university programs in air pollution control: review and outlook

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From the inception of the National Air Pollution Control program, the U. S. Congress has been mindful of the need and importance of adequate manpower. The challenging technical problems which lie ahead in enforcement, monitoring, testing and research can be effectively dealt with only by individuals with specialized knowledge, skills and experience. In this paper the authors look at undergraduate and graduate training that is being carried out, employment opportunities and the way these may change in the future. A recently completed survey of college level air pollution training in the United States and Canada is included in the report.

For many years before federal legislation, there was concern about air pollution control. Problems were solved as they were recognized by scientists and engineers. With growth of cities, industry, and the use of the automobiles, problems became larger and more difficult and costly to solve. Universities began to devote research effort to all aspects of air pollution.

From the inception of the National Air Pollution Control program, the U.S. Congress has been mindful of the need and importance of adequate manpower. The first federal air pollution control law (P.L. 159–1955) contained provisions authorizing the use of funds for supporting the establishment of training programs for air quality specialists for service in federal, state, and local control agencies and private industry.

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The support for both short courses and academic programs at the undergraduate and graduate levels gradually expanded over the next twenty years. Much of the success in staffing governmental agencies, at all levels, with qualified air quality personnel can be attributed to these programs. Many of the most qualified air quality professionals currently in industrial practice obtained their training directly or indirectly through these federally supported programs.

While it is evident that encouraging progress has occurred within the past two decades, it must be recognized that a major impediment in efforts to restore the quality of this nation's air continues to be a shortage of sufficient qualified manpower. Many air pollution control agencies are undermanned or lack top-quality air specialists.

Major changes brought on by the recently enacted Clean Air Act of 1977 require the promulgation of many new regulations pertaining to such complex issues as prevention of significant deterioration, industrial growth in nonattainment areas, and permits for new facilities. Obviously these new requirements will impose additional work loads on control agencies which already are understaffed, as well as on private industry and consulting firms. The resulting demand for personnel will be in terms not only of numbers, but also of high professional qualifications.

The challenging technical problems which lie ahead in enforcement, monitoring, testing and research can be effectively dealt with only by individuals with specialized knowledge, skills, and experience. The need for continued and expanded support for academic programs of education and training is obvious.

Studies have been made of air pollution control training available in the U.S. and Canada.[1] Community colleges, undergraduate universities and graduate schools currently offering such coursework are listed in Appendix 1.

Studies have been made that attempted to identify the number and type of job openings that would require some specialized training in air pollution control.[2] The type of training most suitable for individuals for various types of air pollution control responsibilities has been discussed at several recent Air Pollution Control Association meetings.

In this paper, the authors will look at training being carried out at universities, employment opportunities presently available, and the way these may change in the future.

Undergraduate Air Pollution Training

Undergraduate training in air pollution control is likely to take the form of one or two elective courses. This work is often offered as part of a chemical, civil, environmental, or mechanical engineering, a public health or environmental science program. Stinson has defined a graduate of an environmental engineering or science program which has incorporated a minimum of four upper level or graduate courses in air pollution as one criterion for a professionally trained air pollution abatement practitioner.[3]

Table I. Average distribution of coursework in environmental engineering from 15 undergraduate schools.[4]

Humanities	17.2%
Mathematics	12.4
Computer Science	1.0
Chemistry	8.2
Physics	6.7
Biology	2.6
Engineering Science	26.4
Environmental Engr.	14.6
Electives	9.5

Patterson's review of fifteen undergraduate environmental engineering programs provides further information on the nature of some programs.[4] Six of these were accredited by ECPD. The average distribution of coursework in these programs is shown in Table I.

Air pollution control makes up part or all of the environmental engineering coursework.

Aaroe[5] spelled out the need for undergraduates in environmental science programs to be exposed to communication skills, economics, psychology, chemistry, chemical engineering, physics, biology, physiology, math, statistics, and legal affairs. In his analysis, Patterson found that many of the undergraduate environmental science programs do not incorporate basic engineering and mathematics courses. Students may find it hard to find a satisfying job in air pollution control if they have not had enough basic sciences and math.

Table II. University level environmental education.

Comment	Reference
No university should offer an environmental course as a first degree. One should study in one or more of the earth sciences from architecture to zoology. Twelve months of individual field work should be required also.	11
Larger industries use inhouse and on the job training to train environmental manpower but rely on institutions to provide basic education.	2
The spectrum of environmental curriculum is too broad to be covered in one undergraduate degree. A graduate degree for the practice of environmental engineering is necessary. The undergraduate should receive training in one area of environmental engineering plus an overview.	9
Graduate education is essential to provide needed and desired high level professional competence. Undergraduate programs can provide the most effective educational programs for the profession.	8

The concept of environmental training at the undergraduate level has been the subject of considerable discussion in the literature.[4,6–10] A summary of some of the published and unpublished thoughts is listed in Table II and indicates that a difference of opinion exists on what undergraduate studies should involve.

