Chapter 47
Quality Assurance Standards: USDA Perspective of the Extensive Soil Survey of Abu Dhabi Emirate

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Abstract Soil scientists from USDA-Natural Resources Conservation Service were invited by the International Center for Biosaline Agriculture (ICBA) and the Environment Agency-Abu Dhabi (EAD) to participate in a quality assurance review of the extensive soil survey of Abu Dhabi. The review was of interest to USDA not only due to the application of US soil survey mapping and classification standards but the emphasis on developing soils within the emirate into useful and productive agricultural areas. Meetings were conducted with scientists of ICBA and EAD and the soil survey management team of GRM International (Australian mapping contractor) to review various aspects of soil mapping, soil survey documentation, and day-to-day operational procedures. Field visits included examination of representative polygons of preselected map units with on-site investigation by backhoe and hand dug pits traversing a widely diverse set of landscapes and landforms across

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several regions of the Abu Dhabi Emirate. Processes for soil pedon examination, recording of soil properties, classification of soils, mapping procedures, and determination of map unit composition were evaluated. Additional methods used within the USA were presented for consideration when conducting future soil surveys. Laboratory procedures used in the analysis of soil samples were based primarily on USDA-NRCS methods, and derivations unique to the Abu Dhabi soil survey were reviewed. In support of ongoing cooperative efforts between the agencies of USDA, ICBA, and EAD, soil samples were collected for detailed analysis in an effort to develop new methodology for identification and quantification of anhydrite, as well as elucidate the mechanism and controlling factors for the formation of this mineral in soils of the region. Field and laboratory methods, standards, and procedures implemented by the project team (both ICBA/EAD and GRM) with their high level of technical skills, knowledge, and experience have ultimately yielded an array of high-quality soil survey products greatly enhancing the wise use of one of the region's most precious natural resources—its soil.

Keywords Abu Dhabi Emirate • Map unit • Quality assurance • Soil mapping • USDA-NRCS

47.1 Introduction

Soil survey quality assurance is a process of providing oversight and review to ensure that soil survey products meet the stated objectives outlined in their guiding documents, such as "terms of reference and scope of work" for the soil survey of Abu Dhabi Emirate (ICBA-EAD 2005). The extensive soil survey of Abu Dhabi Emirate was completed using fourth-order survey standards of USDA with some modifications to fit Abu Dhabi conditions. A total of 22,000 observations over an area of 5.5×10^6 ha were completed. The survey covered the entire emirate but excluded offshore islands, restricted areas such as military and urban, and the previously surveyed coastal land area. More information can be seen in Chap. 1 of this book (Shahid et al. 2013).

Assistance was requested from USDA-Natural Resources Conservation Service (NRCS) by the Dubai-based International Center for Biosaline Agriculture (ICBA) and the Environment Agency-Abu Dhabi (EAD) for a quality assurance (QA) review of the ongoing extensive soil survey of Abu Dhabi. Two soil scientists (John Kelley and Michael Wilson) conducted a QA review of extensive soil survey of Abu Dhabi Emirate (Fig. 47.1a) from November 7 to 20, 2008.

Phase I is an extensive soil survey of the entire emirate conducted at a scale of 1:100,000 (EAD 2009a), while phase II is an intensive survey of 400,000 ha of the lands with the greatest agricultural potential conducted at a scale of 1:25,000 (EAD 2009b). The review is of interest to USDA not only due to the application of the US

Fig. 47.1 (**a**) USDA staff visit to UAE University laboratory; (**b**) USDA staff meeting with high-level project management; (**c**) USDA staff interaction with project staff; (**d**) witnessing sand spear—an innovative equipment to sample loose sandy samples; (**e**) USDA staff met soil mineralogist at UAE University; (**f**) sampling anhydrite profiles in the coastal sabkha

soil survey mapping and classification standards (Soil Survey Division Staff 1993; Schoeneberger et al. 2002; Soil Survey Staff 1999, 2006) but also the emphasis on developing soils within this country into useful and productive agricultural areas. The effort to use soil survey to identify these areas, to determine the limitations for agricultural use, and then to identify methodologies to overcome these limitations has worldwide implications for land-use management.

