Report on

The Required Bio-solids Laboratory Training Workshop

Submitted by

Environmental Research Center

Royal Scientific Society

Submitted to

IALC / University of Arizona

Through

Badia Research & Development Center - Jordan

September- 2007

Introduction

A workshop on Required Bio-solids Laboratory Training was carried out at the Royal Scientific Society RSS of Jordan during the period 30th July- 6th August 2007. The main objective of the workshop was to review and update the analytical procedures in the field of bio-solids sampling and laboratories analyses. The workshop consisted of three main components: first, delivering lectures on bio-solids and relevant previous and current activities in this field; the second, dealing with RSS equipments and sampling issues; and the third, reviewing the operational procedures for bio-solids analysis in order of developing a manual for the analytical procedures of sludge and bio-solids.

The workshop was financially supported by the Sustainable Development of Dry Lands Project that is funded by the United States Agency for International Development (USAID) (Washington and Jordan / the office of Water Resources and Environment -Jordan), under a cooperative agreement with the International Arid Lands Consortium (IALC) / University of Arizona.

Workshop Participants

About 25 participants from the following institutions had participated in the two lectures days, Monday 31st of July and Wednesday 1st of August, of the workshop:

- Royal Scientific Society.
- Badia Research and Development Center (BRDC).
- Environmental Monitoring and Research Central Unit (EMARCU).
- Jordan University of Science and Technology.
- Jordan Environment Society.
- Mutah University.

- National Center for Agricultural Research and Technology Transfer (NCARTT).
- Jordan Institution for Standards and Metrology (JISM).
- Ministry of Agriculture.
- As-samra Company.
- Water Authority of Jordan (WAJ).
- Ministry of Health.
- University of Jordan.
- Jordan Petroleum Refinery.

Workshop Agenda

- **Monday 30th of July**

Table (1) shows the agenda for the opening day of the workshop, Monday the 30th of July 2007. Opening remarks were delivered by the Badia Research and Development Center (BRDC) director, USAID - the office of Water Resources and Environment - Jordan director, the Vice-President of RSS, ERC director (**Figure 1**) and finally the representative of the IALC. Lectures were delivered by RSS team and some of the *ad hoc* committee members for the first day of the workshop; these were: Dr. Nisreen AL-Hmoud and Eng. Asma Al-sheraideh from RSS, Eng. Saleh Malkawi and Eng. Ahmad Ulemat from Water Authority of Jordan (WAJ) and Eng. Khaleel Jamjom from National Center for Agricultural Research and Technology Transfer (NCARTT).

Table (1): Agenda for Monday - July 30th, 2007			
Starting Time	**Ending Time**	**Subject Matter**	**Person/ Organization**
08:30	09:00	Registration/ Picking up workshop materials	RSS
09:00	09:05	Opening Remarks: BRDC	Eng. Mohammed Shahbaz, BRDC President
09:05	09:10	Opening Remarks: USAID	Mr. John Smith, Office of Water Resource and Environment (USAID)
09:10	09:15	Opening Remarks: RSS / ERC	Dr. Khaled Kahaleh + Dr. Bassam Hayek, RSS Vice-President + ERC Director
09:15	09:25	Opening Remarks: IALC	Dr. Akrum Tamimi, Associate Research Scientist & Project Coordinator: University of Arizona
09:25	09:45	Presentation of workshop agenda	Dr. Akrum Tamimi, Associate Research Scientist & Project Coordinator: University of Arizona
09:45	10:15	Break … Coffee, Tea and Refreshments	
10:15	10:45	Management Practices of Sludge and Bio-solids in Jordan	Eng. Saleh Malkaw-WAJ
10:45	11:30	Bio-solids Application for Improving Soil Fertility and Crop Production in Jordan	Eng. Asma Al-sheraideh-RSS
11:30	12:00	Bio-solids reuse for agricultural purposes in Jordan	Eng. Khaleel Jamjom-NCARTT
12:00	12:15	Coffee Break	
12:15	12:45	Bio-solids reuse standards in Jordan	Eng. Ahmad Uleimat-WAJ
12:45	01:15	Pathogen inactivation in Bio-solids using solar drying beds: A case study in Wadi Hassan WWTP.	Dr. Nisreen AL-Hmoud-RSS
01:15	02:00	Current bio-solids activities	Dr. Nisreen AL-Hmoud-RSS
02:00	03:00	Lunch	

Figure (1): Opening remarks by ERC director (Dr. Bassam Hayek) at the opening ceremony of the workshop.