Most universities offer a general course in air pollution which covers primary and secondary air pollution, effects, control technology, legal, economic, and political aspects. A number of these offer undergraduates coursework in meteorology, source and ambient measurements, and engineering design. The number of students who receive this type of training is difficult to determine. The number is not as large as surveys by NRC[12] and NFRC, Inc.[13] indicate.

In one environmental engineering program (Cal Poly) about 10 to 15 students graduate per year with a concentration in air pollution control. These students have a background midway between a classical chemical and mechanical engineer. The types of jobs these graduates have accepted since 1969 are compared with graduates of 14 other undergraduate environmental engineering programs in Table III.

Job opportunities exist for qualified people at this level. Stinson[3] says that 81% of the individuals entering air pollution control agency professional positions between 1973 and 1975 had a bachelor degree as their highest college degree.

Graduate Training[14,15]

Before discussing details of curricula it would be useful to consider the academic setting in which such curricula would operate. It is highly desirable for programs in air quality to extend beyond the education of engineers alone. The educational program can be more meaningful, useful, and interesting to the engineering student if it possesses the capability for educating nonengineers and applied scientists. Not only is there an urgent need for such professionals in this field, but also there are exciting opportunities for them to make valuable contributions to the state of knowledge in this area. Normally the departments of science as well as most engineering departments on campus do not provide sufficient opportunity for individuals desirous of entering the air quality field. In this respect, the environmental engineering field occupies a unique position in the academic world since it indeed provides a focal point for the study of environmental protection.

Table III. Employment breakdown for undergraduates in an air pollution control training program and in environmental engineering programs.

Governmental Agencies	Cal Poly-AP	EnvE Programs[4]
Federal	10%	3.6%
State	6	2.5
Local	10	4.0
Military	4	1.5
Graduate School	4	24.2
Consulting Engineering Firms	26	1.7
Private Industry	28	26.4
Fields not directly related to air pollution	10	4.8
Unknown	2	14.8

Program Scope

The air quality program can accommodate scientists and nonengineers in at least two alternative ways:

1. Accepting qualified chemists, biologists, physicists, and social scientists as candidates for the nonengineering M.S. degree or the Ph.D. degree.

2. Permitting qualified students from other departments to take a sequence of courses in air quality as their minor field. Naturally, the sequence of courses such individuals take would depend on their background, academic and professional goals, and an assessment by the academic advisors. In such an approach the graduate curricula for engineers would strive to optimize engineering, while the curricula for nonengineers would optimize the candidate's particular professional interest.

To accomplish this objective of joint or combined training of engineers and nonengineers, the graduate program has to be versatile enough to provide a variety of courses, electives, research projects, and post-doctoral opportunities to maximize the participation by various types of specialists from a number of the professions in addition to engineering. It is essential to emphasize that not all of the students would be required or in fact be able to take exactly the same sequence of courses.

It should be remembered that in the real world of experience and practice the Air Quality Engineer traditionally works very closely with a variety of physical and social scientists. Does it not make good sense to initiate this type of working relationship and team work on the university campus as a vital part of the graduate studies program? To reflect the true character of such a joint training effort a proper title for the program might be "Air Quality Engineering and Science."

Joint Programs

Let us briefly consider the relationship of such a program to other traditional engineering activities on campus. The principal causes of community air pollution often originate with facilities, processes or devices which are designed or operated by engineers whose previous training included very little, if any, exposure to the concepts of environmental pollution and protection. Thus, such engineers tend to have little appreciation of the potential impact which their activities may make on the quality of the environment.

An additional and important objective therefore of the Air Quality Engineering Program is to offer students in engineering, particularly chemical engineering, mechanical engineering, nuclear engineering, opportunities to take courses or seminars in the field of air resources. Graduates of these departments are the individuals who may eventually conceive, design and operate low pollution potential models of internal combustion engines, fossil-fuel power plants, jet engines, pulp mills, oil refineries and incinerators which currently contribute significantly to atmospheric pollution.

Exposing these students to the fundamental concepts of air quality management should inevitably accelerate the development of machines and processes which not only provide efficiency and economy in accordance with the best traditions of engineering practice, but which also create a minimum degree of adverse impact on the quality of man's environment.

