MAN and Environment

CONFERENCE REPORT

To examine research needs in the modern environment, the National Institutes of Health, upon the recommendation of its Study Section on Sanitary Engineering and Occupational Health, called the Conference on Man and Environment in Washington, D. C., May 5–6, 1958. The following pages carry information from six of the papers presented.

The Modern Environment

brief It is not necessary to study vital statistics to perceive some of the more glaring hazards of modern life. Yet the severity of these hazards cannot be viewed in proper proportions without quantitative information. Many departures from an earlier way of life have occurred within the past two generations, and thus the vital statistics of any earlier time and the mechanisms for their collection are hopelessly inadequate.

We are aware, however, of a heavy toll of deaths and injuries on the highways and in the homes; of accidental poisonings, especially among children, so numerous as to require regional and local poison centers for the prompt transmission of information and advice; of public apprehension concerning the functions of airborne carcinogenic agents, whether from the partial combustion of petroleum or tobacco, in inducing or contributing to the induction of lung cancer; of heated controversies over the treatment of community water supplies; and of the contamination of foodstuffs with insecticides and other foreign substances. And we contemplate with great uneasiness the dispersion in the air and the deposition on the land and in the sea of increasing quantities of radioactive substances. These are on the horizon of the average citizen.

Certain other features of the modern environment appear to have graver significance in their capacity for present and future harm. Never before has man at work been surrounded by so many obvious as well as insidious dangers to health, limb, organic integrity, and life itself.

By the study of accidents and illness we learn the causes of injury, disease, and death. But what are the consequences, throughout a working life, of the almost daily impact of individual and collective insults of minor or subclinical severity? Those with more complacency than curiosity, with more faith in physiological adaptability than can be justified by medical evidence, and with undue comfort derived from crude statistics will respond that the people in no previous society have been known to die young in such small numbers and to live to be old in such large numbers. The easy conclusion is that Americans are healthier now than ever before and that modern life holds no very serious threat to health. But consider the facts less superficially.

Based on a paper by Robert A. Kehoe, M.D., director, department of preventive medicine and industrial health, University of Cincinnati, Cincinnati, Ohio.

Changing Statistics

The microbiological era of medicine and public health has profoundly changed the practice of medicine, has brought into existence and cultivated the techniques of preventive medicine, sanitary engineering, and public health, and has made revolutionary changes in the statistics of human morbidity and mortality. The microbiological diseases, almost to the exclusion of all others, have occupied the attention of the medical practitioner, the investigator, and the educator for more than 50 years. Only recently, compelled by the changes in the causes of illness and death, has attention begun to shift proportionately to chronic degenerative diseases.

Meanwhile the environment of the Nation's population has been changing. The microbiological threats to human life and health have been replaced by the inanimate threat of the machines and materials which inventive man has made, and by the forms of energy with which he has surrounded himself. The physical basis of modern industry is something new under the sun—an environment which, in the making, has taken so much of man's total time, effort, thought, and ingenuity as to leave him little to expend on learning what might be its ultimate effects upon himself.

Not only is the incidence of occupational disease unknown because suitable mechanisms for reporting and assembling information are lacking, but great areas of industry are not under such observation as would provide this information. It is by no means certain, therefore, that the effects of the composite hazards of industry have not affected the national health since, in our gross morbidity and mortality statistics, the brilliant results of microbiological prophylaxis and therapy may have masked these effects. We do not know, and we have no present means of knowing, just what has resulted from the profound changes wrought in the industrial environment by modern technology.

Why are we not more deeply concerned about what has been happening to us during the last half century within the revolutionized environment of our daily work? The time has come when we must carry out physiological and hygienic research hand-in-hand with technological research and when we must develop the techniques of industrial hygiene stepwise with the technology of production.

Health in an Industrial Society

If we are concerned about our industrial population, we also should be concerned about our population generally, for the industrial environment has become, to a remarkable extent, the national environment. This environment which man has created for himself now provides the challenge to both curative and preventive medicine, a challenge that requires additional types of medical knowledge, new medical skills, and new settings.

