

## Development of Waste Management in the Arab Region

Abdallah Nassour, Ayman Elnaas, Safwat Hemidat and Michael Nelles

The Department of Waste Management and Material Flow of the University of Rostock has been active in Arab countries for over 20 years, and has initiated, carried out and scientifically supervised numerous projects. Waste management and material flow is an important theme in the field of German development cooperation in the MENA regions and has gained in significance in recent years.

The current set of issues and suggestions for improvement are the optimisation of waste collection and the introduction of appropriate treatment concepts, for example, but not limited to, the automatized biological treatment of residual waste. In the Arab region the trend is moving away from the production of compost from mixed waste collection and towards the production of substitute fuels for the cement industry. In Jordan, Tunisia and Egypt appropriate MBA-projects are planned. In these regions only simple MBA-concepts with treatment costs of circa 25 to 30 EUR/Mg can be implemented. Waste to Energy is an appropriate concept for the Gulf States. The necessary technical and financial framework must be clarified. The sustainability of the projects, which will be financed by international donors, is a current theme and can only be achieved through the integration of local infrastructure, such as universities, vocational training centres, local engineering firms and waste disposal contractors.

### Waste management in selected countries in the Arab region

The countries in the Arab region contain about 6 percent of the world's population. The total population of the region has increased from around 100 million in 1950 to around 380 million in 2000. During this period the population of the region increased 3.7 times, more than any other major world region. The region has an area of about 11.1 million km<sup>2</sup>.

Most of the countries can be described as developing countries, with the exception of Saudi Arabia, the United Arab Emirates, Qatar and Kuwait. The Department of Waste Management and Material Flow of the University of Rostock has been active in the Arab states for more than 15 years and has been able to gain pertinent experience and develop appropriate solution approaches, and in some cases implementing them. The Arab Spring and its repercussions have however also negatively affected projects. Some countries simply have *bigger problems* than waste management at the present time. However, the situation will make increased efforts in the environmental field both necessary and possible again in the future.

Nonetheless the growing environmental awareness in the region has meant that environmental protection is on the political agenda. In nearly all Arab states, however, waste management developments are still in their initial phase. Most governments in the Arab states have recognised the waste management problems and want to implement

suitable solutions. The situation is however characterised by a lack of clear legal standards, norms and functioning organisational structures. The need for coherent and concrete legal environmental frameworks is great, but so far mostly foreign regulations have been and are being adopted without adjustment to the local conditions. The monitoring and supervision of waste management practices is not possible due to the frequently unclear observed legal standards. The determination of responsibilities in implementation is inadequate. Controls are not undertaken and the existing laws are not adhered to. As a result of the unstable political situation in the Arab region, delays will occur in the further development of waste management structures, although the extent of these delays cannot currently be accurately determined.

The Arab region is highly dependent on its non-renewable resources. Generally, across the region, the waste resource sector is inadequately structured and regulated. Most Arab countries have not yet established proper waste legislation and long term strategies. Waste management in the region is also characterized by:

- Centralization of authority at the national level
- Absence of effective cost recovery mechanisms
- Deficit of trained personnel
- Service inequality between rural and urban areas
- Lack of a reliable database

Recently, some Arab countries have introduced the ISWM concept. Collection and sorting, composting, and the incineration of medical wastes and sanitary landfills are starting to be implemented, while recycling, reuse and resource recovery are still in the initial stages.

In many countries up to 50 percent of the waste generated goes uncollected, and the waste that is collected is largely mixed with industrial and medical waste during handling/treatment and disposal. The typical method of municipal waste disposal in most of the region is dumping, where it is poorly managed and lacks most of the basic engineering and sanitary measures for the collection and treatment of gas and leachate. Figure 1 shows the physical composition of MSW in some countries in the Arab region.

Across the Arab region, recyclable materials such as plastic, glass, paper, metals and textiles are not separately collected, and household waste is mixed with other types of waste when it is collected, increasing the amount of municipal waste generated. The percentage of decomposable material in MSW is very high and varies from 30 to 70 percent, it consists mainly of fruits, vegetables and food scraps, while the proportion of wood is very low. Municipal waste also contains hazardous substances such as drug residues, expired medicines, chemicals, paints, batteries and other materials.