- **Tuesday 31st of July**

Dr. Akrum Tamimi, Dr. Chuck Gerba and Dr. Janick Artiola from University of Arizona held a meeting with some of the lab analysts at Water Quality Studies Division (WQSD)/ERC in order of reviewing the Standard Operation Procedures SOPs for bio-solids chemical and microbiological analyses. There were some proposed modifications on the chemical analyses SOPs to be carried out. These SOPs will be part of the "Analytical Procedures of Sludge and Bio-solids" manual.

- **Wednesday 1st of August**

The activities of the second day of the workshop started at 8:30 am. Table (2) shows the agenda, a number of lectures were presented by Dr. Akrum Tamimi, Dr. Chuck Gerba and Dr. Janick Artiola from University of Arizona (**Figures 2&3**). Many subjects were covered by these lectures such as bio-solids standards and regulations and chemical and microbial pollutants in sewage sludge.

Table (2): Agenda of Wednesday - August 1st, 2007			
Starting Time	**Ending Time**	**Presentation Title**	**Presenter**
08:30	09:00	Registration/ Picking up workshop materials	RSS
09:00	09:20	Characterizing Drying Beds Treated Bio-solids in Jordan	Dr. Akrum Tamimi, University of Arizona
09:20	09:40	Modeling the Reduction of Fecal Coliforms in Sludge in Drying Beds	Dr. Akrum Tamimi, University of Arizona
09:40	10:30	Bio-solids Pollutants & Nutrients: Regulations and Analyses (Part I)	Dr. Janick Artiola, University of Arizona
10:30	10:45	Break … Coffee, Tea and Refreshments	
10:45	11:05	Regulation overview for microbial in bio-solids	Dr. Chuck Gerba, University of Arizona
11:05	11:35	Standards and requirements for microbials in the United States	Dr. Chuck Gerba, University of Arizona
11:35	12:05	Methods for the detection of microbials in bio-solids	Dr. Chuck Gerba, University of Arizona
12:05	12:20	Break … Coffee and Tea	
12:20	12:45	Bio-solids Laboratory Testing Manual: Proposed Contents	Dr. Janick Artiola, University of Arizona
12:45	01:15	Monitoring and Sampling requirements for microbials	Dr. Chuck Gerba, University of Arizona
01:15	01:45	Laboratory QA/QC for microbial	Dr. Chuck Gerba, University of Arizona
01:45	02:30	Emerging contaminates of concern related to bio-solids	Dr. Chuck Gerba, University of Arizona
02:30	03:30	Lunch and Closing Ceremony	

Figure (2): Part of the participants seeing the pictures on the board, which represents the activities that were carried out by RSS during the last three years.

