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ABSTRACT

This report summarizes a study designed to assess current and future manpower needs in wastewater treatment, water treatment, and air pollution control, as well as perform task analyses for the purpose of developing courses of study and instructional materials. Data were collected by means of interviews for all 10 air pollution control areas in Ohio, eight wastewater and water treatment facilities for Ohio cities with a population under 100,000, and eight wastewater and water treatment facilities for Ohio cities with a population over 100,000. Data were collected by mail questionnaire for 200 randomly selected wastewater and water treatment facilities for Ohio cities with a population under 100,000. An anticipated increase of 109 persons (a 31 percent increase) in all wastewater treatment positions from 1971 to 1974 was reported. An increase of 156 persons (a 12 percent increase) is expected from 1971 to 1974 in water treatment positions, and a 119 percent increase (152 persons) is anticipated from 1971 to 1974 in air pollution control positions. These increased personnel needs justify the development of training programs in environmental management occupations. A proposed curriculum for a 2-year program in this area is included. Numerous tables present the data. (AG)

RESEARCH SERIES IN AGRICULTURAL EDUCATION

A Research Report

of a

Graduate Study

MANPOWER NEEDS IN ENVIRONMENTAL MANAGEMENT

By

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FOREWORD

Two essential steps in designing occupational education programs are (1) assessment of current and future manpower needs in the occupational area and (2) analyses of the tasks performed in the various jobs which serve as a basis for the development of courses of study and instructional materials. This report is a summary of a study which was designed to accomplish these two purposes as they relate to environmental management occupations in the State of Ohio. The occupational categories investigated were in wastewater treatment, water treatment, and air pollution control.

The salient findings of the study are presented in this publication. For more complete details of the findings and the procedures employed, the complete report of the study should be consulted (John H. Hillison, Manpower Needs in Environmental Management, Ph.D. Dissertation, Department of Agricultural Education, The Ohio State University, June 1972). The research summarized in this publication is one phase of the Project "Development and Dissemination of Courses of Study and Instructional Materials for Environmental Science and Protection."

Special recognition and appreciation is due Dr. Harlan E. Ridenour, Director of the Ohio Agricultural Education Curriculum Materials Service and Director of the Project, for his assistance and support in the conduct of the study.

J. Robert Warmbrod

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INTRODUCTION

The nation faces a crucial environmental crisis in two major areas -- water pollution and air pollution. The efforts to solve these environmental problems will create not only a great financial need but also a great manpower need. The U.S. Department of Interior estimated in 1967 that the United States would need 18,500 additional wastewater treatment operators by 1972. It was estimated that a total of 30,000 operators would be needed in 1972 at the local governmental level (municipalities). This was an increase of 10,000 over manpower needs in 1967. The Interior Department estimated also that industry needed a total of 12,000 wastewater treatment operators by 1972 -- an increase of 8,500 over the 1967 manpower levels.[1] The National Air Pollution Control Administration (NAPCA) of the United States Department of Health, Education, and Welfare has estimated that 50,900 persons will be needed in air pollution control occupations by 1974. This is an increase of slightly over 27,000 persons who were working in these occupations in 1969.[2]

The investigator believes that publicly supported secondary vocational education can play a key role in preparing workers entering the environmental management field and in providing supplementary instruction for those presently employed. To make the most significant contribution, vocational education should work with both major areas of water management and air management, since both are very closely interrelated.

The Problem

The purposes of the study were: (1) to describe current and emerging occupations in environmental management in Ohio: (2) to estimate the number of persons currently employed and to project employment opportunities in these occupations; and (3) to describe the tasks performed by persons employed in selected environmental management occupations. The occupations investigated were in water pollution control and air pollution control. The specific areas of water pollution control investigated were wastewater treatment and water treatment.

Answers to the following specific questions were sought:

1. What are the current and emerging occupations in water pollution control and air pollution control?

2. How many persons are currently employed in water pollution control and air pollution control jobs and how many additional persons will be needed by 1974 to fill new positions in these jobs?

3. What are the tasks performed by persons in water pollution control and air pollution control jobs, what is the relative amount of time spent by

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[1]Manpower and Training Needs in Water Pollution Control, U.S. Department of the Interior, (Washington: U.S. Government Printing Office) 1967, p. 15.

[2]Manpower and Training Needs for Air Pollution Control, U.S. Department of Health, Education and Welfare (Washington: U.S. Government Printing Office) 1970, pp. 4-10.

workers on the various tasks, and how do supervisors rate the relative importance of the tasks performed by workers in these jobs?

Need for the Study

From conferences with professional environmentalists in both state and municipal agencies it became apparent that personnel must be qualified at an increasing rate to solve both today's and tomorrow's environmental problems. These environmentalists noted that at the present training for prospective employees is offered at few educational institutions. Many employees are either not fully qualified for their positions or must become qualified through on-job training. This procedure has been inadequate to meet employment demands.

> Well-trained operators (of sewage treatment facilities) are clearly among the priority needs. Recent surveys have shown that some of the newest sewage plants are operating at less than maximum efficiency due to the inadequate training of the plant operators.[3]

In an attempt to meet present and future employment demands in environmental management, the Division of Vocational Education of the Ohio Department of Education charged the Agricultural Education Section of the Division with the responsibility of developing training programs to fulfill this need. Typically, agricultural education has provided instructional programs that deal with the environment and its relationship to soils, plants, and animals. However, agricultural education has provided, in Ohio or elsewhere, only limited course offerings in the specific areas of water pollution and air pollution.

Available job descriptions give a basically complete description of the positions in environmental management which were considered in this study. It was clear, however, that no order or sequence of training for the various tasks was established by these descriptions. For the establishment of training programs and curriculum materials to be used in these programs it was desirable to know which tasks must be emphasized and at what phase of the instructional program to emphasize them. One of the major purposes of this study was to establish a hierarchy of importance for the tasks identified for each position to be studied.

The investigator believes the steps that should be taken for preparing properly trained personnel for the environmental management occupational area are as follows: (1) the need for additional personnel must be identified for each of the occupations, (2) the positions must be described by task analysis, (3) curriculums and instructional materials should be established based on the findings of the task analyses, and (4) personnel should be trained based on the curriculums and instructional materials established. This study was designed to accomplish the first two steps in the preparation of personnel for employment in environmental management occupations.

Procedure

Population and Sample. - The population for the study was the wastewater treatment facilities, water treatment facilities, and air pollution control facilities serving municipalities in the State of Ohio. The populations of wastewater treatment facilities and water treatment facilities were stratified into three strata: (1) facilities serving cities of 100,000 or more population which were personally visited, (2) facilities serving cities of less than 100,000 population which were personally visited, and

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[3] Applying Technology to Unmet Needs, Technology and the American Economy, The Report of the Commission, Appendix Volume V, February, 1966, p. v-156.

