

Environmental Laboratories Assessment Study
Part II

**IALC Sustainable Development of Drylands in Asia and the
Middle East, Jordan Component**

U. S. Agency for International Development (USAID)

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Introduction:

Ms. Dima Kayed, on assignment from the IALC Sustainable Development of Drylands Project, traveled to Jordan as part of the second phase of the laboratory assessment project to visit three additional laboratories in Jordan, namely the Water Authority of Jordan (WAJ), Jordan University for Science and Technology (JUST) and the Environmental Directorate laboratories. She also revisited the three laboratories namely NCARTT, WERSC and ERC mentioned in her report, “Environmental Laboratories Assessment Study – Part I” to become better acquainted with the laboratories capabilities. Ms. Kayed provided an exit briefing to USAID’s, Amal Hijazi, prior to leaving Jordan to update the Mission on the study’s progress.

Badia Research and Development Programme:

Contact: Mohammad Shahbaz

Ms. Kayed met with Mr. Shahbaz and Dr. Akrum Tamimi to arrange for the visits to various laboratories in the Kingdom. In the second phase of the study it was decided (prior to Ms. Kayed’s visit) that three additional laboratories should be visited namely: the Water Authority of Jordan (WAJ), the Jordan University for Science and Technology (JUST) and the Environmental Directorate laboratory. The Environmental Research Center (ERC) at the Royal Scientific Society (RSS), the Water and Environment Research and Study Center (WERSC) at the University of Jordan and the National Center for Agricultural Research and Technology Transfer (NCARTT) located in the North part of Amman in the Baqa’a were also visited for the second time to become better acquainted with the laboratory capabilities at each of these locations. A schedule of the visits to each of the laboratories was made and followed with a contact at each location.

Water Authority of Jordan (WAJ), Ministry of Water and Irrigation

Contacts: Mr. Zakaria Al-Tarawneh - Manager
Dr. Nawal Al-Sana’a - Microbiologist

The Water Authority of Jordan (WAJ) falls under the wing of the Ministry of Water and Irrigation (MWI). It consists of four departments: Watershed, Research Studies, Treatment and Desalination, and the Laboratories and Quality Department. The Laboratories and Quality Department main building and the associated facilities are built on 12000 m² of land area in Wadi El-Seer Industrial Zone. The main building area is 3700 m² and it consists of two wings, the laboratories and the administration wing. It has been designed, built and furnished according to international standards. The major goals of the Laboratories and Quality Department are to ensure the safety and compliance of drinking water quality supplied to all citizens in the Kingdom of Jordan to national drinking water quality standards and to protect the water resources from pollution. The

monitoring programs include but are not limited to 1) Drinking Water Quality Monitoring that monitors drinking water quality in pumping stations, main public reservoirs and distribution networks. 2) Water Resources Quality Monitoring that traces any changes and trends in physical, chemical, radiological and microbiological quality of raw water resources. 3) Industrial and Domestic Wastewater Quality that ensures compliance of the wastewater discharged from industrial institutions and public and private wastewater treatment plants to the Jordanian Domestic Wastewater Quality Standards. 4) Surface Water Quality Monitoring which monitors the quality of water in streams, wadis and dams in order to trace point and non-point sources of pollution.

The number of personnel working in the Laboratories and Quality Department is approximately 100. The technical staff constitute about 65% of the total number of employees and hold either an M.S., B.S. or college diploma in either chemical engineering, chemistry, microbiology, physics or hydrology.

The Laboratories and Quality Department consists of seven sections namely: Environmental Monitoring and Assessment Section, Drinking Water Monitoring Section, Environmental Isotope Section, Water Chemistry Section, Wastewater Chemistry Section, Microbiology Section and the Information and Quality Assurance Section. A number of these Sections' laboratories were visited as part of Ms. Kayed's assessment objectives.

I. Water Chemistry Section:

Unit Head: Randa Tuffaha

This Section comprises the inorganic and organic chemistry laboratories. Samples for analysis include drinking and surface water samples. The inorganic lab entails analysis of samples for trace metals and nutrients. It is equipped with various instruments such as 2 Atomic Absorption (graphite and furnace) units, fume hoods, a flame photometer, an EC meter, a pH meter, and 2 spectrophotometers.. The organic laboratory analyzes samples for pesticides, trihalomethanes and phenols to name a few. It is equipped with fume hoods, a Kjeldahl nitrogen analyzer, water baths, ultrasonic baths, HPLC, GC-Mass, GC analyzer and total organic carbon analyzer.

