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Aljaradin, Mohammad; Persson, Kenneth M

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Solid Waste Management in Jordan

Mohammad Aljaradin

Tafila Technical University, Natural Resources Department, Engineering Faculty, Box 179,
66110, Jordan

Email: mohammad.aljaradin@ttu.edu.jo

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Abstract Solid waste became one of the major environmental problems in Jordan, which has been aggravated over the past 15 years by the sharp increase in the volume of waste generated as well as qualitative changes in its composition. The challenges face solid waste management (SWM) in Jordan are numerous. Financial constraints, shortage of proper equipment and limited availability of trained and skilled manpower together with massive and sudden population increases due to several waves of forced migration.

In this work we discussed these challenges; the main problems which stand against developing this sector to sustainable levels in the coming future are identified. Suggestions and recommendations that should be taken in consideration for developing the sector are also presented.

Keywords Jordan, Municipal solid waste, Landfill, Recycling, Legislation, Energy potential, Environmental problem.

Introduction

Final destination sites lies on municipalities, while the operation and management of the final disposal sites is the responsibility of 22 Common Service Councils (CSCs), which were created in the 1980s to serve groups of municipalities, since it was not possible for each municipality to operate its own landfill (METAP 2008), manly the solid waste management in Jordan is undertaken through the public sector and the private sector is not a significant player in this fields. MSW management has been complicated by the sharp increases in the volumes of the generated solid wastes as well as the qualitative changes in the composition of these wastes due to significant changes in the living standards and conditions in Jordan. Financial constraints, shortage of adequate and proper equipment, and the limited availability of trained and skilled manpower have contributed much to the poor solid waste management programs in Jordan. Low level of awareness and education in the communities regarding the health and environmental impacts of improper management of solid wastes has also made it difficult to implement recycling and disposal programs that require the cooperation of these communities to ensure the success of such programs (Manoj Chopra 2001).

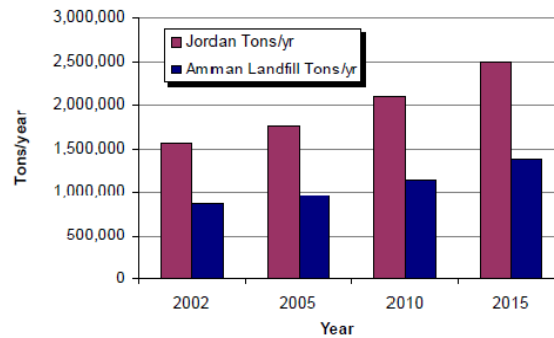


Fig. 1. Projected waste generation 2010-2015 (METAP 2004).

In Figure 1, the projected waste generation in Jordan is presented. The actual amount of solid waste generate over the last ten years, and the projected amount of MSW for the next five years. The MSW has increased steadily, which mainly can be attributed to the increase of population, the change of living standard and by an increase of the waste collection with time. The amount of MSW collected in Amman city is reported to be as high as 90% in 2008 (Al- Nobani 2008). The high rate of collection achieved is explained by an item on the monthly electricity bill, to cover part of the direct operation cost of collection and disposal, which the government recently has decided on (METAP 2008).

Table 1- The Physical Composition of MSW (Abu Qdais 2007).

| Composition | % |
|-------------|-----|
| Kitchen | 63 |
| Paper | 11 |
| Ceramics | 0.3 |
| Garden | 0.4 |
| Plastics | 16 |
| Glass | 2.1 |
| Fabrics | 4.3 |
| Metals | 2.1 |
| Others | 0.6 |

Table 1 shows the physical composition and typical percentage distribution of MSW in Jordan. It can be noticed that the major fraction of composition is food and paper waste (organics which implies a high value of moisture content), as expected, since Jordan is a developing country, and food is the major component of the solid waste stream generated in developing countries (Moh'd Abu-Qudais 2000). About 80% of the total municipal solid wastes are decomposable and recyclable, and the remainder is inert matter. Several studies have been conducted to analyze the composition of MSW generated in Amman area (Manoj Chopra 2001; ayash 2007; Al- Nobani 2008). In general, these studies reveal a declining percentage of the vegetable and organic fraction, possibly resulting from changing consumption patterns. Meanwhile, a gradual increase in the percentage of the plastic fraction has been noted. In general terms, MSW in Jordan is characterized by a high organic content, with combustible matter (consisting of plastic, paper and kitchen garbage) comprising more than 90% of the total waste.