(3) facilities serving cities of less than 100,000 population which were surveyed by a mail questionnaire.

A purposive sample of eight facilities serving cities of 100,000 or more population was utilized because it was assumed that these facilities would have the greatest manpower needs of any facilities in Ohio. District Engineers in each of Ohio's four State Department of Health, Division of Engineering Districts were asked to help select facilities serving cities of less than 100,000 population by choosing two progressive wastewater treatment facilities and two water treatment facilities in their districts. It was requested that these facilities and their employees be as typical as possible of what the district engineers anticipated such facilities and employees to be like in future years.

The samples of wastewater and water treatment facilities serving cities of less than 100,000 population from which data were collected by mail questionnaire consisted of 200 facilities selected at random. Excluding the facilities that were visited, the population of wastewater treatment facilities in Ohio serving less than 100,000 people is 396.[4] The population of water treatment facilities in Ohio serving less than 100,000 people is 601.[5] (See Table 1)

There were a total of ten air pollution control areas in Ohio during 1971. The term "area" refers to a unit of air pollution control rather than facility because geographical areas such as counties are included in the unit. All ten of these air pollution control areas were included in the sample and were personally visited.

TABLE 1

NUMBER OF SAMPLING UNITS IN THE POPULATION AND SAMPLE BY TYPE OF FACILITY AND SIZE OF MUNICIPALITY

Size of Municipality and Type of Facility	Number Units in Population	Number Units in Sample
Cities over 100,000		
Wastewater treatment[a]	8	8
Water treatment[a]	8	8
Cities under 100,000		
Wastewater treatment[a]	8	8
Water treatment[a]	8	8
Cities under 100,000		
Wastewater treatment[b]	396	200
Water treatment[b]	601	200
Air Pollution Control		
Control areas[a]	10	10
State control unit[a]	1	1

[a] Data collected by interviews.
[b] Data collected by mail questionnaire.

[4] Names and Addresses Public Water Supplies, State of Ohio, Department of Health, 1971, 55 pages.

[5] Municipal Sewage Treatment Work in Ohio, Ohio Department of Health, January, 1971, 12 pages.

Collection of Data. - A telephone call served as the first contact with the facility administrator during which arrangements were made for interviewing the facility administrator and employees who were asked to provide task analysis data. Administrators were asked to indicate the number of employees working in the various occupations in 1968 and 1971 and to estimate the number of employees needed in these occupations in 1974. The facility administrator, or the chief operator or foreman if so designated by the administrator, was asked to complete the importance section of the task analysis instrument. Designated persons working in the various occupations were then asked to indicate the frequency with which they performed tasks. The Environmental Task Analysis Form was used for collecting these data.

The Wastewater Treatment Manpower Need Form and the Water Treatment Manpower Need Form were mailed to the 200 randomly selected samples of facilities. Each questionnaire was accompanied by a cover letter explaining the basic purposes of the survey which was co-signed by J.E. Richards, Acting Chief of the Ohio Department of Health, Division of Engineering, and Harlan E. Ridenour, Director of the Ohio Agricultural Education Curriculum Materials Service and the Environmental Studies Research Project. The questionnaires were mailed on November 15, 1971. On December 6, 1971 all facilities not responding to the first mail questionnaire were sent a second questionnaire and a copy of the original cover letter. Of the 200 mail questionnaires mailed to wastewater treatment facilities, 156 (78 percent) were returned; 166 (83 percent) of the 200 questionnaires mailed to water treatment facilities were returned. After comparing the responses of early respondents and late respondents, it was decided to consider the data provided by respondents as a representative sample. Estimates calculated from the sample data are based on that assumption.

MANPOWER NEEDS IN ENVIRONMENTAL MANAGEMENT OCCUPATIONS

Manpower needs in wastewater treatment positions and water treatment positions are subdivided into two major parts -- manpower needs for full time operators working 40 hours or more per week and manpower needs for part-time operators working less than 40 hours per week. In this study it was found that the typical part-time operator worked about 20 hours per week all year or worked full time during one season only, usually the summer. The positions investigated in both wastewater treatment facilities and water treatment facilities were Non-certified Operator, Operator I, Operator II, Operator III, Operator IV, and Laboratory Technician.

Wastewater Treatment Positions

Manpower needs for full time personnel in wastewater treatment facilities serving 100,000 or more people are displayed by position in Table 2. The data illustrate that administrators of wastewater treatment facilities serving Ohio's cities of over 100,000 population anticipated increases in the number of personnel needed from 1971 to 1974 for all positions except non-certified operators. The most dramatic increase in the number of workers needed in 1974 is indicated for the Operator I position. A growth of 81 persons in the Operator I position is noted for the 1971 to 1974 period. This change represents an increase of 145 percent. When comparing the number of persons needed in 1974 with the number employed in 1971, a more modest growth of 19 persons in the Operator II position (a 49 percent increase), 11 persons in the Operator III position (42 percent increase), one Operator IV (a 25 percent increase), and four persons in the laboratory technicians position (a 67 percent increase) are indicated. When comparing the total number of persons employed in all positions it should be noted there were only six more persons employed in 1971 than in 1968 (a 1.7 percent increase); however, the administrators reported an anticipated increase of 109 persons (a 31 percent increase) in all positions from 1971 to 1974.

TABLE 2

MANPOWER NEEDS FOR FULL TIME WASTEWATER TREATMENT POSITIONS IN FACILITIES SERVING CITIES OF OVER 100,000 POPULATION: INTERVIEWS[a] (n = 8 facilities)

Position	Number of Persons employed		Number of Persons needed
	1968	1971	1974
Non-certified operator	218	219	212
Operator I	53	56	137
Operator II	36	39	58
Operator III	27	26	37
Operator IV	5	4	5
Laboratory technician	5	6	10
Total	344	350	459

[a]Data were collected by interviews with facility administrators.

Two factors help account for these increases in manpower needs. Ed Rosendahl,[6] Engineer in Charge, General Engineering Unit of the Ohio Department of Health, named two major factors which influence manpower requirements in wastewater treatment facilities. These factors were (1) a requirement for all facilities to utilize at least secondary treatment procedures and (2) a requirement for all facilities to have a licensed operator (Operator I or higher) on duty during all shifts. Two of the eight facilities did not have secondary wastewater treatment in 1971. Administrators in both of these cities anticipated expansion to secondary treatment by 1974. Secondary wastewater treatment involves complex biological procedures which require personnel with training of the type typically required for the Operator I position.

