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Annex 2: Jordan

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This report has been prepared by the Department of Statistics/Environment Division in cooperation with Ministry of Environment and the National Team from responsible ministries).

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Introduction

Jordan, as a Euro-Mediterranean Partner, is responsible for preparing the country assessment to support the Horizon 2020 initiative for depollution of Mediterranean Sea by 2020. During this phase, production of this report on indicators is in line with the production of the state of environment in Jordan. According to the guidance for Shared Environment Information System (ENPI-SEIS) contribution to country-level assessment and the agreement of the project team of the Review, Monitoring and Research (RMR Sub-Group), this report focus on the three Horizon 2020 priority areas i.e. municipal waste, wastewater and industrial emissions.

This report has been prepared by the Department of Statistics/Environment Division in cooperation with Ministry of Environment and the National Team from responsible ministries. The National Committee is composed of :

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Acronyms

BAT	Best available technique
BOD	Biological oxygen demand
CDM	Clean Developemnt Mechanism
CEMS	Continuous emission monitoring systems
CHP	Combined heat and power
EIA	Environmental impact assessment
GAM	Greater Amman Municipality
GDP	Gross domestic product
GHG	Greenhouse gas
GIZ	German International Agency
HTPS	Hussein Thermal Power Station
JPRC	Jordan Petroleum Refinery Company
JSMO	Jordan Standards and Metrology Organization
KAC	King Abdullah Canal
KOICA	Korea International Co-operation Agency
KTD	King Talal Dam
KTR	King Talal Reservoir
M&E	Monitoring and evaluation
MCM	Million cubic metres
MSW	Municipal solid waste
MWI	Ministry of Water and Irrigation
NEEAP	National Energy Efficiency Action Plan
NERC	National energy research centre
NGO	Non-governmental organisation
PRTR	Pollutant Release and Transfer Register
RSS	Risk-screening system
RTMS	Real-time water quality monitoring system
SME	Small and medium-sized enterprise
SPS	Samra Power Station
TF	Trickling filter
toe	Tonne of Oil Equivalent
UNEP	United Nations Environment Programme
WHO	World Health Organization
WTE	Waste-to-Energy
WWTP	Wastewater treatment plant

Country profile

The Hashemite Kingdom of Jordan is located approximately 80 km to the east of the Mediterranean coast and is bordered by Syria to the north, Iraq to the east, Saudi Arabia to the east and south and Gaza/West Bank to the west. It covers approximately 89 318 km^2. Administratively, it divided into three regions (17 % centrally, 32 % north and 51 % south of the total land area). Jordan's total population was 6.38 million inhabitants in 2012 (63 % of the population living in the central region, 28 % in the north and 9 % in the south). About 78 % of the population is located in urban areas concentrated in four governorates: Amman, Balqa, Zarqa and Irbid. The highest population density is in the central region, at 278 person/km^2, followed by the north region with 61 person/km^2, and south region with 13 pesron/km^2.

Jordan depends mainly on local precipitation, which is variable in time and space. The climate is arid in more than 90 % of the country, in which rainfall is less than 200 mm per year, while it increases to more than 500 mm per year in the north. Jordan is hot and dry in summer, and cold and wet in winter (Mediterranean climate type). The average long-term precipitation in Jordan for the period from 1937/1938 to 2011/2012) is 8 195 million m^3. Some 80 % of the rainfall occurs from January to March. The mean temperature in cold season is 13 °C while in summer is 32 °C.

Taking into accounts those characteristics, the assessement made in this report covered the national level only.

- Jordan is located to the east of the Mediterranean Sea, and is quite far from it. Moreover, the dominant wind in Jordan is calm, with a high percentage (40 % to 50 %) followed by the north-west wind. So, the Mediterranean Sea is located upwind of Jordan, and it is not expected to be affected by air pollutants emitted from Jordanian industrial sources. Moreover, the calm winds cannot transfer pollutants to the Mediterranean Sea, due firstly to the great distance, and secondly, to the direction of these low-speed winds (< 2 knot), which are western most of the time.

Main driving forces
Population growth is the key driving force for all sources of pollution. The population increased from 4.9 million inhabitants in 2000 to 6.4 million in 2012 (82.6 % urban), not including refugees of the Syrian Civil War. High population growth rates, coupled with forced immigration place great pressures on land and resources, in addition to generating more waste. The average population density increased from 56 person/km^2 in 2001, to 72 person/km^2 in 2012. Immigration is one of the main causes of the high rate of population growth. Jordan has several types of forced immigration, leading to elevated population growth: Palestinian, Iraqi and Syrian. The percentage of the population aged under 15 is 37 %, placing a great deal of stress on Jordanian families.

Jordan is a lower middle income country. The gross domestic product (GDP) at current prices is JOD 21 965 million (2012), compared with JOD 5 390 million in 2000. The per capita GDP was JOD 3 432 in 2012. Due to population and economic growth, the primary energy supply increased from 5.1 million tonnes of oil equivalent (toe) in 2000 to 7.9 million toe in 2012. Providing a reliable energy supply is the core element of the economic development. This increase in energy supply generates many greenhouse gas (GHG) pollutants from waste and industrial sectors. The industrial sector contributes to 's 18 % of the GDP at constant market price, investment in this sector is restricted because of the water scarcity.

Following the financial crise of 1988, socio-economic performance from 1990 was concentrated on economic stability. The socio-economic development strategy for the 2004–2006, prepared with the cooperation between ministries, governmental bodies and non-governmental organisations (NGOs), aimed to reduce the poverty and unemployment rate with qualitative and quantitative investments in the national development sectors.

As the fourth poorest country in water terms, water shortage is a key driver of environmental pressure in Jordan. The per capita share of renewable water resources is among the lowest in the world, and is declining overtime. It is projected to fall from 145 m^3/capita/year (at present), to 90 m^3/capita/year by 2025.

Jordan faced also water pollution with an overexploitation of groundwater, overloaded wastewater treatment plants, uncontrolled waste dumping to streams and rivers, contamination of surface and groundwater from the petroleum refinery company, Thermal Power Station and other diffuse sources. The poverty is affecting the health and quality of life of the population who cannot access clean water for domestic use; they are ultimately reduced to using whichever source of water they can find.

Treated wastewater generated by the 27 existing wastewater treatment plants is an important component of Jordan's water resources for reuse in agriculture. If treated wastewater does not meet standards, its reuse will not be possible. At the same time, wastewater quantity is increasing, as is the population, water use and the development of sewerage systems. Thus, by the year 2020, when the population is projected to reach 9.9 million, and those with sewerage services will have increased from the current 65 % to percentages covering most of the population of the country, about 240 million cubic metres (MCM) per year of wastewater are expected to be generated, and added to the water budget. In rural areas lack public sewerage services; therefore, inhabitants rely mainly on inadequately managed cesspools for black water, open disposal of grey water to the surrounding environment and uncontrolled reuse of grey water for irrigation and other outdoor uses. All of this affects the quality of groundwater, as well posing serious health risks.

Following the population growth, the total number of households increased from 805 949 in 2002 to 1 134 177 in 2010, with 84 % of which are in urban areas (Household Expenditure and Income Survey).

Waste generation is being a big challenge for municipalities as much effort is needed for its collection and treatment. Despite the waste collection efforts of municipalities, a great amount of waste still accumulates in uncontrolled dumps. There is illegal dumping of waste (including industrial waste) into some surface waterbodies, mainly the Zerka River – the second largest in Jordan. The most densely populated area in Jordan is the catchment area of the Zerka River which comprises around 65 % of the country's population and more than 80 % of its industries puttimg high pressure on this water resource. Therefore, pollution in this river's water is extremely dangerous. Solid waste leachate at improper landfills may leak into groundwater and cause serious contamination. New safe landfills are required, and the old landfills need to be rehabilitated. This causes pressure on land use.

High population growth, urbanisation and slum dwellers (unorganised planning of cities) are the crux of the problem in terms of wastewater and sanitation. There is no infrastructure to support the last decade's explosion of expanded construction in all areas around the cities.

Before the implementation of environmental impact assessment (EIA) regulations and environmental licence committees, the unorganised planning of industrial activity sites led to installation of many residential areas close to big industrial activities.

The industrial sector in Jordan has consequently negatively impacted ambient air quality in cities. The heavy industries such as the Jordan Petroleum Refinery Company, Hussein Thermal Power Station, cement plants, phosphate plants and potash plants are considered the main sources of air pollution. Moreover, when the transportation sector, considered the largest and most dangerous mobile source of air pollution in Jordan, increases the number of vehicles, it increases the air pollution, especially in crowded regions.

The increase of the Jordanian population has been accompanied by significant growth in the transport fleet and the number of vehicles. There is also a rise in the categories of industries distributed across various regions and governorates of the country: these are concentrated in the Zarqa and Al-Hashimiyya regions, which host the iron and steel industries, the Jordan petroleum refinery and the al-Hussein Thermal Power Station.

As a result of population growth in Jordan and recent enforced immigrations due to political unrest in the region (in neighbouring countries), the construction sector has witnessed significant growth, resulting in a demand for building materials.

In the coming decades (2020–2050) following activities may cause future environment pressure if not controlled:

- use of oil shale to generate electricity;
- use of alternative fuels and wastes in cement production factories;
- incineration of waste to produce electricity;

- the increase of industries and mining activities in response to market needs.
- Developing a centralised industrial wastewater treatment plant will cause environmental pressure through transport of wastewater, the large amount of treated wastewater delivered, the high cost of plant construction, and the high running cost, which will dissuade plant owners from keeping such a plant in operation.

Priority thematic areas

Solid waste

Problems and challenges

Jordan suffers from a lack of a national plan or strategy for municipal solid waste management, although a draft of such a strategy is already prepared, in close cooperation with Greater Amman Municipality (GAM), but is not officially published yet. And as a result, there are no strict programmes for solid waste segregation at source. Waste separation techniques, availability of separate containers, machines and vehicules to collect waste in each housing unit remain a key problem, then hanpering the efficiency of a separate waste collection. The public awareness and public application of the collection and separation techniques is also lacking behind. Problems also araised from dumping sites — overloaded or poorly managed inducing contamination of surface and groundwater, noise, odours and human health problems (e.g. Al-Russiefeh and Al-Hussainat). The recent population increase (conflicts in surrounding areas and the resulting high number of refugees in Jordan) increase waste quantities, posing a challenge.

