COMMENTS BY STUDENTS ON

"ENVIRONMENTAL ENGINEERING SEMINAR"

HELD DURING SPRING 1970

College of Engineering, L. V. Baldwin, Dean

Colorado State University

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Foreword

Two experimental seminar courses, one undergraduate and one graduate, were offered by the College of Engineering during Spring, 1970. The purpose was to make engineering students acquainted with some of the environmental problems in the foreground of the nation's and Colorado's concern, and to stimulate interest in Environmental Engineering as a career selection by engineering students.

The graduate seminar was composed largely of talks followed by discussion given by invited outside lecturers. Names of speakers and their subject matter in the order of presentation follows; the order of talks was largely dictated by availability. Students were asked at the end to prepare a summary of the seminar essentially conveying their impressions and conclusions for the future. Four of these papers appeared to be of sufficient interest to make them available to a wider audience. They are, therefore, reproduced here in a limited edition for information and guidance of other students and faculty.

Herbert Riehl

COLLEGE OF ENGINEERING

COLORADO STATE UNIVERSITY

Environmental Engineering Seminar
Held during Spring Quarter 1970
Herbert Riehl, Coordinator

Speakers and Subject Areas in order of appearance

Dr. Eric Kraus, Director Institute of Atmospheric Sciences University of Miami Miami, Florida	Thermal Water Pollution
Dr. James P. Lodge National Center for Atmospheric Research Boulder, Colorado	The Smoggy Crystal Ball
Dr. A. P. Altshuller National Air Pollution Control Administration Cincinnati, Ohio	Air Pollution
Dr. Claes Rooth Institute of Atmospheric and Marine Sciences University of Miami Miami, Florida	Problems of Coastal Waste Disposal
Dr. Walter U. Garstka U. S. Bureau of Reclamation (Ret.) Visiting Professor Colorado State University Fort Collins, Colorado	Watershed Management for Environmental Quality
Dr. John R. Bagby, Director Institute of Environmental Health Colorado State University Fort Collins, Colorado	Protection of the Earth's Biosphere from Extraterrestrial Sources
Mr. Ralph Nader 1908 Q Street, N.W. Washington, D. C.	Environmental Problems, Man-Made and Man-Remedied
Dr. Roy Cleere Executive Director Colorado State Department of Health Denver, Colorado	The Role of the Engineer in Environmental Health
Dr. Herbert Riehl Department of Atmospheric Science Colorado State University Fort Collins, Colorado	Meteorological Aspects of Air Pollution

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COLORADO STATE UNIVERSITY

Environmental Engineering Seminar

Spring 1970

Roger J. Sams

Objectives

In recent years environment, ecology, and pollution have been prime news items. These three terms have acquired a multitude of meanings and connotations. All are included in environmental engineering, the subject of the seminar series held at Colorado State University, Spring Quarter, 1970.

Of prime interest and emphasis in this series has been the introduction of the students to the environmental problems that are evident today. A great majority of the problems have basis in a technical field, thus the orientation towards engineering students and staff. Of the notable persons participating in the seminars, most were concerned with the problems that exist rather than presenting particular solutions to them. It should be obvious that such solutions cannot be cut and dried. From the information and basic analyses shown, general trends can be observed and solutions to environmental engineering problems formulated.

This writer's particular area of interest lies mainly in water quality. Thus this paper will have its main emphasis on pollution problems associated with water resources as presented in this seminar series.

Man's War With Nature

From the lectures presented in this series there is a common factor that can be recognized as the source of environmental problems that are known today. This may be termed as man's war with nature. Man has entered into combat with nature rather than using nature and living in harmony with it. Harmony with nature may also yield relatively simple solutions to the problems that are of concern to us today.

The majority of the problems encountered today are a direct product of the affluent society that we have built about us. The desire of man to have unequaled independence in the midst of a burgeoning population has led to the creation of technology, products and ideas to help him survive most comfortably. Of prime importance in stemming the forward thrust of environmental damage is the reduction or non-advancement of the standard of living. It is believed that the young people who are concerned about problems today are willing to accept a somewhat lower level of affluence than is presently being enjoyed.

Thermal Pollution

Human activities have upset the thermal equilibrium of local environments by the introduction of abnormal quantities of heat. Of the heat produced by man, approximately 81% is a result of industrial activities. This heat is predominately waste heat from cooling processes. The electric power industry is an effective indicator of trends in heat production.

As the standard of living has risen in the United States, a great many electrical products and appliances have been developed. Industrial demand for electrical energy has also risen to new heights. At the present time the majority of the power generation in the

United States is from fossil fueled thermal plants. A small part is also being contributed by the use of nuclear energy in generating electrical power. Hydroelectric generation has reached somewhat of a status quo. Only about 26% of the potential has been developed but not all of the remaining potential can or will be developed.

Of primary concern is the dissipation of waste heat created with the thermal generating plant. As matter is converted to energy by burning, a relatively small portion is utilized in creating another form of energy, electricity. Today fossil fueled plants have top efficiencies of about 40%. Nuclear plants have top efficiencies of 33%. Thus the waste heat is released to the environment.

The waste heat eventually goes to the atmosphere but intermediate transport methods have become sources of environmental problems.

