:00 p.m. at each landfill site. Six transportable weighing scales were used. Each weighing scale was able to determine the load of one wheel of a collection vehicle. The weighing process was performed twice at different times of the year at each landfill site. This was done to determine if there was any sign of variation due to the change in seasons. Kuwait's climate is mainly divided into two seasons: winter with moderate temperatures, and summer with high temperatures and occasional sandstorms. A summary of the final results from the random weighing process is presented in Table **5.8.**

TABLE 5.8: SUMMARY OF THE RESULTS FROM THE RANDOM WEIGHING OF TRIP-LOADS

Landfill Site	Weighing Period	
Jeleeb Al Shuyoukh	**17-22 October 1992**	**6-11 June 1992**
Number of Loads Weighed	84	84
Average Weight of Load (t)	7	7
Number of trips/week	1080	960
Total Weight (t)/week	7560	6720
Sulaibiya	**24-29 October 1992**	**13-18 June 1992**
Number of Loads Weighed	48	48
Average Weight of Load (t)	6	6
Number of trips/week	540	390
Total Weight (t)/week	3240	2340
Mina Abdullah	**7-12 November 1992**	**23-28 May 1992**
Number of Loads Weighed	48	48
Average Weight of Load (t)	6	6
Number of trips/wk	240	220
Total Weight (t)/wk	1440	1320
Sum of Total Weight (t)/wk	12240	10380
Total + 15% Private Collection	14076	11937
Estimated Total Weight (t)/y (48 wk)	675648	572976
Per Capita Rate of Generation (kg/d)	1.371	1.163

Source: Author estimation

The difference in the per capita generation rates between the summer and winter seasons was due to the large number of people travelling to avoid the summer heat or to visit their families' abroad. Also, people tend to consume less when it is hot.

Thus, the estimation was made on the following bases:

- Truckloads arriving at the landfill sites was randomly selected for weighing.
- Only waste arriving in rear-loading compactor trucks operating for the Municipality of Kuwait was weighed, since mainly rear-loading compactor trucks are used to collect domestic waste.
- The year was considered to contain only 48 weeks after the deduction of days that were non-operational for the Municipality of Kuwait's contractors.
- An estimated 15%, as discussed earlier, or 315 of the 2,155 tons/day collected by private contractors was assumed to represent the private market share of the contractors. Such collection is performed on behalf of large commercial buildings and large residential complexes. The collection of waste from such clients does not fall under the Municipality's responsibility.
- A total population figure of 1.4 million was used following consultations with the Ministry of Planning, which provided data on growth rates and related information.

5.6 Investigation and Comparison of Kuwait's MSW Composition

5.6.1 Kuwait's MSW Composition

The composition of Kuwait's MSW was surveyed by several agencies between 1982 and 1988. Table 5.9 presents updated averages for the various components of MSW. The data on the average composition indicates a high percentage of organic material. This is mainly due to Kuwait's social behaviour. Food wasting is common, as can be seen in analyses of the composition of almost any household waste in Kuwait. The proportions of paper and plastic are increasing over the years with an obvious drop from the 1984 estimation by Vest Alpine, a consulting company. In general, the amounts of paper and plastic waste are growing due to the increase in imported paper and plastic products for local market consumption. Cardboard and cartons are also considered to be an important part of the MSW composition in Kuwait. Many of the goods arriving at the ports in Kuwait are packed in cartons, which provide great amounts of cardboard for the landfill sites at the end of their use.

This investigation of the composition of MSW covered various districts of Kuwait. The investigation of the MSW composition was performed from 17 to 22 October 1992. A 1-m^3 sample of MSW was collected on each of six days from 11 different districts. The selected sample represented

TABLE 5.9: AVERAGES FOR MUNICIPAL SOLID WASTE COMPOSITION PLUS CALCULATED AVERAGE 1992 (% BY WEIGHT)

1982 - 1988

COMPONENT	KISR 1982 %	VBB 1982 %	VEST ALPINE 1984 %	VEST ALPINE 1986 %	IIC 1988 %	AVERAGE %
Food waste	44.7	46.2	44.0	41.0	36.3	42.44
Wood, yard waste	14.7	5.1	8.8	6.3	3.9	7.76
Cardboard carton	12.2	7.7	10.7	12.0	8.5	10.22
Paper	14.3	18.3	9.1	14.9	19.95	15.31
Textiles	3.4	3.3	7.5	4.4	5.5	4.82
Plastics	5.2	9.6	7.5	14.2	12.95	9.89
Glass	1.6	3.5	1.3	1.9	5.5	2.76
Metals	4.8	4.4	6.3	3.3	4.9	4.74
Non-classified	3.8	1.9	0.5	2.0	2.4	2.12
Total	100	100	100	100	100	100
Amount(ton/y)	536.55	570.86	570.60	597.73	792.1	

districts that reflect different zoning, social, and economic standards. On each day of the investigation, the 1-m^3 sample of MSW was weighed and sorted into fractions. Then each fraction was weighed separately. The moisture content was tested using samples of the paper and food fractions. A chemical analysis was conducted on a sample of dried MSW. The results of the analysis were compared to the corresponding analysis provided by the Municipality of Kuwait from a field study conducted by IIC (1988). Table **5.10** shows the results of the week of sampling to determine the average percentages of the various components of the MSW. These percentages agreed with previous investigations on MSW composition. However, the food fraction had increased due to the possible presence of small pieces of wet paper, as they could not be separated from the foodstuff during the sorting process. Therefore, the percentage of the food waste fraction should be approximately 1.7% lower (i.e., the estimation of the contaminant paper waste), which should instead be added to the paper waste fraction portion.

TABLE 5.10: THE AVERAGE % OF M.S.W. COMPOSITION DURING THE SAMPLING WEEK 17–22 OCT.1992

SAMPLE AREA	FRACTIONS OF M.S.W. IN %								
	Food	Paper	Cardboard	Plastic	Metal	Glass	Textile	Wood	Misc.
Abdullah Salem	50	18	3.5	14	2.6	3	3.6	3.9	1.4
Sulaibikhat	52	16	4	12	2.6	3.2	4	4.9	1.3
Rawda	51	16	4	14	2.6	3	3.8	4.1	1.5
Salmiyah	47	16	4.5	15	2.9	5	2.8	4.9	1.9
Mushrif	52	15	3	15	2.7	3	3.5	4.6	1.2
Sabah Salem	55	14	3	11	2.7	2.5	5	5.4	1.4
Farwaniah	49	15	4.3	14	2.6	3	6	5	1.1
Jeleeb	51	19	2.5	10	2.8	4	5.7	5	1.35
Fahaheel	53	14	3	13	2.75	4	6.5	5.3	1.15
Sabahia	54	16	2.5	10	2.6	2.7	6	4.9	1.3
Jahra	55	13	2	11	2.5	2.9	6.5	5.7	1.4
TOTAL	**569**	**172**	**36.3**	**139**	**29.35**	**36.3**	**53.4**	**53.7**	**15**
AVERAGE	**51.73**	**15.64**	**3.3**	**12.64**	**2.67**	**3.3**	**4.85**	**4.88**	**1.36**

Source: Author estimation.

Table **5.11** shows both the analyses of Kuwait's MSW sample as determined by the Municipality and by the author with the support of Kuwait University.

TABLE 5.11: ANALYSES OF KUWAIT'S MSW

Element	Proportion	
	1988[1]	1993[2]
Food and Paper (i.e., Organic Matter)	60.3%	67.3%
Moisture Content	50-60%	50-60%
C:N Ratio	25:1	25:1
Potassium	Rich	Rich
Phosphorous	Rich	Rich
Heavy Metal	Low	Low

Sources: [1] IIC (1988), [2] Personal investigation (1993).

Based on the results of the investigations, the following table (Table**5.12**) was produced to show the percentages of the various fractions of waste components and their corresponding amounts of waste materials.

Table 5.12: MSW COMPOSITION AND WEIGHTS

Component	Fraction of MSW (%)	MSW Weight (t)
Food	50.0	337,824.000
Paper	17.3	116,887.104
Cardboard	3.3	22,296.384
Plastic	12.6	85,131.648
Metal	2.6	17,566.848
Glass	3.3	22,296.384
Textiles	4.8	32,431.104
Wood	4.8	32,431.104
Miscellaneous	1.3	8,783.424
TOTAL	**100.0**	**675,648.000**

5.6.2 Comparison of MSW Compositions for the USA, the UK, and Kuwait

A comparison between Kuwait's MSW in 1988, and that of the USA is presented in Table **5.13**. The USA's data in this table was obtained from the EPA's 1988 report (Franklin Associates Ltd, 1988). The findings in the EPA's report indicated that the total weight of MSW in the USA in 1988 was 179.6 million tons. This corresponds to a generation rate of 2.0 kg/person/day.

TABLE 5.13: MATERIALS IN MSW BY WEIGHT, 1988

Component	Kuwait (% by weight)	USA (% by weight)
Food Waste	36.30	7.4
Wood & Yard Waste	3.90	17.6
Cardboard	8.50	0.0
Paper	19.95	40.0
Textiles	5.50	0.0
Plastics	12.95	8.0
Glass	5.50	7.0
Metals	4.90	8.5
Non-Classified	2.40	11.6
Total	100.00	100.0

Sources: IIC, 1988; EPA (Franklin Associates Ltd), 1988.

A comparison of waste characteristics between Kuwait and the UK in 1992, showed that the food fractions of the waste were 50 and 28% respectively, and the corresponding paper fractions were about 22 and 37%. The plastic fractions of the waste were about 13 and 2% respectively. The metal and glass fractions of the waste percent were lower in Kuwait's MSW stream, about 2.6 as opposed to 3.3%, while the same fractions of waste in the UK's waste stream **(Holmes, 1992)** were both 9%.

Table **5.14** shows a comparison of the waste composition of urban refuse disposed of at landfills in the UK and Kuwait. The table indicates the variation between the composition of waste for these two countries in very different regions. The data presented are averages for 1992.

TABLE 5.14: A COMPARISION BETWEEN MSW CHARACTERISTICS IN KUWAIT AND THE UNITED KINGDOM BY PERCENTAGE WEIGHT.

Component	Kuwait	UK
Food	50.000	28.000
Paper	20.600	37.000
Metal	2.600	9.000
Glass	3.300	9.000
Textiles	4.800	3.000
Plastic	12.600	2.000
Miscellaneous	6.100	12.000
Weight (kg)/person/d	1.371	0.845
Density (kg/m^3)	146.000	132.000

Sources: Al-hasawi,H.A. (1992). Holems, (1992).

Pfeffer (1992) indicated that a 'typical' solid waste probably did not exist. This is seen to be true since waste generation rates, composition and socio-economic factors are based on highly complex, changeable, and unpredictable conditions that vary constantly between countries and within the same country itself. Some exceptions can be noted within regions such as Europe where the variations are reasonable, and therefore, the waste generation rate and waste composition are more stable than in the Gulf region.

The GCC states depend on the importation of all items needed for life, such as foodstuffs, clothing, medicine and other major goods. These goods come in packages of paper, cartons and less frequently, plastic. The amount of paper and cartons has been increasing in recent years. Unfortunately, there has been only very limited reuse of this kind of waste by a very few cities in the GCC.

5.7 Investigation of Kuwait's Landfill Sites

The landfill of MSW is the most commonly used disposal operation practice in several countries. Landfill is currently the primary disposal route for waste arising in Scotland taking over 90% of waste according to Scottish Environmental Protection Agency (SEPA, 1999). Many municipalities depend on landfill operations to dispose of their MSW due to economic factors. In general; landfill with MSW is a simple alternative to other waste processing techniques, which require much greater capital investment and technical knowledge. However, although landfill with MSW is an economical alternative, the identification of new landfill sites is becoming extremely difficult. As a result, many municipalities have moved their waste management strategies more toward reduction/prevention, recycling and waste treatment in an attempt to avoid the problem of the lack of land. Such movement also helps to create new investment opportunities related to the utilisation of recyclable materials. In this section an investigation of the present MSW disposal practices in Kuwait is presented in an attempt to evaluate the current operations and management, and to provide the data required to assist the Municipality of Kuwait in developing better MSW disposal operations and management.

5.7.1 Sanitary Landfills

A sanitary landfill site is a site, constructed on engineering principles, where waste disposal occurs. Such a site has distinguishing characteristics, which differentiate it from an insanitary landfill site. These characteristics are the site design, site construction and site operation. The sanitary landfill site complies with environmental constraints so it does not affect the health of either the environment or the public either in the present or in the future. The basic distinctions between sanitary andinsanitary landfills (Vesilindet al., 1988) are that in sanitary landfills:

- The waste is put in prepared cells.
- The waste is deposited, shredded and compacted into thin layers.
- The waste is covered daily with a layer of clean soil (sand) and

compacted.

- The waste is treated for leachate and gas.

Another difference between sanitary and insanitary landfill sites is that in the former, decomposition occurs through anaerobic processes, while in the latter aerobic processes take over.

There are many factors that should be taken care of prior to the construction of a sanitary landfill. The selection of the site itself is a major step towards the protection of the environment. As a result, much of the negative impact can be avoided in the future if the selection of the landfill site is based on scientific study and not random selection. Another important factor is the preparation of the site itself with the provision of the required isolation material, gas collection devices, ventilation systems and sufficient amounts of clean soil (sand) for daily covering. Furthermore, decisions should be taken regarding the type of waste that will enter the landfill site and the proposed future use of the landfill site in relation to the national master plan.

As was mentioned earlier, the landfill operation for MSW is the least expensive alternative for waste management, in comparison to waste incineration or composting **(AlHammad, 1990)**. Landfill, therefore, remains an affordable disposal method. Due to the relatively low cost of landfills, resource recovery has become uneconomical according to**Tattam and Feldman's (1992)** studies in the USA. Currently in Kuwait, several problems are occurring due to the improper landfill operations for MSW, and the Municipality continues to operate in the same way with no consideration for the environment or the future use of such sites. It is hoped that with the establishment of Kuwait Environmental Protection Authority (KEPA) the problem of landfill abuse by the municipality contractors will be stopped. KEPA has an important role to play in eliminating the insanitary landfill practices through its regulatory powers to implement the environmental and human health objectives of its strategy which currently underdevelopment. This will be discussed in more detail in the landfill assessment in Kuwait **(in section 5.7.5)**.

In October 1992, the representative of Al Farwaniya and its governor presented to Kuwait's National Assembly and the Municipality of Kuwait a complaint regarding the hazardous effects of the Jeleeb Al Shuyoukh landfill site. The public's discomfort from the bad odours emanating from the landfill site had motivated them to act and to request the prevention of improper disposal operations which would cause great health complications in the near future if not stopped. The main environmental effects are the uncontrolled emission of landfill gases, and the migration of gases and leachate beyond the landfill site's boundaries, which may cause problems in the surface water or nearby housing structures. The government eventually took action by seizing the operation of that site. However, appropriate lessons do not seem to have been learned from this example; a new site near the 7th Ring Road seems to be causing similar environmental problems.

5.7.2 The Problem of Waste Disposal

In several countries, the use of various waste management alternatives to help in solving the issue of waste increase is currently a very serious matter. Waste prevention and reduction of the amounts arriving at the landfill sites are major tasks for the local authorities in almost every city. For example; in the USA and Sweden, the municipalities are interested in planning for the use of waste in generating energy that can, in turn, be utilised in various ways. Therefore, the plans for developing appropriate incineration plants are the most valuable keys for these countries' waste and energy issues, because such plants are relatively inexpensive sources of energy, yet an expensive form of waste disposal. Landfill gases may also be used to generate energy. Landfills may be the single largest sources of methane gas in the UK producing 1.8 to 2.0 million tonnes of methane per annum, a potentially valuable renewable energy source. The motivation behind the selection of incineration as an alternative is based on economic and environmental constraints. However, while this may be the best possible alternative for both the USA and Sweden, such an idea may well be dead even before it is discussed in Kuwait due to the differences in both the needs for energy and the cost of such an alternative over landfill. The circumstances clearly vary from one environment to another. Thus in Kuwait, the most effective alternative may be the landfill at this point in time. Yet, proper planning for what is ultimately the best alternative, based on economic, socio-economic and environmental bases, is considered the best means of selection. Currently, the selection of thebest possible waste treatment alternative is not based on feasibility studies in Kuwait.