All positions displayed in Table 3 reflect an anticipated increase in manpower needs for the period 1971 to 1974. The position showing the greatest growth is Operator I with a need for 169 additional people (a 54 percent increase). This compares to a growth of 49 people (a 19 percent increase) for 1968-1971. The position

[6]Ed Rosendahl, private interview held in the Ohio Department of Health Building, Columbus, Ohio, March 1972.

showing the second largest manpower increase for 1971-1974 is Operator II. This position has an anticipated growth of 135 people which represents an 85 percent increase. The Operator II position had an actual increase of 15 people for 1968-1971 which represented a 10 percent increase.

The manpower increase for all positions represents a growth of 523 persons (a 43 percent increase) for 1971-1974. The actual manpower increase for 1968-1971 was 231 which was a 23 percent increase.

TABLE 3

ESTIMATES OF MANPOWER NEEDS FOR FULL TIME WASTEWATER TREATMENT POSITIONS IN FACILITIES SERVING CITIES OF UNDER 100,000 POPULATION[a]

Position	Number of Persons employed		Number of Persons needed
	1968	1971	1974
Non-certified operator	480	563	619
Operator I	263	311	480
Operator II	143	158	293
Operator III	88	152	194
Operator IV	16	13	94
Laboratory technician	23	46	86
Total	1,012	1,243	1,766

[a]Estimates reported in this table were derived from the sample data reported from the 156 mail questionnaires plus the data collected by interviews with administrators at eight progressive facilities identified by the Ohio Department of Health.

The data reported in Table 4 summarizes manpower needs for all public wastewater facilities in the State of Ohio. For all positions, increases in manpower needs are reflected from 1971 to 1974. The highest anticipated number of additional full time personnel (250 persons) needed from 1971 to 1974 is at the Operator I position. This is a 68 percent increase in personnel during the three-year period. This change compares with a 1968 to 1971 numerical increase of fifty (a 21 percent increase) for the number of Operator I personnel employed.

The estimates for the total number of full time persons in wastewater treatment positions in the 412 facilities indicate a growth in manpower needs. Estimates of the number of persons actually employed in all positions in 1968 and 1971 indicate an additional 237 persons (a 17 percent increase) were working in these positions at the end of the three-year period. Comparable estimates for the 1971-1974 period indicate an additional 632 persons (a 40 percent increase) will be needed during the next three years.

TABLE 4

ESTIMATES OF MANPOWER NEEDS FOR FULL TIME WASTEWATER TREATMENT POSITIONS IN 412 FACILITIES[a]

Position	Number of Persons employed		Number of Persons needed
	1968	1971	1974
Non-certified operator	698	782	831
Operator I	315	367	617
Operator II	179	197	351
Operator III	115	178	231
Operator IV	21	17	99
Laboratory technician	28	52	96
Total	1,356	1,593	2,225

[a]Summary of data reported in Tables 2 and 3.

The employment pattern exhibited by part-time wastewater treatment personnel was quite different from the one displayed by full time personnel. Facility administrators indicated many of the part-time personnel have a second job which is typically away from the wastewater treatment facility. Often part-time personnel in wastewater treatment facilities work also as part-time water treatment operators, or water treatment laboratory technicians, or as workers on the distribution line in water treatment facilities. By far the greatest number of part-time wastewater treatment operators are working in the non-certified operator position. Facility administrators indicated a diminishing need for part-time personnel for each position when needs in 1974 are compared to 1971 employment. One major factor contributing to this diminishing need is an anticipated conversion of part-time personnel to full time personnel. This trend appeared to exist in both large and small facilities.

Estimates of the total part-time manpower needs for wastewater treatment facilities are shown in Table 5. Overall, the data reflect a decreasing need for part-time operators in the 412 wastewater treatment facilities in Ohio. Facilities of all sizes will need fewer part-time wastewater treatment operators in 1974 than were actually employed in 1971. The total number of personnel in part-time positions displayed a change from 239 in 1968 to 356 in 1974, a numerical increase of 117 (a 49 percent increase). The anticipated total part-time manpower need for 1974 is 281 a decrease of seventy-five positions from the number estimated to be employed in 1971 (a 21 percent decrease). The largest single numerical decrease from 1971 to 1974 occurred for non-certified operators.

TABLE 5

ESTIMATES OF MANPOWER NEEDS FOR PART-TIME WASTEWATER TREATMENT POSITIONS IN 412 FACILITIES[a]

Position	Number of Persons employed		Number of Persons needed
	1968	1971	1974
Non-certified operator	151	237	202
Operator I	30	33	30
Operator II	20	30	18
Operator III	15	20	13
Operator IV	5	8	5
Laboratory technician	18	28	13
Total	239	356	281

[a]Estimates reported in this table were derived from the sample data reported from the 156 mail questionnaires plus the data collected by interviews with administrators in the 16 facilities that were visited.

TABLE 6

MANPOWER NEEDS FOR FULL TIME WATER TREATMENT POSITIONS IN FACILITIES SERVING CITIES OF OVER 100,000 POPULATION: INTERVIEWS[a] (n = 8 facilities)

Position	Number of People employed		Number of People needed
	1968	1971	1974
Non-certified operator	54	92	50
Operator I	51	52	82
Operator II	27	29	59
Operator III	15	19	26
Operator IV	7	7	13
Laboratory technician	12	13	14
Total	166	212	244

[a]Data were collected by interviews with facility administrators.

Water Treatment Positions

Table 6 reports the number of full time personnel needed for positions in facilities serving over 100,000 people. Administrators of the facilities who were interviewed indicated two fundamental trends. The first is a decreasing need for non-certified operators. Table 6 indicates a need for 42 fewer persons in 1974 (a 46 percent decrease) for the non-certified position than the number employed in that position in 1971. Facility administrators reported plans to encourage non-certified operators to upgrade themselves to a licensed operator's position. The Ohio Department of Health is in the process of requiring water treatment facilities to have a licensed operator on duty for each shift. This requirement tends to minimize the number of non-certified operators needed.

TABLE 7

ESTIMATES OF MANPOWER NEEDS FOR FULL TIME WATER TREATMENT POSITIONS IN FACILITIES SERVING CITIES OF UNDER 100,000 POPULATION[a]

Position	Number of People employed		Number of People needed
	1968	1971	1974
Non-certified operator	455	571	436
Operator I	347	442	557
Operator II	102	160	223
Operator III	55	92	118
Operator IV	4	8	15
Laboratory technician	50	59	137
Total	1,013	1,332	1,486

[a]Estimates reported in this table were derived from the sample data reported from the 166 mail questionnaires plus the data collected by interviews held with administrators at eight progressive facilities identified by the Ohio Department of Health.

