



**USAID** | **JORDAN**  
FROM THE AMERICAN PEOPLE

# WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH-I-00-08-00024-00 ORDER NO. 04

## SUSTAINABLE BIOSOLIDS BENEFICIAL USE: POULTRY AND LIVESTOCK WASTE STREAMS AND MANAGEMENT ALTERNATIVES - Revised 30 JULY 2015

IMPLEMENTED BY AECOM

July 2015

This document was produced for review by the United States Agency for International Development. It was prepared by AECOM.



# WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH-I-00-08-00024-00 ORDER NO. 04

## **SUSTAINABLE BIOSOLIDS BENEFICIAL USE: POULTRY AND LIVESTOCK WASTE STREAMS AND MANAGEMENT ALTERNATIVES – REVISED 30 JULY 2015**

Submitted to:  
USAID Jordan

Prepared by:  
AECOM

**DISCLAIMER:**

The authors' views expressed in this document do not necessarily reflect the views of the United States Agency for International Development or the United States Government.



## Table of Contents

1. Background.....	1
1.1. Report Scope.....	1
1.2. Amount and Characterization of Livestock Manure in Jordan.....	1
1.2.1. Amount of generated animal manure: .....	1
1.2.2. Characterization of animal manure:.....	2
2. Legal Framework for Manure Handling in Jordan .....	5
2.1. Licensing and Registration of Dairy and Poultry Farms .....	5
2.2. Licensing of Organic Fertilizers Manufacturers (Producers).....	6
2.3. Inspection and Monitoring .....	9
2.4. Ministry of Agriculture (MoA).....	10
3. Collection of Information on Handling and Processing of Animal Manure in Jordan.....	12
3.1. Literature Review .....	12
3.2. Animal Production Enterprises .....	12
3.2.1. General Findings and Conclusions.....	17
3.3. Treaters of Animal Manure.....	18
3.3.1. Questionnaire and interviews .....	18
3.3.2. General Findings and Conclusions.....	20
3.4. Farmers Using Animal Manure in Agriculture.....	20
3.4.1. Questionnaire and sample size .....	20
3.4.2. Animal manure application .....	21
3.4.3. General Findings and Conclusions.....	23
4. General Conclusions and Recommendations.....	25
4.1. Farmers' Awareness .....	25
4.2. Present Legislations and Regulation on Management of Livestock Manure ....	26
4.3. The Role of Livestock Producers .....	26
4.4. Promotion of Technologies.....	26
4.5. Enforcement of Legislation.....	26
4.6. Planning for the Future .....	26

## LIST OF ACRONYMS

DM	Dry Matter
EC	Electrical Conductivity
GAM	Greater Amman Municipality
HHV	Higher Heating Value
JVA	Jordan Valley Authority
JSMO	Jordan Standards and Metrology Organization
MoA	Ministry of Agriculture
MoEnv	Ministry of Environment
MoIT	Ministry of Industry and Trade
MoMA	Ministry of Municipal Affairs
MoWI	Ministry of Water and Irrigation
NPK	Nitrogen, Phosphorus, Potassium
PTAP	Producers and Traders of Agricultural Products
TN	Total Nitrogen
TS	Total Solids
VS	Volatile Solids
WAJ	Water Authority of Jordan
WREC	Water Reuse and Conservation

## 1. Background

The USAID Water Reuse and Environmental Conservation Project (WRECP) works throughout Jordan in institutional capacity building, pollution prevention for industries, solid waste and wastewater management, and water reuse. The project goal is to protect and conserve scarce resources through regulation, *education*, and coordination with industry, local communities and the private sector. The project is implemented by AECOM and a team of international and Jordanian partner firms. This five-year project has four primary tasks:

- Task 1 – Institutional and Regulatory Strengthening
- Task 2 – Pollution Prevention and Industrial Water Management
- Task 3 – Disposal Sites Rehabilitation and Feasibility Studies
- Task 4 – Water Reuse for Community Livelihood Enhancement, including Biosolids

As part of Task 4, the project team studied livestock manure in order to address fly and odor issues as well as risk of pathogen contamination. The study was in two stages: in the first stage the project studied and reported on the amount and characterization of poultry and livestock waste in Jordan. That information was presented in the report titled *Amount and Characterization of Dairy Cattle Manure and Poultry Litter in Jordan*, August 2014. In the second stage, the project reviewed the handling and use of manure in the Kingdom. That review is the subject of this report.

### 1.1. Report Scope

This report reviews current livestock waste management in Jordan, from production, collection, and treatment through distribution and application in agriculture. It also reviews the regulatory framework governing the entire cycle of licensing, producing, handling, storing, transporting and finally using as organic fertilizers. The final section draws conclusions and makes recommendations.

Based on the results of the above investigations, the Government of Jordan should be able to produce a cohesive strategy and plan for the sustainable, viable and economic use of animal manure, in an environmentally sound and socially acceptable manner.

Please note that the use of animal waste as an alternate fuel source was not investigated in this report due to time limitations. However, use of animal waste as an alternate fuel source should be investigated further, potentially through support of other donors and demonstration pilots.

### 1.2. Amount and Characterization of Livestock Manure in Jordan

The findings of the first stage of this study were published in August, 2014 in a report titled *Amount and Characterization of Dairy Cattle Manure and Poultry Litter in Jordan*. The major findings are discussed in the remainder of this section.

#### 1.2.1. Amount of generated animal manure:

Manure production from dairy cattle and poultry (chickens) was approximately 0.49 million tons DM in 2012 and when combined with bedding material, 0.52 million tons DM. Of the 0.52 million tons DM produced, approximately 0.45 million tons could be

considered collectible for beneficial use or disposal. Refer to Table 1-1 for additional information.

**Table 1-1. Dairy cattle manure and poultry litter production in Jordan (2012)**

	Population	Manure Production (million ton DM per year)	Bedding Material (million ton DM per year)	Total (million ton DM per year)	Manure Collectability %	Potential Collected Amount of Manure (million ton DM per year)
Dairy cattle	Milking cows: 48,742 Others: 17,258	0.151	-	0.151	70-75	0.106-0.113
Broilers	196 million birds per year (28 million per cycle, 7 cycles per year, 42-day growing period)	0.2254	0.0294	0.255	90-95	0.230-0.242
Layers and parent stock	10.79 million birds (6.8 million layers and 3.99 million parent stock)	0.112	0.0004	0.1124	90-95	0.101-0.107
<b>Totals</b>		<b>0.4884</b>		<b>0.5184</b>		<b>0.436-0.462</b>

From Table 1.1 above:

- Cattle manure contributed 29.1% of the total manure production (0.151/0.5184 x 100%)
- Poultry manure contributed 30.9% of the total manure production ((0.2254+0.112) / (0.5184) x 100%)
- The proportions of bedding material in broilers and laying litters were 11.5% (0.0294/0.255) X 100% and 0.36% (0.0004/0.1124) x 100%, respectively.