Another important factor to take into consideration is the size of the site selected, since it is essential to estimate the length of time such a site is able to accommodate the MSW generated. This determination is actually based on several other factors such as the rate of waste generation, site topography, waste compaction rate and the site area itself. Also; at least 20-25% of the total waste volume disposed of daily consists of the clean soil (sand) required for proper landfill, and must be considered when estimating the required volume and size of the landfill site to be selected.

As for the MSW generated daily in Kuwait, the following estimation of the land required for disposal is presented in Table5.15, and is based on data produced by the author, the Municipality of Kuwait and the National Statistics Department at the Ministry of Planning:

TABLE 5.15: LAND REQUIRED FOR MSW DISPOSAL FOR 20 YEARS PERIOD.

Kuwait's Population:	**1.35 million (1992 figures)**
Per Capita Waste Generation Rate:	1.371 Kg/d
Waste Density after Compaction:	593 Kg/ m^3
Sand (Daily Cover):	25% of total waste volume
Average Site Depth:	10 m
Site Life Span:	20 y*

Source: Author estimation.

*The 20-y period was assumed since this is a period agreed on by the Municipality of Kuwait's Environmental Department in their strategic plan for waste disposal.

What is the size of the site required for the next 20 years?

- Total waste generated per year: 675,648,000 kg
- Total waste volume per year: 1,139,373 m^3/year
- Added 25% of daily cover: 1,424,216 m^3/year

- Area required: 142,421.6 m^2

Another important related factor is the flow of traffic to and from the landfill site. A traffic network study should be conducted to determine the heavy traffic points so that usually congested routes could be avoided.

Although the Municipality of Kuwait has tried to control its waste disposal problem from the early thirties up through the present time, the management of the disposal operations going on currently are dramatically poor. At present, the Municipality prepares the documents required for the private sector to invest in the utilisation of MSW through recycling and composting plants. What the Municipality seems to keep forgetting is that no matter what kind of technology or waste management scheme they decide to use, a sanitary landfill site equipped with the required devices and operators to run it in an environmentally sound manner will continue to be needed. There is not a single waste utilisation alternative that does not generate residual waste that needs to be disposed of. Therefore, a landfill site is a must in an integrated waste management system since it is the last rung on the ladder of utilised waste. Thus, the Municipality must, at this point, pay more attention to the current waste disposal practices and try to bring such operations under control using appropriate engineering and scientific methods.

5.7.3 Landfill Site Selection

Several technical factors are related to the selection of a landfill site. Some of the most important factors are as follows:

- The size of the landfill site.
- The traffic to and from the landfill site.
- The hydro-geological features of the site.
- The social and economical conditions surrounding the site.
- The climatic conditions.
- The political climate of the city.

The last factor mentioned, i.e., the political climate of the city, is considered to be the most important factor of them all. The political climate affects the decision-maker's ability to concentrate on the actual problem rather than paying attention to unnecessary issues. The road(s) to the landfill site itself should be easily accessible in order to prevent delays in the disposal of waste. Also, the landfill site should be close to the areas of collection, but not so close as to have a negative impact on the health or comfort of the residential and commercial areas in the vicinity. Thus, a study should be conducted to compare direct and indirect waste transport through the use of transfer stations.

Pfeffer (1992) indicates that the distance must be great to warrant an investment in transfer stations (over 40 Km). The estimated average distance between the landfills and the centre of the collection areas of Kuwait is about 24 km. This is a short distance to haul MSW. Yet, if the Municipality of Kuwait intends to transfer the present landfill sites to a newly proposed site about 55 km from the 7th Ring Road landfill site, the potential value of a transfer station will become much higher. Moreover, from an environmental and socio-economic point of view, the operation of the current landfill sites should be stopped due the expansion of the infrastructure of the city of Kuwait and its surrounding areas. The current landfill sites are beginning to form an obstacle to such development. As a result, a transfer station is justified.

The study of the hydro-geological conditions of the site is an important factor in the selection of a proper site, in order to prevent damage in the future by the leachate produced from the decomposition of waste and presence of water during disposal. Part of such a study should concentrate on the quantity and movement of water in the area. As an alternative for treating leachate, the Municipality of Kuwait should avoid low-lying areas, which contain potential surface water. Kuwait has a very high water table; currently in Kuwait, water can be found at 1-meter depths in some areas. Therefore, more attention should be given to the rising of the level of surface water in Kuwait in order to avoid a potential water pollution issue in the future.

5.7.4 Existing Landfill Sites

In the past, a number of uncontrolled open-spaces were used as landfill sites in Kuwait. These locations, which were poorly managed by unprofessional Municipality staff, constituted breeding grounds for vermin and flies. Such operations are banned, and currently, modern mechanised vehicles transport wastes to somewhat controlled landfills yet these sites are best described as insanitary landfills. According to the UNDP (1991), it is estimated that 5 million people die annually from the improper disposal of society's wastes. The majority of the MSW generated in Kuwait is currently disposed of at different landfill sites. There are three main landfill sites for domestic waste disposal that are managed cheaply by the Cleansing Department of the Municipality of Kuwait. There is no charge for waste disposal at the present landfill sites. The Municipality's landfill sites are at present: Jeleeb Al Shuyoukh (MSW was banned at this site as of December 1992), Mina Abdullah, Sulaibiya, and the 7th Ring Road site

Table **5.16** shows the surface area, the number of compactor trucks arriving into the landfill sites and the total number of trips made by the compactor trucks per day.

TABLE 5.16: DESCRIPTION OF SOME OF THE PHSYCIAL PARAMETERS OF THE LANDFILLS IN KUWAIT

Landfill	Surface Area (km^2)	Number of Compactor trucks used per Day	Number of Trips per Day
Jeleeb Al Shuyoukh	5.25	0	0
Sulaibiya	0.38	90	130
Mina Abdullah	0.75	40	60
7th Ring Road	3.00	180	400
Total		**310**	**590**

Source: Author estimation and Cleansing Department statistics.

It is clear from the above table that the waste distribution is concentrated at both the Jeleeb Al Shuyoukh and the 7th Ring Road landfill sites. This is due to their nearness to the bulk of the residential and commercial areas. By investigating the land area required for the future, it was found that no estimation has been made of their future status. Therefore, estimation was made to assist the Municipality in their planning for the future of these landfills.

As was mentioned earlier, it is important from a strategic viewpoint to identify when the landfill space will be used up. Table **5.17** depicts the increase in the land area required for MSW landfills in Kuwait through the year 2000. The author and the Municipality of Kuwait produced the data used in this table.

TABLE 5.17: ESTIMATION OF THE LAND AREA REQUIRED FOR LANDFILL OPERATIONS, 1993-2000

	A	B	C
Year	Population	MSW Amounts per Year (kg) A * 1.371 kg/day	Required Area (m^2) For disposal B/590 kg/m^3/10 m
1993	1,391,515	696,347	118,025
1994	1,434,363	717,773	121,656
1995	1,478,587	739,906	125,407
1996	1,524,234	762,740	129,278
1997	1,571,351	786,326	133,275
1998	1,619,988	810,665	137,400
1999	1,670,196	835,791	141,659
2000	1,722,027	861,724	146,055

Almost all of the present landfill sites studied consist of abandoned earth pits used by contractors to extract sand and gravel for road building, construction, etc. The Municipality of Kuwait's plan is to fill those quarries to the original surface level, but no higher to avoid erosion from the wind. The quarries are often scattered within a specific area with rocks or material not suitable for use remaining in the pits. Currently, the

Municipality of Kuwait has banned the excavation of new sites in response to a recommendation issued by the Environment Public Authority (formerly the EPC). The main reason for prohibiting excavation in Kuwait desert is to prevent the private companies from destroying and over consuming the natural gravel quarries. This ban may open the doors for the recycling of construction and demolition waste materials such as concrete to produce the required aggregates. Also importing aggregates from other GCC states where large amounts of naturally available aggregates may develop successful business.

The objective of this section is to identify the present operating procedures at the existing landfill sites and to recommend the most important corrective measures needed to develop these sites into modern sanitary landfill sites.

5.7.4.1 Jeleeb Al Shuyoukh

This site is considered to be the largest existing landfill in Kuwait. For the last 10 years, the Jeleeb Al Shuyoukh landfill has served as a domestic waste landfill. Because of the site's location close to a populated area, Al Jeleeb, and as a result of the improper procedures applied by the Landfill Section in the Municipality of Kuwait, this site is presently used for C&D

waste. Recently, MSW that would have been disposed at the Jeleeb Al Shuyoukh landfill site has been transferred to the 7th Ring Road landfill site. Both the Cleansing and the Planning Departments took this decision within the Municipality of Kuwait. Authorities including the EPC, the Environmental Protection Department of the MPH, and the Environmental Affairs Department of the Municipality of Kuwait had no involvement in the process of the decision-making to establish any new landfill site. In 1992, the Jeleeb Al Shuyoukh landfill was receiving about 58% of the total domestic waste in Kuwait, equivalent to about 180 collection trips per day. Various types of waste from different sources were accepted at the site, such as hospital, slaughterhouse, and industrial wastes. At the extreme south-eastern area of the site, there was an area assigned for the disposal of construction waste and sewage sludge. Operation at this site was continuous 24 hours per day, 7 days per week. The maximum life expectancy of the site was 10 years. Figure 5.1 shows a map of all landfill sites in Kuwait.

5.7.4.2 7th Ring Road

This site is replacing the Jeleeb Al Shuyoukh landfill site. The Municipality advised the waste collectors to deliver the collected waste to this new site through the media. There was no sign of complaint from either the

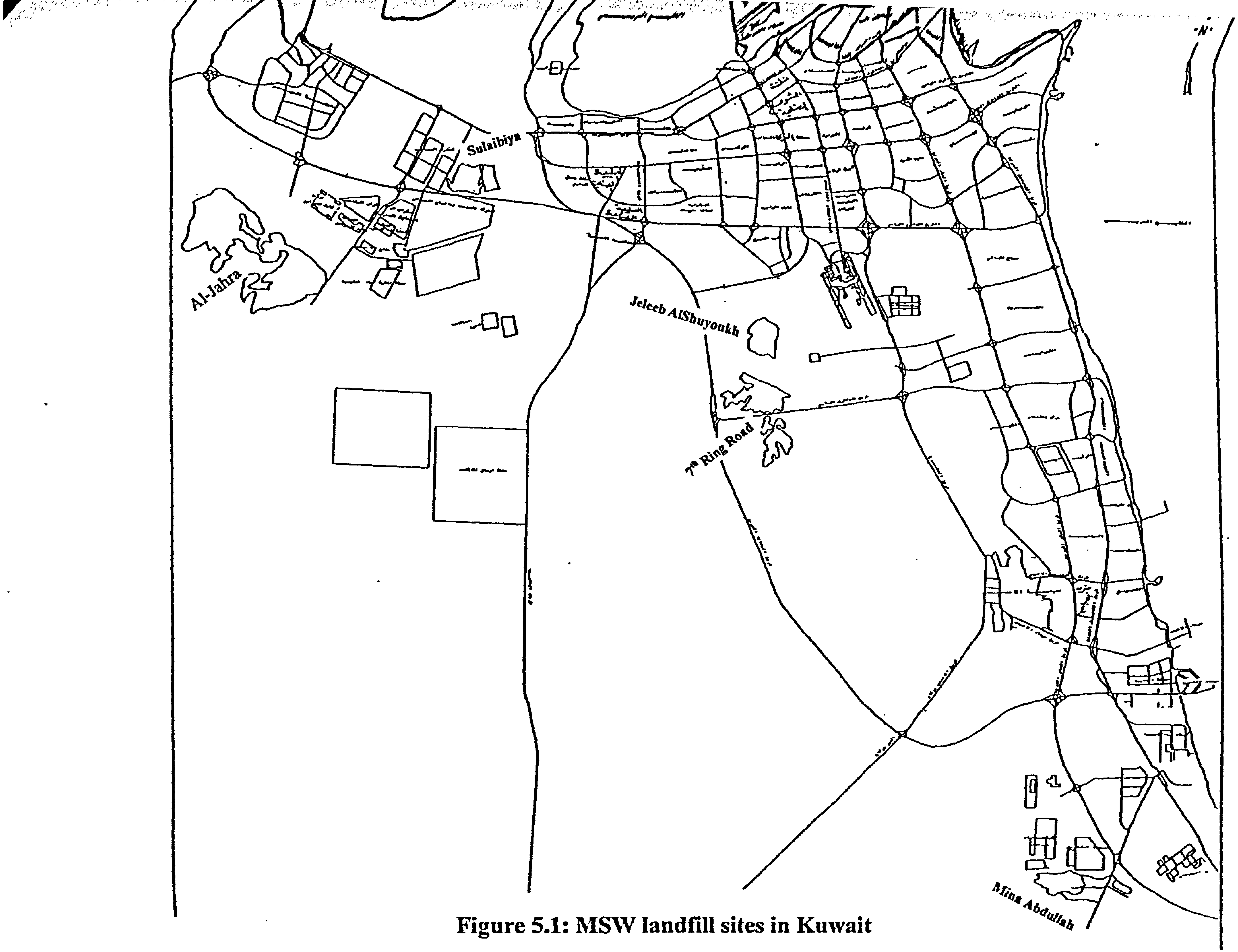


Figure 5.1: MSW landfill sites in Kuwait

Municipality's contractors or the other private contractors as a result of changing of the disposal site. This is mostly due to the short distance between the 7th Ring Road and the Jeleeb Al Shuyoukh sites. At the 7th Ring Road site, all types of wastes are accepted except for hazardous wastes generated from the petrochemical industries. The site may well be able to accept 40 million cubic meters of domestic waste before filling the available volume of quarries; thus, it may last more than 20 years even if all of the waste collected in Kuwait is disposed of at this site.

The Municipality of Kuwait, through its Environmental Studies Centre, is trying to set requirements for and perform an assessment of the dumping operation already taking place at the 7th Ring Road site. Neither the Planning Department nor the Cleansing Department of the Municipality of Kuwait has a strategic plan for improvements in future landfill allocations or operations. Moreover, there is a lack of communication between the departments involved within the structure of the Municipality of Kuwait as regards planning, evaluating, and selecting the best landfill management options. This has resulted in a complicated management issue since such departments should work together in order to produce a reasonable strategy for dealing with the selection and proper operation of landfill sites.

As for the 7th Ring Road site, the Planning Department has not defined the limits of the site. Given the lack of proper waste handling at this site by the Cleansing Department, this site will soon be anotherQurain problem where waste was dumped randomly over a large area without records or plans to help in later identification of the locations or types of dumped waste. The management of the 7th Ring Road site would be much easier if a little co-ordination and future planning were applied.

5.7.4.3 Mina Abdullah

This is the second main landfill site in Kuwait (in addition to the Sulaibiya and 7th Ring Road sites). It handles approximately 13% of the domestic waste generated in Kuwait. It is located on the Al Wafra road to the southwest of the city of Ahmadi. The site receives various types of waste including residential, commercial, and non-hazardous industrial waste.

5.7.4.4 Sulaibiya

This site handles approximately 29% of the total domestic waste generated in Kuwait. Its location is close to the Al Jahra residential area. The site has a life expectancy of approximately 10 years. Different areas are allocated within the site for the disposal of various types of wastes.