If the generating plant is located close to a large body of water such as a lake, river, or ocean, it is usually most economically feasible to draw water from the source and return it after use. The water is primarily used in the production of steam for use in steam turbines and in cooling processes.

When such water is returned to the source, it is almost always without any treatment. That is, treatment in terms of returning it at a temperature at which it was withdrawn. If the water is injected into the receiving body at an elevated temperature many changes may occur. There are changes in the physical properties of the water, namely density, viscosity, vapor pressure and solubility of gases. Chemically, an increase in temperature usually increases the rate of reactions. Biological activity is also greatly affected. Cold blooded organisms rely on their environment to maintain livable

conditions. If such creatures are not aclimated to a new environment, they cease to function and live. Decomposition of organic matter decreases to near zero at temperatures above 40° C. A change in the life cycle of one organism has been found to have profound feedback effects upon the system of which it is a part.

Many examples are evident today of the problems that the expulsion of waste heat into receiving waters has created. Generally the use of water in this way has been dictated by economic considerations. If such problems are created, it should be recognized by those doing the planning that measures must be taken to alleviate the situation. Basically there are two methods that have been practiced: (1) dilute and disperse, and (2) concentrate and confine.

Dilute and disperse almost always is associated with the introduction of hot water into some receiving body. If an immediate dilution and dispersal can be accomplished without any detrimental effects, this method is quite economical. However, as stated before, this method usually brings about undesirable changes in the environment.

Methods of concentration and confinement have been used to a great extent. These generally consist of cooling towers or cooling ponds. Wet towers cool by evaporation. Dry towers cool by conduction of the heat in the water to air passing over pipes. Wet towers are one-fourth to one-half as expensive as dry towers because dry towers require a much larger volume than do wet towers. The use of cooling towers has been somewhat hampered by the public's dislike of the tower's aesthetic qualities. Cooling ponds are very simple to operate but the large volumes of water required in thermal plants make the area required for cooling purposes very large. The cooling process in

ponds is much slower than that found in other methods.

From all this, one may ask what can be done to create a new method of disposal or treatment of waste heat. In higher latitudes, the vapor pressure of water is generally lower allowing for more efficient cooling by evaporation. Modern achitecture and systems design have made large structures such as cooling towers more pleasing to the eye. It has also been proposed that the waste heat be put to some beneficial use. This may be in heating buildings, keeping icebound seaways open, or used in creating year-round food supplies in heated greenhouses.

Looking further into the future, one should look for alternate means of electric power production. It is possible that gas turbines may replace steam turbines. This method relies on petroleum as a source of energy which can lead to other problems. Fuel cells operating on chemical reactions are a possible means of power production also.

Solar energy has possibilities of use if storage facilities can be developed to carry the power demand through hours of darkness. A country-wide transmission network would be required to maintain a source if some areas of the country were overcast for extended periods of time. Magneto hydrodynamics is a method of a non-polluting nature. However this method is in the research stage and practical considerations on a large scale must be made before this method could be competitive.

There are certain short range goals and priorities which could be set. Since all nuclear power generation is government subsidized, new methods of power generation could be aided in this way. Since

most considerations are economic, this could remove a serious obstacle in the development of new methods much less detrimental to the environment.

A restructuring of the country by moving power generation facilities to the higher latitudes has been suggested. This would obviously remove power plants from most of the large load centers. The cost of power would be increased because of increased transmission needs. Eventually industry would move closer to the power facilities and cause a social stratification of the country which may be quite undesirable.

To meet immediate needs, the following are suggested: (1) Use cooling towers or ponds to the greatest extent possible. Create aesthetically pleasing structures. (2) Accelerate research for alternate means of power production such as magneto hydrodynamics.

Air Pollution

As a result of the high level of technological development and affluence in the American society, "energy slaves" are excreting their wastes into the environment at an alarming rate. A good part of this is in the form of products of fuel combustion forced into the earth's atmosphere.

In recent years industry has come under fire for flagrant abuses in air pollution. The automobile has also been blamed for a good deal of pollution. Industry has become subject to rather rigid controls by state legislative action. National and state pressures have started the development of emission controls for the automobile. Regardless of the source controls, there is still going to be some matter in the atmosphere that is not a natural constituent.

As a result of this realization, measures are required to alleviate the effects of air pollution rather than the elimination of air pollution itself.

Necessary to this concept is the accurate knowledge of transport and reactions of air pollutants. When transport phenomena is fully understood, the results of the introduction of a pollutant to the atmosphere can better be estimated. A thorough knowledge of what changes a pollutant undergoes during transport will also be of importance in finding what pollutants are responsible for certain effects. The main tool that can be used in this study is an adequate network of sampling stations. To date, the transport phenomena has not been oberved too well because of the limited size of sampling networks. After an adequate knowledge of these phenomena is attained more definite source controls can be instigated.

There are methods which may be used or started at the present time. By nature they may seem long range, but they are a meaningful method of dealing with air pollution control. City planning in the United States has been known to have not been practiced to the greatest degree desirable. European communities have used city planning as a valuable tool in creating pleasant, healthful communities in which to live.

Of primary interest is the placement of industrial areas on the downwind side of the city. This can be accomplished by present zoning methods. This allows prevailing wind movement to carry pollutants away from the city without subjecting its residents to the bad air from industry.