### 1.2.2. Characterization of animal manure:

The percent of total solids (TS) varied from 48.2% to 66.2% for cattle manure and from 20.5% to 38.6% for poultry manure. Percent volatile solids (VS) averaged 72.0% and 80.3% for cattle and poultry manure, respectively. Percent ash in the dry matter of cattle manure was higher (28%) than that of poultry litter (20%). This may be attributed to the practice of scraping manure from dirt lots in dairy farm facilities.

Percent organic carbon varied from 4.0% to 14.0% for cattle manure and from 1.0% to 5.1% for poultry litter. Overall means of organic carbon were 6.1% and 3.1% for cattle manure and poultry litter, respectively.

The relative proportion of C:N was 3:1, 5:1 and 2:1 for cattle manure, and 1:1, 2:1 and 0.2:1 for poultry litter. These C:N ratios are low, and the composting of these manures will be incomplete.

The higher heating value, HHV (gross energy, heat of combustion, and calorific value) varied between 2.694 and 4.045 Kcal/g and averaged 3.192 and 3.160 Kcal/g for cattle and poultry manures, respectively. It was surprising that the HHV for cattle



manure and poultry litter proved similar, given that the percent ash was higher (28%) in cattle manure than it was in poultry litter (20%).

Cattle manure was alkaline (pH=8.7) whereas poultry litter was acidic (pH=6.3). Electrical conductivity (EC), which is an indication of soluble salts, was higher for poultry manure (15,153  $\mu\text{s}/\text{cm}$ ) than for cattle (10,880  $\mu\text{s}/\text{cm}$ ). Long-term or excessive application of manures with high EC can lead to a build-up in soluble salts in the soil, particularly in medium and fine textured soils having low infiltration rates, and especially in arid areas receiving low precipitation.

The total nitrogen (organic and inorganic N fractions) averaged 2.6% and 3.9% for cattle and poultry manures, respectively. The TN is not an informative criterion, either for availability of N to plants or as an indication of N losses through volatilization, denitrification or leaching after application. The ammonium-N ( $\text{NH}_4\text{-N}$ ) represents the inorganic N fraction commonly occurring in manure, which is plant available. It ranged from 0.11% to 0.15% for cattle manure compared to 0.47% to 0.67% for poultry manure.

Percent P was 1.1 in cattle manure and 1.6 in poultry litter, which could be attributed to the diet composition of cattle versus poultry. The diet of poultry is made up primarily of corn and soybeans containing P bound in the phytate-phosphorous form, which is unavailable to the bird.

Mineral composition of cattle and poultry manures varied widely. Potassium, Magnesium and Sodium concentrations were higher (21454, 12376 and 5234 mg/kg DM) for cattle manure than those for poultry manure (15935, 8426, 1563), respectively. The concentrations of Calcium, Boron, Zinc, and Manganese were higher (14905, 39, 327 and 438 mg/kg DM) in poultry manure compared to those in cattle manure (13223, 31, 125 and 244 mg/kg DM), respectively.

Bulk density ( $\text{g}/\text{cm}^3$ ) averaged 0.27, 0.36 and 0.33 for cattle manure, layers litter and poultry litter, respectively.

Table 1-2 summarizes the properties of the dairy and poultry manure.

USAID Water Reuse and Environmental Conservation Project  
Sustainable Biosolids Beneficial Use: Poultry and Livestock Waste Streams and Management Alternatives

**Table 1-2: Characterization of collected dairy and poultry manure**

Parameters	Unit	Dairy Cattle			Poultry Manure Samples		
		D1	D2	K3	ZLH4	ABR2	HBR3
<b>Physical</b>							
Moisture content	%	48.2	66.2	62.9	38.6	24.5	20.5
Dry matter	%	51.8	33.8	37.1	61.4	75.5	79.5
TVS, in the dry matter	%	70.1	72.2	73.8	84.6	82.0	74.3
Ash, in the dry matter		29.9	27.8	26.2	15.4	18.0	25.7
<b>Chemical</b>							
pH (1:5)	-	8.76	8.54	8.77	6.14	6.95	5.66
EC (1:5)	µs/cm	12090	10040	10510	12540	15860	17060
NH <sub>4</sub> -N	%	0.105	0.108	0.146	0.471	0.670	0.606
NO <sub>3</sub> -N	mg/kg dry weight	2.11	19.1	4.93	1.02	1.52	1.56
Total Nitrogen	%	2.55	2.62	2.59	4.54	3.27	3.96
Organic Carbon	%	6.5	14.0	4.0	1.0	5.1	4.0
C:N ratio	-	6:3	14:3	4:3	1:5	5:3	4:4
Potassium (K)	%	2.3	2.2	1.9	2.0	1.6	1.2
Calcium (Ca)	%	1.0	9.5	2.0	0.8	1.6	2.1
Magnesium (Mg)	%	1.2	1.3	1.2	0.96	0.84	0.72
Sodium (Na)	%	0.55	0.56	0.52	0.19	0.15	0.13
Boron (B)	mg/Kg dry weight	36	40.8	16.8	57.3	38.1	20.1
As	mg/Kg dry weight	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cd	mg/Kg dry weight	<0.25	<0.25	<0.25	0.260	0.28	0.36
Cr	mg/Kg dry weight	4.24	3.99	4.99	11.70	12.40	4.33
Hg	mg/Kg dry weight	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mo	mg/Kg dry weight	11.5	9.68	18.8	8.5	13.2	12.5
Ni	mg/Kg dry weight	5.04	2.70	4.23	2.50	3.29	2.20
Se	mg/Kg dry weight	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb	mg/Kg dry weight	4.77	<4.5	<4.5	<4.5	<4.5	<4.5
Zn	mg/Kg dry weight	123	141	112	468	265	248
Cu	mg/Kg dry weight	21.4	22.8	18.3	35.9	28.5	24.1
Mn	mg/Kg dry weight	283	236	212	522	473	319
<b>Biological</b>							
Intestinal worm Eggs	viable eggs/4g	<1	<1	<1	<1	<1	<1
<i>E. coli</i>	MPN/g	1.8×10 <sup>3</sup>	1.3×10 <sup>3</sup>	6.3×10 <sup>4</sup>	3.9×10 <sup>3</sup>	2.78	11.7
<i>Salmonella</i>	MPN/g	<3	<3	<3	<3	<3	<3

D1 & D2 from Dhulail, K3 from Khalideyah, ZLH4: Zizia Layers, ABR5: Al Esh Broilers, HBR6: Hebraas Broilers.