In **Egypt** local production centres exist for basic sorting plants and composting. There are few waste treatment plants, but most of them have not proved reliable in practice. Targeted technical and organisational concepts are urgently required. Most waste and sorting residue is deposited. The large cities have modern landfills, their operation

however has much optimisation potential. Only a few recyclable materials are separated; these are sold nationally and internationally. There are no thermal recycling or treatment plants for waste. There is interest in M(B)T plants, although international firms only have a chance with technically highly developed solutions as the market for simple technologies is controlled by domestic companies. Funding must however be secured, which so far has only been achieved in a small number of cases. The current concrete project developments are based primarily on mechanical processing plants for recyclable materials that can be exploited domestically and internationally. This also impacts the processing of high-calorific fractions for thermal utilisation in cement industries. The German government institutions – KfW, GIZ, etc. – support Egypt in the establishment of sustainable waste management. The following measures are currently being supported:

- Establishing of a waste authority
- The introduction of separated waste collection
- The design, construction and operation of several pilot projects for the treatment of mixed municipal waste
- The utilisation of refuse-derived fuel from waste for the cement industry

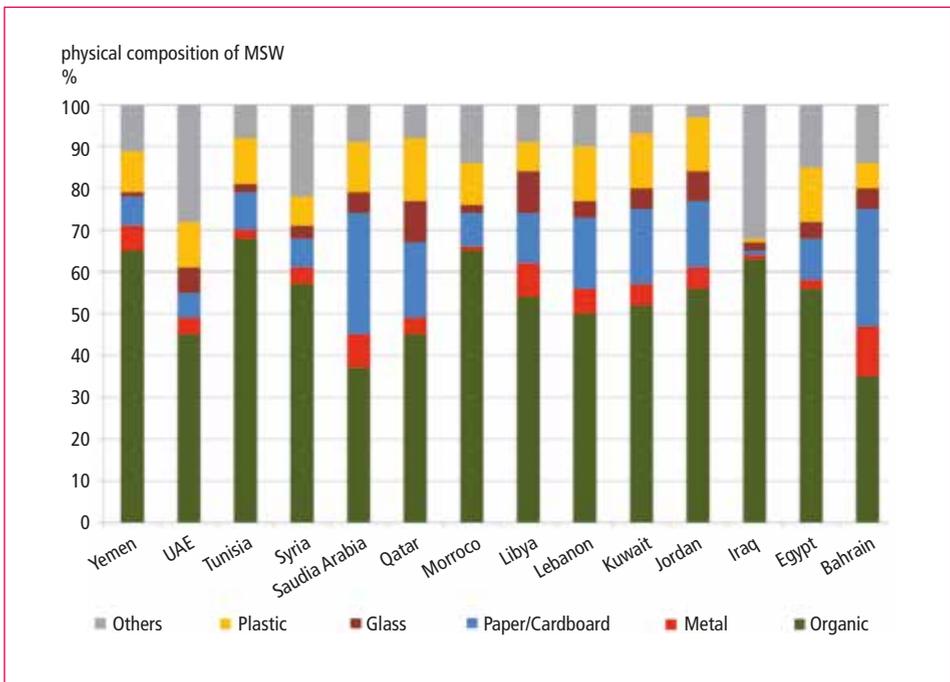


Figure 1: The physical composition of municipal solid waste in some countries in the Arab region

Source: Elnaas, A.; Nassour, A.; Nelles, M.: Waste Generation and Disposal Methods in Emerging Countries. In: Thomè-Kozmiensky, K. J.; Thiel, S. (Ed.): Waste Management, Volume 4. Neuruppin: TK Verlag Karl Thomè-Kozmiensky, 2014, pp. 111-120; ISBN 978-944310-15-2

**Saudi Arabia** produces 12 million tons of waste every year from 170 towns and villages in the Kingdom. Every citizen and resident in Saudi Arabia produces an average of 1.2 kg of waste per day. The daily production of the large cities in the Kingdom – Riyadh, Jeddah, Mecca, Madina and Damamm – represents about half of all waste production in Saudi Arabia. Saudi Arabia has no programs to sort and recycle waste, or to dispose of waste using safe methods, and there is no organized system to deal with this kind of waste. In general, the waste goes to the landfill sites of the municipality. There are some individual, but illegal, initiatives, to make use of waste components, but this does not extend to formal employment. This, however, does not prevent the recycling processes and uses part of the waste that is dumped every day. The main types of waste that are utilized in recycling in the Kingdom are plastics, paper and cardboard, steel and aluminium. Landfills are the main method of and option for waste disposal generated in most of the cities. In the recent years, landfills have been constructed with base sealing. About 95 percent of the generated wastes are deposited without sorting or treatment.