The position in facilities serving less than 100,000 population (Table 7) which displayed the greatest manpower growth for 1971-1974 is Operator I. This position showed a growth of 115 persons (a 26 percent increase) which compares to a growth of 95 persons (a 27 percent increase) for the three-year period 1968-1971. The position with the second greatest growth for 1971-1974 is Laboratory Technician. This position has a growth of 78 people (a 132 percent increase) which compares to an increase of nine people for 1968-1971 (an 18 percent increase). The only position not showing an increase for 1968-1971 is non-certified operator which decreased 135 persons for a 24 percent decrease. For total manpower needs, an overall increase is shown. The 1971-1974 total shows an increase of 156 persons (a 12 percent increase) which compares to an increase of 319 persons (a 31 percent increase) for 1968-1971.

The data reported in Table 8 summarize manpower needs for full time personnel for all water treatment facilities in the State of Ohio. For all positions except non-certified operators an increase in manpower needs is anticipated for the years 1971 to 1974. The largest manpower increase was reported for the Operator I position. This increase was for 145 additional persons (a 29 percent increase). The 1968 to 1971 personnel increase at the Operator I level was ninety-six (a 24 percent increase).

TABLE 8

MANPOWER NEEDS FOR FULL TIME WATER TREATMENT POSITIONS IN 617 FACILITIES[a]

Position	Number of People employed		Number of People needed
	1968	1971	1974
Non-certified operator	509	663	486
Operator I	398	494	639
Operator II	129	189	282
Operator III	70	111	144
Operator IV	11	15	28
Laboratory technician	62	72	151
Total	1,179	1,544	1,730

[a]Summary of data reported in Tables 6 and 7.

The estimates for the total number of full time water treatment positions in the 617 facilities indicate a sizeable growth in manpower needs. Estimates of the number of persons actually employed in all positions in 1968 and 1971 indicate an additional 365 persons (a 31 percent increase) were working in these positions at the end of the three-year period. Comparable estimates for the 1971-1974 period indicate an additional 186 persons (a 12 percent increase) will be needed during these three years. The manpower growth in water treatment personnel has started to develop at a slower rate for the years 1971-1974 as compared to the years 1968-1971. This can be accounted for by the fact that satisfactorily treated water has been supplied to the majority of the populace in cities for many years. While wastewater treatment standards are being increased, water treatment standards have been rather stringent for some time. Facility administrators indicated that the principal need for additional personnel in water treatment positions will be as a result of increased population and a consequent increase in facilities and the capacity of the facilities.

Table 9 indicates the decreasing need for part-time personnel in water treatment positions. Administrative personnel of water treatment facilities have indicated they anticipate converting many part-time personnel activities to full-time activities.

They prefer having persons who do not have to be shared with the distribution repair crew, the wastewater treatment facility, or some other responsibility.

TABLE 9

MANPOWER NEEDS FOR PART-TIME WATER TREATMENT POSITIONS IN 617 FACILITIES[a]

Position	Number of People employed		Number of People needed
	1968	1971	1974
Non-certified operator	224	252	213
Operator I	50	76	65
Operator II	7	14	18
Operator III	12	14	11
Operator V	5	4	0
Laboratory technician	18	29	18
Total	316	389	325

[a]Estimates reported in this table were derived from the sample data reported from the 166 mail questionnaires plus the data collected by interviews with administrators in the 16 facilities that were visited.

Air Pollution Control Positions

The air pollution control manpower needs are reported for both the ten city or multi-county regional offices and for the State of Ohio Air Pollution Control Unit located in Columbus, Ohio. The city offices were located in major cities, while multi-county regional offices include a number of contigious counties with a main office located in a major city. The State of Ohio Air Pollution Control Unit is an agency with State financing and administration. All agencies investigated were publicly financed agencies. Manpower needs for these agencies were investigated for the positions of Inspector, Engineer, Chemist, Technician, and Meteorologist.

Table 10 reports total manpower needs for air pollution control positions for all agencies. Total manpower needs are changing quite rapidly with an anticipated increase of 162 persons in all positions for the years 1971-1974, which represents a 119 percent increase. This increase is compared to a change of sixty-six persons for the years 1968-1971, which represents a 94 percent increase.

TABLE 10

MANPOWER NEEDS FOR FULL TIME AIR POLLUTION CONTROL POSITIONS FOR ALL AGENCIES[a]

Position	Number of People employed		Number of People needed
	1968	1971	1974
Air Pollution			
Control Inspector	44	71	152
Control Engineer	6	23	80
Control Chemist	10	17	29
Control Technician	10	25	36
Control Meteorologist	0	0	1
Total	70	136	298

[a]Summary of manpower needs in city and regional offices and the State of Ohio Air Pollution Control Unit.

The position which showed the greatest manpower growth is Air Pollution Control Inspector. This position had an anticipated increase of eighty-one persons for the 1971-1974 period (a 141 percent increase). The inspector's position had an actual increase of twenty-seven persons for the 1968-1971 three year period (a 61 percent increase).

Air pollution is a relatively new environmental service, especially when compared to wastewater and water treatment. Therefore, it is understandable that air pollution control positions should show very rapid manpower increases. It should also be pointed out that many cities have only recently passed air pollution standards which require additional manpower. It should also be mentioned that new federal standards for air pollution control are to be implemented by 1975. These standards will require many additional people, especially inspectors, for monitoring and enforcement procedures.

The part-time employees needed for air pollution control positions were minimal. Only one city had any part-time employees. That city had no such employees in 1968; it had seven part-time air pollution control technicians in 1971 and anticipated having eight technicians in 1974. The State of Ohio had no part-time air pollution control employees, nor did its administrators anticipate needing any by 1974.

TASK ANALYSES FOR ENVIRONMENTAL MANAGEMENT OCCUPATIONS

This chapter presents findings relevant to the third purpose of the study which was to describe the tasks performed in environmental management occupations. Full time positions analyzed were Non-certified Operator, Operator I, and Operator II for wastewater and water facilities serving cities both above and below 100,000 people. In addition, the position of full time Air Pollution Control Inspector was also analyzed. The Advisory Council for the Environmental Studies Research Project recommended primary emphasis be placed on the positions of Wastewater Operator I, and Water Treatment Operator I, and Air Pollution Control Inspector. The positions which ranked above and below Operator I (Non-certified and Operator II) were used to help define it. The position of Air Pollution Control Inspector is the beginning position in its field and the only one which permits an individual with a high school education to enter. The task analyses provided information used in developing the following job descriptions.