Landfilling

Landfilling is the simplest and normally cheapest method of disposing of waste (R. Taylor 2003). Despite waste reduction and recycling policies, and waste pretreatment programmers to lower the proportion of waste going to landfill, at the end of the day landfills will still be required to accommodate residual wastes. However, although the proportion of waste to landfill may be decreasing, the total volumes of MSW being produced are still increasing significantly (Allen 2000; Beigl and Lebersorger 2009).

Landfilling, practiced in Jordan, is simply dumping the waste in trenches or cells with leveling and compacting by trash compactors to reduce the size and the thickness of the layers, and finally cover the waste with soil.

Landfills in Jordan are operated by CSCs (which usually serve more than municipality in the same governates) with dual supervision of the Environment and Municipalities Ministry.

There are at present 24 landfills in Jordan, listed in table 2. The location of these landfills was not chosen according to the international standards, it was chosen according to population density so as to serve the largest possible number of municipalities, Seven of these landfills are located in the middle region, seven in north region and ten in the southern region. Except for one landfill, the locations have not been based on feasibility studies for proper site selection. The exception is Algbawi landfill of the Greater Amman Municipality, which receives more than 50% of the volume of the generated solid waste in Jordan. The location of this landfill was selected after conducting an environmental impact assessment for best site selection (Al-Tarazi, Abu Rajab et al. 2008). It was also designed and engineered according to international standards while constructed. The rest of the landfill that receives 40% -50% of the volume of waste in the Kingdom are not designed according to international standards for landfills in terms of health or environmental requirements. Linings lack and the methods of dumping practiced could lead to contamination of groundwater, soil and air. For example, Akaider landfill which was located near the Syrian borders and in the vicinity of Yarmouk river basin gives rise to some political tension with Syria, since effluents from the Akaider landfill pose a threat to the Yarmouk basin. Mafraq landfill was located on a geological fault and represents a threat to the groundwater aquifer. Russeifa landfill is located at the main road between the two major cities in Jordan, Amman and Zarqa. Travelers are suffering from the bad odors of the landfill when passing it. Humra is located in a bedrock area where no soil is available for daily covers. Leachate produced is flowing out from the dump site threatening the public health and polluting the soil (Abu Qdais 2007).

The two most important trends in landfill management policy over the last decade have been the almost universal adoption of the containment approach to emission control, which is now mandatory in many countries, and the increasing legal requirement to install barriers such as artificial membranes as bottom liners and caps to landfills, in order to contain emissions. The containment approach requires that all liquid and gaseous emissions produced within the landfill, are contained within the landfill and collected for treatment, so extensive leachate drainage systems, containment ponds and treatment facilities are essential additional components of modern landfills. Artificial lining systems, which represent the high technology engineering solution to containment of emissions within the landfill, are the single most costly feature of modern landfills, and are virtually mandatory for all landfills even in situations where they are unnecessary (Allen 2000; Ramke 2009). In Jordan, waste

disposal was basically open dumping and burning without complying with the proper regulations since 1950, while in the beginning of 1980 the awareness increased for establishing sanitary landfills. Open combustion is still practiced in the old municipal landfill. For more than 35 years, MSW was open combusted also at the biggest landfill in Jordan. After that the total landfill area of 4-5 km² was covered with a soil layer of 30-50 cm depth, but the combustion of the solid waste was not completed. Therefore, the burning process and pyrolysis continues still in an oxygen depleted atmosphere, highly suitable for the formation of environmentally problematic toxic substances such as dioxin, furans and polycyclic aromatic hydrocarbons (PAHs) (Alawi, Wichmann et al. 1996).