The municipalities are responsible for the organisation of waste management and the private sector for technical implementation. More than 95 percent of finance is spent on the collection and transportation and only 5 percent on the treatment and landfilling. The costs of waste disposal are assessed in the Saudi cities with 120-270 SAR/ton. The most abundant waste management facilities in Saudi Arabia are transfer stations, sorting plants for separation of recyclable materials and landfills. Transfer stations are mainly constructed by local companies and most of them are out of service and they are not used to their full technical and economic potential. In recent years simple sorting plants have been built in the major cities – Jeddah, Riyadh, Medina, etc. – to separate the saleable recycled materials from the waste marketed in the local markets. This accounts for a maximum of 10 to 15 percent of the waste. The other 80 to 85 percent is deposited in the nearby landfill. More than 70 percent are organic fractions and cause problems with landfill gas and leachate. Such waste treatment plants are not the solutions for sustainable waste management in Saudi Arabia. They must be built and operate with integrated systems in cooperation with international partners with practical industry experience. It is recommended to start with some test projects.

Several years ago, Saudi Arabia began to build landfills in accordance with international standard with base liner and surface sealing. Saudi Arabia does not have a standard for landfills, the landfill is built is dependent on the experience of the engineering or construction companies. These landfill sites are not operated optimally. The majority of them are *dumpsites* without a base liner. The major cities have started to close the old landfills and treat the landfill gas.

In **Lebanon** there are a few small waste treatment plants (sorting and composting). Local engineering offices have made plans but are frequently overwhelmed. Most projects are poorly planned and implemented from a constructional and procedural perspective. Lebanon has limited space for landfills or other solutions that require large area of land. Therefore, a trend towards incineration options – for example in cement industries – can be recognized. In the city of Saïda a modern MBT plant with an integrated wet-digestion stage was constructed on 2005. The plant has been in

operation since 2013. It should be critically noted that it does not make sense to establish technologies in the framework of development aid projects that have been associated with considerable operational problems in the past and to a certain extent are still to this day. In 2015 calls for tender were made in the fields of waste collection, street cleaning and waste disposal. The tender was stopped after evaluation. A recycling rate of 75 percent is targeted by 2020. Waste management in Lebanon is also demanded as a result of the flow of refugees from Syria.

In **Jordan** there are still no plants for residual waste treatment. Waste management is however a central theme in the framework of the cooperation with the World Bank. Landfills and transfer stations will be financed in this way. The recovery of recyclables, the production and recycling of refuse-derived fuel in the cement industry and the biological treatment of waste are current topics. European engineering offices are being contracted to develop initial concepts and feasibility studies. The pilot project *Simple MBT* in the city of Amman is in the preparation stage. Building on this, further MBT projects could be developed in the coming years, with procedurally simple mechanical processing and aerobic treatment especially in demand. Up to now the German government has predominantly supported schemes for water supply and disposal; since 2015 waste management projects have also been promoted.

In the framework of the German financial cooperation with Jordan a scheme in the field of municipal solid waste disposal is to be promoted. The goal is the construction of resource-efficient as well as environmentally and climate-friendly waste management through the introduction of a labour-intensive collection and recycling system in selected cities in Jordan. The main elements of the planned project, which also comprises a back-up measure, are consultancy services, delivery, as well as internationally tendered construction works.

For Amman a mechanical-biological waste treatment plant for the generation of refuse-derived fuel is in the planning process; the German government-owned development bank KfW is supporting the project. The introduction of separated collection aims to make recyclable material available. A waste disposal centre in Amman will serve as both transfer station and training centre. A project on aerobic or anaerobic treatment is planned for organic waste. GAM announced last year an international waste to energy project. Tenders are currently being evaluated. Jordan has also absorbed an enormous number of refugees from Syria. GIZ and the European Union (represented through GIZ) are supporting programmes in the north of Jordan that aim to manage the supply and disposal problems relating to refugee camps. There are planned several composting and MBT-Plants.

A study funded by the German Society for International Cooperation (GIZ) GmbH in 2015 for estimating the key indicators of domestic waste collection as a planning and control tool for route optimization, including tracking the overall operational cost for solid waste collection. In this study, a methodology for the optimization of the waste collection and transport system, based on a Geographical Information System (GIS), was developed. Using domestic collection round data from three waste collection cities in Jordan (Irbid, Mafraq and Karak), three scenarios for waste collection were suggested.

