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Theses of Dissertation

Feasibility Assessment Of Waste Management And Treatment In Jordan

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1. The solid waste sector in Jordan can be characterised as a disorganised sector with sporadic service coverage. Waste management in the country is one of the major responsibilities of local government and the private sector is not a significant player in this field; there is no significant participation by the private sector. Subcontractors are commonly brought in to handle specific activities such as collection and transportation.

2. Recently, Jordan has realised that the way the country manages its solid waste does not satisfy the objectives of sustainable development. Therefore, the country has decided to move away from traditional SWM options to more integrated SWM approaches. To this end, Jordan's Government has made considerable progress in its ability to organise SWM through an improved legislative framework, stronger institutions and a number of publicly funded projects. In some cases, foreign rules and regulations were enacted without any customisation to suit the characteristics of the country .

3. Jordan defines organisational frameworks, but they are poorly implemented and disrupted by the centralisation of authorities at a national level. In addition, a lack of action by government institutions, the overlapping mandates and responsibilities and unclear lines of authority, a lack of investment by the private sector and the absence of public participation in decision making have all hampered the development of proper SWM practices in Jordan.

4. The fees collected for managing waste are generally charged on the electricity bill. The cost recovery is very low, covering only 60% of the costs in Greater Amman Municipality and no more than 30% in the other municipalities. In some cases, the fees go to a central treasury and are distributed with unclear criteria. The funding system for waste management is mainly characterised by the absence of financial incentives and effective cost recovery mechanisms. Now, there is an attempt towards increasing charges for waste management services by introducing the "polluter-pays" principle.

5. Municipalities are responsible on a day-to-day basis for municipal cleaning, waste collection and disposal of the mixed household waste generated. The existing MSW collection system has been developed based on limited data. It is considered to be adequate in urban centres, but services tend to be poor or non-existent in small towns and rural areas.

6. Under the Deputy City Manager, the Directorate of Environmental Affairs in each municipality oversees waste collection and manages the transport of waste from the collection areas (districts) to the landfill. The waste disposal is managed by the landfill site and treatment department. Each of the aforementioned districts are responsible for their waste collection and for transport to the transfer station (if any) or the landfill. The districts all have a SWM organisation under which drivers, waste collectors and street sweepers are coordinated.

7. Waste sorting and recycling are undertaken by the informal sector, so much of the recycling is done inside landfills and some from the waste containers. About 2–5% of the total generated waste is recovered as recyclable materials, such as PET, other plastics, metals and paper. Sorting of the different types of solid waste at generation source is not yet practised in Jordan, so a 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 NGOs have proved to be very successful, as the public was very positive, but once the projects of the NGOs were terminated, so was the recycling.

8. Composting, due to the high organic content of MSW, has received particular interest recently in relation to the recycling and conversion of organic solid waste into a stable product that can be used as a soil conditioner or fertiliser.

9. Waste disposal in uncontrolled dumps is still practised in many parts of Jordan. The most commonly used method of disposal is in controlled dumpsites. Disposal in sanitary landfills is increasingly being adopted, particularly where there is a strong sense of environmental awareness.

10. Jordan needs a sustainable, flexible and resource-oriented waste treatment system to promote waste minimisation, recycling and resource recovery in order to reduce the solid waste directed to landfills. Composting and mechanical biological/physical treatment options are considered the most suitable solution. Incineration is uneconomic for most cities in Jordan. Further problems are the lower calorific value <7000KJ/Kg, use of waste heat and the requisite knowledge for the operation.

11. Work is underway in Jordan on the establishment of seven plants to produce compost from different types of organic waste. Jordan currently has no experience of sorting recyclable materials from municipal waste and processing the separated organic matter. Therefore, many obstacles are expected to be encountered in the operation of the upcoming composting facilities, such as mismanagement because of the inappropriate technology chosen for the local conditions (resulting in high operating costs and frequent mechanical breakdowns through poor maintenance), a lack of understanding of the composting process, or limited availability of trained and skilled manpower needed for effective operating procedures.