Another valuable tool is the incorporation of green belts or

open areas of land parallel to the direction of prevailing winds. This allows for greater wind velocities because of a smoother boundary. The rough boundary created by large, dense building decreases the wind movement substantially.

Also of possible use is the friction-stovepipe effect. Temperatures are commonly higher toward the center of a city. If the heat sources within a city could be concentrated, the heat would cause a rising of the air at that point. This in turn causes an inflow from surrounding regions to replace the air that has moved upward.

Agricultural Pollution

Another area of environmental concern that deserves a few words is that of abuse of the earth, its soil and water processes. Farming in itself is a crime toward the environment. Organic matter which is naturally intended to go back into the plant cycle is removed as a crop. This also takes away nutrients from the soil that have accumulated.

Farming methods of temperate climates have been forced on tropical areas with disasterous effects. The tropical zones are not too forgiving when treated harshly. The nutrients in the soil are depleted rapidly and do not generate or accumulate very quickly.

Temperate zone farming has advanced to a state where crops are raised on otherwise worthless soil. This however is responsible for other important effects. Artificially applied nutrients do not aid in the generation of a nutrient cycle. Irrigation methods are generally very inefficient and waste water resources.

This type of abuse can and should be studied and researched at

the university level and extended to the people by the extension services of most land grant institutions.

What Can YOU Do Today?

The demand that something be done immediately has been met by the statement that all changes take a long time. The author believes that people can do things, though seemingly inconsequential, that can have an effect on current environmental conditions. Some of these have been enumerated before, but are listed here for thought and reference.

1. Conserve water: Keep a pitcher of water in the refrigerator for drinking. This eliminates the waste when waiting for cold water from a faucet. (There is a trade-off here between conserving water and expending electrical energy but it is believed to be valid.) Landscape your yard in such a way as to use a minimum of water. Take short showers and baths. Is it really necessary to empty the water closet after each use?

2. Conserve electrical power: Do not leave lights burning unnecessarily. Use low wattage bulbs where possible and operate high wattage equipment only when necessary.

3. Organize car pools. Ride a bicycle to work and play.

4. Aid your city planning commission. They need public support.

5. Be prudent in choosing products that may be a potential pollutant. This includes packaging materials.

6. Manage your household solid wastes effectively. Keep the volume to a minimum by crushing boxes, cans, and bottles.

COLORADO STATE UNIVERSITY

Environmental Engineering Seminar

Spring 1970

William R. Kininmonth

Introduction

The seminar series clearly illuminated areas of industrial activity where man is placing excessive stress on his environment. While not covering all areas where man's endeavor, if not carefully controlled, can lead to ecological disaster, the speakers covered a sufficiently wide spectrum of topics to make the engineer and scientist aware of the delicacy of nature.

Mr. Garstke pointed out that all men live on a watershed. Ecologically, life on a watershed is a balance between the producers, the consumers, and the decomposers. This life is dependent on air and water. Man in his quest for "efficiency" is destroying this ecological balance. The air, the rivers, and the oceans are dumps for the waste of man's activities.

Pollution received considerable attention by the speakers but should not be thought of as the only danger to the environment. By Dr. Lodge's definition, pollution is the unfavorable accumulation in the environment of the metabolic waste of the culture. Depleting the environment of an important element, as Mr. Garstke mentioned when referring to soil nutrients and farming, is just as serious a crime on the ecology. Dr. Cleere was concerned with the health of the human inhabitants of the watershed, but his concern could readily be extended

to the other inhabitants on whom man relies. Forcefully, Mr. Nader spoke out against corporation and bureaucratic institutions which are allowed to commit ecological crimes of unbounded magnitude under the guise that the results justify the means.

This summary will be made in the five principle areas with which the nine speakers of the series dealt. These areas were: Principles of Environmental Management, Garstke; Thermal Pollution, Kraus and Rooth; Air Pollution, Lodge and Altshuller; Health, Cleere and Bagby; Practical Aspects of Environmental Preservation, Nader and Riehl.

Principles of Environmental Management

Man's physical environment consists of rock, water, and air, and a constant bombardment of solar energy. In attempting to eliminate the extremes of energy, nature has set the air and water in motion over the rocks. The result of this attempt to form an energy balance is the earth as we know it, with its characteristic circulations and climatic features. The climate determines soil type and with erosion of the underlying rock there is an accumulation of soil nutrients.

In the presence of soil nutrients, carbon dioxide (CO_2), and water, solar energy is utilized by the photosynthesis process of plant life. Plants, plankton and algae are life's producers. It is, however, an ecological crime to indiscriminately farm the land. A pure stand of crop is an invitation to attack by fungi and insects. The removal of the crop is a raid on the soil. Not only is the soil nutrition depleted, but so too is the organic matter which is so necessary to bind the soil. The water holding and nutrient capacity of the soil is decreased.

The length of time that a pure stand of crop can be supported

varies with the climate, but nowhere has agronomy proved permanent. While temperate latitudes are farmed out over several hundred years, tropical land can be worked out in less than ten years. Such crops as rice have a high yield, require a lot of water, and put a tremendous strain on the soil.

A second factor of prime importance in the preservation of the land is the problem of soil erosion. Erosion is a natural process which cannot be stopped, but can be hindered. Erosion by wind and water is violent in desert regions, is slow in the temperate latitudes, and is "on ice" in the tundra regions of the arctic. The clearing of forests in temperate latitudes is temporary, the forests will return. To clear the tundra of the arctic is permanent and the land is permanently scarred. The mistakes of the arctic and arid regions are not easily rectified.