Staff

In order to conduct an effective interdisciplinary air quality activity consistent with the objectives outlined above, it is essential that the program include at least one competent and interested chemist, biologist, and meteorologist. Alternatively, course input from these disciplines could be obtained through cooperative arrangements with other departments. In addition, the air quality activity should strive for good rapport with interested social and health scientists from other faculties on campus. The existence of a multidisciplinary approach in the air quality program creates a favorable academic climate, and engenders a dynamic teamwork spirit essential to both graduate studies and research.

Study Program

A common core M.S. program consists of the following courses:

Fundamentals of Air Pollution
Atmospheric Sampling and Analysis
Atmospheric Sciences (Air Chemistry and Meteorology)
Aerosol Science and Technology
Industrial Pollution Processes
Theory and Design of Air Pollution Control Systems
Source Testing
Air Quality Management

Supporting courses include Applied Statistics, Combustion, Biological Aspects of Air Pollution, and Environmental Health Engineering. Elective courses in such areas as Water Resources, Solid Waste Management, Occupational Health, Environmental Law, and Environmental Economics are encouraged. A thesis program with a nonthesis option is desirable.

A Ph.D. program requires additional courses, a minimum period of graduate resident study, and successful completion of a doctoral examination and thesis. As to the thesis, em-

Table IV. Summary of manpower panelist's statements—68th and 69th APCA Meetings

Comment	Reference
Manpower development prepares people to be effective sometime in the future. Persons graduating now will be making policy in the year 2000, not the year they graduate. They should be soundly grounded in the hard sciences and cognizant of the social sciences.	16
Desirable skills include a basic foundation in physical sciences, engineering, mathematics and chemistry. A company does not hire a person with the expectations that he will know everything about a mill, a process or a particular piece of the equipment, but expects that person to have the technical background and capability to learn about all of these to the ultimate benefit of the company and himself.	17
Over a 28 year span, it has been pitiful to watch the poorly prepared, poorly trained polluting industry air pollution control specialists and the errors they made that added to the calendar time of polluting emissions and exposures and added costs to their employers or customers because of badly selected or poorly specified Air Pollution Control purchases.	18
The role of the new engineer in the area of environmental management in the pulp and paper industry is extremely important to the industry. Since compliance with a regulation on one area is often interrelated with other areas of environmental concerns, our industry needs personnel who have knowledge and experience in several fields of pollution control.	17
My preference for a new employee to work in an environmental control department specializing in air pollution control is for an engineer who is thoroughly trained in mechanical or chemical engineering. I do not value bachelor or graduate degree programs in Air Pollution Control. We have a higher need for understanding the variety of processes and probing what happens in them than we do for the design of control equipment or the knowledge of the effects of air pollution. Most control problems are an application of typical engineering skills, and don't require any specific training in the air pollution control field.	19

phasis is placed on a scholarly and significant work exhibiting the candidate's originality of thought.

Since some of the major barriers to further progress towards cleaner air are not technological in nature but rather social, political, and economic, curricula must place increased emphasis on the ever-widening concept of air quality management. This includes urban planning and management, computer simulation and modeling, engineering economics, legal and regulatory operations, and optimization of control strategies and tactics.

The air quality specialist will need to become more thoroughly familiar with the social consequences of technology, as well as the environmental impact of air pollution in the holistic sense.

Other Views on Training

At the 68th and 69th Annual Air Pollution Control Association Meetings, panel discussions were held which considered air pollution training for industry. Prior annual meetings dealt with training for governmental agencies personnel. A summary of some of the key points from prepared statements by participants in these panel discussions previously unpublished are tabulated in Table IV.

It is important for those involved with training of air pollution control manpower to get this type of feedback. Safe air quality inside and outside the plant is something most people in industry are now working to achieve. It will take in some cases the full-time specialist and sometimes only the part time assignment of an engineer. The services of trained technicians, chemists, meteorologists, industrial hygienists and lawyers are required in various degrees. When an adequate supply of qualified manpower is not available, non-qualified people will be hired to do the work.

In governmental agencies it is most important that one regulate in as intelligent a fashion as possible, and that means having qualified staff. The NRC Commission on Manpower indicated that shortages of well trained manpower and experienced manpower can slow development of control technologies, affect operations and process failures and boost the cost of achieving control. The study was not definitive in where shortages would occur. It focused on the one need—upgrading the current work force. Preparing graduating students better is within the realm of undergraduate education. Upgrading the current workforce can be assisted by graduate programs.