Cost analysis has been performed for each suggested scenario and compared with the current empirical collection scheme. Results demonstrate that the proposed scenarios' savings compared to the current situation in terms of the total cost for waste collection are 15 percent, 13 percent and 23 percent for scenarios 1, 2 and 3, respectively, in the city of Irbid and 6 percent, 3 percent and 8 percent for scenarios 1, 2 and 3, respectively, in the city of Karak. Although using the alternative scenarios was shown to provide significant savings, the operating time of the vehicles was reduced by 30 percent.

During this study, many strengths and weaknesses were determined in the areas covered by this research. Table 1 summarizes the strengths and weaknesses of the cities studied.

Table 1: The main strengths and weaknesses of the areas studied

Study area	Strengths	Weaknesses
Irbid	<ul style="list-style-type: none"> <li>• frequent usage of 3-axle vehicles</li> <li>• good utilization of vehicle payload</li> <li>• good utilization of container volume</li> </ul>	<ul style="list-style-type: none"> <li>• 5 h/d average daily working time</li> <li>• very high transport time percentage</li> <li>• usually just one disposal trip per shift</li> <li>• unbalanced utilization of the collecting routes (working time, container units per route, tonnage per route)</li> <li>• no structured route planning (traditional structures)</li> </ul>
Mafrqa	<ul style="list-style-type: none"> <li>• frequent usage of 3-axle vehicles</li> <li>• good utilization of container volume</li> </ul>	<ul style="list-style-type: none"> <li>• 5 h/d average daily working time</li> <li>• high transport time percentage</li> <li>• usually just one disposal trip per shift</li> <li>• bad utilization of vehicle payload</li> <li>• unbalanced utilization of the collecting routes (working time, container units per route, tonnage per route)</li> <li>• no structured route planning (traditional structures)</li> </ul>
Karak	<ul style="list-style-type: none"> <li>• 3-shift working hour model</li> <li>• 7 h/d average daily working time</li> <li>• frequent usage of 3-axle vehicles</li> <li>• good utilization of vehicle payload</li> <li>• good utilization of container volume</li> </ul>	<ul style="list-style-type: none"> <li>• high transport time percentage (esp. small vehicles)</li> <li>• high amount of sacks</li> <li>• usually just one disposal trip per shift</li> <li>• unbalanced utilization of the collecting routes (working time, container units per route, tonnage per route)</li> <li>• no structured route planning (traditional structures)</li> </ul>

In **Tunisia** programmes exist that are supported by Germany (KfW) and other countries. No plant exists for residual waste treatment yet. The opportunities for MBT are good. The waste authority ANGED has, with the support of KfW, established the first MBT pilot plant in cooperation with the local and international private sector. The universities of Innsbruck, Tunis and Rostock are actively involved. Most landfills are full and therefore some MBT plants are planned. The main objective of the pilot project was to prove that MBT is a feasible solution for the conditions in Tunisia. The results showed that an efficient waste treatment can be achieved with a fairly basic MBT concept. This is by utilizing the biological drying process to produce a substitute fuel for industrial processes and reduce the landfill area required as well as reducing the air emissions from the landfill, in particular greenhouse gases. After three weeks of biological drying with a forced aeration system, the waste was fairly dry with a moisture content between 20 to 30 percent, the waste could be screened efficiently into a coarse fraction with high calorific values, which

can be used as a basis for the production of substitute fuel (RDF), e.g., in cement kilns or combustion facilities. Biodrying removed 30 to 40 percent of solid waste. In the case of RDF utilization from the dried waste the mass of waste to be landfilled was reduced by 60 percent (figure 2). Furthermore, by dumping the dried waste in the landfill, leachate would not be produced if the landfill was carefully covered and protected from rainfall.

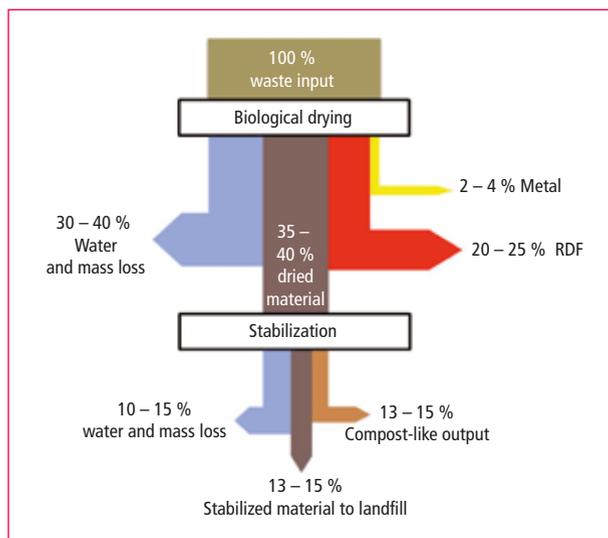


Figure 2:

Mass balance after the biodrying process during the pilot test in Tunisia

Source: Elnaas, A.: Actual situation and approach for municipal solid waste treatment in the Arab region. PhD Thesis, University Rostock, Department waste management and Material flow, 2015

The fines smaller 80 mm were then further composted for 8 weeks. After the composting of the fines fraction further approximately 15 percent of mass reduction was achieved.

**Kuwait** has also had negative experiences with MBT. There is one MBT plant in the country, but it rarely operates and the decision-makers are critical of the MBT technology. Kuwait is very interested in German waste technology and willing for cooperation in this field. The creation of a master plan for the whole country is in the preparation phase. Landfills are the main disposal method. Waste to Energy is an option for waste treatment. Selected technical and financial proposals are currently in the evaluation phase.

**Oman** has offered the management of its hazardous waste. The state authority for waste management, *be'ah*, is insisting for improvements. A mechanical-biological waste treatment plant for 300,000 Mg per year is envisaged. The concept *waste to energy to water* is to be implemented here. Transfer stations and landfills are also to be established.

The **United Arab Emirates** has had many negative experiences in the field of waste management. The recycling rate of the collected municipal solid waste lies below 10 percent; more than 90 percent is deposited. Invitations for tenders for waste incineration plants have been issued, but no treatment plants have been constructed yet. The UAE lacks the experience with corresponding projects and technologies, and the financing by means of waste charges cannot be arranged. In Abu Dhabi a waste management centre will promote and coordinate waste management. A project for the collection of hazardous waste is already in place. The Arab states still have much to do to reach an advanced

stage of waste management. This is independent of the political or financial circumstances in the very different countries. Interest can still best be raised by means of energy recovery from waste.

Actually, most of the above mentioned selected countries are interested in German waste technology and willing for closer cooperation in terms of recovery of recyclables, production and recycling of refuse-derived fuel in the cement industry and the biological treatment of waste. Table 2 summarizes the Current and ongoing projects/activities in the Arab region.

Table 2: Current and ongoing projects in the Arab region

Country	Actual and ongoing projects
Egypt	<ul style="list-style-type: none"> <li>Waste management authority was established in 2016.</li> <li>Pilot projects for the treatment of mixed municipal waste will be financed by KfW</li> <li>Utilization of refuse-derived fuel from several waste types in the cement industry is actual topics by international donors</li> </ul>
Saudi Arabia	<ul style="list-style-type: none"> <li>Several years ago, Saudi Arabia began to build landfills in accordance with international standard with base liner and surface sealing</li> <li>Simple sorting plants have been built in the major cities (Jeddah, Riyadh, Medina, etc.) to separate the saleable recycled materials from the waste marketed in the local markets</li> <li>Medical waste is actual topics in cooperation with international private companies</li> </ul>
Lebanon	<ul style="list-style-type: none"> <li>All municipalities have a big problem with waste management and looking for adapted solutions.</li> <li>Beirut has tendered BOT-Project for waste to energy</li> <li>Decentral solutions for small and middle size municipalities are required</li> <li>Few smaller waste treatment plants (sorting and composting) are available but there is problem with operation</li> <li>In the city of Saida a modern MBT plant with an integrated wet-digestion stage was built in 2005 and in operation since more than 6 years.</li> <li>Government plans to establish hazardous waste strategy and implementation concepts.</li> </ul>
Jordan	<ul style="list-style-type: none"> <li>A lot of international donors support Jordan in waste management.</li> <li>KfW will finance some projects for separation at source and Mechanical-biological waste treatment plant for producing of refuse-derived fuel. The project is at the feasibility study stage.</li> <li>GAM announced last year an international BOT-Tender <i>waste to energy</i> and is currently being evaluated.</li> <li>Programs supported by GIZ and the European Union in the north of Jordan that aim to manage the supply and disposal problems relating to refugee camps. There are planned several projects such as optimization of logistics, composting of organic waste and MBT-Plants.</li> </ul>
Tunisia	<ul style="list-style-type: none"> <li>Waste management authority was established since more than 10 years.</li> <li>KfW support Tunisia in waste management and several MBT-Projects are planned.</li> </ul>
Kuwait	<ul style="list-style-type: none"> <li>Kuwait plans to create a master plan for the whole country, which will be started in 2016.</li> <li>Private sector is responsible for all services in waste management <i>mainly logistics</i></li> <li>Landfilling is the common practice for the most waste types.</li> <li>Small recycling projects are planned.</li> </ul>
Oman	<ul style="list-style-type: none"> <li>Waste management authority was established.</li> <li>Management of its hazardous waste has tendered.</li> <li>A mechanical-biological waste treatment plant for 300,000 Mg/a is expected in the near future.</li> <li>Transfer stations and landfills are also to be established.</li> <li><i>Waste to Water project</i> is at the feasibility study stage.</li> <li>Tender was announced in 2016 for improvement the waste legislations.</li> </ul>
United Arab Emirates	<ul style="list-style-type: none"> <li>A project for the capture and gathering of hazardous waste is already in place</li> </ul>