Non-certified Wastewater Treatment Operator -- Facilities Serving More Than 100,000 Population

Operates and inspects machinery and equipment in the facility including sludge pumps, vacuum filters, incinerators, sludge digestors, and bar racks; records on log sheets information concerning total facility flow, equipment condition, and chemical needs; makes decisions on the general appearance of the facility with reference to cleanliness and work that needs to be performed; consults with other operators and supervisors concerning facility operation; obtains samples for laboratory analysis; helps establish work orders for the next shift by describing what he believes to be the first tasks that should be completed; assists other operators with their work responsibilities; analyzes log sheets written by others on the previous work shift and by peers on his shift; checks available supplies for the facility and determines what should be re-stocked; repairs facility machinery and equipment; makes determinations on the quantity of chlorine that should be added to the wastewater; makes the dissolved oxygen and the settleable solids laboratory tests.

Non-certified Wastewater Treatment Operator -- Facilities Serving Less Than 100,000 Population

Operates and inspects facility machinery and equipment including electric motors, bar racks, grit chambers, sludge pumps, and aeration blowers; records information on log sheets about facility operations such as flow, equipment condition, and chemical needs; inspects the entire facility to check operations; makes decisions on the quantity of chlorine that must be added to wastewater; obtains wastewater samples for laboratory analysis; consults with other operators and supervisors on facility operations; makes decisions on the general appearance of the facility with reference to cleanliness and work to be performed; assists other operators with their work; analyzes log sheets established by operators on previous work shifts and by peers on his shift; repairs facility machinery and equipment; makes decisions on needed operating supplies; works with the public in giving facility tours; orders needed operating supplies; makes the settleable solids, pH, and biochemical oxygen demand laboratory tests; supervises other operators and staff members; completes monthly state reports for the Department of Health; assists in establishing work orders for the next shift.

Wastewater Treatment Operator I -- Facilities Serving More Than 100,000 Population

Inspects and operates facility equipment including sludge pumps, vacuum filters, incinerators, aeration blowers, and bar racks; consults with other operators and supervisors on facility operations; inspects the entire facility to check on operations; records information on log sheets about total flow, equipment condition, and manpower status; makes decisions on the general appearance of the facility particularly with reference to cleanliness and work to be done; obtains wastewater samples for laboratory testing; supervises other operators and staff; assists operators with their work responsibilities; repairs facility machinery and equipment; makes decisions on the amount of chlorine to be added to the wastewater; establishes work orders for the next shift with reference to their work priorities; checks facility supplies by conducting an inventory; works with public relations by giving plant tours; analyzes log sheets established by operators on the previous work shift and by peers on his shift; records data on monthly reports for the State Department of Health; performs such laboratory tests as settleable solids, dissolved oxygen, pH, and biochemical oxygen demand.

Wastewater Treatment Operator I -- Facilities Serving Less Than 100,000 Population

Operates and inspects facility machinery and equipment including sludge pumps, chlorine feeders, bar racks, and anaerobic sludge digestors; obtains samples of wastewater for laboratory analysis; inspects the entire facility to check on operations; records information on log sheets concerning facility flow, equipment condition, and manpower needs; makes decisions on general appearance of the facility with reference to cleanliness and work needs; makes decisions on chemical dosages including zeolites, lime, and chlorine; works with public relations in giving plant tours; consults with other operators and staff members on facility operations; checks the supply inventory; analyzes log sheets written by operators on previous work shifts and peers on his work shift; performs such laboratory tests as pH, biochemical oxygen demand, chemical oxygen demand, settleable solids, and dissolved oxygen; supervises other operators; establishes work orders for operators on succeeding work shifts; operates the lift pumps in the pumping station.

Wastewater Treatment Operator II -- Facilities Serving More Than 100,000 Population

Inspects facility machinery and equipment including sludge pumps, vacuum filters, and incinerators; consults with other operators and staff members concerning facility operations; supervises operators in their activities; operates facility machinery and equipment; analyzes log sheets written by operators on previous work shifts and by peers on his shift; assists other employees with their work responsibilities; records information concerning facility flow, equipment condition, and manpower needs on log sheets; inspects the entire plant; checks facility supplies on inventory; establishes work orders for the next shift and establishes its work priorities; orders supplies to replace those consumed; repairs facility machinery and equipment; obtains samples of wastewater for use in laboratory testing; works with public relations by giving plant tours and writing news releases; makes decisions on operation of the sludge digestor; completes monthly reports for the Ohio Department of Health; makes decisions on the quantity of chlorine which should be added to the wastewater; performs the laboratory tests for settleable solids and pH.

Wastewater Treatment Operator II -- Facilities Serving Less Than 100,000 Population

Operates facility machinery and equipment such as the clarifier, sludge pumps, bar racks, and the chlorination equipment; obtains samples of wastewater for laboratory testing; records information on log sheets concerning facility flow, equipment condition, and manpower needs; inspects facility machinery and equipment; inspects the entire plant; consults with other operators and staff personnel on facility operations; works with public relations by giving plant tours and writing news releases; makes decisions on the general appearance of the facility with reference to cleanliness and work to be done; assists other employees with their work responsibility; makes decisions on the amount of chlorine that should be added to the wastewater during the treatment process; works with equipment in the pumping station; repairs facility machinery and equipment; performs the settleable solids, dissolved oxygen, pH, and biochemical oxygen demand laboratory tests; analyzes log sheets written by operators on previous work shifts and by peers on his shift; checks facility supplies for inventory purposes; supervises other facility employees; establishes work orders and priorities for the next shift.

Non-certified Water Treatment Operator -- Facilities Serving More Than 100,000 Population

Backwashes, operates, and inspects filter beds; records information such as loss of head in the filters and facility total flow on log sheets; consults with other operators and supervisors on facility operations; operates and inspects chlorination equipment; assists other operators with their work responsibility; analyzes log sheets established by operators on previous shifts and peers on his work shift; inspects and operates the flocculation basin; repairs facility machinery and equipment such as well pumps, chlorinators, air compressors, and laboratory equipment; operates and inspects the sedimentation tank; performs the orthotolidine test for residual chlorine; operates and inspects fluoridation equipment; operates and inspects facility recarbonation equipment; operates water softening equipment which adds lime, soda, soda ash, and zeolites; works with the public in activities such as plant tours; performs laboratory coagulation tests to determine the needed flocculation material; operates and inspects aeration equipment.