## 2. Legal Framework for Manure Handling in Jordan

The legislative framework that governs the entire cycle of licensing, producing, handling, storing, transporting and finally using organic fertilizers involves a number of entities and can therefore be very complex. The details of the legal framework governing organic fertilizers were generally discussed in the *Amount and Characterization of Dairy Cattle Manure and Poultry Litter in Jordan*, August 2014. This more detailed legal review will look into legislation issued by MoA, MoEnv, MWI, WAJ and JVA, MoIT, MoH, MoMA, and JSMO as well as any other legislation deemed relevant by the team.

### 2.1. Licensing and Registration of Dairy and Poultry Farms

Regulating manure handling starts by mandating that all poultry and dairy cattle farms to collect raw manure in an appropriate, dry and airtight place (stockpiling manure) until it is sold to local contractors. Below we have summarized current legislations regulating the process of licensing poultry and dairy cattle farms:

- MoA's Instructions for Licensing and Regulating Poultry Farms and Hatcheries No. Z / 4 " ز / ٤ " for the year 2003 and its amendments. Article 9 states that all poultry farms should collect raw manure in an appropriate, dry and airtight place (stockpiling manure) until it is sold.
- MoA's Instructions for Licensing and Regulating Dairy Cattle Farms No. Z / 5 " ز / ٥ " for the year 2003 and its amendments. Article 10 states that all dairy cattle farms should collect raw manure in an appropriate, dry and airtight place (stockpiling manure) until it is sold.
- MoA's Instructions for Licensing and Regulating sheep Farms No. Z / 8 " ز / ٨ " for the year 2012. Article 10 states that all sheep farms should collect raw manure in an appropriate, dry and airtight place (stockpiling manure) until it is sold.
- MoA's Instructions for Licensing and Regulating feedlots for beef production No. Z / 12 " ز / ١٢ " for the year 2012. Article 10 states that all feedlots for beef production should collect raw manure in an appropriate, dry and airtight place (stockpiling manure) until it is sold.
- MoA's Instructions for Licensing and Regulating feedlots for fattening sheep and goats No. Z / 7 " ز / ٧ " for the year 2012. Article 10 states that all feedlots for fattening sheep and goats should collect raw manure in an appropriate, dry and airtight place (stockpiling manure) until it is sold.
- MoEnv Instructions for the Selection of Development Activities' Sites for the year 2011. These instructions apply to all sites of development activities including agricultural activities. Accordingly; all development activities should obtain the licensing committee's approval for the site of the development activity.
- MoEnv Instructions for Organizing the Storage, Transport and Treatment of Organic Fertilizers and their Trading. As a pre-requirement for the licensing of poultry and dairy cattle farms, these instructions offer detailed provisions that specify the requirements of on-farm manure collection sites. These requirements are:
  - The collection sites should not be within the boundaries of the Greater Amman Municipality and other municipalities.
  - The distance between the collection site and the boundaries of municipalities and / or sensitive populations, residential areas, schools,

hospitals, houses of worship, should not be less than 2 Km, and not less than 1km to main roads, groundwater wells, or any water body.

- The distance between the collection site and a licensed poultry farm should not be less than 1 Km.
- The area of the collection site must be sufficient for the amount of collected manure.
- The collection site should be fenced to avoid the dispersal of manure.
- The manure should be covered with a material that allows ventilation and prevents the dispersal of manure.
- The manure collection site can be established within the treatment plant as long as all the above mentioned requirements are fulfilled.

Although MoA and MoEnv instructions require all farms to provide an appropriate, dry and airtight place for manure stockpiling, most farms do not provide such a place, and the manure accumulates inside the farms until it is sold and collected by licensed transporters. The frequency of collecting accumulated manure varies based on the type of poultry; for instance, manure from broilers for meat production farms is removed every 45-60 days, while at farms for layers (for table egg production) and breeders, it is removed every 20 months. Moreover, accumulated manure in cattle farms is collected once-twice a year.

For off-farm trucking and transporting of raw manure, the MoEnv instructions require that water content of raw manure be less than 40%; moreover, as a general rule; transporters should be licensed by the Drivers and Vehicle Licensing Department, and should report to the MoEnv the number and loads of vehicles used in transporting manure and update this information regularly. In most cases, producers of organic fertilizers are the transporters. The licensing of manure transporters is not clear in the legislations.

## **2.2. Licensing of Organic Fertilizers Manufacturers (Producers)**

Licensing of organic fertilizers manufacturers is regulated by MoA Instructions for Licensing Requirements for the Production, Processing, Storage, Handling and Trading of Agricultural Fertilizers and Plant Growth Regulators No. Z / 10 “ ز / ١٠ ” for the year 2014.

These regulations require that organic fertilizers should be treated and manufactured by a registered manufacturer. The pre-requirements for the license include but are not limited to:

- Registration in MoIT
- Approval from the Central Licensing Committee (MoEnv)
- Professions Permit (MoMA)
- Enrolment Certification in the Association for the Producers and Traders of Agricultural Products (PTAP)

There are no prerequisites for the MoIT registration process. For the PTAP Association membership, the manufacturer needs to obtain a professional permit and be registered in MoIT.

MoEnv Central Licensing Committee investigates collection and manufacturing sites to ensure that they lie within the distance limits that are specified in the MoEnv's

Instructions. The Central Licensing Committee consists of representatives from the following ministries and entities:

- The Ministry of the Environment
- The Ministry of Municipal Affairs
- The Ministry of Health
- The Ministry Agriculture
- The Ministry of Water and Irrigation
- Energy and Minerals Regulatory Commission
- Jordan Food and Drug Administration
- The Greater Amman Municipality

Only when the licensing committee issues its approval can the manufacturer proceed to get the final approval from the MoA.

MoA instructions also include requirements for the production site, phases of manufacturing, manufacturing machinery and equipment, and manufacturing halls. Requirements that should be fulfilled in order to obtain the organic fertilizers manufacturer license are divided into four groups:

**Group 1:** Requirements for the organic fertilizers treatment facility (production site):

- The site should be in an industrial zone unless the production site is outside municipalities boundaries.
- The site should be approved by the concerned authorities.
- The buildings of the treatment facility that is located outside the industrial zones should be separated from the surroundings with a concrete wall at least two meters high and with secured gates that are appropriate for pedestrian and vehicles movement and for emergencies.

**Group 2:** Requirements that should be fulfilled during the different phases of manufacturing:

- The treatment facility should include a separate hall for processing raw materials.
- The treatment facility should include a separate hall for processing and packaging the final product.
- Administrative buildings should be separate from the production area and warehouses of raw materials.
- The treatment facility should include separate storage areas for raw material and final products.
- The treatment facility should include a laboratory to confirm the quality of the product. The laboratory should be fully equipped and separated from the warehouses. The manufacturer can contract any qualified private or governmental laboratory to conduct these tests.