II. Environmental Isotope Section:

Unit Head: Susan Kilani

This Section entails the screening of various sources of water such as ground, surface, dams, wells and rivers for environmental and radioactive isotopes. The environmental isotopes include stable isotopes such as oxygen 18, deuterium and carbon 13 and radioactive isotopes such as tritium, radon and carbon 14. These are measured using mass spectrophotometers (oxygen 18, deuterium and carbon 13) and liquid scintillation analyzers (tritium, carbon 14). The quality parameters for measuring radioactivity in water include radon 222, radium 226, alpha and beta emitters and uranium 238 and 234 and associated trace metals. These are

measured using various instruments such as radon detectors, Inductively Coupled Plasma Mass Spectrometer (ICP-MS) and liquid scintillation analyzers.

This Section serves as a regional facility for environmental isotope analysis and has received samples for analysis from Turkey, Lebanon and Syria.

III. Microbiology Section:

Unit Head: Sally Zenati

This Section receives drinking water, wastewater samples (influent and effluent), irrigation water and surface water samples for analysis. Approximately 100-200 samples are received on a daily basis. Drinking water samples are routinely screened for free living nematodes, total coliforms, fecal coliforms, *Escherichia coli*, algae (count and identification) and chlorophyll a. Wastewater samples are analyzed for nematode eggs, *Escherichia coli*, total coliforms, algae (count and identification) and chlorophyll a as are irrigation water samples. Surface waters are routinely screened for algae (counts and identification) and chlorophyll a. Protocols for all tests are available in APH Standard Methods,

This Section is divided into two: drinking water analysis and wastewater analysis. Special tests conducted include screening samples for the presence of *Pseudomonas aeruginosa* (MPN), *Salmonella* sp. (tetrathionate, bismuth sulphite agar and antisera for confirmation) and fecal streptococci in coastal waters. Drinking water and surface waters are occasionally screened for the protozoan parasites *Giardia* and *Cryptosporidium* utilizing Method 1623 (filta max, Dynal beads and IMS). The drinking water analysis division is equipped with 2 incubators, a light microscope, IDEXX system (colilert, sealer and UV lamp), computerized systems for data input, a pH meter, a microbiological safety cabinet, grade II, an analytical balance, refrigerators, fluorescent and inverted microscopes (with monitor). The media preparation and sterilization room houses an autoclave. The wastewater analysis division is equipped with a microbiological safety cabinet, incubators, an ultrasonic for glassware cleaning and analysis, water baths, centrifuges, a fluorometer (chlorophyll a).

Remarks:

Suggestions for workshops included training in the detection of pathogens, and protozoans. This would include lectures and applications in the collection, processing and analysis of samples for protozoan parasites and pathogens.

IV. Wastewater Chemistry Section:

Unit Head: Farouq Dawabsheh

The Wastewater Chemistry Section receives industrial and domestic wastewater samples, approximately 400-500/ month. A number of instruments are available in the laboratory to conduct various tests. Some of the tests conducted on samples and the

instruments available include: a GC-MS to screen for phenols, pesticides, polyhydrocarbon aromatics (PAH), a flow injection system (various wavelengths with various filters) to screen for PO₄, boron, NO₃, NO₂, NH₄⁺ and ABS (alkylbenzyl sulfate), a polarograph to measure selenium and cyanide levels, an ion chromatograph to measure cations and anions, COD (carbon oxygen demand) and BOD (biological oxygen demand), automated titroprocessors and an atomic absorption (AA) unit to screen for heavy and trace metals (routine screening for Pb, Mn, Fe, Cr, Ni, Cd, Cu, and Zn), pH meters, turbidometers and an ICPS-700 for the screening of heavy metals at a lower detection limit. Tests conducted on a routine basis include BOD, COD, pH readings, TSS and TDS.

Remarks:

Suggestions included training on instrument software and on new methodologies for analysis and practical applications.

V. Information and Quality Assurance Section:

Unit Head: Rania Sha'aban

This Section includes a sample reception area, a Laboratory Information Management System (LIMS) for data entry and a room containing containers for sample collection. The sample reception area room receives samples in iceboxes from various regions of the kingdom along with the appropriate request forms. Samples are checked to determine if the physical condition of the sample is suitable as well as if the quantity of sample is adequate for the tests requested. Samples are then routed to the appropriate sections for analysis. The Laboratory Information Management System for data entry was initiated in September 2001.