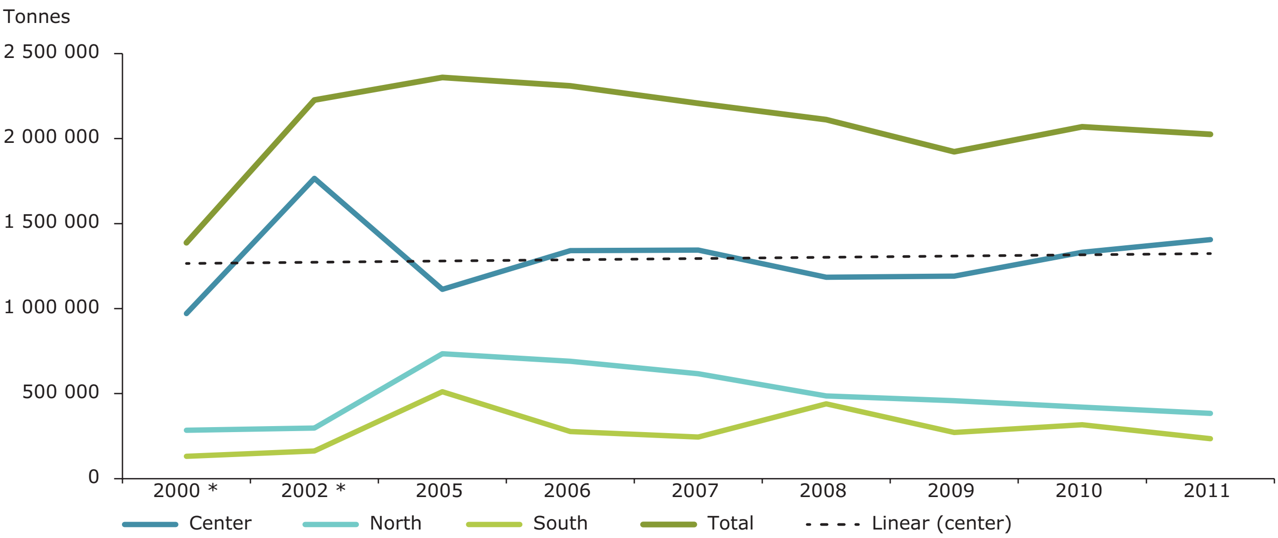
State and impact

The amount of waste generated is estimated based on data collected from a comprehensive survey on municipalities, in addition to some administrative record from Greater Aman Municipality (GAM) and the Jordan Ministry of Municipal Affairs. Data are available annually at national level since 2000.

The amount of waste collected increased by 31 % between 2000 and 2011 (from 1.3 million tonnes in 2000 to 2.02 million in 2011). Between 300 kg/capita/year and 340 kg/capita/year are collected waste; according a research made in 2011 on waste collection efficiency, this number will increase to 420 kg waste/capita/year. The falling quantity of collected waste in 2011 does not reflect less total generated amount of waste, but rather a decrease in efficiency of collection. Most of Jordan's population is served by municipal services.

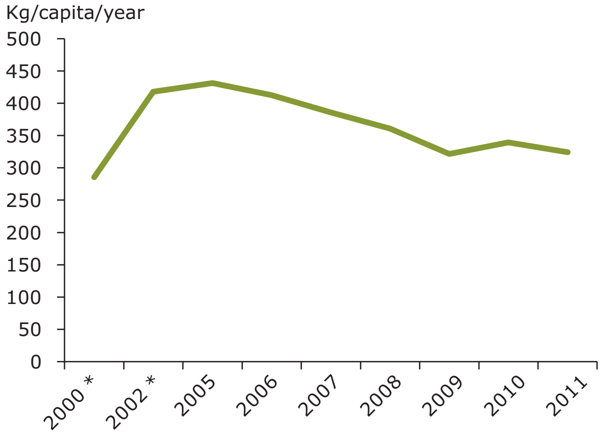
According to the Ministry of Environment, country report on solid waste management situation in Jordan, the municipal waste are compose of 50 % organic, 34.5 % dry recyclable (16 % plastic, 15 %

Figure A2.1 Amount of waste collected by region, in tonnes, 2000-2011



Source: Environment Statistics Report 2005-2011, Department of Statistics.

Figure A2.2 Municipal waste collected per capita, 2000–2011



Note: (*) The cleaning level of Amman is assumed to be 77 % in 2011.

Source: Environment Statistics Report 2005–2011, Department of Statistics, 2014.

paper, 2 % glass, 1.5 % metals) and 15.5 % others. The fraction of recovered municipal waste is 7 % according to the country report on solid waste management of the Ministry of Environment. There is also informal recycling of cartons, plastics and metals. The amount of municipal waste produced is 197.6 kg /1 000 JOD at market price in 2011. The waste management accounts for 0.23 % of the GDP, according to the cost of environmental degradation study conducted in 2006 [1].

Most of the waste generated is placed in containers in a mixed state, without being separated (scavengers recycle metal and glass by separating these from the waste in the containers). In Jordan, 94 municipalities (16 registered landfills), and joint service councils (branching from the Ministry of Municipal Affairs) operate the landfill sites (Ministry of Municipal Affairs, 20014). According to Great Amman Municipality, research report, 2014, the efficiency of waste collection employees in 2011 was 89 %, efficiency of transport vehicles in 2009 was 81 %. Cleaning level of Amman in 2011 was 77 %.

Most of Jordan's landfills are uncontrolled; only one landfill is controlled in terms of lining and leachate collection, namely Al-Ghabawi, which processes 50 % of the total waste generated in the country (see Annex 1: Overview of open dump site in Jordan).

Impacts pof municipal waste on the natural environment and human health/human well-being

The Al-Hussainat dumping site is located on a geological rift, and some of the dumping sites are on stones, causing leakage that pollutes surface water.

Municipal waste: social impact

- Municipal waste is a cause of health problems, nuisances, insects, rodents and odours near containers and dumping sites.
- Municipal waste attracts scavengers, causes many social problems.

Table A2.1 Volume of municipal waste treated, method of disposal, 2000-2011

Indicator	2000	2002	2005	2006	2007	2008	2009	2010	2011
Total collected waste tonnes	1 387 000	2 226 500	2 358 868	2 309 575	2 207 298	2 111 251	1 921 857	2 069 111	2 024 832
Controlled landfill in % [a]	n/a	n/a	n/a	n/a	49.70 %	34.20 %	28.20 %	49 %	48.90 %
Uncontrolled landfill in % [b]	n/a	n/a	n/a	n/a	50.20 %	65.80 %	71.80 %	51 %	51.10 %
Incineration (open burning) in tonnes	n/a	n/a	n/a	n/a	n/a	11 790	809 040	13 387	42 220
Agriculture use in tonnes	n/a	n/a	n/a	0	0	0	n/a	3 433	1 716

Note: [a] This calculation is based on the assumption that 50 % of landfilled waste is in controlled landfills.

[b] Waste transported to uncontrolled landfills, buried, burned in open sites (around 3 % of the total), and disposed of on bare land is considered as uncontrolled landfilling.

Source: Department of Statistics, 2014.

[1] The World Bank; The Cost of Environmental Degradation: Case Studies from the Middle East and North Africa', Lelia Croitoru, Maria Sarraf. Mediterranean Environmental Technical Assistance Program. Hashemite Kinddom of Jordan: Cost of Environmental Degradation'. Unpublished METAP report, Washington, DC, 2006.

- Dumping in open places cause health problems for residents living in surrounding areas and decreases productivity.
- The impact of the Al-Ghabawi landfill is minimal because it is only near cow farms; 9 km to the west, there is small village (Manakhal).

Municipal waste: cultural impact

- Waste accumulates in heritage and national park areas.
- The accumulation of municipal waste negatively affects neighbourhood aesthetics as well as people's behaviour (particularly children). Littering and waste accumulation will become normalised in the culture.
- The accumulation of municipal waste negatively affects the tourism sector.
- The impact of landfills in Jordan is minimal, because the nearest area of historic interest is Ain Ghazal, 16 km north-west of the Ghabawi landfill.

Municipal waste: economic impact

- The increase in total amount of municipal waste puts pressure on transport vehicles, land (damage to roads) and employment.
- Economic loss is incurred because of insufficient waste management
- There are rehabilitation costs.
- The increase in total amount of municipal waste puts extra pressure on the government: inadequate waste management creates economic losses, as more waste transport vehicles and land are needed).
  - If the tourism sector is negatively affected, this will definitely affect the country's economy.

Municipal waste: environmental impact

- Most dumping sites cause soil, groundwater and air pollution.
- They affect human health (odours, pollution) and life (noise, traffic jams) during waste transportation from the treatment plant to the dumping site.
- Dumped waste is often burnt, resulting in emissions which are often hazardous to health, especially when hazardous materials are burnt. Burning of waste always generates emissions of PM_{10} and $PM_{2.5}$.
- Improper waste management does have a significant impact on the climate. Release of CO_2 from waste burning is one such impact, but another and even more significant impact concerns the release of methane from landfills and dumpsites. Methane is considered to have a climate change potential 21 times higher than carbon dioxide. Methane originates from anaerobic deterioration of organic waste.

Responses

A draft of the national strategy for municipal solid waste management has been prepared in close cooperation with the Great Amman Municipality, but has not been officially published yet.

The Ministry of Environment has conducted a study in close cooperation with the risk screening system (RSS), 'Monitoring and Assessment of Water Quality and Studying the Effect of landfills leachate on groundwater'. This project provided vital and necessary information on the environmental situation and the quality of solid waste sent to dump sites (Hussaineyat, Rusayfah, Al Akedar and Al-Humrah), and its effect on the quality of groundwater supplying about 70 % of Jordan drinking water. The project included a study of the quantity, composition, types and sources of solid waste sent to each dump site. Also, maps indicating the risk of groundwater pollution from the study dump sites were drawn up. Groundwater movement models were built to evaluate the effect of leachate, using hydro-chemical or geophysical approaches. The project also collected groundwater samples and conducted field and laboratory tests in line with current scientific practice. Moreover, a literature review of target dump sites was carried out. Based on this, a remediation plan to fix and manage existing and future conditions was proposed, which is divided into three stages (immediate, intermediate and long term).

Efforts are ongoing to improve recycling practices and waste management in the economic sector, there is also public awareness campaign to change behaviour of Amman residents.

A monitoring and evaluation (M&E) software programme has been established to monitor and evaluate solid waste management system in Great Amman Municipality.

2020 outlook and possible impacts on the natural environment

- Improve municipal waste management.
- Improve methods of waste treatment and disposal so they comply with national and/or regional regulations and standards for controlling pollution.
- Have in place a strict national strategy for municipal solid waste management.
- Have achieved a controlled and sanitary status for all the country's landfills and dumping sites.

Wastewater

Problems and challenges

Treated wastewater effluent is considered a water resource, and is added to the water stock for reuse. Efficient treatment of wastewater will help decrease dependency on clean water (used for drinking) for irrigation.

Rehabilitation of water and wastewater networks remains a key problem.

Inefficient treatment causes an increase in nutrient content, mainly nitrogen and phosphorus, leading to eutrophication problems, e.g. the formation of blooms of algae on the surface of King Talal Dam (KTD).

Some maintenance issues in wastewater treatment plants exist due to financial and operational constraints; this result in inadequate treatment in some plants, and consequently, bad effluents quality.

Much funding is invested in enhancing wastewater treatment plant efficiency and even in constructing new plants, placing extra financial burdens on the government.

There is accumulation of large quantities of sludge in wastewater treatment plants. Although there is a Jordanian standard for treated sludge quality to be reused for agriculture, there are many social and religious constraints preventing reuse of such sludge.

Very strict regulations and standards exist for reclaimed wastewater (particularly domestic wastewater) quality to be reused for irrigation purposes. This limits the capacity to reuse such water, exacerbating the country's water-scarcity problem.