**Group 3:** Requirements that should be present in the equipment and machinery used in manufacturing:

USAID Water Reuse and Environmental Conservation Project  
Sustainable Biosolids Beneficial Use: Poultry and Livestock Waste Streams and  
Management Alternatives

- In accordance with the Jordanian labor law, public and occupational health and safety measures should be taken into account to prevent mishandling of machinery and thus accidents.
- The equipment and machinery should be made of non-corrosive and rust-resistant materials. The machinery should be covered during manufacturing processes and the raw materials feeding process should be automated.

**Group 4:** Requirements that should be present in the manufacturing halls:

- The treatment facility should include a separate hall for the preparation of raw material.
- The treatment facility should include a separate hall for the processing and packaging of the final product.
- The treatment facility should include a separate hall for staff personal use based on the number of workers.
- The treatment facility should include a number of toilets and showers based on the number of workers.
- The treatment facility should be established on an appropriate area based on the number of workers, number and size of machines.

The manufacturer license is renewed annually. A request to register agricultural fertilizers will not be considered unless the applicant is licensed for the purposes of importing, manufacturing or trading of fertilizers. In addition, trading any organic fertilizer by a licensed producer before it is registered by the MoA is prohibited.

In order to be able to trade treated manure/ organic fertilizers, all fertilizers should be registered in the MoA, through the "Committee for the Registration of Organic Fertilizers and Growth Regulators". The group consists of the following individuals:

- Head of Lands and Irrigation Directorate
- Head of Agricultural Fertilizers Department
- Representative of the National Center For Agricultural Research and Extension
- Representative of Agriculture Faculty/ Jordanian Universities
- Representative of Agricultural Engineers Association
- Two representatives of The Association for the Producers and Traders of Agricultural Products

The prerequisites for registering organic fertilizers include:

- Analysis certificate from an accredited laboratory
- Analysis certificate of heavy metals in organic soil fertilizers organic soil conditioners
- A certificate that the organic soil fertilizers and organic soil conditioners are free of bacteria, fungi, nematodes and pathological, pests and animal harmful diseases
- Analysis certificate of raw materials for up to 100%
- Labeling of organic fertilizers and conditioners
- A 100Kg sample of the organic fertilizer (supplied by the manufacturer) for testing purposes

Organic fertilizers should only be registered in the MoA and not in MoIT. This registration should be renewed every 5 years.

MoA instructions regulate the licensing of shops selling agricultural products and fertilizers, and specify the final product presentation of the traded organic fertilizers products.

Import of organic fertilizers became prohibited less than a year ago (unless of plant origins), a decision taken in order to protect the local product and because the actual origins of the imported product are not clear.

### 2.3. Inspection and Monitoring

The entities responsible for the inspection and monitoring of organic fertilizers' transportation and production are the Ministry of Agriculture (MoA) and the Ministry of Environment (MoEnv). Within MoE, the Environmental Monitoring and Inspection Directorate and the Rangers are responsible. In MoA, the Fertilizers and Growth Regulators Department and the MoA directorates in the governorates are responsible for inspection and monitoring as per the team's meetings with the head of its department.

#### **Environmental Inspection and Monitoring Directorate in MoEnv and the Rangers**

The Environmental Monitoring and Inspection Directorate within MoEnv is responsible for carrying out the inspection and monitoring duties as outlined in the **Regulation for Environmental Monitoring and Inspection No. 65 for the year 2009** and the **Instructions for Environmental Auditing**. The **Regulation for Environmental Monitoring and Inspection No 65 for the year 2009** aims to ensure the monitoring of facilities so as to ensure compliance with environmental legislation. It also aims to regulate the procedures of environmental inspection. Article 5 of the Regulation divides facilities into three categories for the purposes of environmental inspection and sets out the criteria for the basis of categorization. Facilities subject to these regulations are those subject to environmental licensing; these regulations follow up on the conditions upon which the environmental license has been granted.

The rangers are responsible for the inspection and monitoring of organic fertilizer transporters. This can be done at two points: the exit point from the big animal farms and the entry point to the end users' (farmers') facilities.

MoEnv has additionally issued instructions specific to organic fertilizers titled: **Instructions for the Storage, Transport, Treatment and Marketing of Organic Fertilizers for the year 2009**. As per these instructions, untreated organic fertilizers at the source must have a moisture content that does not exceed 40% and must be transported by a vehicle that satisfies the minimal Jordanian technical standards per the Directorate for the Licensing of Drivers and Vehicles and per JSMO. Additionally, the transporter has to provide and constantly update MoEnv with the number of and the loadings of the vehicles transporting the organic fertilizers.

Section 6 of the same Instructions concerns Environmental Monitoring and Inspection. Article 17 of the Instructions stipulates the following:

“It is prohibited to have untreated organic fertilizer enter the Jordan Valley; this should extend to include the rest of the Kingdom within a year of the issuance of these instructions”.

The same Article also states that a “mechanism needs to be put in place and agreed upon for the tracking of untreated organic fertilizer from where it is produced to the treatment facility.” As per the team’s meetings with the MoE Environmental Monitoring and Inspection Directorate, this mechanism is not yet in place.

Furthermore, Article 20 of these Instructions stipulates:

- a. “JSMO’s conditions for organic fertilizers as outlined in Technical Standard No 962 need to be met.”
- b. “The characteristics of the produced organic fertilizer need to be shown through analysis by a neutral lab. Additionally, the treatment process must be compliant with Article 9 of the same Instructions, and the disinfection certificates of the lab analysis need to be shown based on the produced quantities, such that one test is conducted per each 30,000 tons of produced treated organic fertilizer per year increasing gradually such that the minimum number of samples taken per year is 5.”

However, while the relevant regulations and instructions exist in MoEnv for monitoring and inspection, some gaps remain:

- 1) In the **Instructions for the Regulation of the Storage, Transport, Treatment and Marketing of Organic Fertilizers for the year 2009**, the exact mechanism of inspection, monitoring and tracking of untreated manure is still non-existent as per the team’s meetings with the Directorate for Environmental Monitoring and Inspection.
- 2) While the legislations can be said to be in place and relatively well-developed, the actual practice of them is not active. Meetings with the Directorate for Environmental Monitoring and Inspection revealed that inspection of organic fertilizer producers is not active and that inspection is conducted only upon the receipt of complaints. The main burden of inspection falls upon the rangers who report any violations to the Directorate of Environmental Monitoring and Inspection.

#### 2.4. Ministry of Agriculture (MoA)

While MoEnv has regulations and instructions in place for monitoring and inspection, MoA’s legislation is not quite as clear-cut regarding the inspection of organic fertilizers. The following details are relevant however:



MoA's **Instructions for the Analysis and Testing of Agricultural Fertilizers and Plant Growth Regulators No. Z/8 “ج/٨” for the year 2014** state that JSMO's relevant technical standards apply when taking samples.