5.7.5 Present Conditions at the Landfill Sites

In general, all three currently used landfill sites are poorly managed despite some degree of variation among them. Recently, an assessment of the current conditions at the landfill sites was conducted. The results of the assessment are given in Table **5.18**.

TABLE 5.18: INITIAL ASSESSMENT OF MSW LANDFILL SITES IN KUWAIT, 1993

Criterion	**7th Ring Road**	**Mina Abdullah**	**Sulaibiya**
Prevention of Scavenging	1	0	2
Efficient Operation of Machinery	1	1	1
Site Plan	0	0	0
Safety Equipment	1	0	1
Qualified Inspectors	1	0	1
Facilities for Bulky Waste	0	-	0
Prevention of Waste Burning	2	2	2
Spraying of Water to Prevent Dust	0	0	0
Prevention of the Spread of Rodents, Insects and Stray Animals	0	0	0
Facilities for Sewage Sludge	1	-	-
Daily Covering of Waste	1	1	1
Layering of Landfill Waste	1	1	1
Fencing to Prevent Flying Paper	0	1	1
Shredding and Compacting of Waste	1	1	1
Inspection of Waste Types and Weighing of Quantities	1	1	1
Fencing	1	0	1
Proper Roads on Site	1	1	1
Use of Proper Equipment	1	1	1
Avoiding Water Pollution	0	0	0
Office Facilities	1	0	1
Total	**15**	**10**	**16**

The table presents the main criteria used to assess the three main landfill sites in operation at present. A scoring system was developed by the author to assist in comparing the conditions at the different landfill sites and their compliance with the main criteria considered essential for a sanitary landfill site. The scale ranged from 0 to 2 as follows:

- The site scored 0 if the criteria were not met.
- The site scored 1 if the criteria were poorly met.
- The site scored 2 if the criteria were effectively met.

As a result of this initial assessment, further investigation was made of each site to uncover the main reasons behind the present conditions and the methods used by each site's management.

It was also important to develop a reasonable method of evaluating factors affecting the status and level of performance at each landfill site. An environmental assessment process known as the checklist technique (Vesilind, 1988) was used to determine the potential effects of such factors in table 5.19.

The checklist technique is based on listing the potential environmental impacts, both primary and secondary. These impacts are then quantified by constructing an arbitrary scale. In this case, the following arbitrary scale was used:

- 0 = No or minimal impact.
- 1 = Moderate impact.
- 2 = Significant impact.

The same arbitrary scale can be used to estimate both the magnitude and the importance of factors on the checklist. The values estimated for their magnitude and importance are multiplied and finally summed. These factors are weighting factors.

TABLE 5.19: CHECKLIST TECHNIQUE FOR THE ASSESSMENT OF MSW LANDFILL SITES IN KUWAIT, 1993

Criterion*	7th Ring Road	Mina Abdullah	Sulaibiya
	(Importance x Magnitude)	(Importance x Magnitude)	(Importance x Magnitude)
Efficient Operation of Machinery (2)	2x1	2x1	2x1
Site Plan(2)	2x0	2x0	2x0
Safety Equipment (1)	1x1	1x0	1x1
Qualified Inspectors (1)	1x1	1x0	1x1
Facilities for Bulky Waste (2)	2x0	2x0	2x0
Prevention of Waste Burning (1)	1x2	1x2	1x2
Water Spraying to Prevent Dust (2)	2x0	2x0	2x0
Prevention of the Spread of Rodents, Insects and Stray Animals (2)	2x0	2x0	2x0
Facilities for Sewage Sludge (1)	1x1	1x0	1x0
Daily Covering of Waste (2)	2x1	2x1	2x1
Layering of Landfill Waste (2)	2x1	2x1	2x1
Fencing to Prevent Flying Paper (2)	2x0	2x1	2x1
Waste Shredding and Compacting (2)	2x1	2x1	2x1
Inspection of Waste Types and Weighing of Quantities (2)	2x1	2x1	2x1
Fencing (2)	2x1	2x0	2x1
Proper Roads on Site (1)	1x1	1x1	1x1
Use of Proper Equipment (2)	2x1	2x1	2x1
Prevention of Water Pollution (2)	2x0	2x0	2x0
Offices Facilities (1)	1x1	1x0	1x1
Total	**21**	**17**	**22**

The officials at the Municipality of Kuwait call these sites sanitary landfill sites, even though they are far from satisfactory by many other countries' standards. In a publication issued by the Environmental Protection Society, Al-Muzaini (1992) indicated that the Municipality of Kuwait has tried to develop the operation of sanitary MSW landfills; however, its efforts have failed. The investigations revealed that, although the Municipality of Kuwait has the equipment and the manpower to achieve the objectives of sanitary landfills, MSW is disposed of in various areas within each site with no regular daily covering. Most of the time, an unfinished layer of waste is clearly visible at the end of a working day. As a result, the situation in the landfill sites can be best described as being an open house for scavenging both by people and by animals. Moreover, the inefficient use of the compactors by the contractors' drivers is a major drawback, which prohibits the successful execution of the operation.

The Municipality's inspectors seem to be unaware of these problems and do not present any explanation for the ongoing procedures. It is clear that they lack a grasp of the principles, information, and knowledge of basic landfill engineering techniques and waste management. The development of a condensed training programme on MSW management, including all aspects of waste generation, collection, transportation, and treatment or disposal, is seriously required.

There is a problem with the qualifications of the staff in the Landfill Section of the Municipality of Kuwait's Cleansing Department. None of the employees has any background in sanitary engineering, waste management operations and techniques, or environmental protection measures, among other areas. Leachate and waste-gas generation at landfill sites must be taken into consideration due to the high level of production and the consequential effects on the environment, especially on the surface and groundwater. During a visit to the Jeleeb Al Shuyoukh landfill site, the internal roads of the site were seen to have been heavily sprayed with spent oil from the tankers arriving at the site after collecting the oil from the garages around Kuwait. Such use of spent oil on the landfill site's roads will generate substantial fumes due to the high temperatures in this region of the world; consequently, the operators at the site may develop respiratory problems.

All of the landfill sites lack site plans that provide a complete record of and plan for the waste, as it is disposed. The sites also have no defined limits since most of the sites are a sum of quarries scattered within a given area. In general, the situation with regard to the landfill sites in Kuwait is a dilemma. Action to save the 7th Ring Road landfill site is a must since the site is only few months old. The Municipality of Kuwait has to work toward developing landfill sites in the future based on international experience in the field. An option that may be considered is to try applying engineering methods by designing, constructing, and operating the 7th Ring Road landfill site in an environmentally sound manner, which would properly prepare the site for future use.

The Municipality of Kuwait has to consider the following major features in developing a sanitary landfill site that would be distinguished from the present sites:

- MSW has to be placed in prepared areas of the landfill site as prescribed by the engineering design.
- Heavy machinery has to be used properly to spread and compact the MSW into a pre-specified layer thickness.
- Wastes in all parts of the landfill site that are in operation have to be covered each day with a pre-specified thickness of 2:1 waste to sand, and proper compaction has to be performed.
- A ventilation system must be installed at each landfill site due to the high rate of waste-gas production, as more than 50% of the MSW constituents are biodegradable materials.
- Leachates must be dealt with properly; the use of liners is now recommended. The accumulated leachate should then be pumped out and treated.

5.7.6 The Al-Qurain Landfill: A Case Study within A Case

For several years, waste management practices in Kuwait were uncontrolled and improperly applied. There were no environmental codes or requirements for the Municipality of Kuwait's staff who was involved in the disposal of MSW in Kuwait at the various allocated sites to follow. The management team lacked the ability to perform in a scientific manner. As a result, many of the problems that developed at these dumpsites were the products of ignorance. Environmental protection was not a major concern at any level of the government, and yet, street cleaning and MSW collection were priorities. The disposal of the waste collected was poorly done. Precautionary measures against the leachate and gases produced from the biodegradation of the MSW were not considered or planned for. Consequently, a major environmental problem developed at the Al-Qurain landfill site. Since the early seventies, and continuing until 1988, the problem was out of sight. However, once the issue began to endanger public health and safety, the problem came to the surface.

The Public Housing Authority in Kuwait was the first authority affected by the damage that occurred at the Al-Qurain site. As part of the Public Housing Authority's plans, the Al-Qurain site was destined for major construction and the establishment of several houses, schools, health centres and other public facilities. The project had already begun in several parts of the Al-Qurain area when the contracting company assigned to the project discovered that there were noticeable numbers of black plastic MSW bags that had been dumped in the area where the construction was to occur. In the beginning, the Public Housing Authority thought that the amount of waste so dumped was not great and that the contractor would be able to continue the construction project. The true situation was completely different. A huge amount of MSW had been dumped randomly without any records or site maps to help in later identification of the area that was used for such waste disposal. At that point, the Public Housing Authority requested a meeting with the Municipality of Kuwait's officials to set up a co-operative programme to produce the best possible solution for the Al-Qurain problem.

The Public Housing Authority discovered the problem in August 1988; yet the formation of a technical team to investigate the problem took place more than one year later, i.e., in December of 1989. The team was responsible for investigating the current situation, at that time, and for providing recommendations and implementation procedures. Technical team members came from a range of authorities. The team conducted several tests and surveys at the landfill site to determine the required set of procedures to be implemented later when the Cabinet of Ministers took a decision in the Kuwaiti government. The tests included soil examination and gas analysis to determine the damage inflicted on the surface water and other natural resources, and livestock. The technical team suggested several solutions as follows:

- Total removal of the MSW from the Al-Qurain site to a new sanitary landfill site.
- Burning of waste after its excavation using incineration units at the Al-Qurain landfill site.
- Biological treatment of the waste at the site through the use of bacteria to enhance the biodegradation process.
- Use of a gas ventilation system, and aleachate pumping collection and treatment system at the site (i.e., an engineering solution to the problem).

The technical team rejected three out of four proposed solutions for several reasons, summarised as follows:

- The emission of bad odours and dangerous gases.
- The length of time required for such removal.
- The difficulties to be encountered when applying such a solution.

Finally, a recommendation was made to apply the fourth solution "engineering solution". Still, the Public Housing Authority preferred the total removal of the MSW from the site. On the other side, the EPC objected to the idea of total waste removal. As a result, Kuwait's Cabinet of Ministers decided to send the technical team's recommendation to KISR for further study and comparison of the several proposed solutions. KISR was instructed to recommend the best possible alternative based on scientific and economic factors. At that point, December 1991, KISR became responsible for the handling of the Al-Qurain issue.

5.7.6.1 Proposed Solutions

KISR studied the two main solutions, i.e., total waste removal; and gas ventilation and leachate pumping, collection and treatment. The first solution involved removal of the waste from the present site in Al-Qurain to the quarry area about 60 km north of the city of Kuwait where a new sanitary landfill was to be prepared. The solution was studied from an economic point of view, and estimations for the removal operation were prepared. The estimations included the cost of preparing a new landfill site in the quarry area, the cost of transporting the waste from the Al-Qurain site to the quarry area, the cost of the disposal operation itself, the cost of refilling the Al-Qurain site with clean soil, and finally, the cost of safety, labour, and environmental protection and monitoring. The second solution was based on the design of a network of pipes for the collection of gases from specific points to a treatment centre for final disposal by dispersing it into the atmosphere above the height of existing buildings. Liners were to be used to protect the water table from any possible pollution and/or contamination. This solution was also studied from an economic view to estimate the costs involved. The first cost item estimated was the capital cost, which included an estimation of the cost of preparing the site area, the cost of digging the trench, the cost of using plastic liners, the cost of filling the trench after installing the plastic liners, the cost of the gas collection network, the cost of the ventilation pipes, the cost of the construction of the management building, the cost of the construction of the laboratory and its equipment, and other capital costs. The second cost item was the yearly operating costs, which included the cost of manpower for the project during and after the waste removal operation, the cost of the utility services and other operational costs. The third cost item was the pre-operational costs, which included the cost of the design of the gas collection network, tenders, experiments, training and miscellaneous expenditures.

In the author's opinion, the Environment Protection Authority, as the new governmental body responsible for such tasks, should investigate the problem of potential gas migration. Such an investigation is vital, as gas migration may have already taken place to some of the existing buildings around the landfill site. This is another cost that should be considered part of the cleanup of this site.

5.7.6.2 KISR Recommendations

5.7.6.2.1Total Removal of Waste (Advantages & Disadvantages)

The advantages may be summarised as follow:

- The problem of the MSW at the Al-Qurain site would be solved completely.
- No side effects as to the safety of the public would result, although the effect of gas migration would still need to be considered.
- The area could be used for new construction projects and developed according to the public's needs.

The disadvantages may be summarised as follow:

- The manpower involved in the operation would be exposed to the hazards of the polluted soil.
- The public would be exposed to hazardous pollution from the waste during its transportation from the Al-Qurain site to the quarry area for final disposal.
- The transportation operation would be long. Therefore, the risks involved in this operation would be variable and unpredictable due to the length of the operation, which might extend over 5 years before completion.

- The cost of transporting the waste from one site to the other would be high.
- The problem would not be completely solved since the MSW and its attendant problems would merely be transferred to another location.

Assumptions

The following assumptions were taken into consideration for the estimation of the costs of the total removal of MSW from the Al-Qurain site to a new site in the quarry area.

Area

The term *area* as it is used here refers to the total area that would be required to accommodate the total amount of MSW removed from the Al-Qurain site. The new landfill site's area is about 582,000 m^2 and varies in depth from 1 to 17 m.

MSW Quantity

Since there are no records at the Municipality, a rough estimate of the quantity of MSW disposed of at the Al-Qurain site, based on the area and depth of the site, is about 4.7 millions cubic metres. The waste is mainly composed of organic and inorganic materials. The organic portion of the waste will produce several types of gas, such as carbon dioxide, hydrogen sulphide and methane due to the biodegradation process.

Site Preparation

Before starting the process of transporting the MSW from the Al-Qurain site to the new site at the quarry, the new site should be prepared and fenced. The estimated total area that needs to be fenced is about 870,000 m^2 with a circumference of 4000 m.

Cost Estimation

Table **5.20** presents the total cost of the main elements of the project.

TABLE 5.20: TOTAL COST BREAKDOWN FOR TOTAL MSW REMOVAL FROM THE AL-QURAIN SITE

Project Element	Total Cost (KD)
New Site Preparation	33,200
Waste Transportation	4,111,800
Waste Disposal & Compaction	235,000
Refilling of the Al-Qurain Site	3,301,275
Other Costs (e.g., Health Protection)	770,298
Total	8,451,573

Cost of New Site Preparation

The following factors were used to estimate the cost of preparing the new site to receive the MSW from the Al-Qurain site.

- Four front-loaders operating 8 h/d.
- 500 m^2 of land per front-loader or 4000 m^2/d.
- 55 operating days for preparation of a site 870,000 m^2.
- A cost of KD 60/d/front-loader.
- Fencing to enclose the 4000-m circumference at KD 5/m.
- Fencing at a rate of 100 m/d for 40 d.
- 95 total operating days.
- Cost of preparing the area (e.g., roads) of (4) (60) (55) = KD 13,200.
- Fencing at a cost of (5) (4000) = KD 20,000.
- Total cost = KD 33,200

Cost of Waste Transport

- A single front-loader and 6 trucks.
- 16 h of operation in 8-h shifts.
- Use of trucks with 20-m^3 capacities and 1.5-h/ periods per round trip.
- 8 trips per 16-h operation period.
- 6 trucks per front-loader at the Al-Qurain site to transport waste.
- A cost of KD 120/front-loader/16-h day.
- A cost for transporting waste of KD 15/round trip.

- A daily cost of KD 120 + [6 * 8 * 15] = KD 840.
- 20 * 8 * 6 = 960 m^3 of waste transported per day.