Where man is having his most serious difficulties is in the utilization of energy resources. He cannot presently utilize energy resources without a serious upset to the ecology of his environment. Utilization of coal and petroleum resources is at the expense of conversions of solar energy which took place aeons ago. These resources are not being replaced. Coal and petroleum have been associated with problems of extraction (strip mining and seepage) and their utilization results in pollution of the environment.

Hydropower is the tapping of a naturally occuring and continuously replenishing energy resource. This power supply is strictly limited in terms of the rapidly expanding requirements. A hydropower station also has a limited life since all dams will eventually silt up.

Nuclear power, heralded as the energy source of the seventies,

has not met expectations. Commercial plants are not, as yet, competitive and the products of reaction (with half lives of up to 1,600 years) are more of a threat to the environment than are the present pollutants. Fussion processes, if they can be effectively harnessed, do not supply the pollutants of fission plants, but the supply of heavy hydrogen is strictly limited.

Thus we return to sunlight and photosynthesis. In sunlight there is practically an unending energy supply at the rate of a horsepower per square yard. The photosynthesis process takes place without the necessity of large local temperature gradients and does not result in harmful waste. If man is to live in the twenty-first century, he must give serious thought to the preservation of his energy and food supplies.

Thermal Pollution

Of the total heat produced by man approximately 81% is the result of industrial activities. This heat is predominantly waste heat and discharged in cooling processes. Typically, in the production of power the efficiency is low such that much of the output energy is realized as waste heat. Where electricity production utilizes 3,400 BTU per kw hr, at the same time fossil fuel plants give off heat at the rate of 4,200 BTU per kw hr of production and nuclear plants give off 6,600 BTU of heat per kw hr.

Where relatively small fossil fuel plants could be efficiently deployed across the country, nuclear plants are only efficient beyond a minimum size. There is a developing trend toward nuclear power generation. Associated with this trend is the problem of waste heat disposal.

The most efficient present method of waste heat disposal is by means of water coolant. Although the heat has to be eventually given to the atmosphere for radiation to space, there are problems with direct transfer to the atmosphere. Water has a specific heat 4 times that of air and is over 1,000 times as dense. Only 0.025% of the volume flow of air is required by water to transport the same quantity of heat. Locating future nuclear power plant sites on coastlines should allow for an efficient means of waste heat disposal.

Evaporative cooling was also suggested as an efficient mechanism of waste heat disposal, possibly suited to inland areas. However, a 2,000 megawatt power station would require evaporation at the rate of 1 ton of water per second. The salt residue could well become an unmanageable problem.

As an example of the trouble which can be encountered when the heat disposal problem is underestimated, the speakers discussed the Turkey Point, Florida nuclear power plant. Not only was the plant located on a large shallow estuary-like channel, but the mass flow of water was not very great. Compounding the problem the coolant discharge region was located upstream from the coolant inflow ducts. Effectively the coolant was being recycled, and warmed in the process. At times the bay water temperature was 20° F greater at the outflow than elsewhere.

Dr. Rooth spent time discussing ways to effectively overcome this particular problem. Because of the large quantities of water involved in the cooling process, the cost of pumping from and to the deeper gulf waters beyond the islands is near prohibitive. An ingeneous method proposed was based on the fact that the saturation vapor pressure of water increases exponentially with temperature. Confining the outflow-

inflow area to form a saline pond would effectively isolate the estuary from the power plant. Evaporation in the pond would increase markedly as the temperature of the pond increased. So too would the salinity of the pond (and the incidence of fog in the vicinity). When the salinity of the recirculation pond increased beyond approximately 40 ppm the effluent would be bled off through a relatively narrow duct to beyond the islands. Being denser than the outside water this effluent would sink and be diffused.

Dr. Kraus dealt with the marine ecology changes resulting from anomalous warming. Increasing the temperature increases the metabolic rate of fish. However the amount of oxygen held in the water is decreased. The net result is an oxygen starvation to marine life. Heating the water also results in a supersaturation of nitrogen which has a toxic effect on fish. Similarly, microbe decomposition is increased, but in oxygen deficient water this leads to bad odors, particularly hydrogen sulfide. Some fish species (for example, salmon and trout) will continue to live in warm water, but will not spawn. If it is the spawning grounds of these fish which is heated, the effects are nonlinear. An effective sterilization of a few square miles of spawning ground will significantly alter fish populations over a large area.

A further suggestion was that it may be more efficient to locate future power plants in cold climates where waste heat can be more efficiently utilized. Domestic heating of cities, keeping iced waterways open, and aqua-culture are all possible uses for this presently wasted energy.

Air Pollution

In the processes of manufacture a large fraction of the raw materials cannot be efficiently utilized, and results in waste. Inevitably much of this waste finds its way into the atmosphere, particularly the processes of combustion. The existence of those waste materials which do, or tend to, cause discomfort, impairment to health, etc., is pollution.