12. A research study was performed using the ArcGIS Network Analyst tool in order to improve the efficiency of waste collection and transportation in the cities of Irbid, Karak and Mafraq, Jordan. A Geographic Information System (GIS) has been created based on data collection involving GPS tracking (collection route/bin position). Both key performance and key operational costs indicators of the actual state (Scenario S0) were evaluated, and by modifying particular parameters, other scenarios were generated and analysed to identify optimal routes.

13. The results showed that the three scenarios guarantee savings compared to S0 in terms of the total cost of waste collection of 15, 13 and 23% for S1, S2 and S3, respectively in the city of Irbid; 6, 3 and 8% for S1, S2 and S3, respectively in the city of Karak; and 11,6 and 13% for S1, S2 and S3, respectively in the city of Mafraq. Thus, a direct impact on vehicle operating times can be expected with savings of 30%, without mentioning the additional benefits related to CO_2 emissions, hours of work, vehicle wear/maintenance and so forth.

14. A study was conducted to explore the physical and chemical properties of compost made from different segregated bio-waste raw materials. Four experimental windrow piles, constructed from different types of organic waste (fruit, vegetable and garden waste), were initiated and then temporally monitored. Plant residues and sawdust were used as bulking agents to provide the required C/N ratio needed for efficient decomposition. The compost produced was monitored in terms of moisture content, bulk density, pH, EC, total organic carbon, total organic matter, total nitrogen, total phosphorus, total potassium and C/N ratio, heavy metal concentrations and compost respiration.

15. The experimental process showed overall decreasing profiles versus composting time for moisture, organic carbon, carbon/nitrogen content (C/N) and pile volume, as well as overall increasing profiles for electrical conductivity, total nitrogen, total phosphorus, total potassium and bulk density. These provided qualitative indications that the process had progressed. The quality of the final product was examined and assessed against the quality specifications set out in the German End of Waste Criteria for bio-waste that has been subjected to composting. It was found that heavy metal concentrations (Cr, Cu, Ni, Cd, Pb, Zn and Hg) were within the set limits and much lower than German standards. Furthermore, compost respiration in the samples varied from 3.9 to 7.7 mgO_2/g dm. This indicated that all the compost samples were stable and can be rated as class IV and V final products.

16. A test project conducted in Amman proved that RDF from MSW could be a strategic component of an integrated waste management system in order to achieve the recycling and reduction targets for combustible materials going to landfill.

17. From several factors, high content of organic matter, the required investment and operation cost, easily adapted know-how, etc. biodrying is the more suitable technology for production of RDF from mixed collected MSW in Jordan.

18. The prepared materials were well-blended and aligned in two long windrow piles by a front-end loader and periodically turned on a daily basis. After three weeks, the waste was fairly dry with a moisture content of between 25 and 35%.

19. At the end of the biodrying process, the mass of waste was reduced on average by approx. 35% when the dried waste was directed to landfill without the recovery of material. In the case of RDF utilisation from the dried waste, the mass of waste to be landfilled was reduced by approx. 69%. Furthermore, by dumping the dried waste in the landfill, leachate would not be produced if the landfill was carefully covered and protected from rainfall.

20. The RDF produced was of high calorific value, with low moisture and acceptable chlorine content (0.56–1.20% w/w) compared to the RDF produced in other countries. The quality of the RDF produced did not differ from the RDF quality set by some European countries. Concerning heavy metal content, it is interesting to note that all the RDF samples showed different ranges of heavy metal concentrations. However, in all cases, they were lower than the reported ranges from the other countries considered.

21. The biodrying process allowed an increase of about 58% in the waste calorific value (LHV) as a consequence of the waste moisture reduction. The calorific value of unprocessed MSW ranged from 6.21 to 6.45 MJ/Kg. The calorific value of the RDF produced from the pilot project ranged from 14.83 to 15.58 MJ/kg, which made it suitable as a fuel. The ash content of the RDF produced appeared to have a low range between 16% and 19%.

