2006-993: CURRICULUM DEVELOPMENT AND TRAINING FOR ENVIRONMENTAL RESTORATION / WASTE MANAGEMENT

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Curriculum Development and Training for Environmental Restoration/Waste Management

Abstract

Tuskegee University (TU), in collaboration with University of Cincinnati (UC), is engaged in developing a sequence of two courses and a summer training program to educate and train students in the area of environmental restoration/waste management (ER/WM). The ER/WM activities cut across the boundaries of many scientific fields. Moreover, the site characterization and waste management must be performed in accordance with the current environmental laws and regulations. Hence, knowledge of appropriate codes developed by Department of Energy laboratories and federal agencies would be necessary.

The proposed course sequence is: 1) Introduction to Radiological Engineering and Waste Management and 2) Site Analysis and Environmental Restoration. The first course was developed in Fall 2005 semester and offered at TU as a 3-credit hour elective course during Spring 2006 semester. During summer, students will spend 8 weeks at TU in intensive hands-on training and research activities in some area of ER/WM.

The content of the first course is consistent with current courses in health physics. However, this course contains additional material on nuclear wastes. We believe that this course and associated summer training program would better prepare and train students for engaging in ER/WM related activities.

Introduction

The activities associated with the nuclear weapon production have caused serious damage to the environment and corrective actions are needed. However, to tackle the technologically challenging problem of environmental restoration and waste management (ER/WM) at these facilities, trained manpower is needed.

The complexity of the problem is enormous. The level of technological sophistication necessary to solve the ER/WM problems relevant to National Nuclear Security Administration (NNSA) requires that persons engaged in these activities have an education with strong science and engineering backgrounds. However, there is a shortage of students with this background in the United States due to a declining interest among high school students, particularly African Americans, to be engaged in these disciplines.

In view of this, Tuskegee University (TU), in collaboration with University of Cincinnati (UC), is developing a sequence of two courses and associated summer training and research programs in ER/WM to educate and train African American undergraduate students during the next two years. University of Cincinnati's role in this program is to provide technical expertise and guidance in developing these courses and the summer training and research programs.

Background

For over 60 years, nuclear weapons research and testing facilities have generated large amounts of hazardous wastes[1]. Most of these wastes are also radioactive. Little was known about the long-term effects of ionizing radiation during the early years when much of nuclear weapons research, development, and testing took place. Hence, wastes have been handled in ways that seemed appropriate at the time. Thus decisions were made to store high-level wastes in temporary underground tanks or to bury them in ways that is regarded as inadequate by modern environmental and safety standards. As a result, there was widespread contamination of the land and water around the places where these wastes were stored or disposed off. Therefore, waste management plans must include remedial action as well as current needs.

Radionuclides may exist in all physical forms and our knowledge is still somewhat meager about the transport of these materials through the environment, making the management of these wastes especially difficult. The major technical challenge in ER/WM area is to prevent the introduction of radioactive materials into the biosphere during the effective lifetime of these materials. For this to happen inventories of hazardous wastes have to be taken and the extent of contamination in land and water needs to be surveyed and characterized. Some of the wastes are to be stored and monitored and the contaminated environment has to be restored as close as possible to the original condition, in accordance with the applicable US regulations.

Environmental restoration involves site assessment and implementation of appropriate remediation techniques. It includes evaluating the environmental damage of a site, characterizing the environmental hazards, and cleaning up the site. The process involves the collection of samples of soil and groundwater to determine the nature and extent of the contamination. After the clean up process is complete, the land and water needs to be certified as environmentally clean by all appropriate federal, state, and local environmental regulatory agencies[2]. Work has been going on in the NNSA facilities in the area of ER/WM for a number of years but much remains to be done.

Many science disciplines converge in ER/WM activities[3]. Students need to understand aspects of physics, chemistry, biology, and environmental science including geology, hydrology, and meteorology. In addition to the basic sciences, specialized knowledge in the area of site characterization and waste management, as well as current environmental laws and regulations, and knowledge of appropriate codes developed by DOE national laboratories and federal agencies would be required.

Course Description

The courses envisioned by us are described below. The sequence will include two courses: 1) Introduction to Radiological Engineering and Waste Management and 2) Site Analysis and Environmental Restoration. The first course focuses on elements of radiological engineering, pathway analysis, dose assessment, fuel cycle, and waste management. It is specifically developed to set up the basis and convey the knowledge required for the second course. Juniors/seniors from biology, chemistry, environmental science, physics and all engineering

disciplines are eligible to take this course. This course was developed in Fall 2005 semester and offered at TU as a 3-credit hour elective course during the Spring 2006 semester.

Alabama A&M University (AL A&M) is also participating in this project. Some of this course material was incorporated in an existing course in the biology program at AL A&M and offered to the students there in the Spring 2006 semester as part of the Radiation Biology and Waste Management course.