Future Directions of Undergraduate Air Pollution Control Training

Job prospects often cannot be reliably predicted and projections on demand for engineers should be conservative because such forecasts create fewer social and personal problems.[20] Every indication is that the job market will continue to expand the need for technically trained undergraduates interested in working on environmental problems. The scope of the problems will be large so that an individual will need to be able to apply his academic training and on-the-job experience to constantly new and more difficult problems. Undergraduate education will continue to stress the basic sciences: mathematics, chemistry, physics, the natural sciences, the social sciences, and the basic engineering sciences. The need to integrate these in some way into the curriculum will be important. The design of the specific curriculum to some extent will change based on current problems and feedback from professionals in the field.

Since most undergraduate programs require 130 semester hours, it may be necessary to expand the number of hours. Some people have suggested making the masters degree the first professional degree.

In the late 1800's, chemical engineering curriculum was being formed in the U.S. by having mechanical engineers study chemistry. The author of this historical perspective goes on to state that "the most perplexing problem confronting us today is how to select among new fields, how to respond to opportunity and yet how to retain, within this broadened scope, the unity of thought and action that has given it strength in the past."[21] This is the challenge to those of us who are concerned with developing the best programs to train air pollution control leaders for tomorrow. Universities and the professional community should be involved with this today in considering future directions in air pollution control training.

The disciplines that an undergraduate may enter and be involved with environmental control are listed in Table V.

Future Directions of Graduate Programs

There are several areas of major national concern wherein air quality specialists can and undoubtedly will play a vital role

Air Quality/Energy

It is quite obvious that many of the emerging policies on energy can impact the air environment. Deterioration of air quality need not be a condition for increased energy supplies. The intelligent application of energy and air resource management principles can provide optimum results. The success in developing and applying the requisite strategies and techniques will be dependent upon an adequate supply of specialists possessing the highest level of pertinent technological and scientific skills, working in close harmony.

Air Quality/Transportation

Progress by motor vehicle manufacturers in meeting Federal emission standards has been painfully slow, largely because of inherent technical difficulties. The recent imposition of the additional requirement of fuel economy has added to both the difficulties and the delays. The result is an even greater burden on communities struggling to meet ambient air quality standards. Until motor vehicle emission goals are reached, supplemental strategies must be developed for reducing the adverse effect of motor vehicles on air quality in urban areas. These could include transportation planning and management to reduce vehicle miles driven, mass transit, and smoother traffic movement.

Table V. Job titles that may involve air pollution control.

Air Pollution Control Engineer, Analyst, Specialist, Inspector, Scientist or Technician
Environmental Engineer
Mechanical Engineer
Chemical Engineer
Plant Engineer
Research Engineer
Environmental Health Staff
Occupational Health and Safety Staff
Research and Development Staff
Meteorologist
Industrial Engineer
Chemist
Consultant
Sanitarian
Industrial Hygienist
Public Health Sanitarian
Sanitary Engineer
Safety Engineer

Joint programs of study, at the graduate level, in air resources and transportation are needed to develop the specialists for successfully attacking these problems.

Air Quality/Occupational Health

In protecting the public against the effects of air pollution the reduction of atmospheric levels of pollutants is important but not enough. Millions of workers are exposed to significant, if not potentially hazardous, levels of pollutants for eight hours each day at their place of work. In many cases the concentrations of toxic substances in the workroom are higher and potentially more serious than those in the ambient outdoor air.

The possible additive effects of exposure to both occupational and atmospheric pollutants must be given serious consideration if air pollution control programs can provide the desired protection of the health of the public.

Graduate programs of study combining courses and research in air resources and industrial hygiene could prepare air quality specialists equipped to deal with these problems.

Registration

Registration or certification is now encouraged by many employers. The National Council of Engineering Examiners does not prepare an environmental engineering exam at this time. Questions relating to professional situations involving environmental engineering are included in other fields such as civil and mechanical engineering.[22] Colorado registers engineers as professional engineers upon passing an exam which has contained four questions on environmental engineering out of 104 questions in some 26 disciplines. An individual must answer ten questions in this exam. The California Legislature is currently considering adding an Air Pollution Control Engineer category to the Engineering Registration Act.

The American Academy of Environmental Engineers certifies members upon examination in various specialties of air pollution. The Board for Certified Consulting Meteorologists certifies consultants.

The American Board of Industrial Hygiene certifies upon examination in industrial hygiene, while sanitarians can be certified upon examination by the American Intersociety for Certification of Sanitarians. The National Environmental Health Association accredits programs in public health and environmental health.