22. The findings showed that adding 15% RDF which equals 4.92 tons/h to the fuel used at cement kilns will save 3.24 ton/h Petcoke, 486 USD/h from Petcoke costs, 2.27 tons/ h of CO_2 being emitted into the atmosphere, 34 USD/h from the decrease in CO_2 emissions alone, and 389 USD/h as the net saving.

23. Overall results revealed that the use of RDF as an alternative fuel in cement production will be an economically viable and environmentally sound option that has the potential to result in less solid waste, reduced fuel costs, reduced landfill volume required and reduced air emissions from the landfill, in particular greenhouse gases and an environmentally sustainable future.

24. Two strategies have been considered for an RDF production facility. The first is based on the recovery of RDF and recyclables after the biodrying of raw waste, while in the second strategy the raw waste is processed into RDF, recyclable material are recovered, and the fine fraction is then to be subjected to further stabilisation before landfilling.

25. A technical model was proposed for mixed MSW treatment. It recommends establishment of recycling centres (transfer station, sorting and composting plant) at the municipal level across the country. For the estimation, the mass balance of the generated waste fractions, average waste content of wet/food waste in household waste of 60% and the rates of separate collected of organic waste generation of 10, 20, 30 and 40 % for urban ratio of >85, 70-85, 50-70 and <50 %, respectively, were used. MBT plant efficiency was assumed up to 85%.

26. In this model, it was considered that simple waste-picking activities are normally undertaken by informal private sector workers for recovery of recyclable materials mainly paper, glass, metals and plastics (around 7%). Further, 30% of the remaining mixed solid wastes would be deposited in the landfill without any treatment.

27. With a view to making calculations in terms of the required capacity and numbers of treatment facilities (MBT and composting plants), the amount of waste generated in each municipality was estimated based on the population of each municipality and the average waste generation of 0.9 and 0.6 kg/cap/d in urban and rural areas, respectively.

28. The number of required treatment plants was calculated for each municipality based on the population and amount of waste generated. At the outset phase, due to the lack of experience and expertise, as well as the absence of qualified staff, installation of the proposed treatment plants of a low capacity was considered. To this end, the projected capacity of the MBT and composting plants were assumed to be 5,000 and 50,000 ton/year, respectively.

29. As a result, through the implementation of this strategy, the amount of waste to be landfilled would not exceed 30%, which reduces the environmental effects in the case of the dumping of waste from pre-treatment as the current situation, in addition to the economic aspect in terms of cost reduction dealing with waste within landfill boundaries.

30. For the city of Amman, in particular, a technical treatment model including installation of an incineration plant was proposed. Four scenarios have been proposed to implement this model. It was assumed that the source-separated collection efficiency for food waste would be achieved by 15%, while the efficiency for recyclables, which are more complex to separate, was expected to reach 20%.

31. Scenario 1 represents the MSW mixed collection system which represents the current situation in Amman city. Both Scenario 2 and 3 represent a short-term MSWM plan system. Scenario 2 represents the MSWM under source-separated collection, and the separation efficiency for wet/food waste and recyclables is 15 and 20%, respectively, while the initial amount of waste to be incinerated is 45% and the remaining 20% would be landfilled. Scenario 3 suggests the same calculations for the separation efficiency for wet/food waste and recyclables (15 and 20%) while the amount of waste to be converted to the incineration plant increases to reach 65% and accordingly the amount of waste to be landfilled amounts to 15%. Scenario 4 represents a long-term plan based on scenario 3, where food waste is expected to be biologically treated instead of separately landfilled. The amount to be burned and disposed of represents 55% and 10%, respectively.

32. The proposed technical models above must consider the lack of required resources to enhance the environmental performance of waste disposal as one of the main challenges. Moreover, the absence of qualified and well-trained staff is another major challenge that hinders proper management of the proposed facility.