This software system, LIMS, consists of a network of data information, the central station being linked to each of the laboratory sections. A number of forms are included as part of the data entry namely: request and chain of custody forms, progress report forms and final report forms (see Appendix C for various forms). Routine work in this section includes data logging, data processing, data reporting and hardware maintenance. A room is allocated for the storage of empty bottles used for sample collection. Samples are collected from various sources such as drinking water (90 samples/day), wastewater (influent and effluent, 30-40 samples/day), dams and surface water. A total of approximately 120-160 samples/day are collected, received, processed and analyzed for various parameters by WAJ. Other samples are collected from government or private sectors and sent to WAJ for analysis.

Comments:

The Water Authority of Jordan is a very impressive facility in terms of its equipment, personnel and capabilities. The building housing WAJ is quite new and was built according to particular specifications. It is equipped with the latest instruments and is staffed with well qualified, trained individuals who have years of experience in conducting the laboratory analyses. It is worth mentioning that WAJ participates in proficiency testing and is taking

serious steps towards ISO 17025 for laboratory accreditation. This facility may play an important role in the analyses relating to the wastewater reuse aspect of the project.

Jordan University for Science and Technology (JUST):

Contact: Dr. Ziad Al-Ghazawi

Jordan University for Science and Technology (JUST) is located in the Irbid area. A number of laboratories were visited in various Colleges namely the College of Agriculture, the College of Engineering and the College of Science during the day long visit.

College of Agriculture:

I. Soil Fertility and Plant Nutrition Laboratory:

Contact: Bayan Al-Thamneh- Laboratory Manager

This laboratory is located in the College of Agriculture. The bulk of the analysis is plant and soil samples and less commonly water samples. This is mainly a research lab that conducts tests on samples for various projects. Routine work in this laboratory includes preparation of soil, plant and sludge samples by extraction or digestion. Tests run on these sample types include pH, EC, NPK (nitrogen, phosphorus and potassium), organic matter content, and Kjeldhal nitrogen. Some of the equipment in the lab includes a spectrophotometer, a flame photometer, pH meters and EC meters, centrifuges, a balance, stirrer, hot plate, shaker, and waterbath. Other tests for heavy metals, macronutrients, and micronutrients are conducted at NCARTT using their atomic absorption apparatus.

II. Microbiology Laboratory:

Contact: Dr. Ragheb Tahhan- College of Agriculture, Department of Natural Resources and the Environment

This laboratory is located in the College of Agriculture. Soil samples and oily sludge samples from the refinery are analyzed in this laboratory. Soil samples are screened for bacteria, actinomycetes and fungi. Bacteria are speciated and identified, specifically hydrocarbon degrading bacteria. Oily sludge samples are analyzed for hydrocarbons using HPLC equipment. Equipment found in this lab include a fumehood, a waterbath, light microscope, shakers, hotplates, an autoclave and incubators.

III. Soil Chemistry Laboratory:

Contact: Dr. Zahir Rawajfih- Soil Chemist

This is mainly a research and teaching laboratory located in the College of Agriculture. Three researchers (graduate students) are working on various projects including the use of zeolite to clean-up wastewater and studies on the absorption of boron on calcareous soils. Samples received are soil or water. Soil samples are extracted to obtain a solution after which analysis for phosphorus, boron, NO_3 , and NH_4^+ are performed on the sample. Equipment found in the laboratory include, shakers, filtration racks to clean extracts, centrifugation for separation, distillation apparatus, balances, hotplates, drying ovens, a furnace set at 1000°C for ashing nitrogen, a Kejdahl autoanalyzer 1030, autotitrator, a tube furnace produced on site at the University to burn charcoal, a flame photometer for analysis of Na^+ and K^+ , a steambath and an incubator above and below ambient temperatures.