The advantages of state registration and/or certification for those involved with air pollution control should be the subject of future discussion.

Conclusion

While encouraging progress has occurred, there are many new and more difficult pollution problems lying ahead in the battle to achieve the goal of clean air. Much of the credit should go to the proper utilization of competent manpower. Current and emerging challenges make it imperative that society recognize the importance of relying even more heavily on the best minds that can be marshalled.

At the current pace of development, the gap between the supply and the need for qualified manpower is widening at an alarming rate. The implications in terms of reaching national goals as stated in the Clean Air Act are serious indeed.

A manpower crisis must and can be avoided if the executive branch of our government acts promptly to implement the interest of Congress in insuring an adequate supply of competent engineers and scientists.

Support of high quality undergraduate and graduate training and education programs is the most logical, it not the only, approach to providing adequate manpower resources.

The U.S. Congress has provided a policy for federal leadership in providing incentives for the education and training of the environmental work force. In addition, it has authorized funds for this purpose. It is now up to the executive branch of government, principally the Office of Management and Budget and the Environmental Protection Agency to provide, to the full limit of legislative authorization, consistent and stable support for the education and training of air quality specialists, in compliance with the intent of Congress.

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Appendix I
Colleges offering air pollution coursework in the United States & Canada—1978

State	College or University	No. of Air Pollution Courses	Program In	Degrees	Name
ALABAMA	University of Alabama	3	CE, ChE	MS	G. P. Whittle
ALASKA	University of Alaska	1	Env Q Engr	MS	Gene Dickason
ARIZONA	Northern Arizona U.	2	EnvS	BS	W. C. Malm
	U. of Arizona	3	Atm Sci,CE,ChE, ME	BS, MS	Richard H. Gallagher
CALIFORNIA	California Institute of Technology	7	EnvESci	MS, PhD	J. J. Morgan
	Cal. State U.—Long Beach		CE	MS	W. Reed
	Cal. State U.—Northridge	6	H Sci, ThFS	BS, MS	L. S. Caretto/D. Kelly
	Cal. State U.—Sacramento	3	CE	MS	Ajit Virdee
	Cal. State U.—San Jose	1	CE	BS	William Blythe
	Cal Poly St. U.—San Luis Obispo	14	EnvE	BS, ME	W. E. Holtz
	Humboldt State U.	2	EnvRE	BS	C. M. Anderson
	Loyola Marymount U.	1	CE-EnvE & Sci	BS, MSE	D. R. Anderson
	Stanford University	2	ME	BS, MS, PhD	C. H. Kruger
	U. of Calif.—Berkeley	6	PH, ChE, CE, ME, Ch	BS, MS, PhD	Jerome Thomas
	U. of Calif.—Davis	5	CE	BS, MS, ME, DE, PhD	Dan Chang
	U. of Calif.—Irvine	10	ME, EnvE	BS, MS, PhD	G. S. Samuelsen
	U. of Calif.—Los Angeles	9	Ap Sci, Engr		R. R. O'Neill
	U. of Calif.—Riverside	4	Env Sci	AB, MS	Andrew Chang
	U. of Calif.—Santa Barbara	1	Env St	BS	A. H. Schuyler, Jr.
	U. of Southern California	10	Env Mang, Engr	MS, PhD	John J. Kirlin
COLORADO	Adams State College	1	Env Sci	BA, BS	T. A. Mueller
	Colorado State University	7	Engr	BS, MS, PhD	L. V. Baldwin
DELAWARE	U. of Delaware	1	CE, ChE	BS, MS, Ph.D.	L. A. Spelman
DC	Howard University	5	CE	ME	James H. Johnson, Jr.
FLORIDA	Florida Int'l University	3	Eng. Tech, Ind. Sys.	BS, MS	Jose T. Villate
	Florida Tech. University	4	EnvE	BSE, MSE, MS	J. Paul Hartman
	U. of Florida	6	Env Sci	BS, MS, PhD	E. E. Pyatt
GEORGIA	U. of Georgia College of Agriculture	2	An & D Sci		Charles H. White
	Georgia Institute of Technology	5	ChE	BS, MS, PhD	M. J. Matteson
HAWAII	U. of Hawaii	10	A & S, Engr, PH		C. S. Ramage
ILLINOIS	Bradley University	1	CE	BS	B. S. Muvdi
	DePaul University	1	Ch	BS	Fred Breitbeil
	Governors State University	5	Env Analysis	BA, MS	H. Sievering
	Illinois Institute of Technology	8	EnvE (Eng Sci)	BS, MS, PhD	James Patterson
	Northern Illinois U.-DeKalb				Burley Bechdolt
	Northwestern University	3	CE	BS, MS, PhD	J. E. Quon/H. Cember
	Southern Illinois U. at Carbondale	4	Th EnvE	BS, MS	J. W. Chen
	U. of Illinois at Urbana-Champaign	9	AirR, CE	MS, PhD	J. C. Liebmann
	U. of Illinois at the Medical Center	8	EnvHealth Sci.	MPH, MS, DrPH, PhD	Richard Wadden
INDIANA	Indiana University	1/3	Env Sci	MS	John Zogorski
	Purdue University	5	CE	BS, MS, PhD	John McLaughlin
	Rose-Hulman Inst. of Technology	3	ChE, Econ,EnvE		Noel Moore
IOWA	Iowa State University	3	Erth Sci ChE		George Burnet
	University of Iowa	3	EnvE		Richard R. Dague
KANSAS	University of Kansas	1	CE	MS, PhD	Dennis Lane
KENTUCKY	University of Kentucky	5	ChE	MS, PhD	R. B. Grieves
	University of Louisville	2	ChE, EnvE	ME	Dept. Chmn.
	Western Kentucky University	3	EnvE T, EnvS	BS	Donald R. Rowe
LOUISIANA	McNeese State U.	2	Sci	BS, MD	V. Monsour
	Tulane U.	6	PH, CE	BS, MS, PhD	J. M. Henry
MASSACHUSETTS	Harvard University	5	PH	MS, ScD	D. W. Moeller
	Northeastern University	5	CE	MS	C. J. Gregory
MARYLAND	Johns Hopkins University	10	PH, Env. Hlth. Sci.	MHS, ScM, ScD, PhD	David Swift Charles E. Billings
	U. of Maryland	8	Engr, Met	BS, MS, PhD	Richard L. Pitter