Pollution is common to all scales of life and eventually begins to have a detrimental effect. For example, bacterium also produce waste which must be diffused away. In the event of a build-up of waste the colony size is restricted and the growth of the members is stunted. Classifying pollution as the metabolic waste of a culture, it is readily appreciated that man has some very exotic wastes. Man's wastes include combustion particulates and gases, vapors, liquids and solids. Add to these radioactive and chemical materials and we have a potent concoction in which life is wallowing.

When examining atmospheric pollutants it is found that predominantly these are the result of heat and combustion processes. Power plants, smelting works, foundaries, and motor vehicles are prime offenders.

For life processes the atmosphere has a twofold purpose. Oxygen is a vital constituent and the atmosphere tends to disperse finer particulate and gaseous pollutants.

Oxygen is continuously extracted from the atmosphere by combustion and converted to CO_2. Plants, through the photosynthesis process, extract the CO_2 and return oxygen. Also the oceans absorb large volumes of CO_2. The equilibrium of CO_2 is upset at present,

indicated by the increase in concentration from 295 ppm to 320 ppm since industrialization. The concentration is increasing exponentially. Not only CO_2, but also other, more toxic, atmospheric pollutants are increasing in concentration. These include the oxides of sulfur and the oxides of nitrogen.

The problem of pollution dispersal, as Dr. Altshuller pointed out, is one requiring a meteorological and chemical solution. Preferred trajectories and regions of concentration are needed, but so too is a knowledge of what is chemically happening to the pollutants during this dispersion. Examples include the photochemical conversion of oxides of nitrogen to particulate matter. Chemical damage to Ponderosa Pine to a distance of 100 miles from Los Angeles is experienced. Along a trajectory, pollutants suffer a physical dilution and undergo chemical reaction. It is the combination of these effects which must be assessed for adequate control measures to be instituted.

Environmental Health

Disease and infection can be either air or water carried. There is also the possibility of contamination through contact and the transmission of a host carrier. Dr. Bagby dealt with a particular form of carrier transport--that of returning objects from outer space--and methods used to protect earth from any possible exotic diseases. Dr. Cleere described the methods used by the State Health Department for environmental health control in the State of Colorado.

Generally infant mortality is a good indication of the health services of a locality. The infant mortality in the State of Colorado is lower than the national average, but there are localities, such as the San Luis Valley, where the national average is exceeded.

Many of the once prevalent diseases are all but eliminated. Typhoid and polio are rare while tuberculosis is on the decline. Measles is presently under strong attack. Venereal disease has developed a resistance to drugs and is presently on the increase.

The environmental health department of the Department of Health is concerned with air pollution, water pollution, radiological and occupational problems. This division is responsible for setting up and policing of water and air standards in the state. It is responsible for standards of drinking water, noise in industry and public, and sanitation and waste disposal.

It is worthy of note that water pollution control has been in existence for many years and is very effective. In 1880 the population of Denver was 35,000 persons and there were 1800 cases of typhoid that year. Water quality is such that now it is only the small, especially mountain communities which periodically experience health problems resulting from bad water. With the recently established Air Pollution Control Board becoming effective, one would hope for a similar increase in the quality of air.

Practical Aspects of Environmental Preservation

It is only the blind without the faculty of smell who do not sense the present degradation of the environment. While, as yet, pollution is not a major problem in Larimer County, the low altitude build-up of pollution in the air is frequently observed. In the city of Denver, city smog and haze are the norm.

Where previous speakers had pinpointed particular problem areas (power station heat production, motor vehicle emission, etc.) Mr. Nader and Dr. Riehl, from different directions, came to the heart of the problem. In essence, what is the cause of pollution and where is it,

so that steps can be taken to eradicate the problem?

Obviously, environmental degradation is the result of poor planning, and the lack of proper safeguards. Corporate responsibility should include a thorough investigation of all possible means of failure in any system. Meeting minimum requirements of law is not sufficient--the law may well be so outmoded as to be useless. The law should be such that individual, as well as corporate penalties are invoked for negligence, and standards and penalties should increase with the magnitude of the damage following failure. No company should be able to afford the penalties resulting from a 200,000 ton oil tanker running aground, or a railroad tanker of toxic gases becoming derailed, or the overturning of a transport carrying radioactive waste. No company should be able to afford the penalties invoked resulting from the accidental or deliberate release of noxious gases into the atmosphere.

The point of Mr. Nader's talk was that corporations are permitted to commit violence on the community. On the pretext that the results of industry are necessary for life, the by-products of industry (environmental degradation) are regarded as necessary evils and must be tolerated. This does not necessarily follow, and in fact, the basic assumption is open to question. Industry should be examined very critically before its hazards so far outweigh the benefits that man does not have the resources to reverse the trend and rectify the damage.

Dr. Riehl's detailed description of an air pollution study of Denver clearly demonstrated how practical steps could be taken to minimize this problem. Pollution concentrations followed the daily

trend of man's activities. Similarly pollution trends followed marked diurnal trends under conditions of weak airflow. Studies such as the above point the way for organized town planning. Also, knowing the meteorology of severe pollution concentration situations, advance notice can be given to industry to reduce emission during danger periods.

Summary

It is apparent that man's technology has brought him to a stage where the ill effects are being felt and that there is a definite danger that, without a deviation in the trend, industry must eventually choke its master. Several of the speakers were very pessimistic concerning the increasing demands being made on the environment, and the decreasing capacity with which the environment is managing to absorb the demands.