Moreover, MoA, in Article 5 of its **Instructions for the Conditions for Licensing for the Production of Agricultural Fertilizers and Plant Growth Regulators, Preparing, Storage, Handling, Marketing and Declaring No. Z/10 “ج/١٠” for the year 2014**, states the following:

“The Minister of Agriculture has the right to have an inspector do field visits based on Article 64 of the Temporary Agriculture Law No 44 for the year 2004 to inspect fertilizer and growth regulators producer factories and check for any violations. The inspector additionally has the right to take random samples of either the final products or the primary substances whether from the production lines or the stores in order to conduct analyses and ensure compliance with local and international regulations adopted by the Ministry.”

The project team held a meeting with MoA, specifically the Head of the Department for Agricultural Fertilizers and Soil Conditioners. During this meeting, it was stated that the Department for Fertilizers and Plant Growth Regulators is the responsible entity for monitoring, inspection and quality control as concerns organic fertilizers. This Department works through MoA's individual directorates in the municipalities, with the headquarters conducting occasional periodical visits of inspection. The MoA directorates, each of which has its own inspection plan, are provided the registered fertilizers on a quarterly basis. These directorates provide MoA with quarterly reports on the producing and importing factories as well as the places that sell.

The Head of the Department for Agricultural Fertilizers and Soil Conditioners further indicated that MoA's Department for Agricultural Fertilizers and Soil Conditioners works in close cooperation with the Rangers as the Rangers have the legal power to issue violations. He also noted that the main locations of the environmental patrols are at the big farms and at the entrance of the Jordan Valley, and that an average of 5-6 transporter vehicles are caught in violation daily.

The average number of violations per year according to the head of the department for Agricultural Fertilizers and Soil Conditioners is 5-10 out of 307 registered factories that import and produce fertilizer.

Additionally, there is an Inspection directorate within MoA which is responsible for internal inspection of MoA. However, sometimes the Department for Agricultural Fertilizers and Soil Conditioners recruits their help. Meetings with the Association for the Producers and Traders of Organic Fertilizers indicated that, while MoA has an inspection role, this role is not an active one.

### **3. Collection of Information on Handling and Processing of Animal Manure in Jordan**

#### **3.1. Literature Review**

The published information on handling and processing of livestock manure in Jordan is scant. Deficient information on processing of animal manure in the country could be attributed to the fact that both the public and private sectors still view manure as a waste and not as an economic resource.

The USAID Water Reuse and Environmental Conservation (USAID WREC) project team therefore decided to collect information on handling and processing of animal manure from three main resources: animal production enterprises (producers), treaters of animal manure (merchants and companies), and application of animal manure in agriculture (farmers or end users).

#### **3.2. Animal Production Enterprises**

The project team visited three large dairy cattle farms in Dhlail in Zarqa Governorate and in Al-Khalidiyyeh in Mafraq Governorate. Around 60% of the total dairy cattle farms in Jordan are located in these districts. The visited farms were Baladna Cattle Farm and Teeba Dairy Farm in Dhlail, and Hamoudeh Modern Dairy Farm in Al Khalidia.

##### **Baladna Cattle Farm**

The overall impression at this approximately 2,000-head farm, was that operations are properly run without violation of any local environmental quality standards. Water supply is from a fresh water well (700 – 1,200 mg/L TDS). The water is treated with Reverse Osmosis. Onsite water demand is about 70 m<sup>3</sup>/day for watering livestock and 250-350 m<sup>3</sup>/day for wash-down following the three times per day milking. As Figures 3-1 and 3-2 show, there is a separator and lined evaporation ponds for effluent treatment/disposal.

Tractors go round the feedlots three times per day to mix soil and make sure it is maintained dry (see Figure. 3-3). This reduces incidence of animal diseases. Manure is collected and trucked off site to a composting facility (see Figure. 3-4), but the wastewater is disposed of at Al-Akader by tankers.

USAID Water Reuse and Environmental Conservation Project  
Sustainable Biosolids Beneficial Use: Poultry and Livestock Waste Streams and  
Management Alternatives



Figure 3-1: A milking facility, drains to wastewater collection/prereatment/disposal



Figure 3-2: Lined wastewater ponds



Figure 3-3: Tractor mixing manure and soil to make sure it is kept dry



Figure 3-4: Trucking manure to a composting facility.

### Teeba Dairy Farm

We spoke briefly to the farm manager but did not tour the facility. Information obtained was as follows:

- Herd size is around 1500 head
- Liquid waste is taken to Al-Ekeder for disposal
- Manure volume is 4,000 to 5,000 m<sup>3</sup>/year
- Manure collection from the cattle barracks is done by Teeba and not by the local contractor. Hence, the sale price of manure is set to cover operational costs
- Contractors collecting manure need to provide license from the Ministry of Environment (MoEnv) to validate that they do manure fermentation
- Manure is sold to a local contractor for JD1-3 per m<sup>3</sup>

### **Hamoudeh Modern Dairy Farm**

This is a large livestock operation – herd numbers at about 4,000. Each animal reportedly produces about 30 to 35 kg wet manure per day (about 6 kg dry solids/day). Manure production is 12,000-16,000 m<sup>3</sup>/year at 10 to 12% moisture content. Wet manure is collected from feedlots and milking areas. The manure collected in the feedlots is dried/mixed with base material – soil and dried manure – using a farm tractor with a rear-mounted plow attachment. The goal is to promote good housekeeping practices such as proper solar drying (see Figure 3-5).

Approximately 2,000 m<sup>3</sup>/year of the manure is collected for composting; part of this compost is used as an organic fertilizer for Hamoudeh's tree farms (mainly olive trees) and the remainder sold in bulk or bagged for JD4.5/m<sup>3</sup> (see Figure 3 6). The idea of composting was reportedly first proposed to Hamoudeh by a GIZ-MoA initiative; however, the cost for composting is high and the demand for compost too low to justify the costs. The remaining 2,000 to 3,000 m<sup>3</sup>/year of raw manure is sold to manure merchants.



Figure 3-5: Solar drying of manure piles.



Figure 3-6: Bagged compost showing its characteristics

The composting area is an open air facility that receives manure from local livestock operation. The manure is formed into piles and turned over periodically with front-end loaders. There is no mixing of manure with amendment. In winter the piles are not turned; in summer piles are turned 1 to 2 times per week. Water is added as required for process control. The process of watering and mixing continues for approximately 45 days and the manure pile is left to reach a temperature of 70°C. Subsequently, it is transported to the mechanical processing equipment.

Mechanical processing equipment includes three sets of hoppers/inclined conveyors – arranged in series inside a building (see Figure 3-7). A pile of finished “compost” product was present and a sample taken. Pesticide is used to control flies. The first hopper is equipped with a vibrating bar rack – with spacing of about 100 mm (see Figure 3-8). Texture of the material was uniform and much like peat moss. Estimated dry solids were over 90%. The facility was not in active operation during our visit.