MICHIGAN	Ferris St. College	1	Ap H	BS	John R. Fleming
	Michigan State University	3	CE, San.E	MS, PhD	Mackenzie L. Davis
	Michigan Technological U.	2	ME CE	BS, MS, PhD (ME-EM)	John H. Johnson
	U. of Detroit	2	Engr		David Camp
	Wayne State University	5	CE, ME	MS, PhD	Ralph H. Kummler
	University of Michigan		Env. Hlth, ChE, Atmos. Sc.	MS, PhD	Dr. Hecker
MINNESOTA	University of Minnesota	6	PH	MS, MSPH, PhD	Conrad P. Straub
MISSOURI	St. Louis University	5	E. Atm. Sci		Ross Heinrich
	Washington University	3	ME	MS, DSc	S. P. Sutera
	University of Missouri—Columbia	2	ChE	BS, MS, PhD	Jack Winnick
	University of Missouri—Rolla	2	CE	BS, MS	Joseph Senna
MONTANA	Montana Col. Min. Sc. & Tech.	8	EnvE	BS	Koehler Stout
	Montana State University	1	CE	BS, MS, PhD	H. S. Peavy
NEBRASKA	U. of Nebraska	1	ChE		Luh Tao
NEW HAMPSHIRE	Thayer School of Engineering				Carl F. Long
NEW JERSEY	Cook College-Rutgers University	6	Env Sci	BS, MS, PhD	Raymond M. Manganelli
	New Jersey Inst. of Tech.	6	CE, EnvE, ME	BS, MS	R. Cheremisinoff
	Stevens Inst. of Tech.	3	ME	ME	L. Kurylko
NEW MEXICO	N.M. Inst. of Mining & Tech.		EnvE	BS	L. E. Murr
	New Mexico State University	2	ChE	BS, MS	J. T. Patton
NEW YORK	Barnard College-Columbia U.	1	Geog		Tody Berger Holtz
	City College of N.Y.	4		MS	David H. Cheng
	City University of N.Y.	13	Env. Hlth. Sc.	BS, MS	George J. Kupchik
	Cornell University	1	EnvE		C. D. Gates
	Cooper Union for the Adv. of Sci & Art	8	Engr	MS	Char Weng Tan
	Manhattan College	2	ChE		Joseph Reynolds
	Rensselaer Poly. Inst.	6	ChE, EnvE	BE, BS, MS, PhD	David Hansen
	St. Univ. of N.Y. at Buffalo	5	EE, CE, ME	MS, PhD	David T. Shaw
	Syracuse University	7	CE, ChE, ME	BS, MS, PhD	J. Charles Jennett
NORTH CAROLINA	Duke University	1	CE	BSE, MS, PhD	P. A. Vesilind
	East Carolina U.	1	Env H	BS	Trenton G. Davis
	U. of N. Carolina-Chapel Hill	9	PH-EnvSci-Engr	MSEE, MSPH, PhD	R. F. Christman
	U. of North Carolina-Charlotte		Ubn-EnvE	AA, BSE	Richard Phelps
OHIO	Miami U.	2	EnvSci	MS	G. E. Willeke
	Ohio State University		CE, ChE	MS, PhD	
	Ohio University	1	ChE	MS, MSES	Robert Savage
	University of Cincinnati	20	EnvH, CE-EnvE	AA, MS, PhD	John N. Pattison
	University of Toledo	4	Engr.	MS	J. B. Farison
OKLAHOMA	East Central Okla. State U.		Env Sci	BS	M. L. Rowe
	Oklahoma State U.	1	CE		A. F. Gaudy
	U. of Oklahoma-Norman	8	CE, Env Sci	BS, MS, PhD	Larry W. Canter
	U. of Tulsa	1	ChE	BS, MS, PhD	F. S. Manning
OREGON	Portland State U.	9	Engr	BS, MS	Fred Young
	Oregon State U.		ME	MS, PhD	R. W. Boubel
PENNSYLVANIA	Carnegie-Mellon	5	CE, ChE, ME	BS, MS, PhD	Francis McMichael
	Drexel U.	9	Env Sci, EnvE	MS, ME, PhD	P. W. Purdom
	Lafayette College	1	Engr		L. J. McGeady
	Penn. State U.	4	EnvE-CE	BS, MS, PhD	John B. Nesbitt
	Slippery Rock College	3	Env St.	BS	Charlton F. Dresdon
	Villanova U.	4	CE	MS	Robert Sweeny
RHODE ISLAND	Brown U.			MS	
SOUTH CAROLINA	Clemson University	4	Env SE	ME, MS, PhD	Thomas J. Overcamp
TENNESSEE	East Tennessee State U.	4	Env. H	BSEH, MSEH	Albert F. Iglar
	Tennessee Technological U.	2	ChE		John C. McGee
	U. of Tennessee	9	EnvE	MS, ME, PhD	William Grecco
	Vanderbilt U.	5	EnvE & Pol. Mgt, EngSci	BE, BS, ME, MS, PhD	Karl Schnelle
TEXAS	Lamar U.	2	Env Sci	AA, BS, MS	Ewin A. Eads
	Rice U.	2	ChE	BA, BS, MChE	H. A. Deans
	Sam Houston State U.	1	Env Sci	BS	James R. DeShaw
	U. of Houston	4	Engr.	BS, MS, PhD	F. L. Worley
	U. of Texas-Arlington	8	CE	BS, MS, PhD	N. Everard/V. K. Argento
	U. of Texas-Austin	9	CE, Env H	BS, MS, PhD	N. E. Armstrong
	U. of Texas-ElPaso	5	Engr.	BS, MS	H. Bartel
	U. of Texas-Houston	4	Env Sci	MS, PhD, MPH, DrPH	James Hammond