At present the outlook for the environment does not look good. Where nature derives her consistency from small concentrations and weak gradients, man is relying on massive concentrations and steep gradients for his efficiency. A flaw in nature is readily smoothed over and hardly felt. Man's mistakes are becoming catastrophic.

COLORADO STATE UNIVERSITY

Environmental Engineering Seminar

Spring 1970

Richard P. Johansen

This paper is written as a class requirement for the graduate seminar on Environmental Engineering. I will attempt in this paper to present and examine the common problems and remedies that were implicit in each of the nine seminars.

Environmental Engineering, as it was considered in these seminars, is the task of reducing and remedying the pollution produced by man. Pollution, in the context of this course, is not a "resource out of place", but rather an accumulation of the by-products of man and his civilization that either esthetically or physically degrades his environment. The primary concern of the seminars was how to reduce the physical degradation of the environment. This must be done to maintain an acceptable environment for man throughout the conceivable lifetime of civilization.

One theme of the seminars was to be able to define and predict the consequences of pollution and the natural mechanisms that tend to reduce it. The present problem is to try to develop both (1) models that can predict pollution consequences from currently measurable parameters, and (2) different measuring techniques that will provide better information for existing models.

A second theme was the need to establish the consequences of pollution on the ecology and the environment. The roles of all

levels of an ecological chain need to be defined. The individual and overall affects of pollution on the chain need to be known so pollution consequences can be presented factually as a reason for pollution control.

A third theme is the need to find better predictive techniques for the growth and expansion of civilization. This would remove some of the science fiction character of present predictions on population to be served and of per capita consumption in the future. This must be planned for now.

A fourth theme which was directly discussed in several of the seminars and implicit in the rest, was the need to develop cleaner power supplies. Present systems produce a significant fraction of the airborne pollution and almost the total amount of thermal pollution in this country. An examination on energy availability for power production shows the need for a major breakthrough in power production technology within the next 100 years. Without this breakthrough, the per capita power consumption in the United States will have to decrease.

The fifth theme is perhaps the most important to bear in mind with respect to all the seminars we had. All of the presented controls and solutions that are being currently considered are simply stop-gap measures until either new techniques are developed or the situation deteriorates further. Even with new techniques, it appears that a shift in personal goals, motivations, and living standards will occur, either by education or environmental disaster.

The evaluation of pollution, its consequences, and its alleviation involves both the physical sciences and the biological sciences.

The context of the seminars limits our role to the consideration of the physical sciences.

The basic laws to be used in evaluating the diffusion of pollution from a source or series of sources are simple to state. All that is needed is to consider that mass, energy, and momentum are all conserved. The difficulty arises when one tries to write these principles mathematically in terms of measurable parameters. To lessen the complexity of the expressions, assumptions are made related to the measured phenomena. For instance, in air pollution considerations, air is considered incompressible over the height of cities and, in less detailed studies, the air flow characteristics of one detailed study are assumed to apply to a different area. Additionally, regions are characterized by a small number of specific measurements and profile information is collected with an even smaller number of measurements at convenient rather than random locations. Assumptions on localized phenomena have to be made to establish their relationship to the total magnitudes of the measured parameters. Every assumption and approximation included in setting up and evaluating the problem lessens the reliability of the predictions based on the conclusions of the study.

At present, many large scale studies are being done with accepted and experimental techniques to be used with accepted and proposed mathematical models to develop systems with a higher correlation between the predictions and the later observations. Studies are also being done to establish possible relationships between easily measured parameters and the more important natural phenomea. Representatives of the above type studies were presented by Dr. Claes Rooth

of the University of Miami, Florida, and Dr. Herbert Riehl of CSU, and sponsor of the seminars.

Dr. Rooth discussed the techniques and some of the results of the study done on the Turkey Point power station on Biscayne Bay in Florida as part of his general discussion on the growth of the thermal pollution associated with larger populations and larger per capita power consumption.

Dr. Riehl presented a comprehensive study on the actual equations and sampling procedures used on the air pollution problem in Denver and Larimer county. He also presented the metrological phenomena that tend to enhance or lessen the pollution in the Denver area.

These seminars have strengthened my belief that environmental engineering, in all its various phases, is on the starting portion of a growth curve similar to the past decade's growth of the space industry. The magnitude of the problems and the growing public awareness should insure several decades of continuous growth.

This is one of the reasons I chose my present field of study, Sanitary Engineering. The seminars have reinforced my belief that the sanitary engineering field is a promising field to enter.

COLORADO STATE UNIVERSITY

Environmental Engineering Seminar

Spring 1970

Dirk Herkhof

The Seminar course on Environmental Engineering this Spring Quarter offered a variety of different topics concerning the problem of man in his environment. At a time coinciding with Earth Day, which marked a beginning of a lot of people's concern about the present environmental crisis, this course should lead to a mode of attack on this problem from the engineer's and scientist's viewpoint. Though no straightforward answers could be given to any problem, the course led to some knowledge of the many complexities involved and should make us consider, at least, a research program to look at the complexities from all angles which should eventually lead to some practical decision to do something constructive to improve man's environment.

