

Partnership with Bangladesh University of Engineering & Technology in Pollution Prevention Curriculum Development and Research

**Keith A. Schimmel, Shamsuddin Ilias, Franklin G. King/
A.K.M. Abdul Quader
North Carolina A&T State University/
Bangladesh University of Engineering & Technology**

I. Introduction

As a nation with a population of over 130 million on a landmass of 55,813 square miles (about the size of Wisconsin), Bangladesh is known to the West for natural calamity, famine, and poverty. In recent years, Bangladesh has made major strides to produce sufficient food domestically to meet its rapidly increasing population and has made significant gains in export earnings through the ready-made garments industry. However, these gains are being overshadowed by environmental disasters.

The nation is facing arsenic contamination of its water supply. Excessive withdrawal of groundwater for irrigation and massive diversion of natural water flows of the major rivers by building dams has aggravated this problem. In fact, one of the biggest mass-poisoning cases the world has ever known has taken place in Bangladesh. According to UNICEF, the “Bangladesh arsenic problem represents a collective failure on the part of the International Agencies, the Government and other donor agencies which could have acted faster than what we did in getting a fuller picture and extent of the problem.”¹ This is a problem that needs scientific and engineering solutions using “good” science.²

Excessive use of fertilizers and pesticides has adversely affected the surface water. According to the World Conservation Union (IUCN), the environmental ecology of the country is changing rapidly. Alarming, a large number of fish, amphibians and reptiles, mammals, and birds are now on the endangered and threatened species list.³

The fertilizer and textile industries are considered major contributors to surface water pollution. Bangladesh has a number of urea, ammonium sulphate, and phosphate (TSP) fertilizer plants of multi-million ton annual capacity along the banks of major rivers. Unregulated discharge of waste effluent in the rivers is frequently witnessed by fish kills. In the textile sector, production of ready-made garments for export to the U.S., Canadian and European markets has grown rapidly and now dominates Bangladeshi exports. Bangladesh is the fifth-largest supplier of cotton apparel to the United States and is also a major trading partner in the West European market. This unprecedented growth has been a blessing for the economy, but the damage to the environment has yet to be assessed. Textile weaving and dyeing industries are producing enormous volumes of waste effluents containing dyes, alkali, and bleaching agents, usually as mixed-waste and discharged to open waters.

The increasing population and higher levels of human activities, including effluent disposals to surface water and groundwater, have made sustainable management of water resources a very complex, challenging task for Bangladesh. In addition, per capita demand for fresh water is steadily increasing as more and more people achieve higher standards of living and as lifestyles steadily change. Thus, sustainable planning and management of water resources has become a priority consideration for the future welfare of Bangladesh. In that context, pollution prevention should be a priority in any management plan of its meager water resources.

In the context of the above cited scenario, a linkage program between the chemical engineering departments of North Carolina A&T State University (NCA&TSU) and Bangladesh University of Engineering & Technology (BUET) has been established with a focus on pollution prevention. The BUET chemical engineering department is the only program that offers a B.S. degree in chemical engineering in Bangladesh. Chemical Engineering is a discipline that teaches and trains young minds in purification, separation and isolation in a broader sense for process industries. From an environmental point of view, pollution prevention is the study of contaminant purification (P), separation (S) and isolation (I), which we call PSI. These are the underlying activities that will be used to tackle the contamination problem in its totality. This is a formidable task for a single chemical engineering department in a nation of 130 million people, where meeting the basic necessities of life is by itself a war for existence.

However, a solution to these problems is certainly not possible without strong leadership from the country's technical leaders. Toward this end, the outcomes of the linkage program included:

- Faculty Development in Pollution Prevention
- Curriculum Development in Pollution Prevention at both the Undergraduate and Graduate levels
- Development of Collaborative Research in Pollution Prevention with Emphasis on Surface and Groundwater Contamination and Water Purification
- Establishment of electronic connectivity including video conferencing capability with BUET

II. Participating Institutions

BUET is the premier institution of higher learning in science and engineering in Bangladesh. In a nation of over 130 million population, BUET is the only university that offers undergraduate and graduate degrees in engineering. The University started in 1876 in the British India as the Assam Bengal Survey School. The University presently has an enrollment of over 3,000 students in the undergraduate and graduate levels. The University offers degree programs in Chemical, Civil, Electrical, Mechanical, Industrial and Computer Engineering.