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## Conclusion and recommendations

Despite the difficult situation in the Arab region in general, the development of environmental awareness has been relatively pronounced in recent years. This can also be seen in the numerous waste-industrial activities. However many projects and plans have been stopped after the tendering phase or processing of the study and not implemented, as legal, organisational, financial and technical framework for their implementation is lacking. Ambitious targets were set, which could not be followed through under the local circumstances.

The fundamental developments and strategies for the waste management industry in Arab countries are summarised below:

- The majority of obstacles in the development of the waste management industry in the Arab region can be attributed to a lack of practical know-how amongst decision-makers. Predominantly technical solutions are suggested, which are not feasible under the local conditions. Examples of this are the construction and operation of large treatment facilities for more than 1,000-1,000 Mg/d, the construction and operation of waste incineration plants in the private sector, the surrendering of responsibility to the private sector, the covering of essential treatment costs through the sale of recycled materials and the sale of electrical energy, etc.
- KfW, GIZ and other international institutions for development cooperation are trying to support the countries through different projects – pilot project, apprenticeships and higher education schemes, institutional development, etc. The sustainability of the intended projects should be ensured through targeted measures.
- There are many positive fundamental developments to observe. For example, the decision-makers recognise that waste treatment is essential and that it carries costs. The available finances for waste treatment amount to on average 10 to 30 EUR/Mg, depending on the region. In Lebanon more revenue could potentially be raised, as the necessary areas for treatment are difficult to get. Mechanised solutions with low space and landfill needs must be implemented. Another positive development is that the cement industry is prepared to introduce substitute fuels and to encourage investments when necessary. The problem is still the long-term regulation of the cooperation between the cement industry and the municipalities responsible for waste disposal.
- The documentation of data for the waste treatment industry poses a big problem for the region. There is no reliable data in most of the municipalities. The *Introduction of the Waste Industry Concept* is suggested as a solution. The cooperation between the international development cooperation institutions, local and international universities and engineering companies and local municipalities is very important to the development and introduction of a solution. The goal must be to document the current state and the problem, to devise solutions and to check the implementation arrangements.

- In the region the *experience of sustainable waste management* is lacking, especially with regard to the treatment of waste. Waste treatment facilities hardly exist. Most municipalities need multi-purpose *decentralised waste management centres*, for example, small composting plants for 1,000 to 5,000 Mg per year, recycling centres for discarded electrical goods, bulk refuse and dangerous waste, simple sorting plants (50 to 200 Mg/d) to separate organic and recyclable materials, to crush recyclable materials etc. The large cities definitely require industrial-scale pilot projects (about 200 Mg/d) in conjunction with international specialised companies, in order to gain practical knowledge and to lay down the foundations for the waste management industry. In Tunisia, Jordan and Egypt these schemes are in the preparatory and planning phases.
- The responsibility and finance of the disposal of substance groups, especially old tyres, electronic waste, packaging etc., has not been clarified/resolved in most countries. *Product responsibility* is a suggested solution. There are already foundations for its establishment and introduction and it would financially relieve the responsible authorities.
- Numerous targets regarding the waste management industry in the Arab region can be achieved through targeted knowledge transfer.

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Dr.-Ing. Stephanie Thiel, M. Sc. Elisabeth Thomé-Kozmiensky, Janin Burbott-Seidel und  
Claudia Naumann-Deppe

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