The problem can be divided up into several categories. Conservation of our air resources is a burning problem at the present. However, so is conservation of water and other natural resources. The implication of air and water pollution together with population growth is frightening. Plant life, wildlife, and natural beauty suffer. There is also the problem of terrific wastes and squandering on the part of both manufacturers and consumers. The problem is not only of a scientific nature but equally of a sociological nature. The latter may produce even more difficulties than the first, as it

involves a social attitude or a way of life which is not easy to change. We will look at each of these problems in more detail and in light of these, present the question to the scientist and engineer in the form of what role he must play in combating the growing problems. As we shall see, this calls for scientists and engineers from all fields to work together, something which really has never been done before. Then there must be found a different educational program to prepare scientists to work in the environmental problem.

The most frequently heard complaint from the public is that of air pollution. This problem must be attacked by the engineer, the meteorologist, and the chemist. More knowledge must be gained in the area of the chemistry of pollutants. The reactions taking place in the atmosphere are very complex and therefore cause difficulties in tracing both particulates and gaseous pollutants as was pointed out by Mr. Altshuller. Also in view of the increased concern about global contamination, there must be attempts made to study background concentrations and any possible changes. The mechanical engineer should study the emissions for different combustion processes and attempt to develop new devices that emit a minimum of pollution. The latter may not be easy. Care must be taken that one just does not transfer the contamination from one source to another. An example is the concept of the electric car. It would eliminate the pollution from moving vehicles, but at the same time plants must still be operated to produce the power for this car. Thus pollution is just passed on to another location and the problem is not solved.

More attention must also be paid to incorporating knowledge of meteorology and engineering into urban planning. Cities should be

constructed in such a way that the major sources of pollution will not bother most of the inhabitants. Cities could be modeled so as to provide greatest possible ventilation. This can easily be done by studying prototypes in wind tunnels. To ease city traffic, massive transit systems should be considered and even eliminate traffic completely from the city. In the suburbs, residents must be located as close as possible to stores, offices, parks and recreation areas so as to minimize traffic. All this requires close cooperation between the meteorologist, the engineer and the city planner. The meteorologist will be called upon often in the future to study air pollution potential in different areas to make recommendations as to what extent a certain area can be developed. Dr. Lodge pointed out the possible consequences widespread pollution could have on worldwide weather and climate. This should merit more study by the meteorologist.

Another important aspect of man's present problem is that of water resources. Its proper use must be viewed in terms of water use by our industry, agriculture, and vegetation and animal life. The most common problem with industry is that it often causes water pollution. This is a serious problem in that it affects our water supply for human consumption, and kills off much plant and animal life so that it has very adverse ecological consequences. Another increasingly serious problem is that of thermal pollution. Nuclear power plants especially put out large quantities of heat and can warm bodies of water over long distances. This can be very harmful to plant and animal life. Thus we may require the engineer to find other ways of cooling the plant, or these plants can only be allowed

in certain colder regions where the problem of thermal pollution cannot exist.

Proper watershed management is of great importance in conserving our water supply as our needs continue to grow with population. Soil and vegetation must be managed so as to maximize retention of water in the ground. Grasslands are detrimental to proper water and land use. Agriculture depletes the nutrients in the soil over an extended period of time and reduces water holding capacity of the soil. The building of dams not only may have ecological consequences, but also cause water loss both due to seepage through the ground and tremendous evaporation from the water surface. This is a job for the hydrologist and the soil scientist. Their role must be to plan watershed use so as to cause least detrimental effects on both water resources and ecology.

Another area of concern is that of public health. As the problem of disposal of wastes increases, great care must be taken to insure people's health. Air pollution is one health hazard. The use of pesticides and DDT contaminate the food supply. Carbon monoxide exhaust from automobiles along busy streets can reach dangerous levels at certain locations in cities. The engineer must therefore have some knowledge about health effects on people by industry and vehicles. Man's confort is also in jeopardy. Noise levels in cities often reach so high as to cause physical and psychological damage. In factories, noise is a major problem. The effects of the sonic boom created by supersonic transport in the future must be fully investigated. The engineer in the future must therefore be fully aware of the health effects on people of the things he is creating.

No longer will it be possible just to take into consideration the technical and economic aspects in designing, but also health effects on the population.

Another problem to consider is the sociological and political one. Even when we have the technical means to solve the problem, there must still be a change in attitude among the manufacturers, businesses, and the general populace. There is great cost involved in carrying out the technological means to improve our environment. Both the manufacturers and the consumers must be willing to pay for this. As Dr. Lodge pointed out, we must all be willing to give up the idea of an ever-increasing standard of living. All the material wealth we accumulate is very costly in terms of the increased ruining of our environment which it causes. Eventually there must be a stabilization of population. This can only happen if the populace is willing to achieve it. Also, there must be an increased regimentation of both corporations and individual lives, as Dr. Lodge pointed out.

On the part of corporations and manufacturers a big change in policy is needed. As Ralph Nader pointed out, manufacturers are the cause of tremendous waste which the consumer has to pay for. Products are ineffective and even dangerous. Automobile industries build vehicles in such a way that they are obsolete within a few years, so that they can reap greater profits. This is not only unfair to the consumer, but it also greatly increases the ruining of our environment in terms of air pollution and the depletion of basic natural resources. Big corporations have many means to evade the law. They can cause very serious damage to the environment through negligence

without receiving much punishment. The disastrous oil spill off the coast of California is just one example. Big corporations are so structured that no one has access to what is going on. They have enough money to afford anti-pollution devices and yet they don't do it. The present laws are too weak for enforcement and provide many loopholes.