As a result of the above cost-estimation assumptions, the total required time required to complete the removal of waste from the Al-Qurain site would be 4895 days (i.e., almost 13 years). The total cost would thus be KD 4,111,800.

Cost of Waste Compaction

After the waste is transported from the Al-Qurain site to the new site, which is going to be constructed as a sanitary landfill, an additional cost of KD 1.0/load is assumed for waste compaction. The following relation shows the calculation of this cost:

> Total waste volume in cubic metres divided by volume per truck in cubic metres multiplied by cost of compaction per truck.

So;

$$4{,}700{,}000\ m^3/20\ m^3 * KD\ 1.0 = KD\ 235{,}000$$

Cost of Refilling the Al-Qurain Site

It is assumed that the same trucks that haul the MSW removed from the Al-Qurain site to the new site will deliver clean soil to the new site. The estimated cost of refilling the site with clean soil is about 75% of the other elements of the estimated costs, or about KD 3,301,275

Other Estimated Costs

Due to the nature of the project, which concerns the health of both the environment and the operators of the project's various stages, several protective measures should be considered. Therefore, 10% of the project's cost is assumed to be a safety factor to provide proper protection for the labourers and the environment. The estimated cost in this case is KD 770,298.

In conclusion, the cost of the transportation of the MSW and the refilling of the Al-Qurain site with clean soil are the largest elements of the total cost of the project. As a result, the economics of the project may well change if a decrease in the cost of either or both elements is achieved.

5.7.6.2.2 Engineering Solution

In this alternative, the MSW would be covered with a special type of plastic liner that is resistant to the various chemicals and gases emitted by and used with the MSW. The use of such liners protects nearby areas from the migration of the gases produced as a result of the biodegradation of the MSW. Moreover it protects the surface water and water table from probable contamination with heavy metals that may be part of the waste content. The engineering solution is based on the collection of the gases through a collection network constructed from pipes. The collected gases are then treated for further use or are dispersed into the air. The liners can also provide protection for the waste from the rain, which may penetrate to the lower levels of the landfill site and cause increases in the amounts of leachate that may further contaminate the surface water or water table.

The advantages of this solution may be summarised as follow:

- Reduction of the dangerous effects of the possible pollution resulting from the transportation of the waste to a new site.
- Reduction of the effects of gas pollution on the residents living close to the site through the dispersion of the gases into the upper levels of the air.
- Less time required than for the total removal of the waste.

The disadvantages of this solution may summarise as follow:

- The proposed technology is rather new to this region, and as a result, more testing is required to determine the results that can be expected.

- There is a possibility of water pollution if the liners are not of good quality or not well constructed.
- The biodegradation of the waste may take more than 10 years.
- This solution is a partial solution, since the waste remain at the site for a long time.
- The site itself cannot be utilised until all gases have been completely dispersed.

Cost of the Engineering Solution

Table (5.21) shows the list of capital and operating costs

Project Element	Total Cost (KD)
Capital Cost:	
Site Preparation	33,000
Trenching	600,000
Liner material	3,300,000
Landfill the Site after liner installation	60,000
Pipe Network	65,000
Gas-pumping system	63,000
Management & Labour Building	55,000
Testing Laboratory	103,000
Additional cost @20% of total capital cost 4,279,000	855,800
Sub-total	5,134,800
Operating Cost:	
Manpower over the life-time of the project (10 years)	176,000
Utilities	245,000
Sub-total	421,000
Total	5,555,800

Cost of Site Preparation

Site preparation for this option will cost about KD 33,000 for the preparation of the fence and the roads to the site.

Cost of Trenching

The site must be trenched in order to create a buffer zone around the disposal area. The trench is to be 20 m in depth and 1.5 m in width. The estimated cost for trenching the disposal site is KD 600,000

Cost of Liners

Plastic liners may be the most effective means with which to protect the site from the gases that may exit the site to nearby buildings, and to protect the surface water from any rain that may penetrate the waste and carry unwanted pollutants into the water, especially following the biodegradation of the wastes. The estimated cost of liners to cover the sides and top of the site is about KD3.3 million.

Cost of Landfill the Site after Installation of the Liners

The landfill cost is estimated to be about 10% of the cost of the trenching. As a result it is estimated to be about KD 60,000.

Cost of the Pipe Network

This cost covers both the purchase and construction of the pipe network for the collection of gases from the site. The pipes are made of polyvinyl chloride (PVC) and have a diameter of 6 in with holes located in the bottom to allow the gases to enter and flow to the top to be burned later or to be dispersed in the upper levels of the air. The estimated cost is about KD 65,000

Cost of the Gas-Pumping System

The estimated cost of four pumping stations to assist in the collection and burning of the gases is about KD 63,000.

Cost of Constructing the Management and Labour Buildings

The estimated cost of the buildings is about KD 55,000

Cost of Constructing a Testing Laboratory

Due to the possible danger to both the labourers' health and the environment, a monitoring centre that measures the levels of pollutants in the surface water and in the air must exist. As a result, the estimated cost for constructing and equipping a laboratory with the required instruments is about KD 103,000

Additional Costs

Costs such as special clothing for the labourers are to be incurred during the first stages of the project to protect them from the hazardous content of the waste, which may affect their health later on. Also preparing the site's environment to be as safe as possible for those labourers will have a cost attached. As a result, 20% of the total capital cost will be considered a suitable amount for such precautions. Thus, the estimated cost is about KD 851,000. Finally, as a result of all the costs, the total cost of the engineering alternative is estimated at about KD 5.0 million.

Annual Operating Costs

- The cost of manpower for the first year is about KD 26,000, for a staff of four.
- The cost of manpower is estimated about KD 15,000 annually, for a staff of five for the 10-y lifetime of the project.
- The cost of utilities is given in Table 5.22.

TABLE 5.22: COST OF UTILITIES FOR THE ENGINEERING OPTION

Item	Quantity	Unit Cost (KD)	Total (KD)/Year
Water	160,000	1.5/1000 l	240,000
Electricity (kW)	60,000	0.002/kW	120
Fuel (Vehicles)	6,250	0.040/l	250
Other			100

5.7.6.3 Conclusions

The problem of the Al-Qurain landfill site is the product of several factors. The various authorities responsible for land-use, environmental protection, economic development, and housing need to concentrate on solving this issue. One of the main causes of the Al-Qurain problem is the lack of either planning or co-ordination among the various responsible authorities. The lack of expertise in the field of waste-landfill operations is another main cause. These experts may, through the application of an engineering approach, be able to create a better landfill operation and management scheme, and most importantly, can prevent the occurrence of another Al-Qurain situation in the future. The cost of cleaning up the Al-Qurain landfill site is obviously much higher than the cost of properly planning and designing a sanitary landfill in the first place. In the author's opinion, the alternative that should be followed to solve the Al-Qurain problem is the engineering alternative, since the implementation of this alternative will provide a practical model for waste cleanup operations for similar landfill-site problems in the future.

CHAPTER VI

Waste Management Practices in theGCC

6. Waste Management Practices in the GCC

Investigation of MSW management practices in the GCC states is a large and complicated task, which requires a great deal of time and effort if the many GCC cities that exist today are to be covered. However, there are major cities in this region, which can provide sufficient data for the purpose of this thesis. The major cities were considered because of the concentration of population in them. The major cities that were selected were Kuwait in the State of Kuwait, Jeddah and Riyadh in the Kingdom of Saudi Arabia, Dubai and Abu Dhabi in the UAE, Doha in the State of Qatar,Dhofar in the Sultanate of Oman and Manama in the State of Bahrain.

Several questions related to MSW management could not be answered due to a lack of data. In order to collect data on MSW from the GCC cities that were selected, a few select questions were directed to the general managers of the municipalities of these cities. Answers to the questions are presented in Table 6.1. Also a description of the GCC's MSW generation rates, characteristics and handling is presented in this chapter to provide a general idea of the waste management process in each of the GCC states.

The questions asked to each of the GCC municipalities were designed to address three major points related to MSW management. The first point was the possibility of privatisation of the waste management services within the municipality, since some GCC cities, such as Abu Dhabi, Dubai, Manama, and Dofar, are still conducting waste collection and disposal with their own fleets and manpower. The second point was the means by which waste can be utilised. The third point was the subject of regional co-operation in recycling. There was no point in asking environmentally sensitive questions because for political reasons such questions simply would not be answered. The questions were initially directed to the GCC's general managers, who subsequently referred the author to the managers of the waste management departments. The questions presented to and answers received from each of the GCC states' municipalities, and a description of the MSW management system in each state is given. The answers to the questions were obtained through personal meetings and/or telephone interviews.

The following table 6.1 shows the answers for the questions presented to each of the GCC municipalities. These questions are drawn from the objectives mentioned in chapter one of this thesis.

In first question the author tried to sense the potential change in the municipalities' policies on handling municipal solid waste. Also tried to identify any potential future development in waste management system of this region.

In the second question the author was interested in finding out if the municipalities' were to use in the near future a waste minimisation alternative as an option for their waste treatment and utilisation.

The third question was basically to explore the possibility of regional co-operative recycling program that might include some or all GCC states.

Table 6.1 Questions and Answers by some of the GCC municipalities

Municipality	Does the municipality subcontract MSW management?	What is or are the MSW treatment alternatives applied?	Does the municipality welcome the idea of regional co-operation in MSW recycling?
Dubai	No	Landfill, composting, Paper & metal recycling	Only when there are large amounts of certain waste materials
Bahrain	Currently No, yet understudy	Landfill, waste reduction plant	Establishing a plant for each recyclable material if economically feasible
Jeddah	Yes	Landfill, recycling	Locally or regionally with enough MSW materials provided to a central facility
Riyadh	Yes	Landfill	Yes since it will increase regional unification
Doha	Yes	Landfill	Yes to eliminate the disposal of valuable resources
Dhofar	No	Landfill	Yes only for MSW materials generated in large amounts
collectively	Yes	Landfill	yes

See appendix V for more details on the questions and answers.

6.1 Kingdom of Saudi Arabia: Municipality of Jeddah

In 1981, the Municipality of Jeddah commissioned a British consulting company, Powell Duffryn Pollution Control Limited, to conduct a waste management assessment study. The recommendation of that study was that a cleansing programme needed to be implemented urgently. As a result, a five-year contract was awarded to Waste Management International, an American Company, in August 1981. Subsequently MSW collection and disposal operations improved.

According to the Municipality's officials, the sanitary landfill method is the least expensive waste management disposal alternative; therefore, it is the main method applied. There are two sanitary landfills in operation at the north and at the south of the city of Jeddah. At both landfill sites, electronic weighing bridges have been installed, and the amounts of MSW disposed of are recorded for immediate evaluation and future planning.

Recently a landfill located East of the city of Jeddah about 27 Km from city centre receives about 4000 tons of MSW per day. Currently the average amount of waste on daily basis is about 4000 tons of which 2650 tons are collected by the city main contractor from the great region and 1100 tons are collected by private contractors and individual organisation from all areas of the city.

The remaining 200 tons and 50 tons are collected respectively from the south and north by city contractor. The equipment used by city contractors are 160 large rear ending loaders (REL) plus 60 small REL. The number of private contractors is about 10 and they use their own vehicles and distribute their containers to commercial, hospital, hotels, markets, housing compounds, malls and supermarkets. A 240 liter container is commonly used next to small villas and houses. A six feet container is used next to multiple story building. Ten and twenty feet containers are used next to high rise building and public markets. The city contractors employ about 3000 workers.

The city of Jeddah will have the first recycling facility in the Kingdom of Saudi Arabia. The Ministry of Municipalities and Rural Affairs awarded a contract to SADACA for Environment to start a national recycling programme. The cost of the contract will be about one hundred million dollars (Al Samarrai, H. S., Al Zaydi, A.A., and Raju, P. A., 1996). The facility will be able to separate recyclable material and prepare packages for customers to use it as raw material. The location of the facility is in the route to the city landfill. Selected REL will empty their load for separation and the recycling process will be done according to information gathered about waste expectation from different areas within the city as per previous studies and real time monitoring. The recycled materials are: (1) organic material (2) ferrous and non-ferrous metals (3) plastic (4) paper and cardboard (5) glass. It is expected that 20-30% of the waste will meet recycle criteria (quality, purity, etc.). The program is part of master plan of waste management in the Kingdom of Saudi Arabia (Alam, I. A. 1997).

MSW is initially stored in containers and bins. Waste is collected from both residential and commercial areas on a daily basis using modern rear-loading trucks. The Municipality of Jeddah conducts additional city cleansing through the use of motorised street sweepers, water-spraying vehicles and water-suction vehicles.

In order to reduce the cost of transporting the MSW, the Municipality of Jeddah has constructed three transfer stations. They consist of three static compactors with capacities of 12 cubic meter per hour, 11 steel containers, 6 roll-on-off vehicles, and 3 shovel loaders. The city of Jeddah generated about 1250 tons/day of MSW in 1992, which was transferred daily to the landfill sites. More recent figures indicate that the city of Jeddah generates

4000 tons/day of MSW (Alam, 1997). Thus, the MSW problem in Jeddah indicates a much greater waste management need.

In Jeddah, there is a company that pays cash for aluminium beverage cans. The company, Metal Collection Limited, plays an active role in the recycling of Jeddah's MSW. The company introduced its recycling programme in the early nineties in an attempt to encourage public participation in saving the environment. The vast increase in MSW tonnage by the mid-nineties, from 1250 tons per day in 1992 to 4000 tons per day in 1997, forced the Municipality of Jeddah to take action directly by approaching SADACA for the Environment to initiate a recycling programme. Jeddah Municipality hopes to reduce the amounts of MSW being delivered to the landfill sites by increasing the utilisation of the amount of recyclable materials.

6.2 Kingdom of Saudi Arabia: Municipality of Riyadh

Consultants and technical experts from different parts of the world have participated in developing the best waste management schemes for the Municipality of Riyadh. This Municipality has employed several contractors to conduct various types of cleansing services, waste collection, and disposal. The city cleansing in Riyadh was contracted to a national cleansing company, Al-Mawarid, for a period of five years starting in 1987. The cleansing operations involved about 3300 workers and almost 200 vehicles.

MSW disposal, on the other hand, has been contracted to international companies. The main method of MSW disposal is sanitary landfill. In Riyadh, there are two major landfill sites. One landfill site is located at the eastern end of the city, and the other is located to the Southwest of the city. The Municipality of Riyadh's future plans for the first landfill site is for it to be developed into a green area. The Municipality has already planted several thousand trees at the landfill site. The South-western landfill site is expected to be developed by the Municipality as a national park.

6.3 UAE: Dubai Municipality

MSW management is being progressively developed due to the increase in the population and the development of commercial industrial projects. The government provides the necessary cash flow to maintain the city's cleansing and beautification. In the early sixties, the Municipality of Dubai issued the city's cleansing law. Some 20 years later, the Municipality of Dubai revised the law in an attempt to update it according to more current needs and circumstances. For example, the increase in population consequently caused an increase in the quantity of wastes generated and a concomitant change in the need for MSW disposal services.

In the seventies, the Municipality of Dubai distributed waste bags to the residents, schools and government offices free of charge. This was to help the city achieve effective MSW management.

Currently, MSW is being transported more properly and effectively than it was 10 or 20 years ago. MSW used to be collected in cartons that were stored next to each premise. Since the MSW was not put in plastic bags, chances were high that animals would scatter the waste in the streets, and increase the time and effort required for collection.

Since Dubai's MSW contains large amounts of organic material, the Municipality of Dubai encouraged the private sector to invest in composting the MSW generated in the city. In the mid-seventies, a private company built the first composting plant in Dubai. It had a production rate of 130 tons/day. Another private company built a recycling plant where steel is produced from cans in the domestic solid waste and scrap vehicles.