The total estimated daily generation of municipal solid waste in Jordan is about 3800 tons/day, disposed at 24 sites. The northern region contributes about 780 tons/day, the middle region totals about 2620 tons/day, and the southern region contributes about 400 tons/day (Daradki 2008) see table 2.

Table 2- Landfills in Jordan (Daradki 2008)

| Notes | Received Waste Tons / day | Area in km ² | Location | No. | Region |
|---------------|------------------------------|-------------------------|------------|-----|--------|
| | 350 | 80 | Akaider | 1 | North |
| | 100 | 38 | Mafraq | 2 | |
| | 90 | 71 | Kufrinja | 3 | |
| Sum | 100 | 78 | Northern | 4 | |
| | 30 | 60 | Taybeh | 5 | |
| 780 tons/d | 80 | 55 | Saro | 6 | |
| | 30 | 40 | Um | 7 | |
| | 2200 | 12 | Russeifa | 1 | Middle |
| Sum | 150 | 80 | Madaba | 2 | |
| | 140 | 27 | Humra | 3 | |
| 2620 tons/day | 70 | 70 | Dhuleil | 4 | |
| | 20 | 30 | Thiban | 5 | |
| | 30 | 20 | Dier Allah | 6 | |
| | 10 | 48 | Azraq | 7 | |
| | 80 | 60 | Aqaba | 1 | South |
| | 50 | 50 | Maan | 2 | |
| Sum | 85 | 60 | Karak | 3 | |
| | 50 | 45 | Tafila | 4 | |
| 400 | 20 | 26 | Shobak | 5 | |

| | | | | |
|--------|----|----|-----------|---|
| tons/d | 20 | 28 | Eil | 6 |
| ay | 20 | 27 | Qoura | 7 |
| | 15 | 10 | Husania | 8 |
| | 40 | 10 | Southern | 9 |
| | 20 | 15 | Ghor safi | 1 |

Total Sum: 3800 tons/day

Recycling potential from landfills

The most important environmental and economic benefits of recycling are to increase material and energy utilization of solid waste and to reduce environmental pollution from the disposal of waste at landfills. Recycling reduces solid waste and produce beneficial materials; this represents an important business with a high potential for future development. Recycling is growing nationwide encouraged by the economical and environmental benefits it brings (N. A. Al-Ansari 2005). Recycling is very limited in Jordan and undertaken by the informal sector, so much of the recycling is done inside landfills. These operations are not regulated and expose worker to hazards conditions. Sorting of the different types of solid waste at generation source is not yet practiced in Jordan, so considerable amount of recyclable materials are sent to final disposable sites. The processes have not yet reached a sustainable level, but some recycling initiatives and pilot project undertaken by non-governmental organizations (NGOs) have proved to be very successful, as the public was very positive, but once the projects of the NGO:s were terminated, so was the recycling (Al- Nobani 2008). Currently, organized doesn't exist in Jordan. Clear policies and legislation lacks.

This do not prevent private companies to oversee the sorting and recycling by street vendors who collect the remnants of certain materials such as soft drinks glass bottles (98% of these returned to bottle companies for ruse), plastic, cardboard and aluminum cans from many places in society and sell them to waste traders. The private sector companies in Jordan has recognized the importance of recycling and the economic benefit that may accrue from this process (METAP 2008). A number of companies are active in the sorting of waste within landfills (iron and aluminum, plastic, paper, cardboard and glass bottles). Most of the work done inside the landfill is done through scavengers employed by the private sector. Most of the landfills in Jordan are rented for private sector companies , for example, Alakidr landfill is rented with 60000 JD /year, Alhsinyat 40000 JD/ year, and Alhmra landfill with 20000 JD/ year (Daradki 2008). The waste recycling process depends mainly on the prices of the sorted materials as shown in table 3.