The main problem for uncollected wastewater is its collection in septic tanks and transport to treatment plants or dumping sites (e.g. Al-Akaider). This places a great deal of pressure on treatment plants, from both hydraulic and biological points of view, ultimately affecting outlet quality.

State and impact

Over the period 2004–2012, the percentage of households connected to public sanitation system slight increased, but with a huge disparity between urban and rual area. Access to sanitation system in rural area remains very low, with only 2.5 % of the population covered in 2011/20012.

The Ministry of Water and Irrigation targets to reach 70 % of the total population served with improved sanitation system by 2020. According to the National Strategic Wastewater Master Plan Report, October 2013, 86 % of the nation's population will be concern if all the 173 localities with more than 5 000 inhabitants will have a full sanitation structure in place.

Figure A2.3 Percentage of households with access to an improved sanitation system, 2004–2012

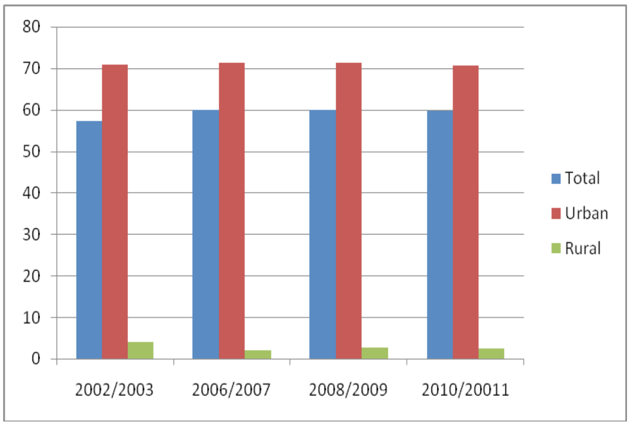
Source: Ministry of Water and Irrigation, Jordan in Figures 2001–2012 — Department of Statistics.

Over the last decade, the volume of wastewater treated increased, with more that 102 million m^3 in 2012 of wastewater effectively treated. Thers is 27 wastewater treatment plants in Jordan; which mainly serve big cities and localities (see Annex 1: Overview of Jordan wastewater treatment plants). The operating capacities of the treatment plants have been exceeded in terms of hydraulic and organic loads in the last years. The cost of treatment ranges from 16.3 fils/m^3 (2) in Aqaba's natural ponds (first wastewater treatment plant stbalished in 1987) to 783.6 fils/m^3 in Wadi Mosa (Extended aeration technology, established in 2000).

The total agricultural land that benefits from the treated wastewater is 14 377 dunam (3), and the total amount of wastewater used is 77 711.4 m^3/ day. In addition, the areas around the treatment plants and in Jordan Valley benefited from this wastewater.

The WAJ Laboratories are responsible for monitoring and controlling wastewater, both domestic and industrial, in order to protect water resources, the environment and public health. In addition to the public treatment plants in Jordan, this programme includes 23 special Ttreatment Plants and 54 industrial sites linked to the public sanitation system subject to monitoring (Ministry of Water and Irrigation, 2013).

Figure A2.4 Share of population with access to an improved sanitation system (total, urban and rural)



Note: (*) The percentage includes public networks and cesspools.

Source: Household Expenditures and Income survey 2004–2005, Department of Statistics.

The wastewater master plan determines the specific investments for wastewater collection and wastewater treatment projects. Projects under priority I are proposed for immediate

Table A2.13 Volume of wastewater collected, of which volume of wastewater treated and type of treatment (million cubic meter), for the period 2002–2011

Indicators	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Volume of wastewater generated (a) (MCM/year)	138.7	147.3	142.4	148.7	172.4	166.2	174.4	183.7	195.3	198.3
Volume of wastewater collected (MCM/year)	83.23	85.46	88.38	89.23	103.46	99.73	104.6	110.16	117.2	119.0
Volume of wastewater treated (MCM/year)	72.37	75.4	86.4	83.6	80.26	90.97	101	102.4	103.0	102.8
% wastewater with primary treatment	83.4	83.9	81.6	81.3	83.8	87.1	10.0 (b)	5.4	5.4	2.9
% wastewater with secondary treatment	16.6	16.1	19.4	19.7	16.2	13.9	90.0	94.6	94.6	97.7
Organic load for all plant operating capacity mg/L	809.58	796.1	729.23	702.1	709.2	711.61	823.5	657.5	721.38	509

Note: (a) Figures are estimated based on the assumption that 60 % of wastewater generated is connected to public network (DOS calculation).

(b) The most important wastewater treatment plant, Alkerbeh Al-Samra, which treats more than 50 % of wastewater, was upgraded to use biological treatment in addition to mechanical treatment.

Source: Ministry of Health, Environment statistics Report/DOS 2002–2012.

(2) JOD 1 = fils 1 000.
(3) 1 dunam = approximately 1 000 m^2.

implementation (20013–2015). It concerns in particular:

- existing wastewater collection systems having sewer overflow problems, or having existing sewers that are overloaded, or having sewers lines that have deteriorated, or having an accessibility problem to maintaining sewer systems.
- expansion of an existing overloaded wastewater treatment plant, or one currently operated very near its design capacity.

Impacts of wastewater on the natural environment and human health/human well-being

Wastewater treatment plants located near groundwater and surface-water resources will affect water quality and soil properties.

Wastewater: social impact:

- Health problems (a high percentage of the population are not connected to proper sanitation), especially in rural areas.
- Lack of awareness of correct wastewater management practices may allow undesirable practices, such as the improper use of grey water for several domestic uses (cleaning the back yard, for example).

Wastewater: cultural impact:

- Improper treatment of wastewater may cause pollution and odours in tourist areas, and that will negatively affect tourism in Jordan.

Wastewater: economic impact:

- Increasing the total amount of generated wastewater will place extra financial stress on the government, as more treatment plants will need to be constructed, and already existing ones will have to be rehabilitated.
- The strict Jordanian standard for reclaimed wastewater quality puts further stresses on current treatment plants, so to the treatment of wastewater can meet the requirements of such a standard.
- Increasing the coverage of households connected to sewerage networks puts pressure on the country's economy.

Wastewater: environmental impact:

- Eutrophication in King Talal Reservoir (KTR).
- Accumulation of large amounts of sludge in treatment plants.
- Negative effects on the agricultural sector (salinity problems).
- High risk of surface-water pollution, especially when discharging improperly treated wastewater into streams and dams.
- High risk of microbiological contamination of crops when reusing treated domestic wastewater for irrigation, unless correct practices (use of mulch and sprinkling irrigation, washing products, peeling, cooking, etc.) are present.

Availability of new water resources (Jordan is a special case, because of the water shortage).

Till the end of 2012, the population growth rate in Jordan was about 2.2 %, one of the highest in the world, as indicated by the population growth figures prepared by the Department of Statistics. This high population growth rate and fast socio-economic development are accompanied by steeply increasing water demand and wastewater production, and the gap between water supply and demand is getting wider.

Thus, the importance of reusing reclaimed wastewater, particularly domestic wastewater, is spotlighted, since such water is considered to be an important, renewable and non-conventional water resource in Jordan. The annual amount of treated wastewater flowing out of the wastewater treatment plants belonging to the Ministry of Water and Irrigation exceeds 113 MCM in 2013, and is expected to reach about 240 MCM in 2020 (Ministry of Water and Irrigation (MWI)/Water Authority — public sanitation).

Therefore, the MWI has updated its national water strategy for Jordan, in order to control and manage the use of all water resources according to environmental and public health regulations. There is an emphasis on encouraging the (direct and indirect) use of treated wastewater, particularly in the Jordan Valley, as one major resource for agriculture. This is the largest water consumer in Jordan, and around 55 % of the total water budget is being allocated for irrigation.

Responses

Environmental protection has been boosted thanks to a real-time water quality monitoring system (RTMS), to protect public health and provide environmental protection and sustainability. The system consists of 13 fully-automated monitoring stations, located on the major surface water resources at Jordan, Yarmouk, and Zarqa Rivers, King Abdullah Canal (KAC), and at the inlet and outlet of the KTR. The main goal of the system is to help improve decision-making in the water and environment sectors through real-time data provision.

The long-term goals of the system are:

- to collect and make available water-quality data on the major surface-water resources in Jordan;
- to provide a data collection platform for national water quality;
- to help improve decision-making in the water and environment sectors through real-time data provision and system modelling;
- To promote data sharing among the national organisations that monitors water quality and conduct research.
- Upgrading the Assamra wastewater treatment plant, 2008.
- Updating water and wastewater standards and regulations according to WHO and other relevant standards.

Many Jordanian standards for reclaimed wastewater quality have been developed: Standards for Reclaimed Domestic Wastewater, Reclaimed Industrial Wastewater, Reclaimed Grey water and Reclaimed Domestic Sludge. The MWI has updated its national water strategy for Jordan to control and manage the use of all water resources in line with environmental and public health regulations, with much emphasis on encouraging the (direct and indirect) use of treated wastewater, particularly in the Jordan Valley, as one major resource for agriculture.

Strict and comprehensive water quality monitoring and management programmes are implemented by the different ministries in close cooperation with the RSS. Such programmes include:

- the National Project for Studying and Monitoring Water Quality in Jordan (1986 to present);
- water resources monitoring at the Jordan Valley (2006 to present);
- assessment of Assamra WWTP performance and its impact on groundwater (2000 to present).

The new WHO guidelines (2006), which present a flexible approach of risk assessment and management, were introduced for the first time in Jordan. A multidisciplinary working group named the ‘Steering committee for the risk monitoring and management system for the safe use of treated wastewater' was formed, comprising an interdisciplinary working team from RSS and all related ministries and governmental institutions, including the Ministry of Environment, Ministry of Health, Ministry of Agriculture, Jordan Valley Authority, Water Authority of Jordan and Jordan Food and Drugs Association.

The team worked in close cooperation with the German International Agency (GIZ) on developing the final proposal of the ‘National Plan for Risk Monitoring and Management System for the Use of Treated Wastewater in Irrigation for the Irrigated Areas Upstream and Downstream of the King Talal Reservoir'. The national plan was issued in November 2011, and at the same time, GIZ, in close cooperation with relevant institutions developed further practical guidelines for farmers and extension workers, entitled ‘Practical Guidelines for the Safe Use of Treated Wastewater in Irrigation'. Both the plan and the guidelines serve as a road map and offer practical steps towards implementing a risk management system that will ensure the safe use of treated wastewater.

All the above-mentioned measures proved very effective.

- The quality of all WWTPs' effluents is monitored according to the Jordanian set of standards.
- More than 90 % of treated wastewater is being reused in 2012. Treated wastewater is considered a main source in Jordan's water budget, where currently, more than 113 MCM of treated wastewater is produced from 26 treatment plants all over the country. Around 75 % of such water is generated by the biggest treatment plant, Kherbit Al-Samra, which is the main supplier of the KTR, the major supplier of blended treated wastewater used in unrestricted agriculture in the Jordan Valley. Treated wastewater flows out of the Kherbit Al-Samra plant down into a natural wadi, 42 km long, where it undergoes natural purification and is mixed with other

spring water until it reaches the KTR. There, it is blended with rainfall and run-off water, and then released down to the Jordan Valley to be used in unrestricted agriculture.