The chemical engineering department offers B.S., M.S., and Ph.D. degrees in chemical engineering. Current undergraduate enrollment in the freshman class is restricted to sixty students. The department operates with six faculty members that all have Ph.D. degrees from abroad. The chemical engineering faculty has offered and is always ready to offer vital consulting service to the growing chemical process industries in Bangladesh. Specially, advice in the fields of corrosion, materials protection, and energy has earned respect and a good reputation for the department. Other areas of expertise are water and wastewater treatment, food processing, techno-economic feasibility of chemical process industries, and technology policy issues.⁴⁻¹¹

The faculty members from BUET who provided support to this activity are listed in Table 1. Dr. Quader was the linkage coordinator for BUET.

Table 1: Team Members of BUET in the BUET-NCATSU Linkage Program

Name	Gender	Department/Rank
Dr. Iqbal Mahmud	Male	ChE/Prof. Emer.
Dr. Nooruddin Ahmed	Male	ChE/Prof
Dr. A.K.M. A. Quader	Male	ChE/Prof
Dr. M. Serajul Islam	Male	ChE/Assoc. Prof.
Dr. M. Sabder Ali	Male	ChE/Professor
Dr. Dil Afroza Begum	Female	ChE/Professor
Dr. M. Mujibur Rahman	Male	Civil Eng./Prof.

NCA&TSU is a unique state-supported University. It is the only comprehensive university in North Carolina that has a College of Engineering and a School of Agriculture in consonance with its land-grant tradition. It is one of the six historically black engineering schools in the nation. The College of Engineering offers B.S. and M.S. programs in Agricultural, Architectural, Chemical, Civil, Electrical, Industrial, Mechanical Engineering and Computer Science. Currently, Ph.D. degrees are offered in the Mechanical, Industrial and Electrical Engineering programs. Two new interdisciplinary Ph.D. programs will begin in fall 2005: Energy & Environmental Studies and Leadership Studies. The current enrollment in the college is about 1800 students at the undergraduate level and over 300 students at the graduate level.

The Chemical Engineering Department has a history of research activity in the area of environmental engineering and pollution prevention.¹²⁻¹⁹ Chemical engineering department faculty lead the multi-million dollar research effort in Environmental Remediation under the Air Force FAST Center and are also a part of the 20 million dollar NSF Science & Technology Center on Environmentally Benign CO₂ Solvents and Processes. Drs. Ilias and Schimmel are designated Lucent Tech Industrial Ecology Faculty Fellow for their work on membrane-based separations in pollution prevention and waste reduction. Since 1997, the department has offered an undergraduate/graduate elective in pollution prevention. Thus, it is logical for NCA&TSU to use its faculty experience in helping BUET with faculty development in the area of pollution prevention and collaborative research in pollution prevention.

III. Partnership Achievements

The two-year project to establish a linkage program in pollution prevention between NCA&TSU and BUET began in March, 2001. The highlights of the activities include:

- Official Visit of Professor Nooruddin Ahmed, Vice Chancellor of BUET (April 3-6, 2001)

At the invitation of Chancellor Rennick of NCA&TSU, Vice Chancellor Nooruddin Ahmed visited A&T State University to officially kick-off the linkage program. During his visit, he met Chancellor Rennick and other top administrators. This provided an opportunity to

discuss the project implementation strategy and possible future collaboration between the two institutions in graduate research and faculty exchanges. He was also given a guided tour to various research centers and institutes by the respective faculty.

- Global Partnership Conference (April 9-11, 2001)

Both NCA&TSU and BUET were represented at the Global Partnership Conference organized by the United Negro College Fund Special Programs Corporation (UNCFSP), which was held in Washington, D.C. As head of the institution, Vice Chancellor Ahmed represented BUET. Dr. Earnestine Psalmonds, Vice Chancellor for the Division of Research, represented NCA&TSU and was accompanied by the Project Director, Dr. Shamsuddin Ilias.

- A total of eleven workshops were offered in Bangladesh as summarized in Table 2.