What of the artificial situation in which many new materials, possessing infinite possibilities for metabolic modification, find their way into the body of man? Is it not evident that our attempts to detect signs of the early or late injurious effects which may follow the absorption of these materials over a period of years or a lifetime are somewhat crude and even naive?

We shall never be able to anticipate and visualize the harmful potentialities of new materials until we achieve a comprehensive understanding of the role of the normal elements and other components of the living organism. Within such a comprehensive background, however, we could probably discover metabolic deviations induced by chemicals now within the organic milieu.

No principle of biology is clearer than that which relates a physiological response to a quantity of stimulus within appropriate time limits. The living organism is resistant in varying degree to varying stimuli, and the stimulus must be adequate to induce a response. Upon this principle we differentiate between harmful and harmless stimuli. In these terms, toxicity relates not to a specific substance but to the concentration of a substance within certain time limits in the tissue or chemical system of an organism. A toxic environment, therefore, is one which, within certain time limits, introduces a harmful quantity of a substance into the organism.

In modern times the changes man has wrought through his technology have brought about greater environmental changes of more profound physiological significance than have all the previous generations of men. The time has come, however, when a much greater and more comprehensive knowledge of the consequences of our changed and changing environment is essential for our safety and perhaps for our very survival.

Technology has created a wealth of materials and captured the forces of nature for man's use, but it has failed to bring an understanding of their biological effects that will keep these forces and materials under control. The gap between technology and biology must be reduced before it is too late. It must become an axiom of modern chemical and technological research that the materials produced and the energy harnessed must be as well understood for their biological potentialities as for their physical and mechanical properties.

Reckless man can release or build up physical forces which may destroy himself and his kind. Probably, however, the same ingenuity which has enabled him to explore and to penetrate other secrets of nature will serve him when he expends it in learning more of his own vulnerability and in developing the means for self-protection.

Water Supply

brief Our research needs may be stated simply: to augment supplies of water by novel means, to reduce water loss, and to treat polluted water for re-use.

By 1975 the use of converted sea water to augment the water supply in coastal cities may

Based on a paper by Mark D. Hollis, Assistant Surgeon General and chief sanitary engineering officer of the Public Health Service.

be feasible and perhaps routine. Novel methods under study offer promise that the ocean may be effectively and economically tapped. At present full-scale plants can distill sea water at a cost of $1.75 to $2.80 per 1,000 gallons. The goal is $0.30 per 1,000 gallons.

While present weather modification techniques may be crude and ineffective, we must accept them as a potential means of increasing the supply of water. The President's Advisory Committee on Weather Control concluded that cloud seeding produced an average increase in precipitation of 10 to 15 percent in mountainous areas of the western United States.

A substantial part of our future water needs may be met by conservation of flood waters, control of losses through evaporation, recharge of aquifers, and the use of hexadecanol in monomolecular layers on water surfaces.

A 10-foot stratum of sandy soil of average porosity underlying a watershed will hold the greatest single flood flow likely to occur on that watershed. Although we now have no way to use water-bearing strata effectively in flood containment and water conservation, more intelligent use can be made of underground reservoirs to supplement surface storage.

Water lost by evaporation in the United States exceeds the amount taken for use in cities and towns. It has been estimated that evaporation from storage units now under construction in the Colorado River system will equal more than one-third of the replacement storage they provide. Research on the use of monomolecular films of long-chain fatty alcohols to suppress evaporation, however, supports optimism concerning the ultimate ability to reduce evaporation by nearly one-half.

Reclaiming Water

Water supply research, however, must concentrate on new processes to reclaim water. Reuse of water is complicated by the growing number of contaminants in solution. The treated drinking water of a community contains an intricate mosaic of stable organic chemical structures which reflect the past history of the supply. To this burden of chemicals, the community adds its increment of solids, including soluble, persistent, nonoxidizable compounds like the alky-benzyl-sulfonate component of detergents. The Nation's use of detergents, 3 billion pounds per year in 1956, is expected to double within the next decade.