College of Engineering;

Department of Chemical Engineering:

I. Chemical Engineering Laboratory:

Contact: Dr. Hasan Mousa

This laboratory comprises three sections, a teaching laboratory, a research laboratory and an analytical laboratory. The Chemical Engineering laboratory contains a number of instruments some of which include a differential thermal gas analyzer for analysis of soil and clay samples, three GC instruments, a GC-FID which analyzes mainly liquid organic compounds such as aromatics and alcohols, a GC-ED which analyzes for pesticides and halogenated compounds and a GC-TCD for analysis of gases, an atomic absorption unit which measures for inorganic and organic parameters and for heavy metals in parts per million (ppm), an HPLC which analyzes for phenols from various water sources, a thermal analyzer, a portable gas analyzer and a BOD and COD unit to name a few.

Department of Civil Engineering:

Contact: Dr. Ziad Ghazawi

I. Sanitary Engineering Laboratory:

Contact: Omar Qudah – Engineer

This laboratory is mainly involved in conducting tests to assess water and wastewater quality. Some of the tests and equipment include: determining the physical characteristics of sludge, measurement of TDS and TSS with the use of conductivity meters, BOD apparatus utilizing the newer sensor system, measurements of COD, DO and chlorine residues, turbidity readings, acid-base titrations, measurement of water hardness, alkalinity, sludge dewatering to enhance settlability, a computerized spectrophotometer to measure water quality parameters

and for analysis of sludge samples (trace elements-humic acids), fume hoods, light microscopes, an autoclave, measurement of total and fecal coliforms using membrane filtration and nutrient agar media, an incubator, flame photometers to measure levels of sodium, potassium, calcium and lithium, centrifuges and analytical balances.

II. Environmental Laboratory:

This laboratory is still under the process of being equipped. Some of the instruments already in the laboratory include a reverse osmosis unit and a jar tester utilized for coagulation of water to reduce its turbidity.

College of Science:

These arrangements were made by Dr. Ghazawi. Ms. Kayed accompanied two individuals from Dr. Ghazawi's department, Ahmed Al-Hammouri an engineer and Rabab Hanieh also an engineer to various laboratories in the College of Science.

I. Water and Fungus Laboratory:

This laboratory mainly conducts research studies. Water samples are analyzed for total heterotrophic plate counts, total coliforms and for *Pseudomonas* (MPA agar) using the MPN method. The laboratory is equipped with incubators, an autoclave, and a laminar flow hood to name a few.

II. Microbiology Laboratory:

Contact: Dr. Ismail Sa'adoon

Much of the work done in this laboratory revolves around research studies with soil samples. Soil samples are analyzed for *Actinomyces* and *Streptomyces*. Soil contaminated with diesel is analyzed for *Pseudomonas*. The laboratory is equipped with a water bath, incubators and a PCR thermocycler.

III. Microbiology-Water Quality Laboratory:

Contact: Dr. Muna Hindia

This is a new laboratory that was set up to analyze all types of water for various microbial, physical and chemical parameters. Two M.S. research students were in the laboratory at the time. The laboratory is now equipped with ovens, balances, a flame photometer, a distiller, a water bath, a centrifuge, a turbidostat, a pH meter and a BOD reader. Routine analysis for chlorophyll a, *Pseudomonas*, and *Candida* will be conducted on various water samples as part of a profile to assess the quality of the water.

Site 1-Demonstration (Demo) Pilot Site:

Contacts: Dr. Ziad Ghazawi

Ahmed Al-Hammouri – engineer, site agronomist

Rabab Hanieh- wastewater engineer

This site is located on the JUST campus and comprises an area of approximately 100 dunums. Secondarily treated wastewater from the wastewater treatment plant (WWTP) on the JUST property is pumped to the wastewater ponds (1000 m³) at the site which are used for surface drip irrigation of the agricultural field. The field is planted with crops such as barley and vetch as well as cactus plants.

Remarks:

The Demo site at JUST was very impressive and looked as if it was working well. The laboratories at JUST are well equipped but are spread out through various colleges namely the Colleges of Agriculture, Engineering and Science. JUST may play an important role in testing of soil and plant samples as well as educating the farmers on wastewater reuse in conjunction with NCARTT. It may also play a role in some research studies (pilot studies) involving reuse of wastewater and biosolids.