Table 2: Workshops Offered by BUET-NCAT IDP Linkage Partnership

Workshop	Date	Topic Title	Participants
1	July 24-25, 2001	Integration of Pollution Prevention Topics into the Engineering Curriculum	24
2	March 12-14, 2002	Environment Protection and Pollution Prevention Issues and Initiatives	37
3	July 29-31, 2002	Environment Protection and Pollution Prevention Issues and Initiatives	63
4	Aug. 27-28, 2002	Hazard Evaluation in Process Industries	44
5	Dec. 18-19, 2002	Membrane-based Separations	16
6	Dec. 26-28, 2002	Environment Protection and Pollution Prevention Issues and Initiatives	50
7	May 27-28, 2003	Hazard Evaluation in Process Industries	43
8	Oct. 22-24, 2003	Environmental Rules and Regulations and Waste Management	28
9	April 26-27, 2004	Integration of Pollution Prevention Topics into Science and Engineering Curricula	13
10	May 13-15, 2004	Environment Protection and Pollution Prevention Issues and Initiatives	34
11	Aug. 7-9, 2004	Environmental Rules and Regulations and Waste Management	47

The eleven workshops/short courses offered at BUET through its Directorate of Continuing Education (DCE) have met the objectives of the thrust area for outreach and capacity building through participation of about 400 professionals. Out of eleven workshops/short courses, four were conducted (without the participation of NCATSU resource persons) with BUET and local resource personnel. This is a vital indicator of sustenance of the program's objective of capacity building.

While conducting workshops, besides the resource persons from NCATSU and BUET, seven local resource persons belonging to NGO, government, and private sectors contributed to these programs. Officials from the Department of Environment (DoE) participated in the workshops both as resource persons and participants. Resource persons from the World Conservation Union (IUCN) and Bangladesh Environment Lawyers Association (BELA), and participants from NGOs, government departments such as LGED (Local Government Engineering Department), PDB (Power Development Board), WDB (Water Development Board), RAJUC (Rajdhani Unnayan Katripakka – Capital Development Authority), RHD (Roads and Highways Department), BCIC (Bangladesh Chemical Industries Corporation) and industries had the opportunity to discuss policy issues impacting environment. DoE's officials got feedback from the participants and other resource persons on how DoE is performing on policy and regulatory matters. It was evident from the discussion that policy makers are under scrutiny and they need to meet the expectation of the concerned citizens.

- Visit to BUET, Dhaka, Bangladesh (July, 2001)

The local host (Dr. Quader – BUET) organized two plant visits while Drs. Schimmel and Ilias were in Bangladesh. One visit was a day trip to Jamuna Fertilizer Company (JFC) at Tangail. JFC has a effluent treatment plant (ETP) for treatment of oily wastewater. The plant officials expressed interest in working with BUET to conduct a performance study on the ETP. The other visit was to a tannery plant in Dhaka. A significant number of tanneries are located in the heart of thickly populated Dhaka City. The waste effluent and odors from these tanneries are of great environmental concern. The possibility of contamination of groundwater from chromium laden tanning effluent is real.

- Videoconferencing Capability between NCA&TSU and BUET that can support a call involving up to 10 people was established. The facility is available to BUET and also to outside users. BUET is the only university in the country that has Video Conferencing Facility with its own V-sat. BUET is now using this facility for distance learning. (March, 2002)
- The program offered four faculty members from BUET an opportunity to interact with their counterpart at NCATSU through short-term faculty exchanges (four to eight weeks). This allowed BUET faculty members to develop course materials in the area of pollution prevention and environment management using NCATSU's library resource and faculty collaboration. As a part of collaborative research projects, BUET initiated two research projects: (i) Tannery waste treatment and (ii) Medical waste treatment.
- Dr. A.K.M.A. Quader, Professor of Chemical Engineering & International Coordinator from BUET visited NCATSU during the period of October 11- December 10, 2001. Dr. Quader, during his visit, worked on the preparation of a course on 'Environment Protection and Pollution Prevention' for the undergraduate students belonging to different engineering and science disciplines studying in Bangladesh. The main objective of this course is to provide a broad base and background for appreciating and dealing with environment and pollution with emphasis on environmental protection and pollution prevention. Dr. Quader presented two graduate seminars to our faculty and students at NCATSU with the following titles: (1)

Removal of arsenic from water using an arsenic selective ion exchange resin and (2) Control of atmospheric emission of a basic chrome sulfate plant.