If we are to create the job of environmental scientist, the complexity of the problem requires him to have a broad knowledge about the different areas mentioned above. It is, however, impossible to go into any great depth in all the different fields and as a result will spread him too thin. Consequently, what we need is an environmental scientist who specializes in one particular aspect of the problem, but who at the same time has a fairly broad knowledge about the different aspects of environment. Therefore, there will be many different kinds of environmental scientists, who each works in one particular aspect of the problem, but all work in harmony to create one common goal and that is improving man's environment. The problem can be divided up into the following areas: engineering, meteorology, water pollution control, watershed management, ecology of plants and animals, agriculture, urban planning and transportation, public health, law, government, and public relations. Also related are conservation of natural beauty and public recreation.

The environmental engineer must study industrial processes in the light of pollution they may create and must develop processes which result in least waste, but which are yet practical to carry out and which give the consumer the greatest benefit for what he pays. He must work closely with the meteorologist in locating future industrial

sites. The environmental meteorologist must be increasingly concerned with modeling of urban atmospheres, and must work closely with the engineer to estimate sources more effectively and must be able to calculate concentration levels of different hypothetical sources. Also, the civil engineer who has done a lot of wind tunnel modeling is of very great importance. Also, undeveloped areas must be examined in terms of air pollution potential so that future developments of industry can be carried out with some degree of knowledge about its effects on the air environment. The environmental meteorologist must also carry his ideas into urban planning. The latter is not easy since it is impossible to restructure present cities. However, in planning future developments, the meteorologist's findings must be put to use. The chemist's knowledge must also be utilized in finding out about the complex reactions taking place among pollutants in the atmosphere.

Water pollution control is the job of the sanitary engineer. However, the basic problem is still that of wastes and how to dispose of them. The ideal would be a process which can recycle wastes so that they can be put to use. The soil scientist should put his knowledge to use in watershed management so that both water will be conserved and land be put to best use over a long span of time. An extensive survey of both developed and undeveloped land is needed to examine the best use any land can be put to. Forests are necessary to preserve the water capability of the soil, keep the soil supplied with nutrients which can support wildlife as to achieve an ecological balance, and to supply recreation areas. Extensive research must be carried out to see the effect of agriculture or grazing on water

supply and nutrients in the soil and the general ecologic effects. This requires close cooperation with the agricultural scientist and the ecologist. Insect and weed control needs detailed study not only from the standpoint of adverse effects on our food, but also its ecological implications. Eradication of one species may lead to the multiplication of another and might greatly effect the ecological balance among organisms. This is very complex and a lot of information is needed in this field.

Public health officials are called on to study the effect of environment on man's health, to monitor air and water to see if it carries any dangers, and to recommend action in case any danger is cited. This involves research in biology, but also, a great deal of experimentation. A staff of specialists in this area is needed. The public health official must keep in close touch with the air pollution meteorologist to monitor air quality and the sanitary engineer who is concerned with waste disposal and water pollution. The meteorologist in turn should get feedback from the public health scientists to apply to his model of dispersion over certain areas which in turn leads to information regarding future industrial and residential developments and urban planning. The engineer also should get feedback from the public health scientists regarding the hazards of certain industrial operations so that they will know what needs most redesigning. Finally, public health officials can set certain air and water quality standards which will take the form of laws which can be enforced against those industries that don't comply with the standards.

As law enforcement is difficult sometimes, it is necessary to have specialists to do research into the different aspects of law

enforcement. Ways must be found to eliminate loopholes as much as possible so that corporations cannot dodge punishment. Ralph Nader has done excellent work in initiating this. What is needed, though, is many more people who are concerned. In this case, public awareness and concern will greatly help. We therefore need environmental scientists who have broad knowledge in all aspects of environment who can serve as representatives to the government and the general public to educate them concerning the different aspects of ways of improving our environment. In that respect, Earth Day has served an extremely useful function.

All this still leaves the question as to how the environmental scientist of the future has to be educated. He should not have a knowledge so broad that he cannot apply anything, nor so narrow that he has no contact with the different interacting aspects of the problem. What we need is a scientist who has very thorough knowledge in a specific field, but at the same time has some knowledge of all the different aspects of environment. The universities at present don't have the program to prepare such a person. Neither is there enough interaction and cooperation among the different fields of study. What is needed is a department of environmental science at the graduate level. This would provide a graduate in a specific field and additional education in other fields related to the total environment so that he can apply his own specific knowledge so that it fits with the total effort to improve man's environment. This would include courses in waste disposal problems, ecology, soil management, city planning, public health, and other fields. Presently, the universities don't provide courses for the purpose of giving an

environmental scientist the broad background he would need. This program will then turn out graduates in environmental science who can apply the knowledge of a specific field to solve the environmental problems.

In conclusion, the great complexity of solving man's environmental problems requires a broad, new program which relates each field with all the others which enter into the problem. Care must be taken that one does not consider one aspect without considering the other aspects as well. At the same time, the environmental scientist must work mainly in his own field so that the best knowledge can be applied. The great need of funds for these programs must also be met by both the government and individual corporations. Efforts must be made immediately to establish a program since there is not much time. Its success greatly depends on the cooperation among the widely different areas.