Drainage from land treated with insecticides, weedicides, and other materials adds to the load of persistent organics now being recovered from all parts of the main stem of the Mississippi River. DDT, in a concentration of 5 ppb, was recovered from Lake St. Clair on the Canadian boundary. The Department of Agriculture's large-scale imported fire ant control operations in the southeastern States eventually will apply dieldrin and heptachlor to some 30 million acres. The United States' production of pesticides and other organic agricultural chemicals rose from 125 million pounds in 1947 to 570 million pounds in 1956.

Management of impoundments, including municipal water reservoirs, for recreational use is also influencing the character of drinking water.

Conventional yardsticks of pollution, B.O.D. (biochemical oxygen demand) and coliforms, give few clues to the presence of these synthetic organic pollutants. Advanced studies on adsorption may indicate useful supplementary treatment for municipal water supplies. Methods for separating dissolved solids from water also are being investigated in connection with desalination.

The toxicological significance of organic chemicals in drinking water has not yet been adequately evaluated. Because of the high cost of toxicological evaluation, a short-time, presumptive test to determine the chronic toxicity potential of specific or complex materials is required.

Particulates and Viruses

Concern with dissolved contaminants does not detract from the familiar problem of particulates. One of the most surprising findings in the recent Chanute, Kans., study was the large amount of organic debris of particle sizes up to 20 microns appearing in the filtered water. This observation supports the opinion that a critical review of filter design criteria is in order. These criteria have not been changed in any important respect in the last generation, in spite of knowledge that the conventional rapid sand filter is less effective than properly controlled chemical coagulation in turbidity removal and less reliable than breakpoint chlorination for micro-organisms.

The assessment of the public health aspects of viruses in the water environment requires improved methods for recovery and identification of viruses, especially in the treatment of water. Also the transmission of infectious hepatitis virus through contaminated water emphasizes the need to develop a tissue culture technique for the growth of this virus.

These are some basic problems of water supply. Should we concede that the routine identification of unknown substances, inert or organic or viable, in water is too difficult? Because of this difficulty, would it be practicable to require the polluter to purify waste completely? Are we giving sufficient attention to the possible adverse cumulative effects of foreign materials in drinking water?

Or, in view of the level of health in our metropolitan areas, are we magnifying unduly our water supply problems? Our concern about some of this is admittedly potential and based on lack of data, especially of the toxicological implications.

For the immediate future, professional judgment will have to be applied to these issues. But the supporting data, through research, should be sought as promptly as is feasible.

Water Pollution

brief

The impact of the development of modern metropolitan areas is of great significance in man's environment. The total population growth of the United States has not only been high but has been taking place almost entirely in the Nation's 174 metropolitan areas, which the Bureau of the Census defines as areas containing at least 50,000 persons with population densities, by counties, exceeding 150 persons per square mile.

The 16,000 units of governments and 3,000 special districts within these metropolitan areas give a measure of the complexities of administration in such tasks as the collection and disposal of waste water used by their inhabitants. A recent book, Special District Governments in the United States, decries the multiplicity of these units, and its author, J. C. Bollens, concludes that special districts are justified for schools but feels that other activities should be returned to local governments.

If a sanitary engineer surveyed the collection and disposal of waste water in metropolitan complexes, he would certainly conclude that special districts are justified for sanitary engineering activities as well as for schools. The fact that the metropolitan area is being used more and more in providing for waste water disposal would seem to justify them.

Perhaps a study of this approach could either assure its continuation or point the way for improved and more economical approaches to water pollution control in metropolitan areas. Such a project would have important economic as well as engineering aspects.

Odor control in sewers, pumping stations, and treatment plants is a definite need in waste water treatment. Fundamental work on odor-causing compounds and odor intensity measurement was done at Harvard University more than 25 years ago. Since that time much has been written about sources of odors and how these may be controlled through cleanliness in the plant and chemical treatment.