- Dr. M.S. Ali, Professor of Chemical Engineering at BUET visited NCATSU during the period April 01 - May 24, 2002. During his visit, Dr. Ali worked on the updating and preparation of a graduate course on "Loss Prevention" for chemical engineering department. He also collected materials on "Hazard Evaluation for Process Industries". These materials were used later for a workshop at BUET for chemical process industry under this program.
- Dr. M.S. Islam, Professor of Chemical Engineering at BUET visited NCATSU during the period of May 14 – June 21, 2003. Dr. Islam worked on developing course materials on plastics waste management and related research areas.
- Dr. Dil Afroza Begum, Professor of Chemical Engineering at BUET visited NCATSU under the exchange program in February 2004 for a month. During her visit, Dr. Begum concentrated developing course materials on air pollution and environmental management. Dr. Begum also visited Dr. Ilias' Membrane Research Lab at NCATSU and expressed interest in collaborative research and graduate student exchange in membrane-reactor-separator area beyond the IDP support.

IV. Sustainability of Program

Although this IDP Linkage Program officially ended August 15, 2004, both BUET and NCATSU will continue to work on the activities initiated by this IDP. North Carolina A&T State University is committed to the continued success of this activity with BUET. The institution commitment of BUET is demonstrated by its cost-share and also support of two research projects: (a) Tannery Waste Treatment, and (b) Medical Waste Treatment. These two projects are fully funded by BUET from its own resources.

Through this program, BUET Chemical Engineering Department gained experience and expertise in developing short courses and workshops on various topics in the area of pollution prevention and environment management. The faculty members of BUET ChE Department are now committed to continue the work through their Directorate to Continue Education (DCE). They plan to offer short courses and workshops as part of outreach and capacity building to the private and public sector on a regular basis. There is a huge demand for these courses in Bangladesh and BUET ChE Department is well-positioned to capture this vacuum.

For a successful, sustainable international partnership, one must consider and recognize:

- previous collaboration and interaction between partners (through graduate students and personal contact)
- good communications (e.g., minimize language barriers and use electronic communications)
- compelling interest in purpose of partnership
- institutional support and commitment

For this partnership everything listed above was there and contributed to its success.

VI. Acknowledgement

This work has been supported by the United Negro College Fund Special Programs Corporation (UNCFSP) and the United States Agency for International Development (USAID).