- Many governmental institutions already have quality monitoring programmes in place, and the available databases are vital, supporting decision-makers in the preparation of national plans for the optimal exploitation of water resources.

- Due to the introduction of the 2006 WHO guidelines, a Jordanian standard for irrigation water quality was developed, using the flexible approach of risk assessment and management presented by the guidelines mentioned above.

- Jordan is considered a leading country in the field of treated wastewater reuse.

- The online water quality monitoring system, which is the first system in the region to be accredited through an international body (United Kingdom Accreditation Service (UKAS)), is available online, to aid decision-making in the water and environment sectors.

2020 outlook and possible impacts on the natural environment

- Adopt high-tech methods of wastewater treatment to encourage use of treated wastewater in different types of irrigation.

- Protect freshwater resources through online water-quality monitoring.

- Encourage all industries to treat their wastewater according to standards, and reuse treated water in irrigation, and in industry processes such as cooling and cleaning of raw materials.

- To ensure that all wastewater treatment plants' effluents quality is in line with national regulations and standards.

- To have the capacity to utilise and reuse all treated wastewater coming out of WWTPs in the country.

- To develop a Jordanian Surface Water Standard.

Industrial emissions

Problems and challenges

The main sources of Jordanian air pollution are anthropogenic, including stationary sources and mobile sources (mainly road transportation) that could emit or cause the formation of different air pollutants: TSP, PM_{10}, $PM_{2.5}$, NO_X, SO_2, CO, HC, O_3, NH_3, H_2S, F_2, NO_3, SO_4, Cl_2, HCl, dioxin, heavy metals such as Pb, odour, noise, etc. The emissions of air pollutants from industrial activities in ‘hot spot' areas such as Zarqa, Sahab, Russiefeh, Marka, Al-Hashimyeh and free industrial sites are the main source of air pollution in the country, resulting in an increase in pollutants levels in ambient air, which in turn causes degradation of the air quality in many areas and adversely impacts the public health. Jordan has large industries that may generate heavy air pollution if their emissions are not controlled properly: cement, potash, fertilisers and petroleum refinery factories.

Monitoring of ambient air quality in Jordan started in 1990, with SO_2, NO_2 and H_2S being monitored at the town of Al-Hashemyya, and particulates parameters being monitored at Fuhais and Al-Qadisia. A network of ambient air quality monitoring was established in 2008 to monitor ambient air quality in eight cities.

The results of ambient-air-quality–monitoring programmes are presented to provide a brief overview of Jordan's air quality status and its trend over the monitoring years. This shows that industrial activities affect air quality at residential areas close to the location of industrial activities, mainly ‘hot spot' areas such as Al-Hashimyeh. Al-Hashimyeh in the Zarqa governorate is surrounded by various air pollution sources, mainly the Jordan Petroleum Refinery Company (JPRC), Hussein Thermal Power Station, Samra Power Station (SPS) and Samra Wastewater Treatment Plant.

Some of the main challenges Jordan faces in controlling ambient air quality are as follows:

- most industries still lack environmental awareness and responsibility;

- many factories were installed before EIA regulations were issued, and accordingly, their effects on ambient air quality were not examined by monitoring and modelling;

- the existence of a high number of SMEs using old technologies;

- the relatively high cost of air-pollution control measures to be applied by industry;
- some significant environmental issues (such as odour) are not taken into consideration in national environmental legislation.

State and impact

The concentration of NO_3 in all dams, rivers and streams is within limits and can be used for irrigation. Some restrictions are needed due to the high salt concentrations indicated in most of the results (it is not for use with sensitive crops).

The standard requires that wastewater treatment must produce effluent with a BOD_5 concentration of 60 mg/l or less, if the wastewater is discharged into wadis (in most instances, this is the case). In addition, the effluent nitrate and total nitrogen concentrations should be equal to or less than 70 mg/l, if the effluent is used for irrigation.

These effluent requirements dictate that for minimum biological treatment such as that for activated sludge, trickling filters or their variations will be required.

Table A2.3 PH, TDS, nitrate concentration in Jordan's dams (2011–2012)

Name	Governorate	Storage capacity (Mm^3)	2011			2012		
			PH (SU)	TDS (mg/l)	NO^3 (mg/l)	PH (SU)	TDS (mg/l)	NO^3 (mg/l)
King Talal Dam	Jarash	75	8.05	1 395	39.3	7.67	1 180	34.8
Wadi Shaeeb	Balqa	1.4	8.58	663	33.4	8.40	569	27.9
Al-Karameh	Balqa	55	7.99	19 059	< 1	8.31	23 372	2.9
Al-Kafreen	Balqa	8.5	9.06	630	7	9.04	547	8.8
Zeglab	Irbid	4	8.01	390	2.5	7.81	427	3.6
Al Wehdeh	Irbid	110	7.69	623	14.2	7.96	651	12.1
Wadi-El Arab	Irbid	18.8	8.59	577	2	8.36	557	2.2
Al-Walleh	Karak	9.3	8.39	219	2	8.27	245	1.9
Wadi-el Mujeb	Karak	35	8.17	497	< 1	7.96	576	1.1
Al-Tanoor	Tafeleh	16.8	8.35	742	3.2	7.67	863	2.0

Source: Ministry of Environment, 2010-2012.

Table A2.4 Summary of JS 893-2006 standards for reclaimed domestic wastewater (mg/l)

Parameter	Cooked vegetables A	Fruit & forestry trees, crops & industrial products B	Irrigation of fodder crops C	Irrigation of cut flower	Discharge to streams, wadis & reservoirs	Ground water recharge
BOD_5 (1)	30	200	300	15	60	15
COD	100	500	500	50	150	50
DO	>2	-	-	>2	>1	>2
TDS	1500	1500	1500	1500	1500	1500
TSS	50	200	300	15	60	50
PH	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0
Turbidity	10	-	-	5	-	2
NO_3^-N	30	45	70	45	-	30
Total-N	45	70	100	70	70	45
E.coli	100	1000	-	< 1.1	1000	< 2.2
Intestinal Helminthes eggs	≤ 1	≤ 1	≤ 1	≤ 1	≤ 0.1	≤ 1

Source: Ministry of Environment, 2010-2012.

Release of toxic substances and nutrients from industrial sector
Under this indicator we will discuss the three main wastewater treatment plants in Jordan for Al-Hassan industrial city, King Abdullah industrial city, and Al-Karak industrial city. The equation for converting concentration (mg/L) to load (kg/year) is: concentration (mg/L) * 1 000 L/m^3 * 1 Kg/10 000 000 mg * outlet wastewater (m^3/year).

The treated wastewater from Al-Hassan and King Abdullah industrial cities is used for irrigation, and some of the treated wastewater from Al-Karak city is directed to the streams. Most of the results indicate high salt content: Cl, Na and HCO_3. Wastewater in the outlet of the King Abdullah treatment plant is considered higher than standard for discharge in streams; it is used only for forest irrigation.

Emission concentrations of SO_2, H_2S, NO_2, NO, NO_x, CO and CO_2 in electrical training centres, Ibn-Al-Anbari and Um Shuraik School, and for available time series in the Al-Hashemya hot spot is in Annex 2.

Likewise, results of monitoring of industrial cities for SO_2, NO, NO_2, NO_x, CO and $PM_{2.5}$ are in Annex 2.

Impacts of industrial emissions on the natural environment and human health/human well-being

They may affect site selection for housing, hotels, restaurants and hospitals: distant locations or upwind locations may be preferred to avoid the impact of industrial emissions.

Industrial emissions: social impact

Increasing the levels of air pollutants in ambient air can damage eyesight, and cause respiratory and nervous system problems as well as some types of cancer. Moreover, the long-term effects of chronic exposure to low levels of air pollutants remain to be assessed. Air pollution remains a major environmental and health problem across the region; the population is exposed to levels of pollution exceeding World Health Organisation (WHO) guidelines, and resulting in increased hospital admissions.

For example, a survey sample of 340 Al-Hashimyeh residents conducted in 2010 showed that 26 % of the families have members suffering from chronic lung diseases (around 7 % of the individuals), in addition to allergies.

Table A2.5 PH, TDS and nitrate concentrations in Jordan's river and streams (2011–2012)

Name	Governorate	2011			2012		
		PH (SU)	TDS (mg/l)	NO_3 (mg/l)	PH (SU)	TDS (mg/l)	NO_3 (mg/l)
Yarmook River	Irbid	8.36	638	4.9	8.32	619	4.5
Link between Tabareah lake and King Abdullah channel	-	8.22	662	< 1	8.49	649	< 1
King Abdullah channels (Deir Alla)	Balqa	8.26	649	3.3	8.08	572	2.7
Alzarqa Stream (connection with Wadi Al-Dulail coming from Al-Smra wastewater treatment plant)	Zarqa	7.95	1455	84.9	8.04	1 298	57.0
Jarash stream	Jarash	7.39	2 429	17.4	7.75	2 797	22.6
Wadi shoaaeb stream	Balqa	8.51	620	33.4	8.31	635	49.8
Wadi kofranja stream	Ajloun	8.50	573	24.2	8.49	623	24.5
Wadi Al-seer stream	Amman	7.56	442	41	7.98	464	39.9
Hossban stream	Amman	8.00	378	35.4	7.94	463	293
Al-karak stream	Karak	8.30	572	74.3	8.14	483	56.1
Wadi Bani-Hamad stream	Karak	7.59	391	20.8	7.71	370	22.0
Al Zarah spring	Dead Sea	8.19	1 564	1.2	8.09	1 211	1.3
Maeen springs	Madaba	8.17	1 133	1	8.11	1312	1.4

Source: Ministry of Environment, 2010-2012.

Table A2.6 Wastewater quantities (*) and quality for the treatment plant of the three industrial cities in Jordan

Treatment plant for 3 industrial cities	Outlet wastewater (m^3/year)	2011					2012				
		BOD_5 kg/year	COD kg/year	TDS kg/year	T-N kg/year	PO4-P kg/year	BOD_5 kg/year	COD kg/year	TDS kg/year	T-N kg/year	PO4-P kg/year
Al-Hassan	419 750	839.5	36 518.3	505 379.0	17 209.8	587.7	22 078.9	11 5431.3	566 662.5	23 925.8	587.7
King Abdullah	438 000	143.0	365.0	1 494.0	36.0	0.9	69.5	244.0	1 830.0	28.0	1.7
Al-Karak	118 625	474.5	13 286.0	13 3453.1	3 558.8	533.8	5 504.2	19 217.3	110 914.4	4 270.5	213.5

Note: (*) The equation for converting concentration (mg/L) to load (kg/year) is Load (Kg/Year) = Concentration (mg/L) * 1 000 L/m^3 * 1 Kg/10 000 000 mg * outlet wastewater (m^3/year).

Source: Ministry of Environment, 2010–2012.

