GEOENVIRONMENTAL ISSUES INVOLVING UNSATURATED SOILS

Name: Radhey S. Sharma
Affiliation: Iowa State University
E-mail: rsharma@iastate.edu
Webpage: http://www.cce.iastate.edu

Geoenvironmental Research Experience

- Migration of LNAPL in an unsaturated/saturated sand
- Risk assessment for groundwater contamination from a contaminated site

Geoenvironmental Teaching Experience

- Environmental Hydrogeology
- Contaminated Land
- Environmental Geotechnics
- Short Course on Geoenvironmental Engineering

Geoenvironmental Consulting Experience

The author worked for 6 years as an Environmental Engineer in Central Pollution Control Board, Delhi. The projects were of a wide range involving environmental pollution prevention and control. Central Pollution Control Board is an equivalent of EPA here in USA.

Appraisal of Geoenvironmental Research, Education and Practice

Geoenvironmental research is rapidly expanding into many new and emerging fields as well as there is significant research in on-going themes. Consequently, the geoenvironmental research covers a wide range of disciplines such as geotechnical engineering, ground and surface water hydrology, chemistry, microbiology, and themes related to societal impacts and policy planning and implementation. One of the primary reasons for expansion of geoenvironmental research is unresolved contamination problems that have impact on human health and quality of life. Development of new technologies is another reason for this expansion in research. For example, developments in nanotechnology and bioinformatics coupled with our better understanding of unsaturated soils are likely to provide new insight into aspects of natural attenuation of contaminants in the geoenvironment. Similarly, our understanding of unsaturated soils is going

to result in new ways of analyzing and designing containment systems for environmental protection. It would be true to say that significant and useful geoenvironmental research has been pursued worldwide and USA is definitely a leader in most of the geoenvironmental research. It is, however, time to look into new opportunities and geoenvironmental problems that need attention on priority basis. This workshop is therefore a good opportunity for us to take stock of strengths and weakness in current portfolio of geoenvironmental research.

Geoenvironmental education is mostly at graduate level and varies from place to place depending upon the available expertise and resources. It is, however, important that students get exposure to a range of topics so that they would be prepared to face the challenge of fast changes in the field of geoenvironmental engineering resulting from new and emerging technologies. Nevertheless, student learning environment should be aimed at preparing life-long learners rather than attempts to include everything in the syllabus.

Geoenvironmental practice is obviously a product of the quality of our geoenvironmental research and education. It would be reasonable to say that practicing engineers have successfully designed and operated a vast majority of geoenvironmental facilities. The pace of technology transfer from research to practice is generally slow and can be improved by concerted efforts by all the stake holders.

Perspective on Emerging Geoenvironmental Issues and Technologies

There are numerous geoenvironmental issues that need substantial amount of further research. In this paper, only the major issues that require understanding of unsaturated soils are briefly outlined and discussed.

Geoenvironmental issues that are going to take significant effort include contaminant transport, attenuation processes and containment systems, especially in vadose zone as this area has not received the desired level of effort particularly from geotechnical engineering community. For example, in designing and operating efficient geoenvironmental facilities, we need to asses the extent and time frame for contamination migration for which we should have more research involving unsaturated phenomenon. The author was the principal investigator for a project involving migration of light non-aqueous phase liquid in an unsaturated/saturated sand. The research involved large scale laboratory testing under controlled condition with measurements of suction, saturation of water and LNAPL, and use of Image Analysis Technique. Detailed results are not presented in this paper, but the reader can refer to some of these results reported by Sharma and Mohamed (2003). The main outcome of the research was significant as it showed the influence of spill volume and rate on the patterns of LNAPL migration. What this research indicated that new research involving unsaturated phenomenon provide vital new information that we need for effective and efficient design of geoenvironmenatl facilities. It would be desirable to pursue it further involving variations in field conditions and linkage of the new information with the degradation behavior of LNAPLs. In fact, natural attenuation processes under unsaturated conditions is an area that needs major effort involving both laboratory and field investigation. New technologies from microbiology and nanotechnology should be pursued to develop new knowledge about degradation of contaminants. Long term performance of containment systems also needs further research. For example, cover systems involve

unsaturated flow, which needs work on understanding the influence of naturally occurring wetting-drying cycles on the performance of the system. There are financial and environmental reasons for using the geomaterials available at a site rather than importing fresh materials from far away places. In order to achieve the desired performance of the geostructures constructed from such materials, a thrust on understanding the behavior of these materials is required. In majority of cases such construction involves compacted materials, which are in unsaturated condition, but can become saturated subsequently. New developments in unsaturated soils are reported by Gallipoli *et. al.* (2003) and Wheeler *et. al.* (2003). There is, however, need for major effort to develop this knowledge further and its application to reuse of materials in construction and operation of various facilities including covers for disposal sites.

References

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