USAID Water Reuse and Environmental Conservation Project  
Sustainable Biosolids Beneficial Use: Poultry and Livestock Waste Streams and  
Management Alternatives



Figure 3-7: Mechanical processing equipment



Figure 3-8: Vibrating Bar Rack with Spacing of about 100 mm.

The farm is equipped with a small wastewater treatment plant. Wastewater generated from farm operations is pumped into a holding tank(s) and clarifier. All units were observed to be operating in a highly anaerobic regime (see Figure 3-9).

Some of the environmental challenges facing the Hamoudeh cattle farm are the illegal disposal of wastewater and solid manure near the farm location. Manure piles are left for long periods of time and burning piles were seen (Figure 3-10).



Figure 3-9: Different parts of the wastewater treatment unit



Figure 3-10: Burning manure pile found near Hamoudeh Cattle Farm

During the visits to the dairy cattle farms the project team observed several sites in Dhlail and Halabat areas where manure is dumped in piles, and wash-down/agricultural wastewater from livestock operations is discharged from tanker trucks to unlined “ponds” posing direct threat for polluting the ground water sources in Dhlail and Halabat areas (see Figure 3-11). Additionally, a number of dead cows were observed on the sides of the road from Dhlail to Al-Khalidiyyeh polluting the environment through releasing bad odors and attracting insects and flies.



Figure 3-11: Illegal dumping of manure and farm wastewater

### 3.2.1. General Findings and Conclusions

The following conclusions were based on the team’s project observations and discussions during the field visits:

- 1) There is an organized network of dairy livestock operations in Mafraq Governorate. Commercial establishments located in the region receive the milk product from such operations and process it for value added commodities – cheese, yoghurt, etc. This is an important industry and the pride in successful operations is evident from facility operators and MoA officials alike.
- 2) Livestock manure is processed in large volumes for reuse in agriculture and landscaping. There are established manure processing practices in place at the larger facilities visited. These appear to be well-received by MoA. There is a market for manure “compost” especially for reuse as soil fertilizer for trees. However, the cost of producing this “compost” is said to be high as compared to simple disposal (or a do nothing alternative)
- 3) Although both of the composting facilities are “quasi composting” operations – no amendment, little process control, etc. - the apparent quality of the manure compost from the two facilities appears to be very high. Samples were collected for possible analysis. The texture is quite uniform and much like peat moss. Dryness is estimated at 90+% Total Solids. Based on observed results, it appears that this “quasi composting” approach could be useful for consideration as a material drying operation.
- 4) Farm managers whom we met seem to be open to considering alternative routes for the management of manure
- 5) MoA officials have expressed the need for an integrated approach and management system for the solid and liquid wastes generated from cattle farms

### **3.3. Treaters of Animal Manure**

#### **3.3.1. Questionnaire and interviews**

The project team managed to interview 10 main treaters of animal manure in the country (see Table 3-2). The interviews were intended to collect the following information: licensed product & factory, place of the source, type of the source, transportation cost of raw waste, area for treatment of the factory, processes & operations, machinery used, amendments, packing, testing parameters before and after treatment, purchasing costs of raw material and selling price of treated material. Unfortunately, many of these parameters were not provided by the interviewed treaters of animal manure.



USAID Water Reuse and Environmental Conservation Project  
Sustainable Biosolids Beneficial Use: Poultry and Livestock Waste Streams and Management Alternatives

**Table 3-2: Key data from treaters of animal manure**

Parameter	Factory Name			
	Dirabani	Jordanian Company for fertilizers	Al-Mareaa	Universal for Fertilizers technology
Licensed (product & Factory)	-	MoA, License 5791	MoA, License 6475	-
Source Manure	مزرعة فواز النابلسي	Several Farms	Several Farms	Several Farms
Manure Type	Cattle	Cattle and chicken	Cattle and chicken	Cattle and chicken
Treatment Processes/Operations	Open field pilling, mechanical screening, semi-mechanical packing	Open field pilling, mechanical screening, semi-mechanical packing	Open field pilling, mechanical screening, semi-mechanical packing	Open field pilling, mechanical screening, semi-mechanical packing
Machinery Used	Loaders, trucks	Loaders, trucks	Loaders, trucks	Loaders, trucks
Packaging	50 liter, truck	50, 95 liters, truck	50, 95 liters, truck	50, 25 liters, truck
Phone/Mobile/Fax	0788768106	0795185474	0788620197	0795816699
Geographic Coordinates	31.807430 36.154988	32.139094 36.322494	32.117078 36.304659	32.148321 36.319255
Parameter	Factory Name			
	Bella	Bella Agriculture	Dobaleen	Deir Allah for Organic Fertilizers
Licensed (product & Factory)	-	-	-	-
Source Manure	Several Farms	شركة حمودة	Several Farms	Several Farms
Manure Type	Cattle and chicken	Cattle and chicken	Cattle and chicken	Cattle and chicken
Treatment Processes/Operations	Open field pilling, mechanical screening, semi-mechanical packing	Open field pilling, mechanical screening, semi-mechanical packing	Open field pilling, mechanical screening, semi-mechanical packing	Open field pilling, mechanical screening, semi-mechanical packing
Machinery Used	Loaders, trucks	Loaders, trucks	Loaders, trucks	Windrow Machine, Loaders, trucks
Packaging	50 liter, Trucks	50, 90 liter, truck	95 liter, trucks	25, 50 liter, truck
Phone/Mobile/Fax	0785520028	0795884072	0797091010	0777880356
Parameter	Factory Name			
	Hasad for Fertilizers	Abed all Rahman for Organic Fertilizers		
Licensed (product & Factory)	MoEnv, License 3978/4/2	-		
Source Manure	مزارع الضليل + مزارع المها الازرق	مزارع الابقار والاعنام في منطقة سحاب +الموقر		
Manure Type	Cattle and Chicken	Cattle, Sheep, Chicken		
Treatment Processes/Operations	Open field pilling, mechanical screening, semi-mechanical packing	Open field pilling, mechanical screening, semi-mechanical packing		
Machinery Used	Loaders, trucks	Loaders, trucks		
Packaging	45, 95 liter, truck	95 liter, trucks		
Phone/Mobile/Fax	0799636209	0795570508		
Geographic Coordinates	32.230940 36.373089	31.759906 36.120751		

### 3.3.2. General Findings and Conclusions

The following could be concluded from the above table:

- The majority of manure treatment plants are receiving animal manure from more than one farm. This may indicate that either (a) the contracted dairy cattle farms cannot provide the required amounts from the raw animal manure or (b) the intention of the factory to diversify the sources of manure, to avoid a monopoly.
- The factories use cattle manure and poultry litter and produce two types of treated manure for the production of vegetables and fruits.
- The processes of manure treatment are similar in all the factories: piling in open fields for solar drying, mechanical screening, and semi-mechanical packing.
- The treated material is packaged in 25, 45-50 and 95 liter bags.
- Routine testing of manure before and after treatment is overlooked.