Table A2.7 Wastewater quantities and quality for the treatment plant of the three industrial cities in Jordan

Treatment plant for 3 industrial cities	2011								2012							
	Al kg/year	Cr kg/year	Cu kg/year	Mn kg/year	Ni kg/year	Pb kg/year	Cd kg/year	Zn kg/year	Al kg/year	Cr kg/year	Cu kg/year	Mn kg/year	Ni kg/year	Pb kg/year	Cd kg/year	Zn kg/year
Al-Hassan	293.8	21.0	8.4	29.8	16.8	37.8	2.1	8.4	293.8	21.0	8.4	21.8	16.8	37.8	2.1	23.1
King Abdullah	4 599.0	35.0	56.9	53.4	43.8	118.3	2.2	135.3	1 138.8	21.9	35.0	37.7	30.7	39.4	2.2	31.5
Al-Karak	83.0	5.9	2.4	4.3	4.7	10.7	0.6	3.8	8.3	5.9	2.4	8.4	4.7	10.7	0.6	4.3

Source: Ministry of Environment, 2010–2012.

Air pollution does not only affect human health, but also quality of life, which in turn impacts their behaviours and activities.

Industrial emissions: cultural impact

In industrial zones, there is a great risk of degradation of material objects, due to emissions of harmful substances which could corrode cultural heritage objects.

Industrial emissions: economic impact

By increasing industrial sources in residential areas, the need for modern environmental technologies will increase, in order to comply with the maximum allowable limits of air pollutants stated in the national and international regulations. Also, sickness due to air pollution leads to lost days at work, which in turn affects income.

New industries will require additional care of an industrial wastewater treatment plant, increasing the financial burden.

Industrial emissions: environmental impact

Air pollution caused by uncontrolled industrial emissions is very harmful to the environment. In addition to the above-mentioned impact of air pollution on public health, it can damage trees, crops, plants, animals and buildings. Air pollution damages nature and biodiversity. Air pollutants are often closely associated with GHG emissions. Poor air quality also affects plants and animals, may put species at risk, and can reduce the productivity of farms and forests.

Responses

There are regulations and standards for controlling air pollution from industrial activities.

The Ministry of Environment has established an ambient air quality monitoring network at different residential areas that are located close to industrial activities. Moreover, several monitoring programmes have been implemented which monitor the levels of concentration of gaseous air pollutants and suspended fine dust in the most affected areas in the country.

Applying EIA studies for new industrial projects are mandatory for environmental approval to be granted, and the implementation of the monitoring plans is checked by the Ministry of Environment.

Some big plants established continuous emission monitoring systems (CEMS) to control air pollutants emissions from their stacks, which are online on the Ministry of Environment website.

Periodical environmental measurements from stationary sources are required to ensure that emissions are within the limits specified by national standards.

The Ministry of Environment and RANGERS (i.e inspectorate) carry out regular compliance inspections and the ministry places those cases of non-compliance under environmental audit.

Several environmental situation settlement plans have been implemented in the polluting industries (Lafarge Cement Company, Lead Melting Factory).

The monitoring and assessment directorate in the Ministry of Environment was established in 2003 to follow up on environmental problems, including air quality through the Environmental Protection Act No 52 of the year 2003.

Issuance of environmental legislation for the protection of air quality from harmful emissions to human health and the environment:

- Air protection By-law No 28 for the year 2005;
- Standards No 1189/2006 for maximum permissible limits of the pollutants emitted from stationary sources;
- Standards No 1140/2006 for ambient air quality in Jordan.

Fuel quality: setting of standards for oil derivatives and sulfur content.

Implementation of several monitoring programmes to monitor the levels of concentrations of gaseous air pollutants and suspended fine dust found in the most affected areas in the country:

- gaseous pollutants monitoring programme in Al-Hashemiyyah area, which measured the concentrations of SO_2, NO_2 and H_2S;
- suspended fine dust concentrations monitoring programme (PM_{10}) in Fuhais and Al-Qadessiyyah areas;
- qualified industrial zones emissions monitoring programme;

- non-qualified industrial clusters emissions monitoring programme (Giza, Rusiefa, Al-Muwaqar, Baqa'a, Al-Khaldiyyeh, Mafraq);

- the Ambient Air Quality Monitoring System, with 12 stations covering 3 governorates (Amman, Zarqa And Irbid) was intended to start work in early March.

Mobile sources:
- will modernise and develop the transport fleet in Jordan via vehicle licensing before five years of licence application;

- examine emissions from vehicles to assess environmental performance for the purposes of licensing;

- renovate and maintain roads and construct bridges and tunnels to reduce the amount of emissions;

- capacity-building of drivers in the environmental fields, through the introduction of environmental information in driving license exams;

- carry out monitoring campaigns for vehicles emissions on the roads (through the environmental rangers).

Stationary sources:
- several environmental situation settlement plans have been implemented in the polluted industries (Lafarge Cement Company, Lead Milting Factory)

- Real-time continuous monitoring of emissions from the stacks connected with the Ministry of Environment (Lafarge Cement Company).

2020 outlook and possible impacts on the natural environment and human health

To have controlled industrial emissions that comply with regulations and standards and do not cause harmful effects on the human health and environment.

Success stories

National Plan for Risk Monitoring and Management System for the Use of Treated Wastewater in Irrigation for the Irrigated Areas Upstream and Downstream of the King Talal Reservoir.

This national plan was issued in November 2011.

At the same time, GIZ, in close cooperation with relevant institutions, developed further practical guidelines for the farmers and extension workers in the form of the **'Practical Guidelines for the Safe Use of Treated Wastewater in Irrigation'**. Both the plan and the guidelines serve as a road map and set out practical steps towards implementing a risk management system that will ensure the safe use of treated wastewater.

The committee recommended establishing a Jordanian standard for irrigation water quality, and the draft of such a standard has already been prepared and will be published in the official gazette by the Jordan Standards and Metrology Organization (JSMO).

Manufacturing of containers by the GAM production dept, specifically 5 300 containers during 2013. The manufacturing cost is JOD 200 per container and the purchasing price is JD 330 per container.

The online water quality monitoring system
This system allows the production of accurate and continuous data that can be used to determine the suitability of water for irrigation in different areas, according to National Standards and Guidelines. The system can help decision-makers in water and environment sectors, water utility managers, engineering consultants and farmers.

Using the data produced by the RTMS system will help these actors understand the water constituents at different locations, and determine how much water is needed to irrigate the target area. For example, using mixed water (King Abdullah Canal (KAC) and King Talal Dam (KTD) water) for irrigation in Jordan Valley will help to improve the properties of the soil, since it contains nutrients such as nitrogen and phosphorus and accordingly will decrease the amount of fertiliser used by the farmers. However, a high nitrogen concentration in irrigation water may also cause excessive vegetative growth and delay in crop maturity.

Remote sensing
In light of the MWI policy adopted to control the quality of drinking water and wastewater, and its conformity to local and international technical criteria, WAJ has implemented the remote sensing project in order to benefit from the technology revolution in controlling and monitoring water quality. The Korea International Co-operation Agency (KOICA) has financed this project. The project relies on modern techniques to perform chemical and physical analyses and to send these data via the Internet from the stations to the controlling centre in laboratories and water quality department.

Three locations has been selected for this project implementation: the As-Samra Treatment Plant, the Salt Treatment Plant and the Zaatari drinking water supply station.

The Ghabawi engineered landfill
It's an old military site, located in the eastern part of GAM. The site is currently equipped with a fence surrounding the whole site, some trees along the western fence, a network of asphalted roads and tracks, an administration building, a workshop building, an electrical transformer, a weighing bridge, the first three cells with the bottom liner system and leachate collection, leachate pumping and transfer facilities, four leachate storage ponds, a water well, and a leachate pretreatment line (for aeration, sedimentation, and filtration). The landfill was designed in line with European standards. Operation of the site involves 80 personnel and a wide range of equipment, including state-of-the-art landfill steel-wheeled compactors. It should be noted that the Ghabawi landfill gas-to-energy

project is a registered Clean Developemnt Mechanism activity.

Recommendations

- Support for adopting the National Strategy for Environmental Indicators and Issues.
- Whenever possible, other end-uses of treated effluents should be considered: recycling, cooling, power generation, etc. As in the case of Aqaba treated wastewater, some effluent is used for the superphosphate industry.
- Improve local regulations and standards regarding the points mentioned above.
- Enforce mandatory rules for industries to regularly monitor and record their emissions and be registered online with the authorities.
- Increase industries' awareness of the benefits of controlling their emissions: they will improve their market image, save on consumption of raw materials and improve their economic performance.
- Integrated waste management system must be adopted. It is no longer a matter of choice, and the system should include separation from the source, collection, recycling and final treatment processes.
- The polluted hot spots in Jordan are well known, the Al-Hashmieh area in particular. Mitigation measures should be focused on these hot spots.
- We encourage the PRTR pilot to be relaunched.
- Regulations regarding industrial wastewater discharge and reuse should be enforced.
- The first source of air pollution in Jordan is emissions from the transportation sector and energy production plants, and the industrial sector is the second. Any mitigation measures that are adopted should consider both these sectors.

Annex 1

Overview of open dump site in Jordan

Year_H2020	NameOfOpen-DumpSite	Municipality	Longitude	Latitude	ReferencePoint	Remarks
2012	Landfill of Joint Services Council of Irbid Governorate (Akaider)	Joint Services Council — irbid	36.112138	32.513765	Village Alakidr — Mafraq Governorate/away from the city of Irbid 27 km	Landfill was founded in 1982, and receives industrial water + olive Zebar + damages
2012	Landfill of Joint Services Council for district north Jordan Valley	Joint Services Council — district north Jordan Valley	35.614393	32.574957	North Shuneh — near big Mosque of Shuneh Building of Endowments — near aramsheh school for girl	1. Need to acquisition of land for landfill 2. Mechanisms old 3. The landfill transfer of nearly 50 tons of waste into Alakidr by van carrying 25 tons Tgaria,and there were two cars to deal with the remaining amount up to 50 tons by the landfill 4. Serves the following municipalities (moath bin jabal Municipality + alwasatia Municipality + al-tayba Municipality + Khaled bin alwaleed Municipality)
2012	Landfill of Joint Services Council for district South Jordan Valley (Breaka)	South Aghwar Municipality	35.488596	31.233735	4 km west of the al-mazra'a Security Center	Needs to be improved and mechanisms
2012	Landfill of Joint Services Council for district South Jordan Valley (Summar)	South Aghwar Municipality	35.478482	30.983427	East Road International Amman - Aqaba, Just 4 km from the area of Summar	Needs to be improved and mechanisms
2012	Landfill of Joint Services Council for Mafraq Governorate (Al-Husenat)	Joint Services Council — Mafraq	36345342	32.256494	The road to Baghdad International — 25 km east of Mafraq Governorate, in the area Al-Husenat Southeast Security Center of um al-jimal -street of Municipality/ front of the initial health center's	1. Landfill was founded in 1985 and receives dead animals from farms in the Mafraq Governorate 2. There are layers of rock at depths close to the soil surface, thereby hindering the process of landfill 3. Lack of Lauder with Metallic wheels LFC for cutting waste and reduce its size 4. they have website: www.msc.gov.jo
2012	Landfill of Joint Services Council of Aqaba Governorate	Joint Services Council of Aqaba Governorate — Aqaba Aqaba Special Economic Zone Authority	35.038825	29.41405	After the security station's for vehicle inspection, 5 km from the back road	1. Landfill was founded in 1997 2. 20 km from the nearest locality

Overview of open dump site in Jordan (cont.)