UTAH	Brigham Young U.	1	ChE Sci		Calvin Bartholomew
	U. of Utah-Salt Lake City	3	Bio, Met, ChE		Noel deNevers
	Utah State U.	2	EnvE	MS	Donald Procella
VERMONT	Norwich U.	5	Eng. Tech.	BS	Charles Chevalier
	U. of Vermont	4	CE	BS, MS	J. C. Oppenlander
VIRGINIA	Virginia Poly. Inst. & St. U.	6	CE, EnvSci, Engr.	MS, PhD	N. Thomas Stephens
	University of Virginia	4	ME	BS, MS, PhD	A. P. Sage
WASHINGTON	Washington State U.	7	ChE, EnvE, EnvS		Donald Bender
	Western Washington University	1	Env St	BA, BS	R. H. Berg
	U. of Washington	11	Air R, CE, Water R	BSCE, MS, PhD, DSc	Vernon Hammer
WISCONSIN	Marquette U.	2		MS	William Murphy
	U. of Wisconsin-Madison	7	Env St	MS, PhD	Reid A. Bryson
	U. of Wisconsin-Milwaukee	8	Ener	ME	Kenneth Neusen
WEST VIRGINIA	W. Virginia College of Grad. Studies	7	ChE, Env St	MS	F. Wm. Kroesser
	West Virginia U.	4	CE	MS, PhD	R. Porter
WYOMING	U. of Wyoming	2	CE	BS, MS, PhD	Robert Champlin
CANADA	Universite de Sherbrooke	2	ChE, Env St	BS, MS, MASc	M. Boulos/M. Beerli
	U. of Calgary	1	ChE	MS	Richard D. Rowe
	U. of Guelph		Hort. Sci, Env. Bio.	MSc, PhD	Douglas P. Ormrod
	U. of Windsor	6		MS	G. P. Mathur
	U. of Toronto	12	EnvE Program	ME, MASc, PhD	J. G. Henry
	U. of Western Ontario	4	Engr Sci.	ME, MESc, PhD	J. L. Sullivan