Another private company collects glass from domestic solid waste and exports it to India. In the mid-eighties, a private company established a paper and carton recycling plant that had a production capability of 200 tons/day. Currently, there are four other companies that collect paper and cartons, and export them to India. According to the Manager of the Waste Management Department in the Municipality of Dubai, some companies are presently studying the feasibility of recycling plastics from MSW.

C&D waste is generated in Dubai from the building of highways, large-sized complexes, hospitals, hotels, and waterfront projects. It is estimated that the average amount of C&D waste is 1000 tons/day; however, Dubai does not have a C&D waste recycling facility. Currently, C&D waste ends up in the landfill site, and the Municipality of Dubai then collects a fine of DHS 2000, or about US$800 per truck load of C&D disposed in places other than the designated landfill sites.

In the early eighties, the Municipality of Dubai allocated four sites for the disposal of MSW, one site for the disposal of hazardous waste produced from hospitals and clinics, and another site for the disposal of C&D waste.

The Municipality based their selection of the sites on the following criteria:

- Height above sea level.
- Distance from desalination plants
- Minimum distance of 40 km from collection areas.
- Impermeable bottom layer at the site.

MSW is collected in 50-liter plastic bins, 240-liter plastic containers and 1-3 cubic meters steel skips. The Municipality uses rear-loading compactor trucks and tippers for the collection of MSW.

6.4 State of Qatar: Municipality of Doha

A few years ago, the Municipality of Doha conducted a major MSW disposal operation at an insanitary landfill site close to the beach area known as Ras-Abboud. MSW was also disposed of in a landfill site located near the industrial area. It is estimated that the MSW quantities arriving at the Municipality's landfill sites amounted to 2440 tons/day. (Anwari, 1997). The MSW in Qatar is high in organic contents, which makes it suitable as feedstock for the production of compost.

The local authority feels that in spite of the advantages gained from land reclamation, negative environmental impacts have nonetheless occurred due to soil movement, surface-water contamination, seawater pollution, emissions of bad odours, and increases in insects and pathogens. The Municipality of Doha is co-ordinating with other environmental authorities to prepare an environmental impact assessment for the selection of a new sanitary landfill site for the disposal of MSW. The study will also be aimed at the development of environmental protection regulations for the new landfill site.

Currently, the collection of MSW by the Municipality of Doha is undergoing serious improvement. A compaction station has been developed by the Municipality to decrease the cost of transporting MSW. This objective has indeed been achieved since the number of vehicles and the numbers of trips per vehicle to the landfills have decreased. The compaction station also receives the material rejected from Doha's composting plant. After compaction of MSW a 57 cubic meter transfer trailer are used to transfer waste to the central landfill site at Umm Al-Affai. Currently Doha municipality is in the process of closing all the insanitary landfill sites due to operational and environmental problems.

All sites are with no ground water monitoring systems and no liner including Umm Al-Affai landfill site. However at Umm Al-Affai the waste is weighed, compacted and covered daily. Whereas in the other landfill sites non of this is being done. Therefore MSW will be transferred from transfer station to Umm Al-Affai landfill site. Ground water contamination seems not to be a problem at Umm Al-Affai.

Approximately 168,000 tons per year of MSW collected by Doha Municipality is taken to the transfer station where about 50%is recycled through composting facility. The remainder of MSW generated is disposed of at Umm Al-Affai landfill. In 1996 about 1million tons were disposed at that landfill. Approximately 80% of the total quantity disposed in the landfill consist of construction and demolition waste with the bulk of the remainder consisting of MSW. MSW recycling is limited in Doha due to the absence of government-development of a large-scale public recycling programme. The Municipality of Doha has, however, established a small-scale recycling process in which metals can be retrieved at the Municipality's composting plant. The recycled amounts of metals are then transported to the Iron and Cast Plant for reuse. Up to 1500 tons per year of such metal has been retrieved, ranging in price in Sterling Pound from 100 to 125 for Cardboard and paper, which comprise 23% of the total MSW amounts generated in Doha, are being recycled by three companies. These companies collect, press, and export cardboard and paper to Dubai for further processing.

6.5 Sultanate of Oman: Municipality of Dhofar

The Municipality of Dhofar is responsible for the cleansing services in the southern region of the Sultanate of Oman. The population of Dhofar is approximately 77,000. The Public Cleansing Department in Dhofar is responsible for the various operations of MSW management. The 238 employees of the Public Cleansing Department work two shifts per day. The Public Cleansing Department has distributed about 3000 waste bins in various places covering both residential and commercial premises. To conduct an effective waste collection operation, the Municipality ofDhofar obtained a fleet of 27 waste compactor trucks of different sizes. There are also two sweepers for the collection of accumulated dust on the sides of the roads. Open trucks are used for the collection of tree trimmings and garden wastes.

MSW is disposed of at the Resout landfill site, which occupies a total surface area of 126 hectare and extends to a depth of 1.5 to 2.0 meters. The landfill site is divided into three main sections:

- Section 1 has a total surface area of 26.6 hectare, and is used for the disposal of scrap vehicles, scrap metal, and tyres.
- Section 2 has an estimated capacity of 230,000 cubic meters, and its low-lying areas are used for the disposal of C&D waste.
- Section 3 has a capacity of 1,100,000 cubic meters and is used for the disposal of domestic waste only.

At the Resout landfill site, there is also a section for burning agricultural waste. Currently, planning is taking place to accommodate hospital wastes and hazardous wastes. The Municipality encourages contractors to recycle scrap metal from vehicles such as trucks, cars and tanks. Generally, scrap metal is sold to metal buyers in Dubai. The Municipality faces a problem with the large number of used tyres that have accumulated at the landfill site over a number of years. The Municipality has decided that for now the used tyres will be allowed to continue to accumulate for possible future utilisation.

6.6 State of Bahrain: Central Municipal Council (CMC)

The CMC in Bahrain has changed the waste collection policy in order to improve public health and environmental protection. As a result, 1- to 2.5 cubic meters containers were distributed around the cities and towns of Bahrain to make it possible to replace the former practice of collecting loose MSW placed on the footpaths. In the past in Bahrain, carts pulled by animals transported waste outside the city limits for disposal at an insanitary landfill site. Currently, modern vehicles perform the collection of MSW, and the CMC distributes plastic bags to the residents in order to ensure proper initial waste storage and effective collection. The 240-liter plastic bins mounted on wheels are the most common containers used for initial waste storage by residential and commercial premises.

Collection of MSW takes place early in the morning to avoid heavy traffic and hot weather conditions. The collected MSW is then transported to the main landfill site, which has been in operation since 1986. The landfill, which is in a worked-out quarry to the south of the village ofAskar in the centre of the proposed city of Khalifa, receives around 200,000 tons of domestic and commercial waste annually. This site is due for closeout by the year 2000. Recently a monitoring programme was put into effect.

Boreholes, which have been sunk in and around the site, indicate that there are no problems with leachate or methane build-up.

The CMC established a waste volume reduction plant in an attempt to increase the capacity of the existing landfill sites. This plant has positively improved the reduction in volume by 70%. Magnetic devices for further utilisation separate items such as metals.

The CMC is also responsible for the collection of medical waste produced by private clinics. The total estimated yearly amount of waste generated from such clinics is about 10 tons. On the other hand, the collection of waste from public hospitals is the responsibility of the Ministry of Public Health. Currently, Bahrain incinerates its medical waste and uses a secured sanitary landfill site for the disposal of hazardous waste.

As for C&D waste, it is taken to four landfill sites located near the cities and towns of Bahrain. The reclamation of the seafront using C&D waste has been an important method of increasing the area of dry land for infrastructure expansion. It is estimated that Bahrain produces about 100,000 tons/year of C&D waste.

Several private companies that collect paper, cartons, metals, and plastic conduct waste recycling in Bahrain. Collection of such recycled materials takes place at the sanitary landfill sites. Labourers conduct the separation and classification of recyclable materials by hand.

Two alternatives for MSW treatment, composting and incineration are currently under consideration. Composting, which requires the separation of the different types of waste materials such as paper, glass and metal, may be incorporated with incineration to decrease the net residue for landfill. Small-scale waste management projects are under consideration by the Environmental Health Directorate. Also under consideration are mulching stations to handle garden waste, which is a useful organic source for the production of compost.

6.7 MSW Quantities and Characteristics in the GCC

Historically, the quantities and characteristics of MSW in the GCC states have not been consistent. The inconsistency of both the quantities and characteristics of MSW in the GCC is generally due to changes in social and economic mode and the instability of the region. The Iraq-Iran War and the Gulf War both had and still have a strong impact on both social and economic development of this region. Subsequently, this region and its population have went through several ups and downs in terms of their modes and behaviour which were reflected in the consumption and generation of MSW. One can notice the changes in the behaviour of the GCC population over the last twenty years when examining the content of MSW and estimating the amounts generated per capita per year. A change in the MSW quantities and characteristics has been noticeable over time. It seems that this pattern of change may continue in the future. For instance, refer back to table 5.7 it is clear that the amount of MSW generated in Kuwait have varied with the years. In 1979 just before the start of the Iraq-Iran War the estimated MSW generated by 1.1 million population was 700,000 tons per year or 0.640 ton per capita per year. Four years later in 1982/1983 the MSW generated per capita per year was down to 0.360 tons in 1982 and up to 0.450 tons in 1983. However, as the Iraq-Iran War went boring the amount of waste in 1986 went down to 0.305 tons per capita per year. In 1988 as the Iraq-Iran War came to an end the MSW amounts was reported to have increased to about .400 tons per capita per year.

In general, the GCC municipalities define MSW as those wastes collected from residential and commercial areas, which are usually the responsibility of the municipality.

Municipal solid waste in the GCC mostly consist of food waste and encompassed few materials such as plastics, glass, paper, cardboard, textiles, and metal. Various estimates have been made on the quantity of MSW generated and collected per capita per day. Although these estimates were conducted by different entities, the general outcome proved that it is difficult to characterise or quantify MSW stream of materials with great accuracy. That is basically due to the use of different techniques in conducting the MSW survey, and the dynamic nature of MSW generation which is based on population, geographical locations...etc. The average composition of MSW in the different GCC states is given in Table 6.2.

Recent MSW composition's estimations are presented in the following tables. These estimations are indicative of the variation in the composition percentages not only between the GCC states but also between some of the GCC cities.

TABLE 6.2: COMPOSITION OF MSW IN GCC STATES & CITIES – WASTE COMPONENT (% BY WEIGHT)

	Food	paper	Plastics	Metal	Glass	Textiles	Misc.	Total	Ref.
K.S.A	53	24	2	9	8	0	4	100	Khan et al. (1989)
Riyadh	36	31	2	16	3	2	10	100	Riyadh Municipality (1992)
Jeddah	38	34	3	15	1	1	8	100	Jeddah Municipality (1992)
Jubail	60	10	22	2	2	0	4	100	Mogarri et al. (1997)
Kuwait	50	22	13	7	3	4	1	100	Al-Hasawi (1992)
Kuwait	51.1	18.6	13.4	5	4.5	0	7.4	100	Koushki (1995)
UAE	47	12	13	9	9	0	10	100	UNDP (1994)
Abu Dhabi	49	9	12	7	9	0	14	100	Abu-Qdais et al. (1997)
Dubai	35	16	13	9	6	8	13	100	UNDP (1994)
Qatar	53	18	15	4	3	0	7	100	Abu-Qdais et al. (1997)
Doha	50	17	7	12	3	3	8	100	Doha Municipality (1993)
Oman	40	21	12	11	5	6	5	100	Al-hasawi (1992)
Muscat	48	17.5	9	5.6	9.9	0	10	100	Muscat Municipality (1993)

Note: Paper includes cardboard, and zero value indicates negligible amounts.

Most of the data in this table were collected from the GCC municipalities and available literature, except for that related to Kuwait, which was estimated by the author through a field survey (as discussed in Chapter 5).

Estimates of MSW quantities are usually based on the amount of waste generated per capita per day. The author observed that the amount of MSW collected may be different from the amount generated. This is due to the lose of moisture in the GCC hot weather conditions. Moreover collecting recyclable materials at the source of generation by different unofficial entites prior to the collection by the municipality's contractors. However, differences between the quantities generated and collected are often ignored and the MSW quantities collected are used to estimate unit solid waste generation rate (Hammoda,1994). The generation rates differ from state to another and from city to another within the GCC region. According to estimate conducted by (ROPME, 1984) researchers the GCC states have generally an average value of 1.5 kg per capita per day. The data on GCC generation rate is shown in the following table 6.3.

TABLE 6.3: MUNICIPAL SOLID WASTE GENERATION RATES IN SOME GCC STATES – (ROPME, 1984)

Country	Population (million)	Generated rate kg/c/d
Bahrain	0.35	1.26
Kuwait	1.69	1.62
Oman	2.0	1.46
Qatar	0.49	1.44
Saudi Arabia	1.28	1.58
Average		1.47

Source: ROPME 1984.

Recent sources for generation rates are presented in the following table 6.4, which indicates close average figure of 1.56 kg/capita/day to ROPME, 1984 estimation.

TABLE 6.4: GENERATION RATES IN SOME GCC STATES

Country/city	Population (million)	Generation rate Kg/c/d.	Reference
Kuwait			
(1)	1.35	1.163	Al-Hasawi (1992)
(2)	1.78	1.37	Koushki et al. (1995)
UAE	2.0	1.6	Hamoda (1994)
AbuDhabi	0.7	1.76	Abu-Qduis et al. (1997)
Dubai			
Oman			
Muscat	0.6	1.91	UNDP (1994)

The GCC states average value of 1.56 kg/c/d is generally lower than typical rates for the U.S.A and Canada estimated at 2.9 kg/c/d as reported by Techobanoglous et al. (1993) and Henry (1989).

WHO, (1995) estimated that the generation of MSW will double by the year 2005 in many Arab countries. However this estimate seems to be high, especially when considering the historical trend in MSW generation rates in the Arab countries, it may take place. Having said that, I believe that this could only happen if the current waste management practices continue with no strategic planning (National and Regional Waste Strategy) and continuous assessment of possible waste utilisation alternatives that may help reduce the MSW amounts at the source of generation.

The GCC's MSW reflects the characteristics and social behaviour of the people of this region. Socio-economic factors, such as level of income, level of education, and social status, determine, in part, the characteristics of the MSW generated by a society. The waste generation rates and compositions usually differ from country to country since waste generation rates, composition and socio-economic factors are based on a highly complex, changeable, and unpredictable conditions that vary constantly between countries and within a single country itself. Some exceptions to this can be seen in Europe where the changes in waste generation rate and waste composition are reasonable and more stable than in the Gulf region. In this author's opinion, this may be due to the very small changes in the European population and that population's socio-economic level. A comparison of the composition of urban refuse disposed of at landfills in the UK and Kuwait was given in Chapter 5. The data indicates that there is indeed variation in the composition of waste in countries in different regions of the world.

6.8 Managing Waste in the GCC States

6.8.1 Types of Management

In the GCC states, MSW management activities are conducted by the relevant municipality, which is also called the local authority. There are two major schemes for managing MSW in the GCC

6.8.1.1 Direct Management

Direct management involves MSW collection by the Municipality's own staff. In this case, the Municipality takes full responsibility for MSW management through the utilisation of its own staff in various departments and divisions. The Municipality uses its own machinery, consultants, accountants, etc., and supplies all of the necessary tools and clothing for its labourers to conduct waste collection and disposal. Usually, the Municipality provides accommodation, food and transportation for its labourers. The labourers tend to be from Asian countries such as Sri Lanka, Taiwan, and Bangladesh. The Municipality takes responsibility for providing its labourers with free health care and free annual airline tickets to visit their homelands.