Year_H2020	NameOfOpen-DumpSite	Municipality	Longitude	Latitude	ReferencePoint	Remarks
2012	Landfill of Joint Services Council for Al-Querah district	Al-Querah Municipality + Municipality Basin Al-desah			front of the company Hijazi and Ghosheh	1. Receives liquid waste landfill Landfill was founded in 2000 2. 3.5 km from the nearest locality
2012	Landfill of Joint Services Council of Madaba Governorate	Joint Services Council - Madba	35.815457	31.688093	Madaba Nettles road ,After purification plant Madaba	1. Landfill was founded in 1973 2. Needs to be improved and mechanisms
2012	Landfill of Joint Services Council of Zarqa Governorate	Joint Services Council — zarqa	36.299775	32.073856	Farm Palace Halabat	
2012	Landfill of Joint Services Council of Zarqa Governorate	Joint Services Council — zarqa				
2012	Landfill of Joint Services Council of Tafeleh Governorate	Joint Services Council — Tafeleh	35.818391	30.745607	Al-jasa — jurf al-darawish	1. Landfill was founded in 1986 2. Nature of the land of the landfill is Rocky 3. Receives Wastewater + olive Zebar
2012	Landfill of Joint Services Council for district Central Jordan Valley(deir alla and shoneh)	Joint Services Council — district Central Jordan Valley	35.564118	32.122435		1. Landfill was founded in 1998
2012	Landfill of Joint Services Council of Karak Governorate (lajoon)	Joint Services Council — Karak	359312	31.236373	The desert road that connects the Karak, Amman,Qatraneh road	1. Landfill was founded in 1996 2. Receives just solid waste
2012	Landfill of Joint Services Council of Balqa Governorate (humreh)	Joint Services Council — Balqa	35.653163	32.06114	Al-humreh	1. Landfill was founded in 1992 2. Nature of the land of the landfill is Rocky 3. Receives liquid Waste + olive Zebar
2012	Landfill of Joint Services Council for iel district	Joint Services Council — iel district			east basta	Landfill was founded in 1983
2012	Landfill of Joint Services Council for Maan Governorate	Joint Services Council — Maan	35.851984	30.181559	East maan city — jafur road	1. Receives liquid waste 2. Landfill was founded in 1993

Overview of Jordan wastewater treatment plants

No	WWTP name	Year of operation	Year of update	Technology	Service governorate	Design capacity after upgrade (people)	Calculated connected population (based on actual biological oxygen demand (BOD) loads) (people)	Av. design flow m³/d	Av. actual flow m³/d	Av. design BOD load kg/d	Av. actual BOD load kg/d
1	Aqaba - natural	1987		Waste stab ponds	Aqaba	124 615	40 210	9 000	7 220	8 100	2 614
2	Aqaba - mechanical	2005		Extended aeration	Aqaba	77 538	46 614	12 000	8 511	5 040	3 030
3	Baqa	1987	1998	Trickling filter (TF)	Amman, Balqa	183 385	110 102	14 900	11 713	11 920	7 157
4	Fuheis	1997		Activated Sludge	Amman, Balqa	36 738	18 830	2 400	2 305	2 388	1 224
5	Irbid, central	1987		TF & active sludge	Irbid	135 668	127 267	11 023	8 635	8 818	8 272
6	Jerash, east	1983	Committed	Oxidation ditch	Jerash	152 308	65 327	9 000	3 333	9 900	4 246
7	Karak	1988	Committed	Trickling filter (TF)	Karak	59 231	27 000	5 500	1 753	3 850	-
8	Kufranja	1989	Under construction	Trickling filter (TF)	Ajloun	96 923	28 523	9 000	2 763	6 300	1 854
9	Madaba	1989	2003	Activated sludge	Madaba	111 077	92 495	7 600	5 260	7 220	6 012
10	Mafraq	1988	Under construction	Waste stab ponds	Mafraq		76 788	-	6 050	1 618	4 991
11	Ma'an	1989	2008	Extended aeration	Ma'an	62 160	14 184	5 772	2 358	4 040	922
12	Abu Nuseir	1986		Active sludge R B C	Amman	67 692	26 965	4 000	2 401	4 400	1 753
13	Ramtha	1987	2005	Activated sludge	Irbid	83 077	55 329	5 400	4 050	5 400	3 596
14	Sult	1981	2005	Extended aeration	Balqa	71 077	59 062	7 700	6 529	4 620	3 839
15	Tafila	1988	Committed	Trickling filter (TF)	Tafila	83 077	15 241	7 500	1 575	5 400	991
16	Wadi Al Arab	1999		Extended aeration	Irbid	321 462	148 548	21 000	10 681	2 0895	9 656
17	Wadi Hassan	2001		Oxidation ditch	Irbid	19 692	22 436	1 600	1 238	1 280	1 458
18	Wadi Mousa	2000		Extended aeration	Maan	41 846	12 095	3 400	2 536	2 720	786
19	Wadisseer	1997		Aeration lagoons	Amman	48 000	37 163	4 000	4 053	3 120	2 416
20	Alekeder Tankers	2005		Waste stab ponds	Mafraq	42 308	-	4 000	3 232	6 000	-
21	Lajoon-Tankers	2005	Under construction	Waste stab ponds	Karak	12 923	-	1 200	735	840	-

Overview of Jordan wastewater treatment plants (cont.)

No	WWTP name	Year of operation	Year of update	Technology	Service governorate	Design capacity after upgrade	Calculated connected population (based on actual biological oxygen demand (BOD) loads)	Av. design flow	Av. actual flow	Av. design BOD load	Av. actual BOD load
						(people)	(people)	m³/d	m³/d	kg/d	kg/d
22	Tal El Mantah Tankers	2005		TF and activated sludge	Balqa	12 308	8 766	400	365	800	570
23	Al Jiza	2008		Activated sludge	Amman	49 231	7 315	4 000	624	3 200	475
24	Samra	1984		Activated sludge	Amman-Zarqa	3 648 000	2 620 523	364 800	240 925	237 120	170 334
25	Al merad	2010		Activated sludge	Jarash	1 10 769	25 620	9 000	2 297	7 200	1 665
26	Shobak Tankers	2010		Waste stab ponds	Maan	9 962	359	350	67	648	23
27	Mansorah Tankers	2010		Waste stab ponds	Maan	-	-	50	13	0	0

Source: National Strategic Wastewater Master Plan, 2013.

Annex 2

Table 1: Monthly and annual averages, recorded max. hourly and daily average concentrations of SO_2 and percentage of hourly and daily exceedances at Electrical Training Cenetr during the monitoring period (January 2012 -December 2012) and the previous monitoring periods

Study Year	SO_2 Monthly averages (ppm)														MAX (ppm)		Exceed. Of JS		
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	HAVG	DAVG	HAVG	DAVG	YAVG
2012			0.001	0.012	0.018	0.105	0.162	0.251	0.235	---	---	0.130	0.169	0.138	1.015	0.465	15.9%	44.1%	0.128
2011			0.044	0.069	0.064	0.074	0.096	0.157	0.113	0.097	0.129	0.101	0.096	0.012	1.007	0.441	9.2%	21.6%	0.087
2010			0.129	0.089	0.010	0.022	0.100	0.159	0.120	0.081	0.088	0.083	0.098	0.089	1.766	0.623	9.4%	19.1%	0.087
2009			0.026	0.024	0.046	0.061	0.070	0.101	0.183	0.168	0.125	0.095	0.164	0.041	1.438	1.192	6.1%	15.5%	0.090
07-08	0.022	0.012	0.003	0.017	0.065	0.092	0.090	0.076	0.124	0.109	0.145	0.153	0.025	0.014	0.813	0.424	4.6%	15.2%	0.071
06-07	0.027	0.024	0.020	0.025	0.054	0.073	0.080	0.130	0.082	0.087	0.096	0.058			1.746	0.349	3.1%	7.4%	0.065
05-06	0.026	0.026	0.025	0.026	0.082	0.074	0.118	0.164	0.166	0.173	0.095	0.063			2.484	0.579	7.8%	19.8%	0.087
04-05	0.007	0.006	0.021	0.034	0.070	0.066	0.208	0.212	0.253	0.259	0.145	0.074			6.545	0.7	11.1%	32.1%	0.113
03-04	0.023	0.001	0.009	0.033	0.049	0.052	0.072	0.074	0.053	0.045	0.046	0.024			0.851	0.188	1.1%	1.3%	0.040
02-03	0.012	0.004	0.008	0.015	0.004	0.080	0.075	0.094	0.127	0.091	0.063	0.046			---	---	3.1%	9.3%	0.047

Note:Maximum allowable hourly, daily and annual averages in JS 1140/2006 are *0.3, 0.14* and *0.04* ppm, respectively.

Table 2: Monthly and annual averages, recorded max. hourly and daily average concentrations of SO_2 and percentage of hourly and daily exceedances at Ibn Al-Anbari School during the monitoring period (January 2012 - December 2012) and the previous monitoring periods

Study Year	SO_2 Monthly averages (ppm)														MAX (ppm)		Exceed. Of JS		
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	HAVG	DAVG	HAVG	DAVG	YAVG
2012*			0.003	0.001	0.004	0.009	0.008	0.012	0.002	0.001	0.001	---	---	0.001	0.289	0.039	0.0%	0.0%	0.003
2011			0.015	0.001	0.001	0.008	0.027	0.022	0.016	0.017	0.008	---	---	0.007	*0.309*	0.094	0.0%	0.0%	0.013
2010			0.011	0.013	0.004	0.004	0.005	0.005	0.005	0.004	0.004	0.005	0.003	0.007	0.226	0.097	0.0%	0.0%	0.006
2009			0.027	0.021	0.011	0.012	0.010	0.004	0.002	0.016	0.038	0.003	0.003	0.006	*0.560*	0.105	0.1%	0.0%	0.012
07-08	0.029	0.014	0.026	0.050	0.084	0.048	0.049	0.037	0.065	0.073	0.057	0.039	0.028	0.013	*0.739*	*0.257*	3.1%	3.4%	0.047
06-07	0.019	0.019	0.020	0.031	0.060	0.059	0.052	0.093	0.089	0.093	0.075	0.048			*0.640*	*0.228*	3.6%	4.9%	0.055
05-06	0.057	0.027	0.039	0.039	0.067	0.094	0.089	0.060	0.043	0.097	0.063	0.047			*0.926*	*0.247*	5.1%	8.2%	0.063
04-05	0.005	0.003	0.016	0.033	0.055	0.049	0.101	0.065	0.091	0.090	0.083	0.037			*0.870*	*0.303*	4.1%	5.8%	0.052
03-04	0.011	0.003	0.012	0.035	0.025	0.090	0.102	0.043	0.017	0.014	0.012	0.014			*0.488*	*0.435*	2.0%	2.9%	0.032
02-03	0.014	0.011	0.016	0.025	0.039	0.039	0.051	0.054	0.064	0.099	0.063	0.032			---	---	2.8%	3.9%	0.041

Note:Maximum allowable hourly, daily and annual averages in JS 1140/2006 are ***0.3, 0.14*** and ***0.04*** ppm, respectively.
* Frequent interruptions occurred during the monitoring period at the monitoring site. However, the monthly averages were calculated to give an indication of the monthly trends in SO_2 levels .