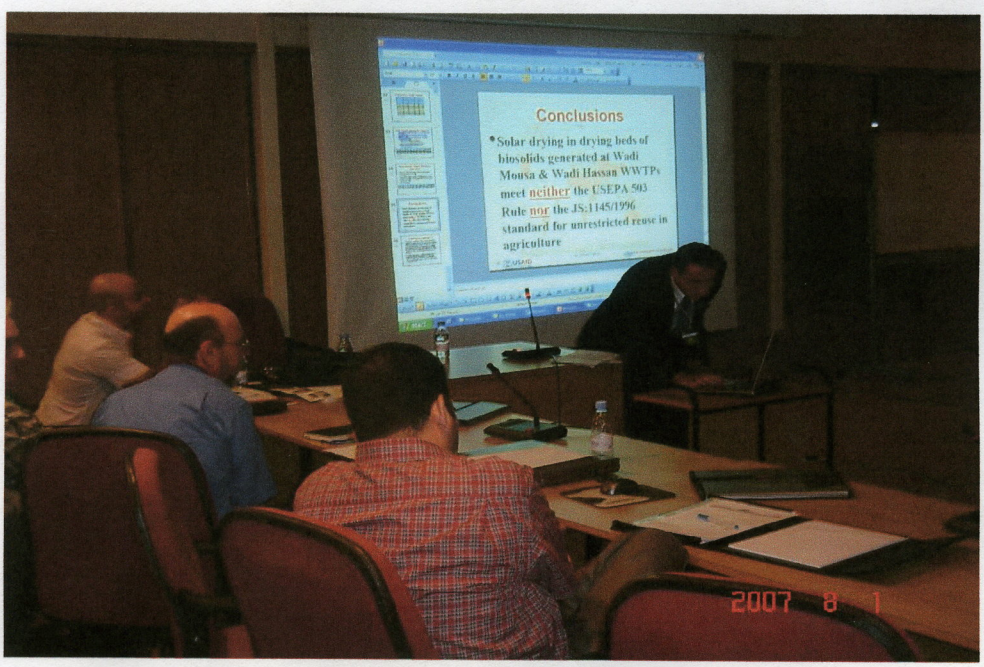

Figure (3): Dr. Akrum Tamimi presenting one of his lectures during the second day of the workshop.

- **Saturday 4th of August**

The University of Arizona team visited the different bio-solids activities carried out by RSS at Madaba wastewater treatment plant; the land application experiment, the sludge treatment and bio-solids modeling experiments (**Figure 4**).

Figure (4): Field visit to Madaba Wastewater Treatment Plant by Dr. Chuck Gerba & Dr. Janick Artiola (UoA) and one of ERC staff.

- **Sunday and Monday 5th & 6th of August**

The University of Arizona team held a meeting with some of WQSD staff in order to formulate the outline of the **"Bio-solids Manual for Reuse and Disposal: Regulations, Sampling and Analysis, and Management"**. The proposed outline is shown in the annex of this report.

Outcomes of the Workshop

- Developing the awareness at key Jordanian agencies concerned in sludge / bio-solids treatment and reuse, bio-solids sampling and laboratory analyses.
- Reviewing and updating the analytical procedures of sludge and bio-solids at RSS laboratories.
- The training achievements were utilized in developing the outline for the manual of "Bio-solids Reuse and Disposal".

****

ANNEX

Outline for the "Analytical Procedures of Sludge and Bio-solids" Manual.

Bio-solids Manual for Reuse and Disposal:

Regulations, Sampling and Analysis, and Management Guidelines. (proposed combined contents, includes Volumes I, II and III)

Prepared by:

RSS—Jordan

For Distribution and Use by:

Date:

August, 2007

Revision No:

000-0

Table of Contents

1-Introduction to Bio-solids

Provide general background of bio-solids:

-Composition: solids, nutrients

-Benefits (nutrients source, soil enhancer).

-Potential problems:

-Metal-nutrient accumulation can transfer to plants and create pollution.

-Excessive nutrients can produce lower crop yields.

2-Jordanian Regulations

(insert JS1145/2006) complete

3-Bio-solids Sampling requirements and protocols

(see pertinent JS1145/2006 sections and explain/clarify specific requirements, by section # as needed)

Applicable to bio-solids materials:

-Liquids <20% solids
-Solids and Semi-solids >20% solids

Definitions:

-Grab Samples: Applicable to liquids only.
Individual for pathogens, metals and nutrients.
-Composite Samples: Applicable to solids and semi-solids only.
Several grab samples combined. Up to eight (8) grab samples per composite.

Sampling Locations:

-Drying beds:
a-Divide bed into 4 8 sections.
b-Take at least 4-8 sub-samples (one from each section).
c-Collect each sub-sample from entire dry layer.
d-Composite sub-samples to one sample. Total sub-samples = 4

-Storage/aged bio-solids pile:
a-Divide pile into 4 sections.

b-Take two sub-samples from each section – one from center of pile with sampling tube and one from top 15cm of pile surface (at ½ height) using a scoop or plastic container

Important Note: use similar mass-volume for each composite sub-sample.

d-Composite sub-samples into one sample. Total sub-samples = 8

Note for metals and nutrients ONLY.

Repeat above process two more times.

Collect three discrete samples per pile. Label as replicates A,B,C

-Storage Tanks, Tankers (liquid samples only):

a- One or more grab samples must be collected in each unit. (examples: pumping/discharge point of each tank, tanker).

Sample Containers:

-For Liquid samples: 1-4Liters: Use 1L sterile or new plastic (HDP) bottles.

-For Solid, semi-solid Samples: 200-800ml total. Use 3.8L new, freezer safe, self-sealing ziploc® freezer quality plastic bags or equivalent.

Use 25-100ml glass or plastic sterile beaker to collect composites. Important Note: use similar mass-volume for each composite sub-sample.

Sample Holding Conditions and Storage

See Table__

Table _ Bio-solids Sample Preservation, Holding times and Volume/Mass Requirements.