47.2 Review Process

47.2.1 Initial Familiarization

In the initial stage of the review, meetings with scientists of ICBA and EAD and the soil survey management team of GRM International (Australian mapping contractor) were conducted to familiarize the review team with the soil survey project terms of reference (TOR) and scope of work (ICBA-EAD 2005). Additional time was spent examining various aspects of the mapping, soil survey documentation, and day-to-day operational procedures used by field staff and the management team (Fig. 47.1b).

47.2.2 Field Visits

The review team was provided ample opportunity to examine office, laboratory, and field mapping protocols. Field visits included examination of representative polygons of preselected map units with on-site investigation by backhoe and hand dug pits. A widely diverse set of landscapes and landforms were traversed across several regions of the Abu Dhabi Emirate. The process for soil pedon examination, recording of soil properties, and classification of soils was demonstrated by the survey staff. Required information needed in pedon descriptions and concepts regarding use of horizon suffixes, uniformity of descriptions, and cementation classes were also discussed and ideas for their usage exchanged (Fig. 47.1c).

At the initial field site, a new and unique sampling procedure (use of the sand spear) was demonstrated that will prove to be very beneficial in examining/sampling similar soils in the USA (Fig. 47.1d). A typical soil survey field office was visited, and mapping and documentation procedures used by the soil survey crew leaders were demonstrated. Noted was the excellent working relationship (rapport and informational exchange) between the management and field mapping personnel of GRM International. Interaction of this nature is critical to the success of any survey project.

47.2.3 Databases

Database management of field information was initially based on the USDA pedon data entry system and later modified to meet the unique needs of the Abu Dhabi survey. Pedon descriptions were scanned and entered into a system that appeared very user friendly. The system utilized facilitated data entry and examination of completed pedon descriptions. Data output was formatted to allow pedon descriptions to have a universal format. A sufficient system of quality assurance of these

data is in place from training of the field soil surveyors, review of the collected data by the senior soil scientist, and QA of the computerized data compared to field sheets. The soil information system is called "Abu Dhabi Soil Information System (ADSIS)," and it is now available online at www.adsis.ae.

47.2.4 Mapping Procedures and Determination of Map Unit Composition

Remote sensing of Landsat imagery facilitated the creation of map units. The process of initial delineation of mapping units or polygons was routinely completed in the office, followed by on-site transects of 12–15 points to discern polygon boundary placement. GRM has established a standard for minimal field information required. The procedures used for determining the composition of mapping units and the development of map unit names were reviewed. A variety of methods used within the USA were discussed, and the advantages and disadvantages are identified. Methods and analysis used by the survey staff, although somewhat modified from the USDA procedures, are well within the principles established in the USDA procedural guide.

All pedon descriptions examined were accurate and well documented. During site investigations, soil survey project mapping crew leader and members were eager to interact and discuss taxonomic criteria as well as field procedures with the USDA representatives in order to validate record collection/documentation according to USDA standards. At several of the sites, they enthusiastically demonstrated their field procedures for determining chemical and physical soil properties (e.g., electrical conductivity, pH). The knowledge and skill level by the field staff of complex landscape/soil relationships was very apparent.

47.2.5 Laboratory Data

Laboratory procedures used in the analysis of samples were based on USDA-NRCS methods (Burt 2004). Deviations from current USDA methodologies are generally procedural and would not impact the overall quality of the data or the placement of pedons in the soil classification system. One deviation noted that may need to be further explored and tested was the analysis of 33-kPa water retention (water retained at field capacity) using sieved, <2-mm soil material rather than natural soil aggregates as is common in the NRCS laboratory.

In addition, the validation and cross-checking of laboratory data for quality was discussed. This process is ongoing via interlaboratory comparison of data with the USDA-NRCS laboratory and a laboratory at the University of Western Australia. Also, the mineralogy data was examined. There were concerns regarding

the methodology for determining the semiquantitative mineral classes from the results of x-ray diffraction analysis.

47.3 Summary

Over the extent of the visit, the excellent spirit of cooperation and technical expertise shared among the representatives of the ICBA/EAD and the staff of GRM became very apparent. The ICBA/EAD and GRM International teams exhibited a sincere interest in making changes or implementing recommendations identified by the USDA representatives. Detailed discussions were conducted throughout the visit (most in an informational context). Suggestions were directed toward immediate improvements in the soil survey, ways to best utilize the completed soil survey products (descriptions, maps, laboratory data, etc.), and the identification of future needs.