## 3.4. Farmers Using Animal Manure in Agriculture

### 3.4.1. Questionnaire and sample size

Several farmers were interviewed using a simple structured questionnaire (Appendix A). The main components of the questionnaire included:

- general information about the farm (area, location, type of agricultural production)
- fertilizers used (type of fertilizer, application rate, purchase source of fertilizer, price)
- approach adopted to using the fertilizers (timing of use, period of spreading on the field, mixing fertilizers with soils, problems of using fertilizers)

The original plan was to select 6 farmers from northern, middle and southern parts of Jordan valley, a total of 18 farmers, representing protected vegetables, open vegetables and fruit tree production. However, production of open and protected vegetables ceased in early June due to the high temperature in Jordan Valley. So it was not possible to meet the farmers in their farms in that location. Instead, a visit was conducted on Saturday, 6 June, 2015 to the Vegetable and Fruit Market in Jwaideh, where farmers were selected randomly. If they use animal manure, they were interviewed about their use of animal manure for the different types of agricultural production. The interviewed farmers are listed in (Table 3-3).

**Table 3-3: Interviewed farmers using animal manure in agriculture**

Farmer Name	Farm Location	Production Type	Area (ha)
Azzam Al-Juneidi	Al-Jeezah	Open: vegetables	50
Eyman Al-Ghazawi	Om-Aljema/Mafraq Governorate	Fruit trees	45
Abo Imad Al-Satari	Ghore Kebed	Open: vegetables	7
Abdallah Al-Zaben	Mafraq Governorate	Fruit trees	120
Yousef Masoud	Kraimeh	Fruit trees (citrus)	4
Yousef Masoud	Kraimeh	Protected: vegetables	12

### 3.4.2. Animal manure application

#### Location and size of farms

The farms were located in southern Amman, Mafraq Governorate and Jordan Valley and represented the main irrigated agricultural production areas in the country. The farm area ranged between 7 and 120 ha.

#### Agricultural growing systems and produced crops

The agricultural production included: protected vegetables or under cover, open field cultivation of vegetables and fruit trees. The following crops were produced under each growing systems which may be slightly changed from season to another according to foreseen market demand and contractual production (Table 3-4).

**Table 3-4: Major crops grown under the different crop productions systems in the country**

Growing System	Grown Crops
Protected	Tomatoes, cucumber, colored pepper, beans
Open field	Potato, tomatoes, watermelon, onions, lettuce
Fruit trees	Citrus, stone fruits

#### Animal manure

The used organic manures originated from four different animal production systems: dairy cattle, laying hens, broilers litter and sheep pellets. The interviewed farmers are convinced that the majority of animal manure was not fermented. The farmers provided two main indicators to support their opinion on the issue that the used animal manure was not fermented:

- The delivery of manure to their farms is delivered only by certain manure merchants and the delivery is performed in most cases like smuggling something. In other words, there are no clear commercial enterprises that you can refer to regarding the sales and distribution of animal manure.
- The sudden proliferation of flies after spreading of manure on the field which obliges farmers to work it with the soil as soon as possible to reduce the flies' population.

The prices of manure is based on volume; either on the "Single" or "Diana" capacity. The usual capacity of the "single" truck is between 24-25 m<sup>3</sup> compared to 6 m<sup>3</sup> for "Diana". Charged prices (delivered at the farm gate) for the different types of manures are listed in (Table 3-5). The farmers preferred the laying hens manure because they believe that it is stronger than other types of manure and because of its high content of nitrogen (uric acid).

The cost of mixing manure with soil is considered as the main problem. Farmers pay around JD85 for the spreading and mixing of 24 m<sup>3</sup> of manure.

**Table 3-5: Price of animal manures in Jordan**

Type of Animal Manure	Price (JD per 24 m <sup>3</sup> )
Laying hens	350-400
Broilers litter	200-220
Dairy cattle	170-190
Sheep pellets	350-370

### Growing systems and types of animal manure

The type of used animal manure was governed by the type of the growing system (see Table 3-6). The majority of farmers preferred **sheep pellets** for improving the soil fertility of orchards grown with fruit trees. The reasons were:

- The sheep pellets are delivered in bags which are easily distributed along the line of grown trees which is followed by a manual or mechanical mixing (e.g. using a chopper) in case of manure clogs
- The sheep pellets are less attractive to flies. This could be attributed to the relatively hard surface of pellets, which do not provide a suitable micro-nest for flies for laying eggs and later for the growth of larvae.

The main two complaints from sheep pellets were:

- The first was the presence of plant seeds in the pellets (especially *Cuscuta* (حامول) which increase the flourishing of weeds in the orchards.
- The second was the high prices (JD350-375 per 24 m<sup>3</sup>).

The **laying hens manure** is commonly used for protected vegetable production especially in case of growing tomatoes and cucumber. Farmers were reluctant to use **broilers litter** in most growing systems because the sawdust comprised a significant proportion of the litter and is not-degradable in the short run and consequently has no benefit to plants.

The **dairy cattle** manure is becoming less popular for use in agriculture and farmers only purchase it because it is cheaper (JD170-190 per 24 m<sup>3</sup>) compared to other types of manure:

- The cattle manure is unfermented and serves as a good habitat for proliferation of flies which may serve as vector for certain pests.
- Farmers believe that cattle manure contains high content of salts which in turn increases the salt content of soils which negatively affected crop productivity.

**Table 3-6: Growing systems and preferred type of animal manure**

Growing System	Preferred Type of Animal Manure
Orchards of fruit trees	Sheep pellets
Protected vegetables	Laying hens
Open field vegetables	Poultry litter
Open field vegetables	Dairy cattle

### Timing of manure application

Farmers apply animal manure (mainly sheep pellets) to the orchards of fruit trees during the November-December period to benefit from the potential rainfall, and it is usually the time of pruning and removal of pruned material. This maximizes the value of workers. In case of open field production of vegetables, animal manure (dairy cattle or broilers litter) is applied during February-April period just before planting when the temperature is suitable for plant growth. In protected production of vegetables, manure is usually applied in summer (August-September) after the conclusion of growing season, to solarize the soils. This is the first step towards the preparation of plastic houses for the coming growing season.

### **Spreading period of animal manure before mixing**

To avoid the problem of flies, animal manure is spread on the field and directly mixed with the soils especially in the orchards of fruit trees and open field production of vegetables. In protected vegetable production, animal manure is spread in the plastic houses along the planting lines, soaked with water and then covered with black plastic sheets as an attempt to increase soil's temperature to kill the pathogens in the soils. It is worth noting that farmers in Jordan Valley are adopting the solarization of soils to kill the pathogens. The spreading time of animal manure in the orchards of fruit trees and open field production of vegetables lasted for few days and is usually governed by the availability of workers. This shows the importance of mechanical application (spreading and mixing) of animal manure to reduce the costs of manure application and at the same time facilitating the management of growing systems.