Organism/ chemical	Holding Conditions	Maximum Storage Time	Sample Volume (Liters)	Sample Mass (dry weight basis) (grams)
Fecal Coliforms	If longer than one hour hold once	6 hours	1-4	1
Salmonella	Ice and to 4°C	24 hours	1-4	4
Enteric virus	Ice and to 4°C or Freeze at 0°C	24 hours	1-4	4
	or Freeze to –20°C	2 weeks		
		1-2 years		
Helminthes	Ice and to 4°C	2 weeks	1-4	4
Metals (solid+semi-solid samples	Ice and to 4°C	6 months	200-500ml	30-50
Metals (liquids)	pH<2 with HNO_3	6 months	300-1000ml	30-50
Mercury(liquids only)	pH<2 with HNO_3	6 months	300-1000ml	30-50
TKN	Ice and to 4°C	48 hrs (wet sample)	300-1000ml	30-50
TKN minus NH_4	Sealed bottle	6 months (dry sample)	–	30-50
Ammonia-N	Ice and to 4°C	48hrs(wet sample)	100-500ml	10-25
Total-P, Salts	See metals	See metals	See metals	See metals

Sample Labeling, Handling and Shipping

At a minimum, individual samples should have the following information written on each sample using a self-adhesive sticker (waterproof ink) using a waterproof marker:

Date and time of collection:_____
Location:_____
Sample type: (composite/grab)
Collector Name(s):_____

Each group/containers of samples (one or more) must be accompanied by chain-of-custody form: See example form in Appendix:

4-Health and Safety, Training

(see pertinent JS1145/2006 sections and explain/clarify specific requirements, by section # as needed)

-Sample collection and handling

Use disposable rubble gloves to collect and process samples required.
Personnel that routinely handles bio-solids samples should be vaccinated against hepatitis A virus.

-Training personnel

Laboratory in charge of analyses must provide to technicians in charge of field sample collection:

a-basic instruction on field sample collection techniques; see section__ above, to technician(s) in charge of sample collection.
b-sample containers, see Table__.
c-Labels chain-of-custody forms and transportation containers.

5-Bio-solids Analyses Methods

(see pertinent JS1145/2006 sections and explain/clarify specific requirements, by section # as needed)

RSS, Please insert pdf copies as picture files of SOPs for testing of all parameters listed in RS1145/2006

-Physical
-Biological
-Chemical

As discussed in the presentation and with you on Tuesday, please upgrade your SOPs to include:

-A short basic introduction and theory behind the analysis
-Method provenance (example: USEPA SW-846 Method 3050) and/or
-Adapted method: (example: Royal Scientific Society ERCSOP81)
-Important QC: SOPs for pollutant analyses

- Must include bio-solids-specific practical quantitative pollutant detection limits for all metals and nutrients.

- Use Bio-solids Reference Standards to check recoveries/validate method changes.
- Laboratory QC, including replications, precision (laboratory replicates).

Special note: Please, review SOPs for the analyses of Hg, As, and Se. Please, review method detection limits, as (based on the latest data set from JUST, Wadi-Mousa and Wadi-Hassan) they may be too high.

6-Record-keeping

(see pertinent JS1145/2006 sections and explain/clarify specific requirements, by section # as needed)

Sample collection forms

-Chain-of-Custody

Example form

CHAIN-OF-CUSTODY RECORD PROJECT NAME: SAMPLER(s) (SIGNATURE):				LABORATORY NAME ADDRESS TEL:	
Date	Time	Location	Type	# of Containers	Remarks

-Sample tag form (see minimum requirements in section 3.0)

Bio-solids Producer forms

-Chemical and Biological Analyses data form

Copy should be provided to Bio-solids Users

-Vector reduction form data should be available when bio-solids are remove from site.