Environmental Directorate Laboratories, Ministry of Health

Contacts: Dr. Bashir Al-Kaseer – Laboratory Director

Fatimah Tawalbeh – Laboratory Manager

This set of laboratories is housed in a building in the city of Amman and is under the umbrella of the Ministry of Health. The laboratories were first started up in 1982 and further developed in 1989 as the concern for the environment and the health of the population increased. This entailed providing the laboratories with the latest instruments such as the HPLC and GC and increasing the technical staff. This resulted in a gradual increase in the number of instruments and tests performed as well as an increase in the number and types of samples received and analyzed. The laboratories are now involved in the chemical and microbiological analysis of various sources of water (drinking, mineral, wastewater, industrial wastewater, treated wastewater, dialysis units). Ambient air samples are also analyzed for heavy metals using the atomic absorption (AA) unit. Blood and urine samples collected from patients in hospitals and those individuals whose work may pose an occupational concern are analyzed for heavy metals utilizing the AA unit. The laboratories also monitor and screen mineral (bottled) water coming into the Kingdom of Jordan and water sold in Jordan by companies that utilize reverse osmosis to ensure its safety. These laboratories periodically monitor and run control checks on water samples from WAJ (Water Authority of Jordan). There are two major laboratories, the chemistry laboratory which serves as the central laboratory for Jordan and the Microbiology laboratory.

I. Chemistry Laboratories:

Contact: Fatimah Tawalbeh

A number of tests are run on various types of samples. Drinking water, ground water and tap water samples are routinely analyzed for turbidity, pH, TDS, NH₄, Al, Mn, Fe, Cu, Zn, Cd, Cr, Ni, As, Ba, Se, CN, Na, Cl, SO₄, F, NO₃, Pb, B and trihalomethanes. Mineral water samples are routinely analyzed for TDS, Mn, Cu, Zn, F, NO₃, NO₂, Pb, Cd, Cr, As, Ba, Se, CN, and Hg. Wastewater samples are routinely analyzed for TDS, TSS, BOD, COD, Cl, PO₄, NH₄-N, NO₃-N, T-N, Fe, Ni, Cu, Pb, Cd and Cr. Industrial wastewater samples are routinely analyzed for TDS, pH, EC, TSS, BOD, COD, NH₃, SO₄, PO₄ and Cl. Treated wastewater, surface waters, dams and dialysis units are analyzed for EC, pH, TDS, Hardness, Ca, Mg, Fe, K, NH₄, Na, SO₄, Cl, NO₃, NO₂, F, NH₃, PO₄, and Cu. All tests are run and compared to specified Jordanian standards. Ambient air samples, blood samples, urine samples and food samples (rarely analyzed) are routinely analyzed for heavy metals using the AA unit.

Some of the equipment found in these laboratories include: 3 atomic absorption (AA) units, spectrophotometers, a Gas chromatograph, (GC), a GC-Mass, an Ion chromatograph, 2 turbidity meters, 2 spectrophotometers, 2 pH meters, 3 EC meters, a BOD incubator, a microwave digester, a distillation unit and a COD meter.

II. Microbiology Laboratory:

Contact: Khawla Al-Rifai – Quality Assurance Officer

There are twenty microbiology laboratories in the Kingdom all of which fall under the umbrella of the Environmental Directorate Laboratories. The laboratory tests and procedures are conducted and followed as specified by Standards Methods, 20th edition. Drinking water samples are routinely screened for total coliforms, fecal coliforms, *E. coli* using the Most Probable Number (MPN) method as well as nematodes (free-living larvae). Treated wastewater samples are screened for the presence of the pathogens *Salmonella*, *Shigella* and *Vibrio cholerae*. Mineral water samples are routinely screened for the presence of total coliforms, fecal coliforms, fungi and *Pseudomonas aeruginosa*. Rush results on treated wastewater, drinking water and all surface waters are screened for total coliforms and fecal coliforms utilizing the IDEXX Colilert system.

The microbiology laboratory is equipped with 4 fume hoods, 2 water baths, 5 incubators, 4 ovens, 2 autoclaves, 8 refrigerators, 5 balances, 4 microscopes, a pH meter, a filtration unit to screen for free-living nematodes in drinking water, and 2 magnetic stirrers. Media preparation takes place in a specialized room where bottles for sample collection are stored.

The Environmental Directorate laboratories are also responsible for the training of personnel in all types of tests related to any type of source water as well as the monitoring of the various laboratories in the Kingdom that partake in these types of tests.

Remarks:

The laboratories are well equipped and staffed. They have received quite a few of their instruments as donations from USAID and are working closely with this organization to prepare for ISO 17025 accreditation. They may be very helpful in conducting tests on the wastewater reuse aspect of the project and as a monitoring facility.