Non-certified Water Treatment Operator -- Facilities Serving Less Than 100,000 Population

Operates and inspects chlorination equipment; performs the orthotolidine residual chlorine laboratory test; records information on log sheets for gauge readings on filter head loss and facility total flow; analyzes and interprets log sheets established by operators on previous work shifts and peers on his work shift; works with the public in such activities as plant tours; repairs facility machinery and equipment, especially water softeners, filter beds, pumps, and polymer agitators; backwashes, operates and inspects the filtration system; consults with other operators and supervising personnel concerning facility operators; assists fellow operators with work that is primarily their responsibility; operates and inspects the flocculation basin; operates and inspects the sedimentation tank; performs coagulation tests to determine the necessary flocculation material needed; operates and inspects recarbonation equipment; determines and adds the amount of lime needed for pH control; operates and inspects aeration equipment.

Water Treatment Operator I -- Facilities Serving More Than 100,000 Population

Records information on facility log sheets such as water flow, equipment condition, and manpower needs; operates, inspects, and backwashes the filter beds in the filtration system; operates and inspects chlorination equipment: consults with other operators and staff members on facility activities; assists other operators and staff members on facility activities; assists other operators with their work responsibility; repairs facility machinery and equipment such as electric motors and hydraulic pumps; inspects and operates the flocculation basin; works with public relations by giving plant tours; runs the laboratory test for the causative micro-organism coliform; analyzes log sheets written by operators on previous work shifts and by peers on his shift; operates and inspects the facility's sedimentation tank: performs the orthotolidine laboratory test for residual chlorine; calculates and adds the lime and soda ash needed for water softening; operates, inspects, and calibrates fluoridation equipment; inspects and operates facility recarbonation equipment; performs the coagulation test needed for determination of needed alum and ferrous sulfate for flocculation.

Water Treatment Operator I -- Facilities Serving Less Than 100,000 Population

Records information on log sheets concerning such facility activities as water flow, equipment condition, and manpower needs; works with public relations by giving plant tours; backwashes filter beds; inspects and operates the flocculation basin; performs the orthotodiline laboratory test for residual chlorine: repairs facility machinery and equipment such as electrical controls, water softners, and electrical pumps; consults with other operators and supervisors concerning facility operations; analyzes log sheets written by operators on previous work shifts and peers on his shift; operates and inspects chlorination equipment: inspects and operates the sedimentation tanks; calculates and adds the quantity of lime and soda ash needed in the water softening process; operates and inspects the facility's filtration system: conducts the laboratory test for the causative micro-organism coliform: performs the laboratory test for coagulation in determining needed alum and ferric chloride: operates, inspects, and calibrates fluoridation equipment: operates and inspects the facility recarbonation equipment; operates and inspects the aeration machinery.

Water Treatment Operator II -- Facilities Serving More Than 100,000 Population

Operates facility chlorination equipment; records information on log sheets concerning facility water flow, equipment condition, and manpower needs; inspects and operates the filtration system; consults with other operators and staff personnel concerning facility operation; works with the public by giving plant tours and writing publicity releases: inspects chlorination equipment: repairs facility machinery and equipment such as the carbon, alum, and lime distributors, and electric pumps: assists other employees with their work responsibilities: backwashes filter beds in the filtration system; performs the laboratory test for the causative micro-organism coliform: analyzes log sheets written by operators on previous work shifts and by peers on his shift; operates and inspects the sedimentation tank: operates and inspects the flocculation tank; calculates and adds needed lime and soda ash for water softening; operates and inspects the recarbonation unit: supervises facility personnel; completes monthly reports for the State Department of Health; performs the laboratory test for coagulaticn in determining needed flocculation material: operates and inspects facility aeration equipment; operates, inspects, and calibrates fluoridation equipment.

Water Treatment Operator II -- Facilities
Serving Less Than 100,000 Population

Records information on log sheets concerning facility water flow, equipment condition, and manpower needs; works with public relations by giving plant tours and news releases: assists other employees with their work responsibility; runs the laboratory test for the causative micro-organism coliform; performs the orthotolidine test for residual chlorine; repairs such facility machinery and equipment as electrical pumps and controls and water softners; consults with other operators and staff members concerning facility operations; inspects and operates the flocculation tank; analyzes log sheets written by operators on previous work shifts and by peers on his shift; inspects and operates the filtration system; calculates and adds needed lime and soda ash for water softening; inspects and operates the facility's chlorination equipment; backwashes the filter beds in the filtration system; inspects and operates sedimentation tanks; inspects and operates aeration equipment; performs the laboratory test for determination of needed flocculation material.

Air Pollution Inspector

Advises supervisor of investigation findings; investigates air pollution complaints reported to his office; obtains evidence to help substantiate proceedings used in courts; enforces air pollution control laws involving trash fires; inspects incinerators to insure their conformance to air pollution code requirements; gives evidence in legal proceedings; meets with suspected violators and explains alleged violations; takes photographs and movies of air pollution caused by trucks and power plants; checks safety devices on boilers; makes air quality surveys for the specific pollutants of sulfur dioxide, nitrogen dioxide, and carbon monoxide: inspects boilers for their conformance to air pollution code requirements; operates the spot machine, optical density machine, field air analysis machine, and the Ringleman Chart for particulate air pollutants; takes both flue gas samples and non-flue gas samples.

SUMMARY AND CONCLUSIONS

Current and emerging environmental management occupations were identified by State Department of Health personnel, by advisory council members of the Environmental Studies Research Project, and by certain administrators of environmental management facilities. These identified occupations were used as the basis for obtaining manpower needs.

Summary of Findings

The findings indicated that facility and agency administrators anticipate an increase in the number of full time personnel needed for virtually all positions when they projected manpower needs to 1974. Administrators of wastewater treatment facilities and air pollution control agencies anticipated increased personnel needs for all positions. Administrators of water treatment facilities anticipated increased personnel needs for all positions except the non-certified operator.

Facility and agency administrators anticipated a decrease in the number of part-time personnel needed for most positions when they projected manpower needs to 1974. Administrators of wastewater treatment facilities anticipated a decrease in personnel needed for all positions except Operator II. Except for the position of technician, there were no part-time air pollution control employees. These anticipated manpower needs are summarized in Tables 11 and 12.