Bibliography

1. Ghosh, G., "General Overview of UNICEF and Its Initiative in Bangladesh and West Bengal," International Conference on Arsenic in Bangladesh Ground Water: World's Greatest Arsenic Calamity, Staten Island, NY, February 27-18, 1999.
2. Mortoza, S., "Arsenic Contamination – Too Formidable a Foe," West Bengal and Bangladesh Arsenic Crisis Information Center, 2000.
3. IUCN Bangladesh 2000, "Red Book of Threatened Animals of Bangladesh," IUCN – The World Conservation Union, 2000.
4. Quader, A.K.M.A., **Design and Building of Process Plants – some practical guidelines**, World University Service Press, Dhaka (1992), ISBN 984-30-0018-8.
5. Quader, A.K.M.A., Considerations in the design of an ammonia-urea synthesis plant, Proceedings of the Workshop on "Chemistry and Technology of Fertilizer Industry", Dhaka University, (Dec. 20, 1986-Jan. 1, 1987).
6. Quader, A.K.M.A., Exploration and development of oil-gas in Bangladesh (in Bengali), Unnayan Bitarkka, vol. 6, 43-53, March – Dec. (1987).
7. Quader, A.K.M.A., Industry-University interaction: an experience of Bangladesh, Proceedings of National Seminar "Chemical Engineering Education and Research" Organized by Indian Institute of Chemical Engineers, India, Calcutta, 62-66, Nov. 2-3 1989).
8. Quader, A.K.M.A., Lessons learnt from carbon dioxide stripper failure of urea plant at Ghorasal, Proceedings of Indian Chemical Engineering Congress 1995, Dec. 27-30 (1995), held at Indira Gandhi Centre for Atomic Research, Kalpakkam.
9. Quader, A.K.M.A., Development of chemical engineering education in Bangladesh, Proceedings of the seminar on "Changing Scenario of Chemical Engineering Education and Research" for celebrating the Golden Jubilee of Indian Institute of Chemical Engineers – Feb. 97, held at Calcutta, Feb. 7-9, (1997).
10. Quader, A.K.M.A., Fifty years' development of chemical industry in Bangladesh, Chemical Engineering Research Bulletin, BUET, Vol. 11, 73(1999).
11. Quader, A.K.M.A., Environmental rules and regulations of Bangladesh, presented at the National workshop on "Waste Water Treatment in SME", held at BCSIR, Dhaka, 1-4 February (2000).
12. Ilias, S., Schimmel, K.A., "Membrane Bioreactor Model for Removal of Organics from Wastewater," Journal of the Air & Waste Management Association, vol. 45, pp. 2-7 (1995).
13. Rodriguez de San Miguel, E., Aguilar, J.C., Bernal, J.P., Ballinas, M.L., M.T.J. Rodriguez, J. de Gyves, and Schimmel, K.A., "Extraction of Cu(II), Fe(III), Ga(III), Ni(II), In(III), Co(II), Zn(II), and Pb(II) with LIX 984 Dissolved in n-Heptane," Hydrometallurgy, vol. 47(1), pp. 19-30 (1997).
14. Ilias, S., Schimmel, K.A., Yezek, P.M., "Non-Dispersive Liquid-Liquid Extraction of Copper and Zinc from an Aqueous Solution by DEHPA and LIX 984 I a Hollow Fiber Membrane Module," Separation Science and Technology, vol. 34(6&7), (1999).
15. MacKinnon, R.J., Schimmel, K.A., Loehr, C.A., Best, J.F., Wolfram, J.H., "Scaling In Situ Bioremediation Problems by Application of Multiphase, Multicomponent Transport Theory," Chemical Engineering Communications, vol. 158, pp. 123-156 (1997).
16. Schimmel, K.A., Ilias, S., Akella, S., "Non-dispersive Liquid-Liquid Extraction of Zn(II), Cu(II), Co(II) and Cd(II) from Dilute Solution with DEHPA in Hollow Fiber Membrane Module," Separation Science and Technology, vol. 36(5&6), (2001).
17. Ilias, S., Schimmel, K.A., Tsatsu, N., "Stripping of Zn(II), Cu(II), Co(II) and Cd(II) from DEHPA Using EDTA in Hollow Fiber Membrane Module," Separation Science and Technology, vol. 36(5&6), (2001).

18. Escobar, A., Schimmel, K.A., de Gyves, J., Rodriguez de San Miguel, E., "Hollow-fiber Dispersion-free Extraction and Stripping of Pb(II) in the Presence of Cd(II) using D2EHPA under Recirculating Operation Mode," Journal of Chemical Technology and Biotechnology, vol. 79(9), pp. 961-973 (2004).
19. J. Lou, K. Schimmel, P. Kuzviwanza, V. Harinath, "Biodegradation of polyvinyl alcohol in aqueous environment", Polymeric Materials: Science and Engineering, **2004** 91, 827-831.

KEITH A. SCHIMMEL

Keith Schimmel is Associate Professor of chemical engineering at North Carolina A&T State University, Director of the energy and environmental studies Ph.D. program, and a registered professional engineer in North Carolina. He received a B.S. degree in chemical engineering from Purdue University. He also holds M.S. and Ph.D. degrees in chemical engineering from Northwestern University.

SHAMSUDDIN ILIAS

Shamsuddin Ilias is Professor of chemical engineering at North Carolina A&T State University and a registered professional engineer in Ohio. Dr. Ilias received his B.S., M.S. and Ph.D. degrees in chemical engineering from Bangladesh University of Engineering & Technology (Dhaka), University of Petroleum & Minerals (Dhahran), and Queen's University at Kingston (Canada), respectively.

FRANKLIN KING

Franklin G. King is Professor of chemical engineering at North Carolina A&T State University. He has served the department as Chairman for sixteen years. Dr. King received his B.S., M.S. and D.Sc. degrees in chemical engineering from Penn State, Kansas State and Stevens Institute, respectively. He also holds a M.Ed. degree from Howard University.

A.K.M. ABDUL QUADER

A.K.M. Abdul Quader is Professor of chemical engineering at Bangladesh University of Engineering & Technology. He has served as Dean of Faculty and Head of the Department. He received a B.S. degree in chemical engineering from E.P. University of Engineering & Technology (Dhaka) and holds a Ph.D. degree in chemical engineering from the University of Bradford (U.K.).