Table 3: Monthly and annual averages, recorded max. hourly and daily average concentrations of SO_2 and percentage of hourly and daily exceedances at Um Shuraik School during the monitoring period (January 2012 - December 2012) and the previous monitoring periods

Study Year	SO_2 Monthly averages (ppm)														MAX (ppm)		Exceed. Of JS		
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	HAVG	DAVG	HAVG	DAVG	YAVG
2012			0.003	0.003	0.005	0.003	0.005	0.027	0.003	0.003	---	0.031	0.002	0.005	*0.657*	*0.144*	0.18%	0.41%	0.007
2011			0.001	0.002	0.004	0.002	0.005	0.002	0.003	0.001	0.002	0.004	0.003	0.004	0.287	0.034	0.00%	0.00%	0.003
2010			0.002	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.003	0.002	0.002	0.004	0.204	0.053	0.00%	0.00%	0.002
2009			---	0.003	0.001	0.003	0.003	0.005	0.001	0.002	0.002	0.005	0.003	0.002	*0.306*	0.030	0.01%	0.00%	0.003
07-08	0.009	0.005	0.007	0.003	0.005	0.009	0.006	0.006	0.002	0.002	0.007	0.005	0.005	0.004	*0.322*	0.059	0.01%	0.00%	0.005
06-07	0.007	0.005	0.004	0.010	0.001	0.009	0.017	0.012	0.009	0.015	0.003	0.018			*0.933*	0.134	0.18%	0.00%	0.010
05-06	0.006	0.013	0.004	0.003	0.005	0.005	0.010	0.005	0.003	0.007	0.008	0.007			*0.494*	0.050	0.03%	0.00%	0.006
04-05	0.006	0.007	0.005	0.001	0.008	0.007	0.005	0.004	0.005	0.003	0.005	0.008			*0.375*	0.035	0.02%	0.00%	0.005
03-04	0.006	0.005	0.009	0.005	0.008	0.007	0.006	0.003	0.003	0.002	0.006	0.010			*0.497*	0.073	0.04%	0.00%	0.006
02-03	0.004	0.003	0.009	0.003	0.015	0.005	0.015	0.006	0.007	0.005	0.010	0.011			---	---	0.20%	0.30%	0.008

Note:Maximum allowable hourly, daily and annual averages in JS 1140/2006 are ***0.3, 0.14*** and ***0.04*** ppm, respectively.

Table 4: Monthly average, and recorded max. hourly and daily average concentrations of H_2S and percentage of hourly and daily exceedances at Ibn Al-Anbari School during the monitoring period (January 2012 - December 2012) and the previuos monitoring period

Study Year	H_2S Monthly averages (ppm)														MAX (ppm)		Exceed. Of JS		
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	HAVG	DAVG	HAVG	DAVG	YAVG
2012*			0.002	0.002	0.002	0.010	0.014	0.014	0.005	0.003	0.002	---	---	0.001	**0.265**	**0.036**	1.8%	14.7%	0.004
2011			0.003	0.001	0.001	0.006	0.015	0.007	0.010	0.007	0.002	---	---	0.003	**0.189**	**0.041**	6.0%	16.6%	0.006
2010			0.002	0.006	0.001	0.003	0.004	0.005	0.004	0.003	0.002	0.002	0.001	0.002	**0.259**	**0.053**	0.4%	0.9%	0.003
2009			0.003	0.003	0.023	0.023	0.022	0.041	0.013	0.014	0.008	0.003	0.002	0.002	***0.528***	**0.112**	11.3%	33.7%	0.009
07-08	0.003	0.004	0.002	0.002	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.002	**0.068**	**0.011**	0.4%	0.9%	0.002
06-07	0.014	0.020	0.023	0.036	0.072	0.071	0.066	0.114	0.110	0.114	0.092	0.051			***0.742***	***0.292***	38.1%	83.9%	0.065
05-06	0.020	0.014	0.011	0.014	0.019	0.020	0.031	0.028	0.021	0.050	0.023	0.016			***0.426***	***0.374***	24.3%	77.5%	0.023
04-05	0.012	0.010	0.010	0.008	0.014	0.014	0.053	0.012	0.020	0.040	0.020	0.011			***0.628***	***0.286***	16.9%	58.8%	0.018
03-04	0.016	0.009	0.012	0.014	0.014	0.021	0.018	0.014	0.009	0.006	0.011	0.013			***0.726***	***0.152***	11.7%	47.6%	0.015
02-03	0.014	0.010	0.009	0.008	0.010	0.011	0.007	0.003	0.009	0.016	0.015	0.008			**---**	**---**	10.1%	36.1%	0.010

Note: Maximum allowable hourly and daily averages in JS 1140/2006 are ***0.03*** and ***0.01*** ppm, respectively.
* Frequent interruptions occurred during the monitoring period at the monitoring site. However, the monthly averages were calculated to give an indication of the monthly trends in H_2S levels .

Table 5: Monthly average, and recorded max. hourly and daily average concentrations of H_2S and percentage of hourly and daily exceedances at Um Shuraik School during the monitoring period (January 2012 - December 2012) and the previuos monitoring period

Study Year	H_2S Monthly averages (ppm)														MAX (ppm)		Exceed. Of JS		
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	HAVG	DAVG	HAVG	DAVG	YAVG
2012			0.005	0.004	0.006	0.002	0.009	0.038	0.002	0.002	---	0.026	0.006	0.009	0.212	0.093	5.7%	24.8%	0.008
2011			0.003	0.002	0.003	0.001	0.001	0.001	0.003	0.002	0.002	0.003	0.004	0.005	0.142	0.019	0.3%	1.5%	0.002
2010			0.011	0.008	0.004	0.004	0.002	0.002	0.001	0.001	0.004	0.002	0.003	0.003	0.206	0.035	2.5%	7.7%	0.004
2009			---	0.011	0.006	0.010	0.003	0.005	0.002	0.003	0.004	0.009	0.015	0.009	0.139	0.035	7.4%	21.1%	0.007
07-08	0.005	0.033	0.013	0.005	0.004	0.007	0.006	0.006	0.002	0.006	0.012	0.015	0.022	0.011	0.287	0.057	11.1%	38.8%	0.010
06-07	0.091	0.042	0.044	0.054	0.001	0.005	0.026	0.018	0.015	0.024	0.005	0.026			***0.933***	***0.188***	17.7%	48.8%	0.030
05-06	0.110	0.104	0.030	0.026	0.038	0.033	0.022	0.020	0.013	0.025	0.034	0.047			***0.828***	***0.308***	26.9%	69.7%	0.038
04-05	0.055	0.064	0.050	0.018	0.049	0.040	0.027	0.014	0.031	0.017	0.036	0.058			***0.827***	***0.265***	23.9%	67.7%	0.038
03-04	0.084	0.038	0.049	0.010	0.059	0.017	0.025	0.016	0.021	0.014	0.026	0.058			***1.534***	***0.263***	21.4%	58.7%	0.035
02-03	0.043	0.026	0.013	0.022	0.027	0.008	0.017	0.009	0.012	0.008	0.017	0.024			---	---	16.5%	49.0%	0.021

Note: Maximum allowable hourly and daily averages in JS 1140/2006 are ***0.03*** and ***0.01*** ppm, respectively.

Table 6: Monthly average, recorded max. hourly and daily average concentrations of NO_2 and percentage of NO_2 hourly and daily exceedances at Electrical Training Center during the monitoring period (January 2012 - December 2012) and the previous monitoring periods

Gas Type	Study Year	Monthly averages (ppm)												MAX (ppm)		Exceed. Of JS		
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	HAVG	DAVG	HAVG	DAVG	YAVG
NO	2012	0.003	0.004	0.005	0.003	0.003	0.008	0.007	0.006	0.004	---	0.004	0.003	0.070	0.017	NA	NA	0.004
	2011	0.005	0.005	0.003	0.003	0.005	0.012	0.009	0.007	0.007	0.006	0.007	0.010	0.150	0.029			0.007
	2010	0.005	0.004	0.004	---	0.005	0.013	0.011	0.012	0.006	0.006	0.009	0.013	0.879	0.059			0.009
	2009	0.007	0.006	0.005	0.005	0.004	0.011	0.013	0.007	0.002	0.006	0.008	0.010	0.249	0.046			0.007
	2008	0.001	0.003	0.006	0.004	0.004	0.003	0.007	0.010	0.004	0.004	0.007	0.007	0.114	0.039			0.005
	2007		0.005	0.010	0.006	---	---	0.000	0.000	0.001	0.002	0.001	0.001	0.298	0.039			0.002
NO_2	2012	0.023	0.012	0.016	0.018	0.011	0.012	0.017	0.011	0.009	---	0.006	0.005	***0.574***	0.138	0.08%	0.64%	0.013
	2011	0.014	0.014	0.014	0.014	0.016	0.016	0.017	0.019	0.017	0.014	0.019	0.017	***0.142***	0.037	0.00%	0.00%	0.016
	2010	0.008	0.026	0.014	---	0.026	0.033	0.035	0.016	0.012	0.014	0.017	0.017	***0.465***	0.104	0.26%	0.75%	0.019
	2009	0.014	0.014	0.014	0.014	0.013	0.018	0.020	0.015	0.012	0.016	0.017	0.017	***0.170***	0.030	0.00%	0.00%	0.015
	2008	0.015	0.015	0.012	0.015	0.013	0.013	0.013	0.014	0.012	0.013	0.015	0.014	***0.203***	0.058	0.00%	0.00%	0.014
	2007		0.014	0.016	0.011	---	---	0.013	0.005	0.000	0.000	0.025	0.025	***0.155***	0.060	0.00%	0.00%	0.011
NOx	2012	0.026	0.016	0.021	0.021	0.014	0.020	0.024	0.017	0.013	---	0.010	0.008	0.578	0.139	NA	NA	0.017
	2011	0.019	0.019	0.017	0.017	0.021	0.028	0.026	0.026	0.024	0.020	0.028	0.027	0.202	0.051			0.023
	2010	0.013	0.030	0.018	---	0.031	0.046	0.046	0.028	0.018	0.020	0.026	0.030	0.895	0.129			0.028
	2009	0.021	0.020	0.018	0.018	0.017	0.028	0.032	0.022	0.014	0.023	0.026	0.027	0.350	0.074			0.022
	2008	0.015	0.017	0.017	0.019	0.016	0.016	0.020	0.024	0.016	0.016	0.019	0.018	0.203	0.057			0.018
	2007		0.019	0.025	0.017	---	---	0.015	0.005	0.001	0.002	0.027	0.024	0.347	0.061			0.013

Note: Maximum NO_2 allowable hourly, daily and yearly averages in JS 1140/2006 are ***0.21, 0.08 and 0.05*** ppm, respectively.