Table 3- The prices of some sorted materials

| Recycle | Price ^(JD /Ton) |
|----------------|-----------------------------------|
| plastic | 300 |
| Colorful | 200 |
| A white | 350 |
| Iron | 250 |
| Aluminum | 110 |
| Cardboard | 65 |

Also a number of commercial and industrial establishments have agreements with various CSC to dump their waste at certain disposal sites. Each establishment is arranging its wastes collection and transport to the disposal site. Some private companies are given

monthly cards or passes according to individual contracts that varies with the type and volume of waste generated. The companies pay 1400 JD per month to deposit daily loads of 8-10 tons (UNDP 2006).

Energy potential from Landfills

The current energy situation in the country does not lead to energy independence; it is important for Jordan to develop its indigenous sources of energy. The introduction of biogas as an alternative source of energy has found considerable acceptance in Jordan for producing clean renewable electricity (Al-Ghazawi and Abdulla 2008). The gas emitted from a landfill is approximately half methane, a potent greenhouse gas. Landfill gas is estimated to be the largest anthropogenic source of methane emissions in the US and third largest in the world (METAP 2008).

Biogas from landfills has been used for several decades in most industrialized countries. By using biogas technology large quantities of organics waste can be almost totally converted into energy (Al-Dabbas 1998).

The Kyoto protocol was signed by Jordan in 2001. Within the Kyoto protocol, developing countries are granted "virtual carbon emissions" that can be used in the country or sold to developed countries that have surpassed their emission limits. In this transaction the industrial country will buy the amount of carbon emissions of a developing country at a global carbon market rate in the form of funding for alternative energy projects and direct financial support tailored also for climate change mitigation and adaptation (Batir Wardam 2009).

A Biogas Company was established on Al Russeifa close landfill in 1997. The main objective was to reduce the green house gas emissions from the landfill, as well as utilizing the fresh organic waste in the production of methane gas for power generation. The plant which started working in the year 2000 consists of two parts. The first part receives the biogas from wells of the closed landfill, while the second part receives the biogas from the digester, where fresh organic waste is received and digested anaerobically (Batir Wardam 2008), in order to produce biogas that can be generated to electricity and to produce a clean solid residual that can be utilized for organic fertilizers. The factory is expected to reduce 1.4 million tons of carbon dioxide emissions annually, and to generate 20,000 megawatts hourly of electricity when in full operation. The plant reduces the emission of 5,000 tons of methane and saves 6,000 tons of diesels for the use of generating electricity. The reduction in carbon dioxide emissions can further on be sold in the global carbon market at an average of 7.5 Euros/ton of carbon reduced (METAP 2008).

Table 4- Electrical energy production in Jordan (GWh) (Electricity 2010).

| | | | | | |
|---------------------------|----------|----------|----------|----------|-------------|
| | 20 | 200 | 2 | 2 | 2006 |
| Electricity Sector | 84 | 913 | 1 | 1 | 18.4 |
| Steam units | 71 | 752 | 5 | 6 | 13.9 |
| Gas Turbines /diesel | 46 | 341 | 6 | 3 | -52.2 |
| Gas Turbines /Natural | 77 | 648 | 9 | 9 | -2.9 |
| Diesel Engines/HFO | 1 | 2 | 4 | 1 | -75 |
| Hydro Units | 53 | 57 | 5 | 6 | 19.6 |
| Wind Energy | 3 | 3 | 3 | 3 | - |
| Bio Gas | 6 | 5 | 6 | 1 | 66.7 |
| Combined Cycle | 0 | 558 | 3 | 5 | 31.8 |
| Industrial Sector | 49 | 516 | 4 | 3 | -17.3 |
| Steam Units | 42 | 445 | 4 | 3 | -15 |
| Diesel Engines/HFO | 74 | 71 | 2 | 1 | -53.6 |
| | 89 | 968 | 1 | 1 | 16.9 |

In Table 4, the change in electrical energy supply in Jordan for the years 2004-2007 is presented. The growth rate in biogas production for electricity generation is large, but still the proportion of the total electrical energy supply from non-fossil sources is small. The biogas contribution for producing electricity has increased slightly from 2004 to 2007. The biogas as a renewable source of energy is welcome in Jordan for producing clean renewable electricity; the increasing of production in 2007 will encourage the government to invest more in this sector, However, Nothing much have been done in this regards after.