6.8.1.2 Indirect Management

Indirect management is based on competitive bidding for MSW collection contracts. In this case, the Municipality authorises a contractor or a group of contractors to perform MSW collection and disposal on behalf of the Municipality. This is usually done through limited-time contracts of between one and five years for an agreed sum to be paid monthly to the contractors by the Municipality. The contracts' terms of reference are often not clear and may be the cause for many claims to be filed by the contractors or the Municipality. The Municipality has a limited yet vital role in monitoring, following up on and reporting on the contractor's performance should there be any deviation from the contracts' terms of reference. There are three different types of municipality/contractor agreements.

6.8.2 Types of Agreements

6.8.2.1 Agreement Type I

In this type of agreement, the contractor is responsible for providing the required labourers, such as technicians, drivers, and inspectors; as well as the various types of waste containers, trucks, and tools in accordance with the Municipality's specifications. Maintaining the desired levels of cleanliness and environmental protection are other responsibilities of the contractor. This type of agreement is the most commonly used by the GCC's municipalities.

6.8.2.2 Agreement Type II

The Municipality, in this case, provides the required equipment, such as trucks, tools, and containers, to the contractor. The contractor is then responsible for providing the necessary labour to operate and maintain the equipment.

6.8.2.3 Agreement Type III

In this type of agreement, the Municipality provides all the required equipment and labour for the cleansing operations, while the contractor's job is to manage both the equipment and the labour.

6.8.3 Terms of Reference

Companies involved in waste management contracts are usually responsible for applying the following terms of reference used in the Municipality's contracts in this region.

- To collect, transport and dispose of all kinds of generated and accumulated refuse and waste (domestic, commercial, industrial, demolition, scrap vehicles and other bulky household refuse).
- To clean and sweep the streets, and dispose of animal carcasses and water from any source.
- To clean buildings, public toilets and monuments.
- To maintain and repair cleaning equipment and vehicles.
- To manage disposal sites with appropriate technology.
- To establish integrated training programmes for municipality personnel.
- To organise educational and public relations activities to promote awareness of cleaner cities.

6.9 Concluding Remarks

6.9.1 Assessment of the Findings

The recommendations stated in some of the studies conducted by the GCC's municipalities on MSW have been poorly implemented if at all. In addition, the GCC municipalities often fail to conduct studies to determine the services required and their associated costs, and whether the municipality should conduct the waste collection using its own staff or contract the task to a private cleansing company. For example, the Municipality of Doha hired a private foreign contractor to manage their MSW collection and disposal operations only to determine later that it was more cost-effective for the Municipality to conduct its own MSW collections and disposal operations.

Jeff Sanislo (1988), general manager of AlMulla Environemntal Systems, a joint venture between Browning – Ferris Industries of the United States and Al Mulla Group of Kuwait, stated that there are three reasons for such a study:

- It provides a benchmark with which to evaluate private sector bids.

- It provides a public-sector model on which to estimate costs since private collectors' true costs are difficult to determine.
- It provides a pre-planned public collection scheme and cost estimation that could be implemented should only unsatisfactory bids be received for collection services.

According to Lawrence (1980) there are three primary purposes for waste characterisation. First, the data become the basis for planning, economic analysis, design, and subsequent management and operation of disposal system or materials/energy resource recovery facilities. These data must take into consideration the varying nature of the material to be processed. Second, waste characterisation for rehabilitation or retrofitting of a facility redefines the quantity and type of waste for disposal. For this purpose, waste characterisation is concerned with marked changes in legislation or in the economy in general, which may have some effect on the waste generated. Third, plant optimisation, emissions monitoring, and/or malfunction analysis of a waste-to-energy facility can be expedited by the characterisation of the wastes being processed.

The GCC municipalities have conducted several MSW characterisation studies since 1960, for the purpose of managing and operating a treatment system with the emphasis on compost production. The studies also had the purpose of improving the cleanliness of their cities.

Improper storage of MSW is unattractive, attracts insects and rodents, and causes fires. The use of different types of MSW storage containers appropriate to different locations is an important factor in minimising collection costs. Some GCC cities still use unacceptable containers such as bins, drums, and cardboard boxes. An empty metal drum weighs 35 to 40 pounds (17-20 kg) and over 100 pounds(50 kg) when full. The weight and sharp edges cause injuries to labourers.

Whether the municipalities themselves or contractors manage refuse collection, the most common MSW method used is curb-side collection. The public sets their containers on thecurb-side for pickup on a daily basis. Waste spillage around the containers affects the environment adversely. Loose waste spread around the containers due to improper storing or a need for larger containers attracts insects and rodents, and allows papers and odours to be blown through the area.

In general, MSW may be classified as residential or commercial based on its source of generation. MSW in this thesis includes household and commercial wastes. Therefore, the data in Table **6.5** on MSW in the GCC states presents the amount of waste generated from residential and commercial premises that are disposed of in landfills.

TABLE 6.5: GCC MSW AMOUNTS AS DISPOSED IN LANDFILL SITES

Component	Qatar	Saudi Arabia	Bahrain	UAE	Oman
Food	109500	579720	82150	184683.80	204400
Paper	43800	480743	24800	84426.88	107310
Plastic	14600	28279	21700	68596.84	61320
Metal	7300	282790	7750	47490.12	56210
Glass	7300	28279	10850	31660.08	25550
Textiles	1825	7070	3875	42213.44	30660
Wood	-	-	-	15830.04	-
Miscellaneous	3650	7070	3875	52766.80	25550

Source: GCC states municipalities' personal communication.
NB: All amounts are given in tons per year.

6.9.2 Issues and Trends in the GCC's MSW

The GCC's municipalities use landfills as the method of choice for MSW disposal. The trends in managing the GCC's MSW are slow moving. Limited attention is given to other MSW management alternatives, such as recycling, composting, and incineration. The GCC's municipalities differ in their views on the best possible alternative for waste management. This is due to various reasons among which are the following:

- The municipalities in the GCC vary as to the degree and level of attention they give to the various issues concerning waste management.
- Research and development is available yet unorganised, unrecognised and in some cases scarcely thought of.
- Limited concern is given to well organise awareness programmes.
- The public's attitude in most of the GCC cities toward waste minimisation or sorting at the source of generation can be quite confidently that described as negative. (See Chapter 8 for a survey related to the attitude of a sample of students at Kuwait University as an example of the attitude of the GCC's population.)

Public involvement in formulating waste management policies and strategies is a driving force that pressures legislators to come up with better legislation. Moreover, the GCC states need to develop an efficient and cost-effective system for storing, collecting, transporting, and disposing of household and commercial waste. According to Al Sayigh (1993), Director of Environmental Health at the CMC in Bahrain, the current and future problems pertaining to waste management need to be clearly identified and analysed with a view toward assessing their impact upon the present operational methods and toward developing ways of eliminating existing problems or limiting their influence on any rational system. The problems may include:

- Financing the service
- Population growth.
- Irrational organisational structures.
- Vehicle availability.
- Planning and planning control.
- Refuse storage facilities.
- Legislation and law enforcement
- Weather.
- Land use.
- Service Conditions.

6.10 Recent development in recycling in GCC states and cities

6.10.1 Saudi Arabia - Jeddah

The Ministry of Municipalities and Towns in Saudi Arabia has signed a contract for the recycling plant project of Jeddah with a national company (AlAmoudi Group which is in a joint venture agreement with GKN of UK) in 1993. The contract was extended in 1994 to include the city of Riyadh. The terms of the contract indicated the following:

- Starting date of the contract, July 30th 1994.
- 30 months duration for erection of the plant.
- Contract is valid for 20 years with two possible extension periods of five years each.
- Designed plant capacity is 500,000 cubic meters per year.
- Land area available for the project is 270,000 meter square.
- Products expected to include PVC, HDPE, PE film, and mixed plastic metal scrap, fibres and compost.

The current status of the project shows that there has been progress in finalising the blue prints of the plant, fencing the project area, and collecting scrap cars. However, the actual implementation of the plant (civil, mechanical, and electrical work) has not been started yet.

The Ministry is pursuing the completion of the project with the company by extending the period of the implementation of the project. Since the company has requested that from the ministry in order to work on securing the finance, select the consultant, review the final design documents, and finalise the legal documents for the construction of the plant. The company indicated that the project final draft would include the following sub-projects:

- Compost production facility.
- Recyclable materials separation facility.
- Plastic treatment facility.
- Wastewater treatment unit.
- Power station.

Consequently, the Ministry is forming a team, which will be following up on the implementation of the project stages and components. The team main objective is to facilitate the relation between the company and the Ministry and to determine whether to continue with the implementation steps of the project or to take legal action against the company based on the terms of the contract agreement.

6.10.2 Kuwait

Recently, Kuwait Municipality invited both national and international companies working in the field of MSW recycling in order to present their proposals on how to utilise almost 1800 tons of MSW out of 2500 tons total produced per day in Kuwait. Kuwait Municipality allocated two sites, one in Amghara and the other in Mina Abdallah, for these companies to include in their proposals. It is envisioned that the companies will be implementing two projects to utilise the 1800 tons of MSW generated per day. Currently the compost plant in Amghara is supposedly handling about 700 tons of the 2500 tons generated per day. The Municipality is expecting from these companies more creative solutions for its waste. Although there is interest in producing compost for local consumption, the Municipality is more interested in the production of recycled materials such as plastics, glass, paper, and metals.

Couple proposals presented to the Municipality by international companies included interesting concepts for the utilisation of MSW. The first concept seeks the production of kids play tools, chairs, containers …etc., which will be produced by mixing and melting the MSW with certain petrochemical materials and then pour the mix in certain designed moulds for each product. The products can be then coloured and protected with sealer before selling to customers.

The second concept is based on bio-gas production, which can be then used for the production of electricity. The Municipality is still considering the recycling option over any other alternative for the utilisation of MSW in Kuwait. The Municipality's officials appreciate the first concept more than the second concept since the generation of electricity is rather inexpensive in Kuwait. The Municipality is still searching for other potential recycling project proposals from the private sector companies.

Currently the Municipality is studying a proposal that is designed to recycle all types of plastic waste. The private company that is interested to perform the recycling of plastic wastes is requesting the support of the Municipality. The private company is willing to invest in setting up a recycling facility if the Municipality would enforce the source separation concept in Kuwait and deliver the plastics waste to the site of the recycling facility. The Municipality is unsure of the success of this project even if it provides the support required to the private company. This due to the weak financial and market study presented in the proposal. In general the Municipality indicated that it will continue to work closely with the private sector companies on the issue of MSW recycling and hopes to find some viable alternative for the recycling of MSW in Kuwait.

6.10.3 UAE – Dubai

Recently, Dubai Municipality established a program for source segregation waste collection (textile items) system around large super markets called (used clothes charity scheme). The objective of the program is to increase awareness and fosters the development of a recycling culture to increase the recycling rate. For example in 1997 MSW amounts generated were 707359 tons of which 2.35% was textile, and to increase the benefit to those needy people thus the scheme will meet its humanitarian aspects.

Private companies have provided the necessary finance for the required bins. While the collection of the used clothes from these bins will be conducted by charity groups. Supervision of the operation will be the responsibility of Dubai Municipality. Another recycling program established by Dubai Municipality was the source segregation waste collection system in parks and tourist attractions for the collection of aluminium cans, glass bottles and containers, paper/cardboard and plastic.

The primary benefit of such program is the increase of public awareness. The secondary benefit is that the program may have a positive impact on litter control within parks and tourist attractions. Dubai Municipality indicted that one company for the collection of recyclable materials will handle each park.

Generally speaking some of the GCC states are working toward better planning and implementation of better waste management practices.

CHAPTER VII

MSW Treatment Techniques Used in the GCC States

7. MSW Treatment Techniques Used in the GCC

The MSW, specifically the recyclable portion, generated in the region of the GCC states should be viewed by both governments and the public as a valuable resource and be utilised in its most beneficial form. The disposal of MSW in landfills should be the last alternative in terms of treatment. The governments of each of the GCC states, while exploring techniques for the utilisation of their own MSW, should collectively consider the regional integration of a MSW utilisation system as a long-range strategy for the region. It is important that they collaborate to determine the proper set-up for the utilisation of their MSW. The application of a regional, strategic plan for the utilisation of MSW may reduce much of the financial and technical burden currently being experienced by some of the GCC states standing alone. In this chapter, an investigation of the current GCC MSW treatment methods is presented and the best possible alternative for the effective utilisation of MSW is proposed.

7.1 Material Recovery

From a management point of view, two possible schemes can be applied in the GCC states to recover valuable materials from the MSW generated in the region:

- Source separation, which is defined as the segregation of specific materials at the point of generation for separate collection; residence sources separate recyclable as part of curb-side recycling programmes.
- Central separation, which is defined as having a facility where MSW collected by either the public or the contractors is delivered and segregated by component.

Before applying either of the two schemes, a full understanding of the public's behaviour and perception toward waste in general is required. Therefore, a telephone survey of 150 persons living within the State of Kuwait randomly selected from the telephone book was conducted in late 1992. Only 100 persons agreed to answer the questionnaire. The results indicated that about two-thirds of the sample had some preference for a source separation scheme over a central separation scheme for waste recovery and felt that the authorities should consider enacting proper legislation to assist the public in implementing a recycling programme. Whether or not incentives are offered to the public for sorting their waste, the authorities still need to invest time, effort and funds in educating the public about waste minimisation and separation. According to the telephone survey, most of the people in this region would be offended if they were paid for their sorted waste. For details on the telephone survey see appendix VI.

Mogarri et al. 1997 conducted a public opinion survey with respect to MSW management in Jubail, Saudi Arabia. The survey concluded that more than 70% of the households would respond positively to segregate waste at home especially if the authority provides plastic bags. On the contrary the people were not interested in taking segregated waste to a centralised location for recycling.

In a similar behaviour study (Bennett, 1990) on recycling participation conducted in Citrus County, Florida, USA, a total of 800 responses revealed that a person's values have a greater impact on their willingness to recycle than the convenience offered by a recycling programme.

Although most of the world's authorities realise the ecological and environmental imperatives to preserve nature's resources, some of them still fall far behind in protecting their own local environments. The GCC states, to a certain extent, realise the importance of resource recovery and reuse. Yet, more work is needed in this respect. Since most of the GCC states' land areas are empty deserts that are difficult and costly to cultivate, the use of organic components from MSW is a possible alternative with which to treat the desert land (See Section 7.2).

There are various reasons why the GCC states should engage in large-scale recycling and composting that are proportional to the quantity of MSW generated both in the present and in the future. The most obvious reasons are:

- The reduction of the adverse effects on environmental and public health.
- The minimisation of the land area required for landfill sites.
- The minimisation of imported resources.

Moreover, such an operation would provide an excellent opportunity to attract investors interested in the economically valuable contents of the MSW. The reason for such a combination, i.e., recycling and composting, is purely due to the economic feasibility of such a waste management alternative. During late seventies, the Municipality of Kuwait's Compost Plant charged about KD 1 per ton of final compost product, which cost about KD16 to produce according to the Municipality's records. This cost differential was due to the government's intention to provide the compost as a service to the farmers. Another contributor to the economic disparity was the income lost from selling quantities of recyclable materials, as the government never considered utilising those materials.

7.1.1 Source Separation

As explained previously, source separation involves the sorting out of certain materials with an economical value and setting them aside from other MSW materials. To apply the various types of source separation requires discipline and effort on the part of the concerned participants. Although there are various methods to choose from to ensure the co-operation of the public in a source separation programme, such as information, incentives, legislation, etc., it seems that due to the attitudes and traditions (i.e., socio-economic level) of the people of the GCC, source separation may well be applied without specific financial incentives. An incentive programme might be well received if the form of incentive, not necessarily cash, were to provide items such as children's educational tools or pictures depicting recycling in a positive light. Such incentives might help to ease the public's reaction to the idea of getting paid for their wastes and it would be another way to ensure the environmental education of the new generation of children.