While cleanliness is essential, the fullest control of odors has been achieved at the Owl's Head plant in New York City through plant housing with exhaust gases discharged through a stack after treatment with ozone. A circular trickling filter at Sarasota, Fla., uses plastic covering on an aluminum frame for a filter cover. Research in odor control could be a re-evaluation and extension of the work at Harvard. Experience to date seems to indicate that the most reliable control is the housing of plant units and treatment of the exhaust air. Basic information on the economy of various designs would be helpful.

Further research in higher degrees of waste water treatment could also be done. At present a 90 percent removal of B.O.D. is looked upon as "complete" treatment. However, satisfac-

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Based on a paper by Ralph E. Fuhrman, executive secretary, Federation of Sewage and Industrial Wastes Associations, Washington, D. C.

tory disposal of treated hydrowastes will become more necessary in future years because the volume of wastes to be treated will increase and the volume of a receiving stream will remain constant.

With the processes now established, stabilization ponds or intermittent sand filters may be relied upon to reduce B.O.D. residuals to 5 percent or less. But devising processes practicable where the large areas required for these methods are not available would aid the reclamation of water for re-use for purposes other than drinking or cooking.

It is important to watch continually the publication of research reports. Unpublished research work remains hidden from most other researchers. For this reason, all research, whether or not it appears productive, should be reported at its conclusion so that the wasted effort and money to repeat it can be avoided. As a minimum step, condensations of lengthy reports or theses should be offered for publication in the technical press.

Re-use of Water

The most important research needed in water pollution is in the reclamation and re-utilization of waste waters. Acute shortages of fresh water, long a problem in the arid west, are beginning to plague areas of the midwest, east, and south as the demand for water skyrockets. Man's greatest impact on his water resources is his increased demand for fresh water and his reckless pollution and abandonment of once-used water.

Among the consequences demanding new or improved knowledge are:

- The survival rates and destruction mechanisms for all types of pathogens in various treatment processes.
- The calculated risk in health hazards and other detrimental effects associated with use of waste waters for irrigation, recreation, stock watering, and perhaps for human consumption.
- Mechanisms for the removal or inactivation of sulfates, nitrates, and phosphates, especially in waste waters being used for ground-water recharge.
- The modifications of polluted water as it flows through porous media of varied geochemical composition, and, conversely, the effect of such water upon soil structures.
- Systems analysis in the water balance of an area.

Based on a paper by J. E. McKee, professor of sanitary engineering, division of engineering, California Institute of Technology, Pasadena.

Air Pollution

The following listing of the present problems of air pollution is a composite of the convictions of a number of informed people. It is probably significant that each one suggested essentially the same listing, although there was no general agreement on the relative importance of the items.

Chemistry of Air Pollution Systems

Substances causing eye irritation, accumulations of ozone, damage to vegetation, and possible physiological damage in man appear to be labile, transitory constituents of an ever-changing system and therefore have proved difficult to measure or identify. Their existence appears to depend on the photochemical formation of free radicals, if indeed certain types of free radicals are not responsible for the observed and suspected effects. Since the existence of free radicals is essentially co-terminous with the activating solar energy, capture and analysis apart from the continuously activated system have not been accomplished or seriously attempted.

Of course, the primary reactants involved in the chains of reaction can be recognized; in Los Angeles the elimination of oxides of nitrogen and of organic vapors, especially the unsaturated compounds, would effectively inhibit the formation of the suspected labile intermediate compounds. But it has proved difficult

Based on a paper by Leslie A. Chambers, director of research, Los Angeles County Air Pollution Control District.

to ban by fiat either of these two classes of reactants. It is my opinion that the practical form of control of such reaction products will prove to be a selective elimination of those species of primary compounds determined to dominate the identified chain reactions.

Sulfur Compounds and Aerosols

Still missing is considerable information about what happens to sulfur compounds in photochemically activated atmospheric systems. Prof. H. Fraser Johnstone and associates are contributing valuable experimental evidence of the rate of formation of SO_3 from SO_2 in the presence of moisture and catalytic particles, and Dr. Mary Amdur has produced evidence of enhancement of SO_2 toxicity by the presence of NaCl aerosols of small average particle size. But there are numerous theoretically possible interactions among SO_2 and the assorted organic and inorganic free radicals believed to form in polluted air during irradiation.