Many studies have been conducted to estimate the benefit from using the biogas from landfills, one of these studies estimated the total emission reduction from two landfills in Jordan in the life span (25 years) of the biogas plants will be about 1,406 Gg CH₄. It will generate electricity at a cost of US\$0.046 per kWh, which is less than the Jordan electric long-run marginal cost of generation at 5.5cents per kWh. Moreover, annual savings of US\$4.65 million will be achieved by the replacement of fuel oil with the generated biogas (Al-Ghazawi and Abdulla 2008). Also studies concerning the energy content of MSW in Jordan was conducted and it was accounts for 6% of the annual imported oil consumption of the country and may result in annual saving of US\$24 million in case of the utilization (Moh'd Abu-Qudais 2000).

Legislation and Polices

Solid waste management in Jordan is regulated by a number of authorities under different legislations that are implemented through different governmental sectors, such as the Ministry of Municipalities, Ministry of Health, and Ministry of Environment, with very weak level of coordination. These laws (Environment law no. 1 of 2003, Ministry of Environment, public health law no. 21 of 1971, Ministry of Health, law of organization of cities, villages and buildings no. 79 of 1966, prevention of repulsive and fees for solid

waste collection within municipality's boundaries no. 1 of 1978. Ministry of municipalities) are extremely generic. They simply indicate the responsible agency for waste management, the fees that should be collected for the offered service, and the fines that should be paid in case of noncompliance with proper management of MSW (Abu Qdais 2007). The Ministry of Environment is a new and evolving public entity, with many political and economic bottlenecks blocking its functions (Batir Wardam 2007). But it has the legal strength of a very robust and efficient environmental law that provides the Ministry with the tool and the teeth to act. The Environmental Protection Law was one of the package of temporary laws issued in 2003 and it was officially endorsed by the parliament in 2006 and issued as the law number 52 for 2006, the law considers the Ministry of Environment to be the competent authority for the protection of environment in the Jordan, and the official and national authorities shall be bound to implement the instructions and resolutions issued under the provisions of this law which gives the Ministry all the judicial powers it requires implementing the law, two major articles provide the Ministry with the required ammunition to save the Jordanian environment and its people's health from industrial pollution in particular, one of the articles gives the Ministry the legal power to inspect any facility, and according to the findings gives the Ministry the right to close the facility in order to implement mitigation measures and stop the environmental violation (Environment 2002). This inspection system was further strengthened with the establishment of the Environmental Police in 2007 where the police are now acting as an implementation tool and a fully-fledged partner in the implementation of the environmental law, but this legal frame work doesn't specifically target solid waste management, and the landfilling responsibilities. Besides, this legal framework wasn't implemented in ground for solid waste mangement which still is the responsibility of the goverment it self, hence this is one reason which stand against developing the proper management of solid waste in Jordan.

There is a need for new regulations dealing specifically with solid waste issues in a comprehensive, efficient and detailed manner, with clear responsibilities and enforcement mechanisms. The need for a legal framework that promotes resource recovery and minimization options and enforces the polluter pays principle has been discussed previously (Batir Wardam 2007). A National Agenda for solid waste utilization was prepared in 2005 and launched in 2006 comprising a comprehensive political and socio-economic reform plan for the country until 2017. The National Agenda was based on research and integrated inputs from key players and organizations from within and outside the government. The main goal of the National Agenda is to achieve consistent policies and ensure that they will not be subject to government change while taking into considerations the need to regularly develop and update these policies.

The section on waste management is the most comprehensive environmental section in the National Agenda. The first recommendation is to develop solid waste management policies, promote environmentally sound disposal sites, encourage recycling and minimize solid waste generation. Although there is no clear waste management policy in Jordan yet many steps should be taken to achive these recommendations (Abu Qdais, Bani Hani et al. 2009).