Table 7: Monthly and annual averages, recorded max. hourly and 8 hours average concentrations of *CO* and percentage of hourly and 8 hours average exceedances at the monitoring sites during the monitoring period (January 2012 - December 2012) and the previous monitoring periods

site name	Study Year	CO Monthly averages (ppm)												MAX (ppm)		Exceed. Of JS		YAVG (ppm)
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	HAVG	8 hrs	HAVG	8 hrs	
Electrical Training Center	2012	3.341	2.212	2.713	1.142	0.168	---	---	---	0.001	0.018	0.016	0.068	7.425	5.302	0.0%	0.0%	1.300
	2011	0.000	0.009	0.000	0.069	0.028	0.000	0.031	0.000	0.000	0	0	0	2.034	---	0.0%	0.0%	0.011
	2010	0.022	0.097	0.225	---	0.064	0.152	0.205	0.123	0.015	0.004	0.024	0.013	3.463	---	0.0%	0.0%	0.075
	2009					0.596	0.337	0.346	0.195	0.242	0.221	0.019	0	1.980	---	0.0%	0.0%	0.223
Ibn Al-Anbari	2012	0.242	0.538	0.005	0.110	0.055	0.000	0.000	0.000	0.001	0.002	0.189	0.136	6.123	5.404	0.0%	0.0%	0.119
	2011	0.000	0.205	0.011	0.047	0.333	0.612	0.656	0.627	0.166	0.534	0.13	0.144	5.156	---	0.0%	0.0%	0.301
	2010	0.012	0.003	0.564	0.018	0.051	0.065	0.751	0.470	0.029	0.003	0.026	0.041	2.777	---	0.0%	0.0%	0.159
	2009					0.169	0.120	0.291	0.106	0.053	0.063	0.055	0.048	2.140	---	0.0%	0.0%	0.109

Note: Maximum CO allowable hourly and 8 hours averages in JS 1140/2006 are ***26*** and ***9*** ppm, respectively.

Table 8: Monthly and annual average concentrations of CO_2 at the monitoring sites during the monitoring period (January 2012 - December 2012) and the previous monitoring periods

site name	Study Year	CO_2 Monthly averages (ppm)												YAVG (ppm)
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
Electrical Training Center	2012	645	590	360	353	307	---	---	---	594	548	518	474	501
	2011	428	371	371	327	301	260	320	333	270	311	303	250	321
	2010	386	428	449	---	371	349	316	349	359	308	297	372	354
	2009					271	373	341	385	380	360	348	284	349
Ibn Al-Anbari	2012*	468	402	414	444	398	437	335	295	653	612	240	526	434
	2011	418	448	479	489	398	424	418	352	302	466	392	425	417
	2010	484	496	386	410	405	517	512	506	417	353	271	455	434
	2009						290	339	367	383	360	490	457	383

* Frequent interruptions occurred during the monitoring period at Ibn Al-Anbari school. However, the monthly averages were calculated to give an indication of the monthly trends in CO_2 levels .

Table 9 **Monthly and yearly averages, and max. hourly and daily averages of SO_2 concentrations, and percentages of hourly and daily exceedances of monitoring sites in all industrial cites (Amman, Irbid and Karak), November 2010–November 2011 and November 2019–November 2010**

Site name	Study Period (year)													Max. (ppm)		Exceed. Of JSTD		
		July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	HAVG	DAVG	HAVG	DAVG	YAVG ppm
Sahab	2010/11					0.010	0.002	0.003	0.005	0.007	0.004	0.003	0.003	0.167	0.032	0.00 %	0.00 %	0.008
		0.004	0.001	0.005	0.002	0.006												
	2009/10	0.014	0.014	0.016	0.01	0.007	0.007	0.01	0.017	0.005	0.005	0.003	0.004	0.403	0.101	0.06 %	0.00 %	0.008
		0.006	0.010	0.004														
Irbid	2010/11					0.000	0.001	0.001	0.003	0.003	0.002	0.002	0.000	0.249	0.104	0.00 %	0.00 %	0.002
		0.002	0.004	0.008	0.001	0.000												
	2009/10	0.005	0.005	0.003	0.002	0.002	0.002	0.002	0.003	0.005	0.000	0.000	0.000	0.05	0.018	0.00 %	0.00 %	0.002
		0.000	0.000	0.000														

Table 10 **Monthly and yearly averages, and max. hourly and daily averages of NO, NO_2 and NO_x concentrations, and percentages of hourly and daily exceedances of monitoring sites in all industrial cites (Amman, Irbid), November 2010–November 2011**

Site name	Study param.														Max. (ppm)		Exceed. of JSTD		
		Nov. 10	Dec. 10	Jan. 11	Feb. 11	Mar. 11	Apr. 11	May 11	Jun. 11	Jul. 11	Aug. 11	Sep. 11	Oct. 11	Nov. 11	HAVG	DAVG	HAVG	DAVG	YAVG ppm
Sahab	NO	0.002	0.003	0.002	0.001	0.003	0.002	0.001	0.001	0.001	0.002	0.002	0.003	0.008	0.181	0.023			0.002
	NO_2	0.011	0.011	0.009	0.008	0.013	0.011	0.010	0.009	0.013	0.012	0.014	0.014	0.014	0.064	0.036	0.00 %	0.00 %	0.011
	NO_x	0.013	0.014	0.011	0.009	0.016	0.012	0.011	0.010	0.015	0.014	0.016	0.017	0.022	0.227	0.047			0.013
Irbid	NO	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.035	0.004			0.001
	NO_2	0.005	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.007	0.004	0.002	0.012	0.019	0.108	0.026	0.00 %	0.00 %	0.008
	NO_x	0.006	0.011	0.009	0.008	0.008	0.006	0.007	0.006	0.007	0.005	0.003	0.013	0.021	0.124	0.030			0.009

Table 11 Monthly and yearly averages, and max. hourly and daily averages of NO, NO_2 and NO_x concentrations, and percentages of hourly and daily exceedance of monitoring sites in all industrial cites (Amman, Irbid), November 2009–November 2010

Site name	Study param.													Max. (ppm)		Exceed. of JSTD		
		July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	HAVG	DAVG	HAVG	DAVG	YAVG ppm
Sahab	NO	0.001	0.001	0.001	0.003	0.003	0.003	0.004	0.006	0.005	0.003	0.002	0.003	0.318	0.032			0.003
		0.005	0.006	0.004														
	NO_2	0.008	0.013	0.009	0.013	0.017	0.015	0.014	0.016	0.015	0.018	0.013	0.010	0.173	0.049	0.00 %	0.00 %	0.013
		0.009	0.013	0.012														
	NO_x	0.009	0.014	0.010	0.016	0.020	0.018	0.018	0.022	0.020	0.021	0.015	0.013	0.318	0.06			0.013
		0.014	0.018	0.017														
Irbid	NO		0.001	0.001	0.002	0.004	0.002	0.002	0.003	0.002	0.001	0.000	0.000	0.349	0.02			0.002
		0.000	0.000	0.000														
	NO_2		0.003	0.004	0.007	0.009	0.006	0.007	0.011	0.009	0.007	0.005	0.004	0.026	0.030	0.00 %	0.00 %	0.007
		0.006	0.004	0.005														
	NO_x		0.004	0.005	0.009	0.013	0.009	0.010	0.014	0.011	0.008	0.005	0.005	0.383	0.047			0.008
		0.006	0.005	0.007														

Table 12 **Monthly and yearly averages, and max. hourly and 8-hour average concentrations of CO, and percentages of hourly and 8-hour average exceedance during the monitoring period, recorded at the monitoring site in Irbid, November 2010–November 2011**

Study	**CO monthly averages (ppm)**												**Max. (ppm)**		**Exceed. of JSTD**	
Period	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	HAVG	DAVG	HAVG	DAVG
2010–2011					0.760	0.523	0.488	0.562	0.611	0.572	0.602	0.616	4.81	3.07	0	0
	0.666	1.035	1.028	0.896	1.012											
2009–2010	0.202	0.137	0.097	0.071	0.099	0.078	0.068	0.075	0.176	0.223	0.366		4.19	3.17	0	0

Table 13 **Monthly and yearly averages, and max. daily average concentrations of PM2.5 and percentages of daily average exceedances during the monitoring period recorded, at all monitoring sites in Jordan, November 2010–November 2011 and November 2009–September 2010**

Site name	Study period	$PM_{2.5}$ monthly averages (ppm)																
		July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March		April	May		June	MDAVG μ/m³	Exceed. of JS DAVG	YAVG μ/m³
Irbid	2010–2011					27	36	-	-	-	17		25	23		156	1.7 %	27
		30	30	29	34	33												
	2009–2010			16	24	26	41	-	-	53	32		30	23		423	11.9 %	36
		26	100	21														
Sahab	2010–2011					44	308	56	39	39	34		26	19		1102	10.7 %	51
		22	26	73	40	27												
	2009–2010			25	52	50	43	30	53	36	37		46	41		271	14.7 %	43
		48																
Karak	2010–2011					24	66	35	59	46	39		46	210		612	13.6 %	51
		59	28	32	32	18												
	2009–010			30	24	31	35	29	35	40	33		53	71		302	15.1 %	46
		48	88	61														

Annex 3

Waste characteristics

Background information			
#	**Parameter**	**Unit**	**Value**
	Population	No	6 388 000
	Municipal solid waste (MSW) generation	Tonne/year	2 077 215
Composition of MSW **Food waste** **Dry recyclables** **Paper and cardboard waste** **Glass** **Metals** **Plastics** **Others**		 % % % % % % %	 50 34.5 15 2 1.5 16 15.5
	MSW per capita generation: urban rural	 Kg/capita/day Kg/capita/day	 0.9 0.6
	Estimated MSW general annual growth	%	3
	Hazardous industrial waste generation	Tonne/year	45 000
	Medical waste generation	Tonne/year	4 000
	Agricultural waste generation	Tonne/year	> 4 million
	Packaging waste generation	Tonne/year	700 000
	Construction and demolition waste generation (Amman)	m^3/year	2.6 million
	Scrap tyres generation	No/year	2.5 million
	Waste oil generation	Tonne/year	10 000–15 000
	E-waste generation	Piece/year	30 000
Technical performance — MSW			
	MSW collection/ sweeping coverage: urban rural	 % %	 90 70
	MSW final destination: **Recovered** **Composted** **Landfilled** **Engineered landfill dumpsite**	 % % % %	 **7** **0** **48** **45**
	Number of containers	No	50 000
	Number of transport vehicles	No	1000
	Number of workforce	No.	10 000
	Number of MSW engineered landfills	No	1
	Number of MSW dumpsites	No	21
	Number of MSW large composting plants	No	0
	Number of MSW MRFs	No	1 Offline
	Number of cardboard recycling plants	No	8
	Number of metal recycling plants	No	5

Table waste characteristics (cont.)

	Number of plastics recycling plants	No	5–10
Financial performance — MSW			
	Total costs	M JOD	51
	Total revenues	M JOD	23.6
	Cost recovery Amman Other municipalities, average	% %	60 30
Technical performance — other waste streams			
	Number of hazardous industrial waste treatment centres	No	1
	Number of medical waste treatment units	No	~30
	Number of manure composting plants	No	1
	Number of scrap tyre recovery plants	No	15
	Number of scrap tyre recycling plants	No	2
	Medical waste treated in existing facilities per year	%	50
	Hazardous industrial waste treated and/or stored in Swaqa per year	%	10–20

Source: Country Report on Solid Waste Management Situation in Jordan, Ministry of Environment, 2001.

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