The author is not confident of the ability of the people of the GCC to follow decrees regarding MSW source separation since previous decrees covering various areas of waste management and city cleansing have proved to be failures. For example, Decree Number 9 issued in 1987 gives the right to persons other than the regular inspectors of the Municipality of Kuwait to give out fines to those who do not adhere to the decree. The decree itself prohibits the public from littering and polluting the footpaths, streets and public areas. Moreover, destroying trees and vegetation is also prohibited by the decree. Just a few years later it seems as though no such decree were ever issued. The enforcement of the decree by the Municipality's inspectors is poor, and as a result, the public tends to be careless. The author suggests the involvement of the local police to enforce this law.

The GCC's municipalities should prepare a strategic plan for the recycling of MSW in order to achieve tangible benefits. The benefits from preparing such strategic plan may be summarised as follow:

(1) Efficient system design suited to local demographics, which will result in lower costs, and more citizen participation.

(2) Market orientation in choosing recyclable materials to collect in order to maximise revenues and avoid need to stockpile large quantities of goods.

(3) High community interest and awareness, which would result in higher participation rates and higher quality recyclable materials received from their various sources.

A complete recycling programme should take into consideration all the possible constraints that might delay or prevent the development of waste recycling initiatives. The GCC waste materials generated from residential and commercial centres are easier to separate at the source of generation. Aluminium cans, papers, and cartons could be of value if separation at the source were performed in such a way as to maintain the materials in as pure a form as possible. This would definitely make the processing of such materials easier than would separation of mixed waste materials arriving in the contractors' collection vehicles. The two main source separation schemes are as follows:

- Collection of sorted wastes by the households, known as a collect system, involves the collection of wastes sorted into groups such as papers, glass and metals, from households. Collection can be performed on a daily basis at the same time as the regular daily collection of all other MSW, or according to another timing schedule set by the municipalities according to the demands for the collection of such waste materials. Both the collection system applied and the socio-economic level of the area of collection influence the need for different containers or plastic bags for the classification of the sorted materials. The GCC's municipalities will face a lack of co-operation from their households in sorting and separating waste materials if this type of source separation is started on a large scale involving all areas. Gradual introduction of such a programme in different areas may well have a greater impact on the desire of the households in other areas to participate, since in this society, people tend to mimic successful schemes and then compete to prove their superiority.

- Recycling facilities, known as a bring system, should be strategically located at the main population and commercial centres. The municipalities must inform the public of these locations a long time before even starting such a programme to familiarise and psychologically prepare the participants for their use. The participants should be made aware of the importance of the effort and care needed when sorting the waste materials prior to delivery to the recycling facility. A typical recycling facility (station) would consist of different containers for the different types of waste material.

Neither the collection of sorted wastes from households nor the recycling station method is in use, under the control of the municipalities, in any of the GCC states. Separated MSW is a valuable resource that has the potential to decrease the total cost of MSW collection. The GCC municipalities are not expected to generate profitable revenues from the separation of waste materials. Thus, performing source separation should be looked at directly from an environmental point of view with the possible added benefit of generating revenue. Income from the sale of the sorted materials should be put back into the community's recreation and educational institutions and/or programmes or to further environmental objectives.

Two other source separation schemes that are available are as follows.

- A profit programme, known as a re-purchase program, can be applied in two different ways: the deposit system and the reverse vending system. The deposit system has been in use in the GCC states since 1960. It started, basically, when soft drinks first began to be sold in bottles in the region. This system was greatly disruptedby the advent of the use of aluminium cans in the soft-drink industries in the GCC states. The other system, the reverse vending system, involves being paid cash back for recoverable materials delivered. It is not widely applied in the GCC states other than Saudi Arabia. Currently, a private metal company in Jeddah, Saudi Arabia, is promoting the idea of aluminium can recycling by offering cash for any amount delivered to their station.

- Collection of paper from commercial centres is conducted independently by various private companies. Since 1970, most of the GCC states have noticed a continuous increase in the consumption of the quantities of writing paper, corrugated cardboard, and most recently, computer and photocopying paper. Various companies have taken the initiative and started collection programmes for such waste materials from commercial and governmental facilities. Most of these companies have a baling system and export the baled paper and cartons to India and other countries. Recently, some paper recycling plants in Kuwait, Saudi Arabia, and the UAE have begun recycling operations, and market their products around the GCC states and internationally. Their sources for recyclable paper material are local shops, hotels, ministries, banks, and private buildings. These papers are high-grade wastes.

7.1.2 Central Separation

In these methods, MSW is received from various centres within a city. Transport of the waste may be by private companies, the public and/or the government. This is the most convenient method for waste generators, since waste may be collected with no sorting or separation at the various sources. Since the success of the central separation method is based primarily on a high degree of sorting, a central separation facility can include a pre-treatment unit followed by several separation stages such as screening, sink-and-float separation, stream classification, ballistic separation, magnetic separation, electrostatic separation and optical separation. Central separation can also be done in much less technical way by simply placing the waste materials on a conveyor belt and having workers standing on both sides of the belt pick out the recyclable materials.

The pre-treatment unit plays a very important role in providing the suitable shape and size required for the different methods of separation that follow. A common type of screen called a rotating drum is usually used for screening MSW. The purpose of screening is to divide the waste materials into the required particle sizes by means of a screen with openings of the chosen size.

Another system, which is based on the density difference between the solid waste materials and liquid, is known as sink-and-float separation.

A system that utilises both the size and density to separate waste materials according to the difference in falling velocities in a liquid or air is known as stream classification. One such device, the air classifier, separates paper and plastics from heavier materials such as organic wastes, glass and heavy metals. The lighter materials follow the air stream and the heavier ones sink through the air stream to the bottom where they collect.

The ballistic separator uses a rotating hammer to pitch the materials to different zones for the different waste fractions, i.e., light, medium, and heavy. The heavy, non-compostable materials are thrown the longest distance and the light waste materials such as paper and plastics are thrown the shortest distance. In between is the area where the organic materials are thrown.

To separate an item such as magnetic iron from MSW; it is possible to use a magnetic separation system. A common type of magnetic separation is the magnetic drum in which a fixed magnet is used to accomplish the separation.

Another way to separate certain elements of the MSW is the use of electrostatic separation. Such a method can be used to separate aluminium from the MSW stream. By passing the aluminium through high electrical voltage, it becomes magnetic and can then be magnetically separated.

Finally, optical separation is basically used to sort out glass of different colours, and to separate glass from china and ceramic. Most of the world's central separation facilities have problems selling their products on the market due to the presence of high amounts of non-desirable waste materials in either the paper or plastics. Therefore, source, or curb-side, separation separation, programmes should be encouraged among the citizens of the GCC states.

The general consensus is that recycling plants tend to lack reliability and have difficulties producing separated material of appropriate purity.

Systems in which materials are separated by hand from a moving conveyor belt could be cost-effective in the GCC where such wages are low.

The continuous increase in the discarding of paper, cartons, plastics, aluminium, and glass in this region could be prevented, and an effort should be made to establish recycling programmes involving MSW separation.

7.2 Composting

7.2.1 Composting Principles

Composting is an aerobic degradation process by which organic material is decomposed by micro-organisms under controlled conditions. The reactions generate heat, raising compost temperature during the composting period. Waste volume is reduced by about 30% for waste with a high proportion of newsprint to perhaps 60% for garden debris (Golueke, 1991). Acceptable composting depends on various factors such as the composition of the wastes, the carbon-to-nitrogen ratio, the water content and the oxygen supply (De Bertoldi and Civilini, 1988). Composting can be differentiated from other waste management alternatives since it is basically a biological process, as opposed to recycling and incineration, which are physical processes. Normally, the heterogeneous organic material in any MSW has an indigenous mixed population ofmicro-organisms from the atmosphere, water and/or soil.

When the moisture content of the organic material reaches 50 to 60% in the presence of oxygen, micro-organisms need a source of carbon and macro-nutrients, such as nitrogen, phosphorus, potassium, and certain trace elements, to survive. The biological oxidation of part of the carbon (i.e., the organic waste) provides the energy required for metabolism, and the rest is given off as heat. The relationship between temperature and time in composting can be understood from the four stages of the process (AlNawawy, A.S., 1988): mesophyllic, thermophyllic, cooling, and maturing.

At the beginning of the composting process, the mass of the heap is at ambient temperature and is usually slightly acidic. As the indigenous mesophyllic organisms reproduce, the temperature rises rapidly. During this stage the pH drops due to the production of simple organic acids. When the temperature reaches levels above 40°C, the performance of themesophyllic drops, and the degradation process is controlled by thethermophyllics. At 60°C, the thermophyllic fungi die off, and the spore-forming bacteria and actinomycetes continue the reaction. The cellulose and lignin fractions are scarcely attacked at temperatures over 60°C; yet, waxes, proteins and hemicellulloses are readily degraded. As all the degradable materials become used up, the rate of the reaction slackens until eventually the rate of the heat generation becomes less than the rate of the heat loss from the surface of the heap, and the mass begins to cool down. A re-invasion action by the thermophyllic fungi on the cellulose takes place when the temperature falls below 60°C. As the temperature drops to 40°C, the mesophyllic organisms restart their activity. The pH drops again slightly, although it usually stays alkaline.

The last stage, maturing, occurs at ambient temperature with mesophyllic organisms predominating and macro-fauna appearing. During this stage, complex secondary reactions of condensation and polymerisation take place, giving rise to the final end product, humus, and more particularly, the stable and complex humic acids.

7.2.2 Composting Process

Composting is a inconspicuous process, and the product depends on various factors (Haug, 1993) such as:

- Composition of the MSW.
- Moisture content.
- Carbon-to-nitrogen ratio.
- Temperature.
- Agitation.
- Aeration.
- Homogeneity of the MSW.
- Availability of sufficient nutrients for micro-organisms.
- Particle size.

Prior to initiating the composting process, it is necessary to sort and separate the non-compostable fractions from the MSW stream by mechanical operations, such as shredding and pulverising.Hamoda (1997), several methods of composting are in use, which differ primarily in the fermentation process employed:

(1) Static fermentation in naturally or artificially aerated windrows artificially aerated composting drum and hangers, naturally aerated piles and windrows moved in regular intervals; or (2) Dynamic fermentation in artificially aerated fermentation towers with one or more stories or artificially aerated rotating composting drums. In summary composting can be done in two ways either the open-windrow method (static composting), or the enclosed mechanical Method (dynamic composting).

A generalised process flow diagram for the composting process is shown in figure 7.1 (Tchobanoglous et al. 1993).

The windrow method involves setting up a long, low pile of prepared MSW. Usually the pile measures 3 meters wide and 2 meters high. For a period of 6 weeks, the windrows are mixed about twice a week, based on the moisture content. Mixing helps to aerate the decomposing organic. The 6-week period is known as the digestion period. Extra 1 to 3 weeks may be required to guarantee complete digestion. The pile temperature may well reach 65°C during the digestion period due to the natural metabolic action of thermophillic microbes, which thrive at this high temperature. At this elevated temperature, most of the pathogenic organisms are being demolished. In this method, curing requires an additional 2 weeks.

The enclosed mechanical method primarily uses one or more enclosed digesters. Usually these digesters use forced aeration and agitation to produce a more consistent compost product. In this method, after the initial 2 to 4 weeks composting process is finished, the compost is stored in piles for curing (known as the stabilisation period) for 4 more weeks.

Figure 7.1: Generalised flow diagram for the composting process (Tchobangolous et. al., 1993)

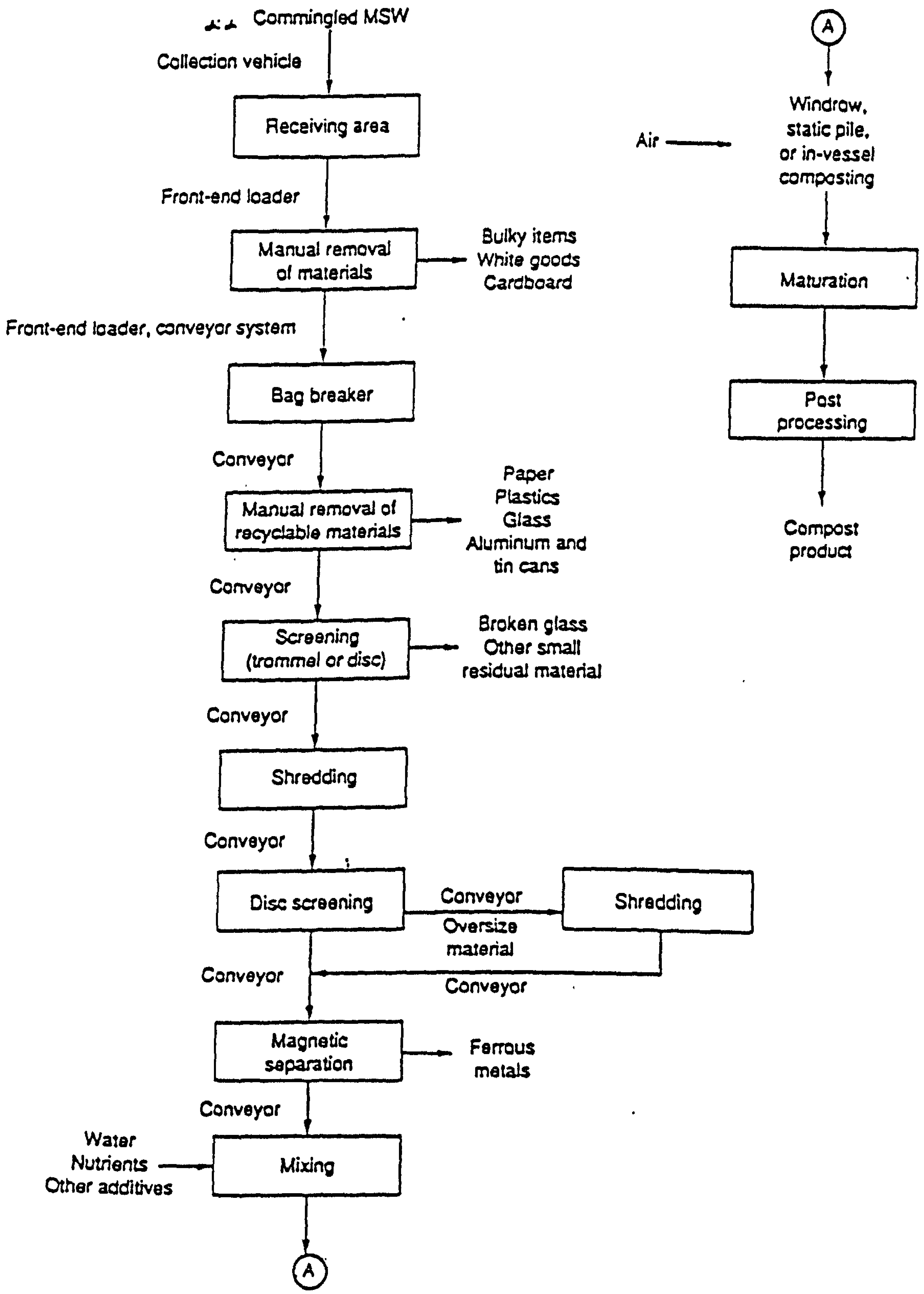


Fig. 7.2 shows a schematic diagram of an enclosed, mechanically operated, compost facility (i.e., Abu Dhabi Compost Plant). In both methods the curing period is essential parameter in the safety of compost production. If the composting process does not achieve almost 100% kill of all organisms, they will be present in the finished product. When this product is applied to land, the potential for contaminating crops arises and members of the public eating such crops, especially vegetable crops eaten uncooked, are at risk (Lund, H.F. 1993).