The dedication of project management and project staff (both ICBA/EAD and GRM) with their high level of technical skills, knowledge, and experience has ultimately yield high-quality soil survey products greatly enhancing the wise use of one of the regions' most precious natural resources.

47.4 USDA Evaluation

The following observations were offered as part of the USDA QA review:

- GRM International is meeting and/or exceeding USDA standard field mapping procedures and data collection protocols for an order 4 soil survey based on our review of data in the office and field.
- The examination of typical pedons revealed that properties described fit within the range of taxonomic criteria ensuring correct classification of soils using the USDA Soil Taxonomy system.
- The system of soil correlation currently being used by GRM is consistent with USDA standards and provides for an accurate accounting of the various soil components commonly found in mapping units. It was suggested that documentation of naming conventions for mapping units and a summary explanation of map unit composition be provided in the final soil survey report. An initial review draft of this documentation was provided by GRM personnel and reviewed and approved by the USDA staff.
- The database appears to be designed for future use in soil survey maintenance and updates and capable of storing of additional data when the survey is complete.
- The laboratory procedures appear to be established, well designed, and sufficiently tested (Fig. 47.1e). The overall completed set of laboratory data should be cross-checked for potential analytical problems (Shahid and Ahmad 2004) as some inconsistencies (revealing possible analytical errors) were apparent in some older

data. This task appears to be ongoing with interlaboratory comparisons as well as examination of internal data consistency. These consistency checks should include evaluation of sample dispersion during particle-size analysis by use of the 1,500-kPa water retention/clay ratio, as well as use of TPL (total pretreatment loss) and LAT (loss on acid treatment) analyses to validate other extraction/quantification methods for salts, gypsum, and carbonates.

- The laboratory procedures of TPL and LAT should be better documented in the soil survey. They are cited as based on USDA procedures, but these methods are not currently used within the NRCS laboratory. The TPL procedure is used only (and infrequently) within USDA as a pretreatment method for particle-size analysis and was not designed within our laboratory to be quantitative. This is not to say that the method is not reliable, quantitative, or useful but appears to the reviewers as a more fully developed method than has been available in the past.
- Reporting conventions should be modified regarding reporting of laboratory data. Modifications should specifically target lower reported values, including an understanding and reporting of analytical detection limits and establishing "trace" and "nondetectable" thresholds. Elimination of "zero" values is necessary in the reported data. Also, blank values and dashes in the data tables should be defined. Within the USDA system, "tr" is used for measurable values below quantitative limits (e.g., trace), "--" for analyses performed but no analyte detected, and a blank is used when the analysis was not performed.
- The method to determine the semiquantitative class for reporting soil minerals by x-ray diffraction should be documented in the soil survey. This documentation should include the initial mineral quantification procedure used (e.g., relative mineral percentage based on peak height above background) as well as specific class placement. The class placement may be unique to the survey based on reasonable distribution of results.
- The reporting of Atterberg limits within the survey laboratory data differs from standard USDA protocols (Soil Survey Staff 2009) that are based on American Society for Testing and Materials' standards (Method ASTM D 4318). Within this ASTM method, liquid limit and plastic limit are reported as percent water content of the soil in the defined states, while plastic index is the range of water content where the soil behaves plastically and is defined as the difference in water content between the two states. For samples where either or both the liquid limit or plastic limit cannot be measured, the plastic index is reported as "nonplastic."

47.5 Continued Cooperation Between USDA and ICBA/EAD

The cooperative efforts between the agencies of USDA, ICBA, and EAD were initiated over a year ago with questions of the presence and quantification of the mineral anhydrite in soils of coastal and inland sabkhas. Cooperation has been

further facilitated by our review of the use of USDA soil survey standards and soil taxonomy for the ongoing soil survey of the emirate of Abu Dhabi. Use of the USDA standards in this desert environment will help us to further test the applicability of soil survey mapping protocols around the world. The fact that Abu Dhabi Emirate has invested in a soil survey and is interested in protecting and preserving soils for agriculture production is very commendable. The continued cooperation between the ICBA, EAD, and USDA will be valuable for all parties.

The most immediate avenue for cooperation has been the sampling of selected soils in Abu Dhabi. A sequence of pedons along a coastal sabkha from the tidal influenced soils to inland areas were evaluated and sampled to develop the methodology for identification and quantification of anhydrite, as well as elucidate the mechanism and controlling factors for the formation of this mineral in soils of the region (Fig. 47.1f). Collected samples were shipped to the USA and analyzed by the NRCS Soil Survey Laboratory.