Environmental problems resulting from landfills

In the beginning of the 1970ies, the government of Jordan realized the pollution associated with the solid waste landfilling, uncontrolled landfills, open dumping and partial combustion. Many problems are connected to this which could threaten the ground water, surface water resources and soil.

Due to the unacceptable situation of a Russeifa landfill, in 2003 the landfill was closed after establishing al-Ghabawi landfill, this is the only development since 1999.

Still many landfills represent a highly threaten to environment. However, many studies have been conducted to investigate some of these threats; the effect of the leachate from the landfill Alakidr was investigated in 2001. Physical and chemical parameters were estimated within an area of 6 km from the landfill site and the impact on the ground water flow direction was covered. The result from that study showed that the landfill constitute a serious threat to the local aquifers (Abu-Rukah and Al-Kofahi 2001). Thermodynamic analysis of subsoil pore water indicates that Fe, Cu, Zn and Pb exist as metal hydroxides at Alakidr landfill and downstream it (Abu-Rukah and Abu-Aljarayesh 2002). Marka landfill in amman and Alakidr in Irbid city were investigated in order to determine the environmental situation in context with waste deposal techniques, and measuring the contamination levels (Wichmann, Kolb et al. 2006). A case study of Zarqa City indicated that the pollution was more obvious in the Al-Russifa area at the phosphate mining manufacturing facilities. Open dumping is still the only practice at the landfill, so it is strongly affected by sludge accumulation, odor, insects and rodents. The generated leachate contaminates soil, groundwater and surface water, the leachate contains very high levels of BOD (36,900mg/L) and COD (157,920 mg/L) (Mrayyan and Hamdi 2006).

An environmental impact assessment (EIA) study for the solid waste landfill was prepared for the Russeifa area, northeast Jordan. As the landfill was not subjected to thorough EIA prior operation, serious environmental problems are still occurring; many alternatives were proposed to rehabilitate the landfill (El-Naqa 2005). The low level of awareness regarding the health and environmental impacts of improper management of solid waste makes it difficult to implement recycling and disposal programs. When putting recycling and disposal programs into practice, cooperation between both the public and the private sectors is required to ensure the success of the solid waste management program all over Jordan (Mrayyan and Hamdi 2006). There is a need for establishing a real program to urge the citizen to participate in the preservation of the environment and changing consumer behavior by raising the awareness on different aspects of the solid waste by many institutions such as NGOs, municipality, governments, international agencies, university, and schools. The awareness initiative varied from production publications that include materials such as brochures, posters. The awareness varied from producing publication to actual activities such as seminar, conferences and workshops in schools (METAP 1999; METAP 2008).

Conclusions and Recommendation

The current situation of landfills in Jordan is not promising because of the bad situation for most of the operating landfills. The weak financial status of the municipalities and

CSCs, stand against getting modern solid waste collection and successful landfill operations. The absence of a national solid waste management strategy and a solid waste law is obvious. At present, there are no defined objectives, priorities or standards for solid waste management in the county, none of the municipalities or CSCs have or use written procedures for MSW management, either at collection stage or for the operation and management of landfills, procedures handed down verbally, based on precedent and tradition, rather than technical grounds of best practice, environmental protection, site selection, health and safety of workers, etc. According to the legal review, there is overlap and uncertainty in the legal responsibilities; the Ministry of Environment and Ministry of Health have no role in enforcing environmental and health standards. However their involvement appears to be tentative and reactionary and they act normally only when there is a particular issue.

Many of these laws were issued early last century need revision and updating to deal with MSW and landfills in a clear framework.

This situation prevents the creation of properly organized, regulated and cost-effective waste management services and acts as a major disincentive to the involvement of the private sector in the development of an integrated solid waste management industry which could be the hope to develop sustainable solid waste and landfill management. Municipalities must make provision for future landfill needs by allocating suitable land in their long-term strategies. It is crucial that each district have an appropriate site for waste disposal otherwise wastes will be illegally dumped or exported to other areas. All landfill sites should be operated to a standard, which protects human health and the environment. Where landfill standards have not reached the minimum for protection of health, it is recommended that action be taken immediately.

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