Bio-solids User forms

At a minimum a form must provide the following information:

-Date of collection from wastewater treatment facility

-Amount of bio-solids (dry/wet weight/volume)

-Type of bio-solids

-Class A,

-Class B

\-or other designation (i.e drying bed, anaerobic digested)

-Location of Bio-solids application

-Farm name, Field (hectares)
-Amount applied (tons/hectare)
Metals loading rates: (list 9 metals individually)
Annual: kg/ha
Lifetime: kg/ha
-Crop type:
-Site restrictions:

Example Form

3.F. Specific Information on Arizona Land Application Events. ****to be completed by Land Applicators only

Application Site/Location	Field ID	Amount of Biosolids Applied (in dry tons)	Preparer	Pathogen Treatment Method	Vector Attraction Reduction Method	Loading Rate	Nitrogen Conc. (Organic + ammonium)	Type Of Crop Grown After Application	Agronomic Rate of Crop Grown	The Cumulative Concentration Of Pollutants (Mg/Kg) In Soil				
Example: Norris Farms, Aztec, AZ		350 Tons	Fountain Hills SD	Class B Alt. 2	Option 9			Corn						
1.										As =	Cd =	Cr =	Cu =	Pb =
										Hg =	Mo =	Ni =	Se =	Zn =
2.										As =	Cd =	Cr =	Cu =	Pb =
										Hg =	Mo =	Ni =	Se =	Zn =
3.										As =	Cd =	Cr =	Cu =	Pb =
										Hg =	Mo =	Ni =	Se =	Zn =
4.										As =	Cd =	Cr =	Cu =	Pb =
										Hg =	Mo =	Ni =	Se =	Zn =
5.										As =	Cd =	Cr =	Cu =	Pb =
										Hg =	Mo =	Ni =	Se =	Zn =
6.										As =	Cd =	Cr =	Cu =	Pb =
										Hg =	Mo =	Ni =	Se =	Zn =
7.										As =	Cd =	Cr =	Cu =	Pb =
										Hg =	Mo =	Ni =	Se =	Zn =

3.G. Land applicators must attach soils analysis for 2004 if using R18-9-1005(D)(2)), Pathogen Reduction results and VAR results.

Revised May 2004

Biosolids or Sewage Sludge Annual Report

Page 6 of 6

7-Nutrient Application Rates (Recommended)

(see pertinent JS1145/2006 sections and explain/clarify specific requirements, by section # as needed)

-Provide General guidelines for applications rates based on nutrient requirements

example

Type of Site/Vegetation	Schedule	Application Frequency	Application Rate
Agricultural land			
Corn	April, May, after harvest	Annually	5 to 10 dry tons per acre
Small grains	March-June, August, fall	Up to 3 times per year	2 to 5 dry tons per acre
Soybeans	April-June, fall	Annually	5 to 20 dry tons per acre
Hay	After each cutting	Up to 3 times per year	2 to 5 dry tons per acre
Forest land	Year round	Once every 2 - 5 years	5 to 100 dry tons per acre
Range land	Year round	Once every 1 - 2 years	2 to 60 dry tons per acre
Reclamation sites	Year round	Once	60 to 100 dry tons per acre

-Provide a List of crop requirements specific to Jordan.
-List N, P, K and micronutrient (Cu, Zn, Mo..) requirements.

-Develop preliminary N use guidelines based completed Research data.

8-References

EPA.1994. A plain English Guide to EPA Part 503 Bio-solids Rule. EPA/832/R-93/003. The Environmental Protection Agency. Office of Waste Management. Washington, DC.

EPA.2000. Bio-solids Technology Fact Sheet: Land Application of Bio-solids. EPA 832-F-00-064. U.S. Environmental Protection Agency. Office of Water. Washington, DC.

Code of Federal Regulations (40CFR 503, EPA 1993a).

National Bio-solids Partnership. Part 503 Regulations Core Documents CD. 1999.

Article 10. Arizona pollutant discharge elimination system disposal, use and transportation of bio-solids. R18-9-1001. May 2001.

.....

9-Appendix

A. Sample Calculations

See references above

Geometric Average Determination of Fecal Coliforms

- Analyze samples for fecal coliform using MPN dilution method.
- Take the log (Base 10) of each result.
- Take the average (arithmetic) of the logs.
- Take the anti-log of the arithmetic average. This is the geometric mean of the results.

Example: The results of analysis of seven samples of sewage sludge are shown below. The second column of the table shows the log of each result.

	Fecal Coliform (MPN/dry gram sewage sludge)	**Log**
Sample 1	6.4×10^6	6.81
Sample 2	4.8×10^4	4.68
Sample 3	6.0×10^5	5.78
Sample 4	5.7×10^5	5.76
Sample 5	5.8×10^5	5.76
Sample 6	4.4×10^6	6.64
Sample 7	6.2×10^7	7.80
Average (Arithmetic)	1.5×10^6	
Antilog (geometric mean)	6.18	
Log standard deviation	1.00	