### **Packed versus unpacked manure**

The farmers have different opinions on the way manure is delivered to the farm. Farmers having problems with workers and not owning machines for spreading and mixing preferred the packed manure; others, usually owners of large farms and the necessary machines for spreading and mixing the manure, preferred the unpacked manure – mostly to reduce the costs.

### **Problems of using animal manure**

All farmers believed that the main advantage of manure application is to improve soil conditions (as soil conditioner) to conserve soil moisture. However, the farmers raised the following problems that are associated with the use of animal manure:

- Being an organic media and not fermented, it attracts flies which multiplies in large numbers and creates many problems from nuisance to vectors of pests.
- The salt content of manure accentuates the salinity problems in the soils of Jordan Valley because of the intensive agriculture which requires high application rates of chemical fertilizers. This issue needs research and verification.
- The high costs associated with spreading and mixing of animal manure with soils compared to low costs of application of chemical fertilizers.

## **3.4.3. General Findings and Conclusions**

### **Lack of effective monitoring system**

It can be said confidently that the delivered (or more precisely smuggled) animal manure to most agricultural farms in the country is unfermented. This shows that the monitoring system for treating and distribution of animal manure in the country is deficient. There are several key needs associated with this situation:

- An urgent need for an effective legitimized monitoring system, which starts with a close inspection of treating manure, assessment of produced quality against the specified standards, proper packing and labeling, and proper delivery to farms.
- A need to establish several distribution centers (similar to those of the subsidized feed stuffs) at the main agricultural production areas in the country to serve as the solely vessel for conveying the treated manure to farmers to have a full control on the distribution process.

- A need to enforce labeling of the product (name of treater or treatment plant, origin of manure, composition) for liability purposes. **Lack of extension programs related to manure application**

Specialized extension officers in application of animal manure to the different growing systems are not available, in terms to knowledge and presence. and the merchants of manure distributors are actually the key extension entities for promoting their commodities.

- Protection of farmers from fraud (regarding the composition, origin, and treatment of manure) and conservation of agricultural production systems requires an effective awareness program for treaters/distributers and end users of animal manure.
- The NGOs engaged in agricultural issues such as the Farmers Union should be trained to play an effective role for enhancing the awareness of the importance of using well-treated animal manure.

#### **Lack of an effective policy for proper disposal of animal manure**

The agricultural sector in the country is growing and requires a comprehensive policy to compete with the regional agricultural sectors. This policy should tackle the issue of disposal, treatment and application of animal manure. Animal manure should be viewed as a “multiple use resource” for agricultural and non-agricultural purposes.

- Revising the laws, bi-laws, legislations and regulations related to disposal, treatment, distribution, use and application of animal manure in the country.

## 4. General Conclusions and Recommendations

The current practices of stockpiling the manure and disposing of it seasonally as untreated manure fertilizer, causes considerable environmental and health problems for the animal farm owners, agriculture farmers and nearby communities in Jordan.

Untreated manure is transported for long distances mainly from Mafraq, Zarqa and other governorates to the Jordan Valley, where it is stored and then handled during land application for agriculture. Then it is typically, but not always, treated in-situ with the soil through solarization. This is a common practice in the Jordan Valley, primarily to disinfect topsoil; solarization provides some level of treatment to the manure, but its effectiveness is difficult to monitor. Other waste treatment processes such as fermentation and composting are implemented by smaller private companies. These processes are however not closely monitored, treatment quality is questionable, and according to the site investigations conducted by the project team, these companies treat only a small percentage of the waste.

Jordan must reduce the hazards posed by animal waste throughout Jordan and optimize the benefits to be derived from this by-product. This challenge requires a coordinated effort between ministries and the private sector. Some of the main recommendations that can improve the overall situation of manure management in Jordan are described below:

### 4.1. Farmers' Awareness

The livestock producers are aware of the potential spreading of livestock diseases to humans and other animals because of poor management of livestock manure, but they have overlooked the impact of this issue on their surrounding environment. This may ruin the reputation of their products.

Enhancement of farmers' awareness on proper management of livestock manure could be achieved by several means, especially the following:

- Development of an effective extension program on proper management and handling of livestock manure. This program would mainly target farmers and therefore should be developed by "field experts" with long experience in manure management at the farm level.
- Demonstration of a practical set-up, at a selected farm, to show proper storage and processing of manure using simple technology that is suitable to livestock production systems in the country.
- Development of a website on manure management to disseminate/exchange information on manure issues. This website can be developed to serve as a forum for professionals in livestock production and management of manure.
- Development of programs for rewarding farmers demonstrating sustainable management of livestock manure.

#### **4.2. Present Legislations and Regulation on Management of Livestock Manure**

The committees responsible for the management, processing and application of animal manure should consolidate the legislations and regulations that are embraced by the different ministries. This would serve to avoid conflict of interest and to aid in proper applications of guidelines and instructions related to manure.

#### **4.3. The Role of Livestock Producers**

Livestock producers in the country used to depend on the Government to solve problems of the livestock sector as they arose. Strengthening the partnership between livestock producers and the Government is essential to the finding of proper solutions especially in regard to the environmental issues and concerns associated with handling and disposal of livestock manure. For example, the livestock producers should develop a comprehensive plan summarizing their perspective on how to handle the livestock manure.

#### **4.4. Promotion of Technologies**

The MoEnv, MoA, MoWI, as key players and planners for management of natural resources and environmental quality should develop a comprehensive plan to introduce proper technology for handling and processing of livestock manure. Incentives, like customs exemptions, on the machinery and tools required for manure management could be one strategy to encourage farmers or Farmers' Cooperatives to purchase these tools to promote sustainable management of manure. On the other hand, the produced crops using well-treated manure can be given an advantage for marketing inside and outside the country through the recognition that this produce was grown according to the regulations and standards of "Proper Treatment and Use of Animal Manure".

#### **4.5. Enforcement of Legislation**

Regardless of the pitfalls in present legislation and regulation that are related to management of animal manure in the country, enforcing these instructions should be closely observed. Permanent and mobile check points should be established to monitor the illegal dumping of animal waste (solid manure, slurry, dead animals) in wadies or at road sides. A systematic plan, proactive not reactive, should be developed for these check points to monitor how much farmers, manure treaters and manure distributors abide by the acting regulations.

#### **4.6. Planning for the Future**

The entire livestock sector in the country requires restructuring, especially the foci of livestock facilities in the country. The livestock sector is expanding and most of the production facilities are located near the main cities. This urban livestock production should be reconsidered, re-positioned at remote areas, and provided with good infrastructure that reduces the impact of manure on human health and the surrounding environment.