TABLE 11

ANTICIPATED CHANGE IN FULL TIME MANPOWER NEEDS FOR 1971-1974

Position	Number of Persons employed in 1971	Manpower change 1971-1974
Wastewater Treatment		
Non-certified Operator	782	+ 49
Operator I	367	+250
Operator II	197	+154
Operator III	178	+ 53
Operator IV	17	+ 83
Laboratory Technician	52	+ 44
Water Treatment		
Non-certified Operator	663	-177
Operator I	494	+145
Operator II	189	+ 93
Operator III	111	+ 33
Operator IV	15	+ 13
Laboratory Technician	72	+ 79
Air Pollution Control		
Inspector	71	+ 81
Engineer	23	+ 57
Chemist	17	+ 12
Technician	25	+ 11
Meteorologist	0	+ 1

TABLE 12

ANTICIPATED CHANGE IN PART-TIME MANPOWER NEEDS
FOR 1971-1974

Position	Number of Persons employed in 1971	Manpower change 1971-1974
Wastewater Treatment		
Non-certified Operator	237	-35
Operator I	33	- 3
Operator II	30	-12
Operator III	20	- 7
Operator IV	8	- 3
Laboratory Technician	28	-15
Water Treatment		
Non-certified Operator	252	-39
Operator I	76	-11
Operator II	14	+ 4
Operator III	14	- 3
Operator IV	4	- 4
Laboratory Technician	29	-11
Air Pollution Control		
Inspector	0	0
Engineer	0	0
Chemist	0	0
Technician	7	+ 1
Meteorologist	0	0

The task analyses showed a wide variety of tasks being carried out by persons employed in the selected positions. The analyses also indicated a high degree of relationship between employees' ratings of percentage of time spent on a task and their supervisors' ratings of the importance for that task. The results also showed a slight variation in the tasks completed by people with the same position in facilities serving cities of various sizes. Generally, employees in facilities serving less than 100,000 people carried out more tasks than their counterparts in facilities serving more than 100,000 people.

Conclusions and Recommendations

The increased personnel needs identified in this study justify the development of training programs in environmental management occupations. As indicated by members of the advisory council for the Environmental Studies Research Project and by facility administrators, many of the occupations analyzed can be filled by high school graduates. Specifically, these positions are: Non-certified Wastewater Treatment Operator and Wastewater Treatment Operator I, Non-certified Water Treatment Operator and Water Treatment Operator I, and Air Pollution Control Inspector. Vocational education programs should be offered in comprehensive high schools and joint vocational schools for the purpose of preparing personnel for environmental management occupations.

It is recommended that these programs be implemented as a two-year course consisting of a one-semester introductory course and three semesters of occupationally specialized instruction. Facility administrators indicated a need for workers to have desirable attitudes concerning work habits, knowledge of the overall environmental field, and for an appreciation of their particular job. In addition, the students must make decisions concerning specialty areas to pursue. These areas should be explained in the introductory course.

The specialized course is crucial for the development of useable occupational skills. This tri-semester course, which would follow the introductory course, could be used to develop the necessary skills for job entry in any or all of the areas of wastewater treatment, water treatment, and air pollution control. The number of skills developed would be limited by the students' ability, inclination, and interest. A cooperative placement program is considered crucial for the specialty course. A proposed curriculum for the specialized course is as follows:

Unit I. Wastewater Treatment Operation

A. Objectives: The student should be able to:

1. Inspect machinery and equipment such as pumps, filters, incinerators, aeration blowers, and bar racks to determine their satisfactory or unsatisfactory operation.

2. Operate machinery and equipment such as pumps, filters, incinerators, aeration blowers, and bar racks according to manufacturers' and facility specifications.

3. Complete and analyze log sheets according to facility standards.

4. Inspect the preliminary, sludge handling, primary, and secondary areas of the facility determining satisfactory and unsatisfactory operations and general appearance.

5. Demonstrate the ability to obtain correctly samples for laboratory analysis.

6. Make and carry out decisions on facility and operators' priorities and functions.

7. Demonstrate the communication skills used in consultation situations with other operators.

8. Perform laboratory tests such as biochemical oxygen demand, pH, settleable solids, chemical oxygen demand, and dissolved oxygen according to State Department of Health standards.

B. Content: Instruction should be provided in:

1. Wastewater and its composition

a. Introduction and sources
b. Solid composition
(1) Organic
(2) Inorganic

c. Liquid composition
   (1) Water
   (2) Chemicals
   (3) Grease

d. Gases present in wastewater
   (1) Oxygen
   (2) Hydrogen sulfide
   (3) Carbon dioxide
   (4) Methane

e. Disease causing organisms
   (1) Virus
   (2) Bacteria

2. Septic tanks and Imhoff tanks

a. Septic tanks
   (1) Functions
   (2) Structure
   (3) Chemical processes
      (a) Aerobic decomposition
      (b) Anaerobic decomposition
   (4) Maintenance
   (5) Safety

b. Imhoff Tanks
   (1) Comparison of septic and Imhoff tanks
   (2) Function
   (3) Structure
   (4) Chemical processes
      (a) Aerobic decomposition
      (b) Anaerobic decomposition
   (5) Maintenance
   (6) Safety

3. Preliminary treatment

a. Purposes
b. Racks and bar screen
   (1) Functions
   (2) Types
   (3) Maintenance
   (4) Safety

c. Communitor
   (1) Functions
   (2) Types
   (3) Maintenance
   (4) Safety

d. Grit chamber and detritus tank
   (1) Functions
   (2) Sizes and capacities
   (3) Maintenance
   (4) Safety

e. Pre-aeration tank
   (1) Function
   (2) Sizes and capacities
   (3) Maintenance
   (4) Safety

f. Preliminary tests
   (1) Sampling
      (a) Equipment
      (b) Procedure
      (c) Safety
   (2) Testing
      (a) Equipment and chemicals
      (b) Procedure
      (c) Safety

g. Chemical treatment
   (1) pH measurement
   (2) Lime addition
   (3) Chlorination

h. Records and record keeping
   (1) Plant records
   (2) State records

4. Primary treatment

a. Purposes
b. Sedimentation tank (clarifier)
   (1) Function
   (2) Types
   (3) Sizes and capacities
      (a) Detention time
      (b) Velocity of flow
      (c) Temperature
   (4) Maintenance
   (5) Safety

c. Primary tests
   (1) Sampling
      (a) Equipment
      (b) Procedure
      (c) Safety
   (2) Testing
      (a) Equipment and chemicals
      (b) Procedure
      (c) Safety

d. Records and record keeping
   (1) Plant records
   (2) State records

5. Secondary treatment

a. Purposes

b. Types
   (1) Activated sludge
      (a) Principles
      (b) Facilities
      (c) Aeration
      (d) Trouble-shooting
      (e) Maintenance
      (f) Safety
   (2) Trickling filter
      (a) Principles
      (b) Facilities
      (c) Trouble-shooting
      (d) Maintenance
      (3) Safety