Dr. Amdur's work has also shown the possibility that some species of aerosols influence the toxicity of some kinds of gaseous pollutants. Another function of aerosols, suggestd theoretically and supported by the experiments of Prof. Jack G. Calvert and associates at Ohio State University, is the possibility that specific kinds of airborne particles act catalytically to a significant degree in the photochemical system.

Effects of Specific Pollutants

Prolonged dosages at low levels of concentration of highly reactive oxidants, free radicals, and condensation products of the photochemical reactions of organic compounds are strongly suspect in various chronic and acute diseases of the respiratory system. Which are culpable, if any? At what levels of concentration do they cease to be troublesome over long periods of exposure? Do they produce or predispose to carcinomas of the lung and other sites? Does long exposure to any of them at some level of concentration affect longevity, work efficiency, or general well-being? Do any of them, specifically or in combination with other circumstances, affect respiratory or other restrictive systematic impairments? All these questions need to be answered.

Analysis

For a long time in the future, the tools available will limit the understanding of atmospheric reactions and their products, the effective monitoring of pollutant levels, and useful pollution surveys. Instrumentation and analytical methods for air pollution work need to be inexpensive, simple, direct, and specific in principle and in operation. New and cheaper methods for establishing patterns of pollution movement in all three dimensions of the air reservoir will be essential for regional zone planning.

It is reasonably suspected that, of the numerous measurements habitually incorporated into air pollution surveys, only 1 or 2 give information fully as useful as that obtained by collecting all the measurements in any given local situation. One of the most pressing immediate needs is the provision of bases for selecting 1, 2, or 3 simple, direct indexes of pollution related to identifiable patterns of pollution sources.

These subjects for research could certainly be extended into the engineering control of sources of pollution. As technological changes occur in manufacturing processes, transportation, and commerce, a continual procession of new abatement techniques will be demanded and developed.

The Next 50 Years

Much less certain, however, are the major air pollution concerns of the next half century. The following suggestions are based on a few indications of what seems destined to affect the air supply or improve our capability for cleansing it.

Pollution by radioactive chemicals. A considerable body of opinion insists that the airborne products of nuclear fission and fusion processes are endangering the health of present and future generations. Nothing foreseeable will prevent the continued exploitation of atomic energy for peaceful or military purposes. Inevitably, local and worldwide problems of pollution by radioactive byproducts will increase in frequency and intensity.

Meteorological control of local air pollution. Significant strides toward long-range weather prediction have been made during the past 20 years, and some progress toward local modifications of meteorological phenomena has been reported. Our imminent capability for satellite observation of air movements and the availability of nuclear energy makes it worthwhile to consider modifications of regional meteorology to assure more adequate air movement.

Effect of air pollution on world climate. Some evidence has been advanced that combustion processes are adding CO_2 to the atmosphere so rapidly as to cause accumulation in spite of the water reservoirs with which this gas must be in equilibrium. A significant change in CO_2 level in the air could, in theory, produce profound effects on world climate. Worldwide monitoring of CO_2 concentrations, an International Geophysical Year project, might well be continued.

Jurisdiction in air pollution control. Many of these situations imply the extension of air pollution study and control beyond local, State, and national jurisdictions. Already a need has appeared in a few regions to establish acceptable procedural and survey patterns that will permit authorities to act jointly. Preparation for concerted action among governments will be essential to effective application of technological principles.

The problems we face are increasing in some exponential relationship to national and world populations. Almost all the environmental factors demanding attention are of two kinds: those involving competition for finite amounts of the materials required for human existence, and those resulting from the accumulation of byproducts of the human utilization of such substances.

Thus air, water, and basic nutritional, industrial, transport, and energy requirements become the foci of efforts to maintain health, reasonable living standards, and some comfort in the face of an exploding population. Sooner or later health agencies will have to face the fact that 600 million people cannot live well in the waste products of resources capable of sustaining half that number.

Food Technology

brief

Food processing and distribution is about an $80 billion industry, the largest in this country. Concomitant with the industry's growth there has emerged a need for further information about the effects of processing upon food.