COMMUNITY COLLEGES

DELAWARE	Delaware Tech & Community College	2	EnvTech	AAS	James T. Lober
FLORIDA	Miami Dade Comm. Coll.	4	CE	AS	W. W. Travers
IOWA	Kirkwood Community College	1	Env. Ed Oc	AAS	Harold B. Kort
LOUISIANA	Delgado College	3	Env H	AS	Sushil K. Gilotra
MAINE	Eastern Maine Voc. Inst.	1	Env CT	AS	Donald Weston
MARYLAND	Charles Co. Comm. Coll.	1	Poll. Abtmt Tech.		William T. Engel
MASSACHUSETTS	Springfield Tech. Comm. Coll.	1	Env Tech	AS	William Gaitenby
MINNESOTA	916 Area Voc Tech School			Voc Tech	Charles Hanf
NEW JERSEY	Middlesex County College	1	Env H Sci	AAS	D. Trainor
NEW YORK	Hudson Valley Community College	1	Env Tech	AAS	C. Fred Zipprich
NORTH CAROLINA	Fayetteville Technical Inst.	2	Env Eng Tech	AA	Boyd Ayers
OHIO	Hocking Technical College	1	Env H	AA	David Mingus
	Lakeland Community College	6	Appl. Sci.	AA	Ralph W. Bell
	Muskingum Area Tech. College	6	Appl. Sci.	AA	Daniel Hehr
OKLAHOMA	Oklahoma St U-Tech Inst.	3	C Tech	AA	Garland Pendergraf
	Oscar Rose Junior College	1	Eng/Sci-Env Sci	AS	Harold Fox
OREGON	Oregon Inst. of Tech.	5	Env Tech	AA & Bachelors	Leroy Fisk
PENNSYLVANIA	Northampton County C.C.	2	Env S	AA	R. C. Richardson
SOUTH CAROLINA	Sumter Area Tech College	1		AA	Robert C. J. Chan
TENNESSEE	Chattanooga St. Tech. C. C.	2	Chem & Env Sci	AS	J. G. Giesemann
	State Tech Inst at Memphis	1	EnvE Tech	AE	R. S. Joshlin/J. Johnson
VIRGINIA	Wytheville Community College	1	Engr Tech/Math	AAS	Gary T. Laing
CANADA	Mount Royal College	5	Env Q Con	AA	Dennis Leask

Abbreviations Used

A & S: Arts and Sciences
Air Env St: Air Environmental Studies
Air R: Air Resources
An & D Sci Animal and Dairy Science
Ap H: Applied Health
Ap Sci: Applied Science
Atm Sci: Atmospheric Science
Bio: Biology
CE: Civil Engineering
Ch E: Chemical Engineering
Ch E Sci: Chemical Engineering Science
D Sc: Doctor of Science
Engr: Engineering
EnvE: Environmental Engineering
E. Atm. Sci: Earth and Atmospheric Sciences
Ener: Energetics
Engr Pol Engineering & Public Policy
EnvE Sci: Environmental Engineering Sciences
Env.H: Environmental Health
Env H Sci Tech: Environmental Health Science
Env Mag: Environmental Management
Env Oc: Environmental Occupations
Env Q Con: Environmental Quality Control
Env R E: Environmental Resources Engineering
Env S: Environmental Service
Env Sci: Environmental Science
Env SE: Environmental Systems Engineering
Env St: Environmental Studies
Env CT Environmental Control Tech.
EnvTech: Environmental Technology
Erth Sci: Earth Science
Geog: Geography
H Sci: Health Science
ME: Mechanical Engineering
Med: Medicine
Met: Meteorology
PH: Public Health
PS: Public Service
Sci: Science
Th E: Thermal Engineering
Ubn E: Urban Engineering
WR: Water Resources
WRE: Water Resources Engineering Management
ThFS: Thermal Fluid Systems
Ubn-EnvE Urban and Environmental Engineering