A quantitative method for anhydrite has been developed using the difference between the routine water-acetone procedure of NRCS to quantify gypsum and anhydrite together with a weight loss procedure for quantification of gypsum alone (Wilson et al. 2012). This study found an increasing amount of anhydrite in soils furthest from the coast. These results should help refine the maps of the Abu Dhabi coastal area.

Future efforts in cooperation can result in developing land-use interpretations for the survey of the emirate. Once developed, the application will prove useful to surveys both in the USA and in other arid areas of the world.

47.6 Future Development and Use of Soil Survey in Abu Dhabi

The information (maps, field and laboratory data) collected during the soil survey will prove to be a very valuable resource tool for land management and development. It is vital that a well-trained and experienced staff be maintained to interpret and help utilize the spatial and tabular data. For example, in the USA, four to six experienced soil scientists per state are employed on a full-time basis in order to provide technical soil services. The provided services are directed toward specific as well as general user needs and include interpretation of soil data, education, and limited training. Natural resource education for the public must begin at a young age to ensure an appropriate respect for soil.

In addition to the resource soil scientists, a cadre of over 400 soil scientists is located in 144 permanent soil survey offices across the USA. These offices are assigned responsibility for major land resource areas and cross provincial (state and county) boundaries. Each office is responsible for the maintenance and update of the published soil surveys.

The US soil survey information is available on the Internet at http://websoilsurey.nrcs.usda.gov/app/HomePage.htm. This site has greatly expanded the accessibility of soil information by the public. It has fostered greater use of natural resource

information as well as increased contact with users. This contact with the public is important to ensure the appropriate use and interpretation of the soil survey information.

The mapping of the soils is only the beginning in terms of natural resource management and protecting this valuable resource. Soil scientists must be available to provide assistance to agricultural persons and others in understanding utility and limitations of the maps and provide a range of assistance on topics such as suitability of soils for irrigation, nutrient management, land reclamation, or erosion and salinity control. Soils are one part of the ecosystem that controls the sustainability of life. Desertification is an extremely important problem to this region that must be addressed by the understanding of the soil. How we manage soils and what tools are appropriate to use affect the long-term sustainability of this resource.

The utilization of the survey is not limited to agriculture. The soil survey is the primary tool to prevent loss of agricultural lands by urbanization. The importance of soils is also related to urban land use and the environment, such as construction of homes and buildings, wind or water erosion, and groundwater protection. Increasingly, there is a greater problem with contamination of urban soils by pathogens and other contaminants. Many of the diseases related to human and animal health are soilborne problems, often a deficiency or excess of certain trace elements. Food security and safety and the global carbon cycle are also important issues that are addressed by this science.

Thus, once the soil survey is made available to the public, a great demand for the time and expertise of soil scientists can be expected. The level of expertise of these scientists must be maintained in order to ensure an in-depth knowledge of soils and soil survey, but also an understanding of how the survey process is conducted and the benefits and limitations of the product. Soil scientists are increasingly asked to help develop public policy and regulations related to land-use management. Maintaining a well-trained cadre of soil scientists is critical for full utilization of the soil information.

47.7 Conclusions and Recommendations

It is gratifying that the soil survey standards of USDA-NRCS are being used and successfully applied in the soil survey of the Abu Dhabi Emirate (EAD 2009a, b). Universal application of procedural guides such as those provided in the USDA National Soil Survey Handbook and Soil Survey Manual ensure uniformity and consistency in soil survey products worldwide. The use of soil taxonomy as an international classification system for the mapping and interpretation of soils was an original intent of the designers of the system. Using this system has proven to be both challenging and rewarding to the Abu Dhabi survey team. The research and contributions by EAD soil scientist Dr. Mahmoud Abdelfattah and ICBA soil scientist Dr. Shabbir A Shahid in the area of anhydrite mineralogy are acknowledged and greatly appreciated.

The field survey staff, the survey management team, and the sponsoring administrators are to be commended for conducting an outstanding soil survey program. Their expertise in soil science and management has resulted in the development of an excellent soil survey product that will prove to be of great value to the people of Abu Dhabi for years to come.

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