The food processor today is well aware that he must consider the factors of color, flavor, texture, convenience, stability, aesthetics, nutrition, and safety, all of which influence consumer acceptance.

To maintain or obtain the desired color it is at times necessary to use particular processes or chemicals. Fundamental work on natural colors and the various processing treatments influencing them is greatly needed. Intensive studies are being conducted on the nature of flavor and the effects of various processes and storage conditions.

In recent years convenience has received more attention than any single factor in the processing of foods. In many foods convenience has dictated the use of a great variety of chemicals and new processing techniques and the mixing of various food components. A large amount of work remains to be done on the stability, safety and nutritional properties of these products.

Other Consumer Influences

Stability, or shelf life, is extremely important in all foods, for practically none are imperishable under adverse temperature conditions. Deteriorative changes resulting in loss of flavor, color, texture, and nutritive value occur very commonly during storage. At State food conferences being held to encourage better nutrition, much is said about variety in the diet and proper nourishment, but nothing is heard about storage deterioration and its possible effect on nutrition.

These deteriorative changes may also be important from the standpoint of safety. There is some evidence that the chemical products re-

Based on a paper by Emil M. Mrak, chairman, department of food technology, University of California, Davis.

sulting from such changes can be harmful and some may affect appetite. The need for research in food stability during storage is apparent.

The aesthetic values of foods are a major consideration. While insect contamination is probably not harmful, it is repugnant and chemical fumigants are used to control it. There should be sufficient data to support the view that these fumigants are safe.

The nutritional value of foods is of prime importance. Consumers generally believe that fresh products are far superior to canned, frozen, or dried foods, yet we know that fresh products can deteriorate very rapidly in acceptability and nutritive value. Because of improper harvesting, distribution, and handling of fresh foods, I would not be surprised to find that, on the whole, processed foods have better vitamin retention than the fresh.

Food processors must be careful about chemical residues, insect fragments, and other such items in their products, but relatively little attention is given to these in marketing fresh produce. There is a need for extensive studies on the acceptability, nutrition values, and general quality of fresh produce.

Changes in Processing

Great changes are taking place in canning procedures. The so-called short high-temperature procedure is receiving more consideration because of a possibility of increasing case yields, faster operation, and better color and flavor. However its relationship to storage stability, nutritional value, and acceptability of the produce is not completely known.

The rapidly increasing rate of production of frozen foods, particularly precooked or partially cooked dishes, makes it improbable that an adequate study has been made of the changes in microflora that occur during this type of processing.

Concentration of foods by the use of a vacuum at relatively low temperatures is now a common processing procedure. However, a great deal is yet to be learned about its effect on enzymes, chemical changes, microbial survival, and vitamin retention.

Circumstantial evidence indicates that foodborne infections are fairly common, but to my knowledge the amount of work being done to investigate them is limited. How extensive is salmonellosis? Are staphylococcus infections increasing? Would not a thorough understanding of the causes of these infections and the development of control procedures be better than prescribing drugs after infections?

Today most of our foods are packaged. The Food and Drug Administration insists that safe materials be used in packaging; nevertheless we need to know how these materials may affect food.

The food industries are mechanizing as rapidly as possible even though the effects of mechanization on acceptance, nutritive values, and storage characteristics are not completely understood. For example, the bulk handling of cling peaches from the farm to the consumer is almost a reality, yet we do not know the results such handling will have on the fruit. Last year transporting peaches in water in plastic containers was tried. Those in the containers for 6 hours had a low acceptability because of off flavors.

If we are to give the consumer canned peaches that are perfectly safe, with highest vitamin content and best color and flavor, it is important to know what happens between the orchard or processing plant and the consumer. Quite possibly some treatment during processing may adversely influence storage of the product, causing a loss in nutritional value or color or even the production of compounds resulting from deterioration.

Food should be considered from the time the seed is planted, the egg is laid, or the animal born, until it is consumed. So much can happen to food as it passes through various stages, and any one factor may so markedly affect it, that nothing can be overlooked.