7.2.3 Composting Facilities in the GCC States

The GCC states have realised the importance of using composting plants to fulfil their need for soil conditioning material to improve the quality of the surrounding environment. Table 7.1 shows the existing GCC states' composting plants as of 1992. Several GCC states have constructed composting facilities applying various state-of-the-art methods. The majority of the composting plants within the GCC have imported the-know-how, management and operation of such technologies from Europe.


FRESH COMPOST
REJECTS LOADING
WET SEWAGE
IRON LOADING
FINE COMPOST BULK LOADING
REJECTS
FINE COMPOST IN BAGS
LEGEND
1. SLAT CONVEYOR
2. SLAT CONVEYOR
3. HAMMER MILL
4. CHAIN CONVEYOR
5. MAGENTIC SEPARATOR
6. DIGESTOR DRUM
7. CHAIN CONVEYOR
8. FINE HAMMER MILL
9. CHAIN CONVEYOR
10. HANGER
11. CROSS BELT
12. FERMENTATION AREA
13. STORAGE AREA
14. ADDING UREA
15. HOPPER (FEEDING BOX)
16. CHAIN CONVEYOR
17. REFINING MILL
18. SCREENING MACHINE
19. CHAIN CONVEYOR
20. DESTONER
21. BELT CONVEYOR
22. BELT CONVEYOR
23. BAGGING ANDWEIGHING MACHINE
24. BULK LOADING
25. REJECT (GLASS AND STONES)
26. REJECT (PLASTICS AND WOODS)
27. REJECT (MAIN BIG PLASTICS)
28. REJECT FERRO-METALS.
29. VIBRATOR
30. ADDING WATER
31. FORK LIFT

TABLE 7.1: PRESENT GCC COMPOST PLANTS

STATE	CITY	PRODUCTION CAPACITY TON/DAY	YEAR OF FIRST PRODUCTION
SAUDI ARABIA	Yanbu	300	1984
	Haal	140	1984
UNITED ARAB EMIRATES	AlAin	150	1978
	AbuDabi	600	1979
	Sharjah	150	1977
STATE OF QATAR	Doha	300	1984
SULTANATE OF OMAN	Muscat	150	1986
STATE OF KUWAIT	North Kuwait	700	Proposed
	South Kuwait	700	Proposed

Source: Personal communication and visits.

Several systems are applied in the different plants within the GCC. The windrow system is applied in most of the plants of the GCC states. However, some plants use the enclosed mechanical method. In Oman and Saudi Arabia, the use of forced aeration with the dynamic fermentation cell system has been implemented, whereas, in the UAE, the static fermentation cell system has been used. The main problem with most composting facilities within the GCC is the low standard of management, which consequently affects the production of a high-quality compost product.

Other problems may result from the lack of technical support that is required by such operations, and the limited quantities of spare-parts for the major pieces of equipment. In any case, the composting facilities should be effectively managed based on the process objectives rather than by managing crises occurring due to unplanned shutdowns

In the following section, a presentation of the several composting plants within the GCC states is provided. In general, the composting processing technology can be described as follows: the first-stage size reduction is carried out by fast-rotating mills (also known as slow cutters in plants which increased their capacity after going online). Occasionally, composting drums are installed. The main composting takes place in the open. For subsequent refining, which is usually the bottleneck of these plants, several operations have developed their own technology (to be described).

The following comments on the compost plants in the GCC states are based on personal visits.

7.2.3.1 UAE: Abu Dhabi

Buhler (Switzerland) built the first drum that went into operation in 1977 Extensions of another three drums became operational in 1979. The total project cost was almost US$52 million divided almost equally between mechanical and civil works. The design output was 480 tons/day of MSW plus sewage. The actual throughput was350 to 400 tons/day of MSW plus water. It has not been possible to use sewage as the high salt content inhibits the process. The water table, which is very saline, is within 1 meter of the land surface and seeps into the sewage pipes, which are laid up to 14 meters below the surface.

Each of the four drums is 33 meters long and 4.7 meters in diameter, and revolves at 2 round per minute. Each drum has a hammer mill in front of and behind it. The hammer mill in front of the drum is a twin rotor mill with two 132-KiloWatt motors driving the rotors, and the hammer mill behind the drum is a single shaft mill driven by a 37-KiloWatt motor. The drum has a 160-KiloWatt motor and runs at a single speed. The retention time in the drum is 15 to 24 hours, and the material is then screened over an internal double-screen with apertures of 30 and 50 millimetres. Urea is added to the material before windrowing. The theory is that the MSW is heavy in paper content, which affects the carbon-to nitrogen ratio to the point where additional nitrogen has to be added to enable the process to work. At this stage, the material is transported by belt to the composting building, which is an open-sided, roofed structure of steel construction. The material is turned 4 or 5 time in a 2-month period and is then matured for a further month before final screening to 10 millimetres. The turning is done with an air-cooled, diesel-powered, Buhler Compostar 4000 machine. The finished product is high in fibre and dry.

The plant manager reported that the Municipality uses about 70% of the compost, and the remainder is sold to the public for about US$236/ton bagged, and about US$200/ton loose. A total of 42,000 tons/year of finished and screened compost is produced The rejects are compacted and transported a distance of 35 kilometres to the local landfill site. A total of 153 workers are employed to operate the plant on a 2-shift basis (7 hours/shift). The plant is non-odorous but unclean. The maintenance appears to be barely adequate. There appears to be very little understanding of the process. No expansion of the plant is imagined but some modifications are being considered to increase its throughput. These modifications include changes to the hammer mills (which are regarded as very inefficient and expensive to maintain) and using Buhler spare parts.

The main source of organic waste fractions is the Municipality's collection areas and other private buildings.

7.2.3.2 UAE: Al-Ain

The original compost plant was built in 1978 by Buhler and was later extended by Voest-Alpine in 1986. The original plant is a standard Buhler plant. It has hammer mills in front of and behind the drum. The compost is windrowed and turned by a Buhler Compostar 4000 turning machine. As with similar plants, difficulties in composting have been reported with urea being added to the material after it exits from the drum in an attempt to assist the process by improving the carbon-to-nitrogen ratio. The problems are evident from the very bad odours emanating from the windrows, resulting from the anaerobic condition of the materials.

The plant consists of hammer mills placed in front of a Buhler drum with a twin shaft and a 130-kiloWatt motor driving each shaft. The hammer mill behind the drum is also a Buhler twin shaft with a 75-kW motor driving each shaft. The drum is 30 meters long and 3.2 meters in diameter, and has retention time of 17 to 18 hours. The plant's design throughput is 125 tons/day of MSW plus 25 tons/day of 1% to 10% dry solid sewage sludge.

While the actual throughput can be raised to 200 tons/day by working two shifts, the design running time is 9 hours/day. The capital cost is estimated at about US$15 million. The main problems are incomplete composting due to the anaerobic conditions, mouldy odours and the need to locally make the hammers due to the excessive cost of importing them.

The new plant is a very complicated two-line plant. The design throughput is 137.5 tons/day for each line based on a 6-hours operating day. A bypass conveyor has been installed to enable all the material to be fed into the original Buhler drum if required. A simplified flow description for each line follows.

A receiving hopper is emptied by polybag crane into an elevating plate conveyer. This conveyor feeds the MSW into a cutting tooth-type crusher from which the material is conveyed under an overband magnetic separator and into a rotating screen. The rejects are compacted and transported 5 kilometres to the landfill site. The material that passes through the screen is passed to a mixing drum 7 meters long and 3 meters in diameter, that operates at 20 rounds per minute and has a 20-minutes retention time, when it is mixed with sewage sludge. From the mixing drum, the mixture is conveyed to the covered forced-aeration pads. The aeration is actually induced and not forced, i.e., air is sucked through the compost by a fan rather than being blown through it. The aeration area is split length-wise into 25 sections; each section is 6 m wide and contains 4 aeration pipes. Each unit of 4 looped pipes is connected to a header pipe, which, in turn, is connected to 2 fans (each with a 75-Horse Power motor and capable of moving 18000 cubic meters/hour of air). There are 2 header pipes with a total of 4 fans. After the material has entered in the pre-composting area,it is loaded by a polybag crane and fed into a conveyor which transfers it to the post-composting area. In the post-composting area, it is again subjected to aeration, but this time of a much more gentle nature as only 2 fans are used. Both the fermentation and the maturation areas are fitted with overhead sprinklers to control the moisture content of the material. The maturation area is both walled and roofed. The finished compost is screened and destoned prior to being bagged or sold in bulk.

All of the compost produced is sold, and the chief engineer reports that there is insufficient MSW generated in the area to satisfy the demand. Private buyers pay about US$200/ton for loose compost and about US$236/ton for bagged material. The Department of Agriculture subsidises the sale of compost to farmers so that they pay about US$165.5/ton for loose compost and about US$199/ton for bagged compost.

The main problems are that the crusher and the screen cannot handle dry paper and cardboard, resulting in 45% rejects. The Voest-Alpine personnel claim that this is deliberate, as paper and cardboard, being cellulose, cannot be composted. This reasoning is incorrect; cellulose is well known to be compostable. The efficiency of the final screening and destoning plant is very low. The finished compost is high in plastic, stone and glass contents, and the fibrous material is very coarse. The capital cost of this project was about US$25 million. The plant throughput as designed is 400 tons/day of MSW plus 125 tons/day of sewage sludge. Yet, the actual throughput is only 240 tons/day of MSW plus 100 tons of sewage sludge.

7.2.3.3 State of Qatar: Doha

A plant with two identical lines, each having a design throughput of 150 tons/day was supplied by Buhler, although the actual operating throughput per line is 130 tons/day. Each line consists of reception, a hammer mill, a magnetic separator where ferrous material is sent to a baler), a drum from which rejects move to a compactor and exhaust air exits through a compost filter, a tramway and a tipper to the fermentation area.

The composting material is turned 3 times in 4 weeks by a Buhler Compostar 4000, air-cooled, diesel turning machine. The compost is then matured for 3 to 5 weeks prior to screening. A bagging plant has been installed but has filled only a limited number of bags in many years due to operating problems. Because of the high levels of zinc found in the compost, water injection was introduced to replace the sewage sludge added to adjust the moisture in the drum. The retention time in the drum is 24 hours. The total ferrous material recovery is 5 to 6 tons/day. In recent years, the Municipality has taken all the compost output at no cost. The plant's manager says it is too expensive for the local farmers, who prefer to use animal manure.

Line 1, built in 1975, has a drum, which revolves at 1.4 rounds per minute during the day and 0.7 round per minute at night. It has a 3-mesh long integral screen, and a 120-kiloWatt motor. The hammer mill has a 132-killoWatt Buhler motor. The windrows are in the open. Line 2, built in 1983, has a Buhler drum, which is 35 meters long and 3.7 meters in diameter with a twin-drive motor. The twin-drive motor shifts operation between day and night. The hammer mill is also a Buhler design. The windrows are under cover in a walled, roofed building. The total operators and administrative staff numbers 50. The total input reaches 50 tons/day, and arrives from the towns of Al-Rayyan and Doha. The plant operates 6 days/week for 8 hours/day. The maintenance programme is apparently very good, and cleanliness is excellent. No odours emanate except those from the MSW. Four labourers are stationed at the receiving area to remove any items the hammer mill cannot handle. The final product has a large amount of fibre and does not seem to be properly broken down. In general; the rejects percent is between 40 and 43% of the total input.

7.2.3.4 Sultanate of Oman: Muscat

In Muscat, a private company has constructed a compost plant. The Oman Organic Fertiliser and Chemical Industries operates the plant. It has a single process line that was designed and built by OTV of France, and commissioned in 1986. The plant has a design throughput of 150 to 160 tons/day of MSW, to produce 50 tons/day of finished compost. The rejects amount to 35 to 40% by weight, and are transferred about 40 kilometres to the landfill. The plant stopped regular operation in April 1987, due to a lack of demand.

7.2.4 Assessment

In general, the experience of MSW composting facilities so far in the GCC states has been disappointing, and in some cases, completely unsatisfactory. Paradoxically, it seems that the more technically sophisticated and expensive compost plants proved to be the most problematic in terms of unreliability, poor performance and high operating and maintenance costs. Conversely, it appears that the less-sophisticated, simpler plants have proved to be the least troublesome and least costly to operate and maintain, and have achieved better overall performance in terms of throughput, and the quantity/quality of compost output. It is clear that the suppliers of many of the existing compost plants have paid insufficient attention to local needs and conditions in their plant designs. The quality of the final compost product is essential for such plants in the GCC states since the local markets are quite open to other types of compost imported from Europe or from local production of animal manure. Therefore, the competition is high and the demand is for better quality compost. Table 7.2 presents the sale prices for compost products in the GCC states.

TABLE 7.2: SALES PRICES FOR COMPOST PRODUCTS IN GCC COUNTRIES
SALE PRICES

PLANTS LOCATION	ITEM	(A) FOR STATE	KD.	(B) FOR PRIVATE	KD.
Abu Dhabi Compost Plant, UAE				Through Municipality:	
				DH 300/Ton FOB Bulk	= 23
				DH 350/Ton FOB Fine	= 27
	Bulk Coarse Compost	DH 600/Ton FOB Bulk	= 46	Through Plant:	
	Fine Bagged Compost 25Kg/bag	DH 700/Ton FOB Fine	= 54	At 30% discount of state price	
				DH 420/Ton FOB	= 32
				Coarse Compost	
				DH 490/Ton FOB	= 38
				Fine Compost	
Sharjah Compost Plant, UAE	Rough Compost	DH 250/Ton FOB	= 19	10% discount for Municipality	
	Bulk Refine Bagged	DH 300/Ton FOB Bulk	= 23	(Highly subsidized)	
	Fine Bagged Compost	DH 400/Ton FOB Fine	= 31		

Ahli Petrochemical Dubai Compost Plant, UAE	Bulk Fine Compost Bagged Fine Compost		DH 400/Ton = 31 DH 420/Ton = 32 All Sales to private sector 5% of net sales to Municipality
Al Ain Compost Plant, UAE	Bulk Bagged	DH 600/Ton FOB = 46 DH 700/Ton FOB = 54	DH 490/Ton FOB = 38 DH 590/Ton FOB = 45 (50% subsidized through Agriculture Dept. for farmers)
Doha Compost Plant, Qatar			Previous selling prices Q50-130 = 4-10 Production cost QR160/Ton for Rough Compost N QR 310-320/Ton for Fine compost bagged. Subsidy 100% therefore its sold almost free of charge for private
Oman Compost Plant, Oman	Government provides subsidy on a very limited quantity to the farmer		OR 32/Ton Subsidized = 24 OR 40/Ton Non-Subsidized = 30 (Fine bagged compost) 25 Kg/bag OR 60/Ton Approximate = 45 Export Price R 50/Ton Approximate = 37

DH = KD.0.077
QR = KD.0.078
OR = KD.0.747

However improved processing technology has made it possible to produce almost any quality of compost required by the user and has reduced the processing time (Hamoda et al., 1997). In several of the GCC compost plants the quality is very low. The final product contains large amounts of plastic. In most cases, the main source of the waste materials is the MSW delivered to the plants. If the households were to apply source separation techniques, great benefits would accrue, especially in terms of the quality of the final compost product. Source-separated organic composting is becoming standard practice in many European countries. Factors that influence trends in source separation in Europe seem to be the level of environmental activity and co-operation of the citizenry. Participation in source-separated organic collection programmes runs between 60 and 80% for single-family and small multi-unit complexes. Compost produced from source-separation programmes is consistently of higher quality than mixed-waste compost, both in terms of having lower concentrations of heavy metals and less physical contamination. Establishment of compost standards by the EEC's Composting Commission would undoubtedly affect countries that continue to practice mixed-waste composting (Segall, 1992).