The second course will deal with risk assessment, current environmental laws, regulations and radiation standards and protection practices in the United States. Hands-on experience on numerical analysis and dose assessment codes developed by the national laboratories and federal agencies will be provided to students as part of this course.

We believe this sequence would better prepare and train the students for both engaging in activities related to ER/WM, as well as creating the basic knowledge for those who would like to pursue graduate studies in this field. In addition, we believe that the hands-on experience on running appropriate codes and the section on environmental site analysis and regulations is unique not only to historically black colleges and universities but also to US academic programs that teach core curricula and research programs on this subject.

The contents of the first course are described below. The second course is now in the process of development.

1. Introduction to Radiological Engineering and Waste Management

   a. Atoms and Chemistry – Elements of the periodic table and their characteristic properties as related to wastes; Isotopes and radiation emitted by waste – 2 lectures

   b. Radioactivity – The process of radioactive decay; Half-life and activity, Important radioisotopes in wastes and contaminated environment – 4 lectures

   c. Radiation Interaction with Matter – Alpha, beta, gamma, and neutron range-energy relationships; Interaction mechanisms - 3 lectures

   d. Elements of Radiation Shielding – Elements of shielding calculation and design – 4 lectures

   e. Biological Effects of Radiation – Radiation and living cells; Risk comparison with chemical wastes – 2 lectures

   f. Health, Safety, and Environmental Protection – Radiation pathways analysis; Long term effects – 3 lectures

   g. Meteorology – Migration of airborne nuclear wastes; Gaussian plume model – 2 lectures

h. Geology and Hydrology – Earth's water cycle; Waste retention in geologic media – 2 lectures

i. Toxicology – 1 lecture

j. Radiation Detection – Radiation detector properties; Ionization chambers; Proportional Counters; Geiger-Mueller counters; Spectroscopy – 4 lectures

k. Radiation Dose Assessment – Calculation of external and internal dose; Inhalation dose – 4 lectures

l. Fuel Cycle – Fuel production, usage, processing, transportation and disposal – 2 lectures

m. Sources of Radioactive Waste – Source characterization – 1 lecture

n. Classification of Wastes – High-level, transuranic, and low-level wastes – 2 lectures

o. Disposal of Wastes – Shallow land burial; In-situ processing; Waste isolation pilot plant – 2 lectures

While much of this content is consistent with current courses in health physics, the addition of the sections on nuclear waste broadens the scope and provides a background needed by this student population. Moreover, the combination of hands-on experience detailed below with the knowledge conveyed in the second course on appropriate environmental computer codes, site analysis and US regulations would cover most of the basic ER/WM related issues.

Summer Activities for Students

During the summer, students will spend 8 weeks (40 hours per week) at TU in an intensive training and research in some areas of ER/WM. The summer activities will be divided into two components, namely, hands-on training and research. The hands-on training activities take place in the morning and research is conducted in the afternoon. These activities are described below.

Hands-on Training

We utilize laboratory experiences to facilitate student learning. Since 1960 TU has been an active user of radioactive materials in various research activities. A large amount of radioactive wastes has been accumulated since that time at the TU campus. Many of these wastes are unlabeled. TU is now in the process of identifying and cataloging these wastes for eventual disposal. We are also in the process of cleaning up several rooms which were previously used for research with radioactive materials. Thus TU provides an ideal environment where students can learn how to take smear-tests of working surfaces and identify the radioactive contents of unlabeled containers and the amount of radioactivity in them. They will also learn the rules and regulations of the State of Alabama for handling radioactive material.

Research

Our students will also engage in research activities in areas related to ER/WM. Several student teams will be formed, each team consisting of 2-3 students belonging to different disciplines. Each team is assigned a research topic of its choice. Participating students are required to work effectively across the disciplines as one team. In a multidisciplinary team, engineering students benefit from working with non-engineering students to define the technical requirements and specifications of their project. In parallel, individuals from other disciplines benefit from exposure to engineering problem solving techniques.

Future Plan

Our ultimate goal is to have a comprehensive curricular development and implementation of minor concentrations of study in the environmental sciences and engineering as a complement to the current majors in science and engineering. Offering continuing education courses on ER/WM topics and development of graduate level courses and programs are two other longer-term goals.

Conclusion

This paper describes an educational program being developed on ER/WM that is geared toward NNSA goals. Undergraduate students from science and engineering disciplines can take these courses for credit towards their degrees. Students will also participate in an intensive, 8-week, full-time summer program. At the end of each year, many African American students will graduate with a cross disciplinary knowledge of ER/WM. Also, several faculty members will become trained to teach these courses on their own at the participating institutions which will somewhat alleviate the needs of ER/WM industry of having a sufficient number of trained instructional personnel.

References

1. US Department of Energy, National TRU Waste Management Plan DOE/NTP-96-1204, Revision 2, December 2000
2. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Rev. 1, August 2002
3. Saling, James H, Audeen W. Fentiman, Radioactive Waste Management, 2nd Edition, Taylor and Francis, 2002