c. Settling tanks
   (1) Capacity
   (2) Supernatant

d. Chlorination
   (1) Equipment
   (2) Determining amount

e. Secondary tests
   (1) Sampling
      (a) Equipment
      (b) Procedure
      (c) Safety
   (2) Testing
      (a) Equipment
      (b) Procedure
      (c) Safety

f. Records and record keeping
   (1) Plant records
   (2) State records

6. Sludge treatment
   a. Composition
   b. Purposes
   c. Methods
      (1) Thickening
      (2) Digestion with or without heat
      (3) Vacuum filtration
      (4) Incineration
      (5) Wet oxidation
      (6) Chemical conditioning
      (7) Heat drying
      (8) Elutriation
      (9) Sand beds
      (10) Maintenance
      (11) Safety
      (12) Chemicals

   d. Sludge disposal

e. Gases produced
   (1) Carbon dioxide
   (2) Methane
   (3) Hydrogen
   (4) Hydrogen sulfide
   (5) Nitrogen
   (6) Oxygen

f. Utilization of sludge gases
g. Sludge tests
   (1) Sampling
      (a) Equipment
      (b) Procedure
      (c) Safety
   (2) Testing
      (a) Equipment and chemicals
      (b) Procedure
      (c) Safety

h. Records and record keeping
   (1) Plant records
   (2) State records

7. Human relations
   Should be integrated into appropriate areas of the curriculum

Unit II. Water Treatment Operation

A. Objectives: The student should be able to:

1. Complete and analyze log sheets according to facility standards.

2. Operate machinery and equipment such as filters, chlorinators, the flocculation basin, the sedimentation basin, recarbonation machine, fluoridation machine, and the aeration blowers according to manufacturer's and facility specifications.

3. Inspect machinery and equipment such as filters, chlorinators, the flocculation basin, the sedimentation basin, recarbonation machine, fluoridation machine, and the aeration blowers to determine their satisfactory or unsatisfactory operation.

4. Demonstrate the communication skills used in consultation situations with other operators.

5. Perform laboratory tests such as orthotolidine test, coliform test, and the coagulation test according to State Department of Health standards.

6. Make and carry out decisions on facility and operators' priorities and functions.

7. Inspect the chlorination area, aerators, flocculation and sedimentation area, filtration area, and the clear wells determining satisfactory and and unsatisfactory operations and general appearance.

B. Content: Instruction should be provided in:

1. Water sources and its uses

   a. Ground water supplies including measurement of water flow
   b. Surface water supplies
   c. Uses of water
      (1) Domestic uses
      (2) Public uses
      (3) Industrial uses

2. Water quality

   a. Reasons for water treatment
   b. Quality control tests
      (1) Sampling technique
      (2) Source and control of taste and odor

   c. Drinking water standards
   d. Composition of water from various sources
   e. Self-purification and storage
   f. Methods of water treatment

3. Aeration

   a. Purpose
   b. Types of aerators
   c. Operation and maintenance
   d. Laboratory tests

4. Coagulation and flocculation

   a. Purpose
   b. Process of coagulation and flocculation
   c. Coagulants used
   d. Chemical handling, storage, and safety
   e. Flocculation equipment
   f. Laboratory tests

5. Sedimentation

   a. Purpose
   b. Process of sedimentation
   c. Operation
   d. Laboratory tests

6. Filtration

   a. Filter media and types of filters
   b. Operation procedures and facilities
   c. Records

7. Softening of water

   a. Purpose
   b. Procedures

c. Laboratory tests
d. Records

8. Protection of water supply sources

a. Bacterial control
b. Control of water-borne diseases
c. Chlorination safety

9. Human relations
Should be integrated into appropriate areas of the curriculum

Unit III. Air Pollution Inspection

A. Objectives: The student should be able to:

1. Advise a supervisor of investigation findings in both verbal and written form.

2. Investigate air pollution complaints by operating a spot machine, optical density machine, field analysis machine and a Ringleman Chart.

3. Obtain legal evidence by taking photographs and movies.

4. Inspect boilers by testing for sulfur dioxide, nitrogen dioxide, carbon monoxide and checking safety devices for conformance to both manufacturer's and city code standards.

5. Meet with suspected violators of the air pollution code and accurately explain violations.

6. Give accurate testimony in court during legal proceedings.

B. Instruction should be provided in:

1. The Air Pollution Problem

a. Types of pollutants
(1) Particulates
(a) Smoke
(b) Fog
(c) Haze
(d) Dust
(2) Gases and vapors
(a) Sulfur dioxide
(b) Nitrogen oxides
(c) Carbon oxides
(d) PAN
(3) Radioactive fallout

b. Effects of pollutants
(1) Atmospheric effect
(a) Visibility
(b) Climate

(2) Vegetation effect
(3) Material effects
(4) Animal effects
(5) Human effects

c. Sources of air pollution
(1) Transportation sources
(2) Stationary sources
(3) Incineration of solid wastes
(4) Miscellaneous sources

2. Ambient sampling

a. Reasons for ambient sampling
b. Determination of sample size
c. Determination of sampling rate
d. Determination of sampling time
e. Approaches to sampling
(1) Visual methods
(2) Settling devices
(3) Filtration devices
(4) Gaseous pollutants
(a) Static samplers
(b) Automatic samplers
(c) Vegetation analysis
(d) Grab sampling

3. Air quality criteria and standards

a. Air quality criteria
(1) Biological effects
(2) Physical effects

b. Air quality standards
(1) Air quality criteria
(2) Another community's standards
(3) Earlier levels

c. Emission standards
(1) Typical emission standards
(2) Setting emission standards

4. Air pollution control programs

a. Objectives
(1) Preserve the health and welfare of man
(2) Protect plant animal life
(3) Prevent damage to physical property
(4) Ensure an esthetically attractive and enjoyable environment

b. Typical air pollution control programs
(1) Local government
(2) State government
(3) Interstate government
(4) Federal government

c. Activities of a typical program
  (1) Defining air pollution problems
    (a) Emission inventories
    (b) Air quality measurements
    (c) Monitoring air pollution effects
    (d) Handling complaints
    (e) Visual detection
    (f) Source sampling
  (2) Correcting problems
    (a) Preparation of air quality standards
    (b) Preparation of emission control regulations
    (c) Enforcement of laws and regulations
    (d) Testimony in the courts

5. Human relations
Should be integrated into appropriate areas of the curriculum.

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