AIR AND WATER POLLUTION

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FOREWORD

How can I make my scientific training relevant to todays problems? How can I apply my knowledge to solving some of the social and physical ills of present-day society? How can I make my work more relevant? How can I become involved in the mainstream of current activities in the environment? These are some of the questions that many scientists and engineers are asking themselves -- professors who are giving thought to the future of their students; researchers who are concerned about making an impact through their work; and science students who want to have career opportunities when they graduate.

All of them will therefore welcome a volume such as this one which deals with some of the underlying and basic research problems in air and water pollution. Surely cleaning up our air and water are among our most pressing problems to which physical and biological scientists can make a real contribution. And, surely, the treatment of these problems will benefit from the new approaches and talents that can be brought to bear on them if a larger portion of the scientific community becomes involved. This is why the organization of a Workshop addressed to non-specialist scientists is especially valuable. The speakers, who were carefully chosen, given a brief review of the state of science relating to the environmental problems in question, and then point out where the most important unsolved basic research problems are.

The organizers of the Workshop are to be congratulated, as are the various agencies which supported it for deciding to publish the proceedings in order to bring the message to a wider audience.

S. Fred Singer
Deputy Assistant Secretary
Department of the Interior
Washington, D. C.

February, 1971

PREFACE

The papers collected here were presented at the Workshops on Research Problems in Air and Water Pollution, held at the University of Colorado the first two weeks in August, 1970.

The Workshops grew out of a series of discussions among a group of Boulder scientists interested in becoming involved with research on environmental problems, but having need for clearer ideas of the extent to which research efforts are needed. In these discussions, the notion was often aired that the most important aspects of environmental problems are probably legal or political rather than scientific--that we probably already have the technologies to "solve" our environmental problems--but that our institutions, for various political and economic reasons, are slow or reluctant to implement these technologies. In spite of this intuitive feeling, it was deemed desirable to discover what opportunities are available in pollution problems for the scientist whose background has been primarily in the basic sciences.

With this purpose in mind, the Workshops were organized under the sponsorship of the University of Colorado and in cooperation with the National Center for Atmospheric Research and the ESSA Research Laboratories (now NOAA). The Workshops were supported in part by a grant (NSF-G1-32) from the National Science Foundation. The speakers at the Workshops were scientists and engineers actively engaged in pollution-related research, while the audience consisted mostly of interested scientists who were not pollution specialists. The speakers were asked to briefly review the state of the science of the problems being addressed and to point out what they considered to be the most important unanswered basic research questions relating to these problems. Although this format was not always followed, most papers were presented this way.

A broad spectrum of problems was reviewed and no attempt was made to present a comprehensive review of any particular problem areas. Part I of this monograph contains papers from the Water Pollution Workshop, dealing with (1) effects of water pollutants on biota, and (2)

physical and chemical phenomena in water and waste-water treatment. Part II, representing the Air Pollution Workshop, deals with problems in (1) tropospheric chemistry, (2) local pollution dispersion studies, (3) global effects of air pollution, and (4) effects of air pollution on biota.

To what extent did the Workshops succeed in demonstrating the importantance of basic or applied research compared to the social and political aspects of pollution problems? For problems where effective controls are now available, that is a question each reader of this monograph should decide for himself--as the answer one gives depends largely on how one feels pollutant controls should be related to knowledge of the effects of pollutants on life. One point should be abundantly clear to any reader: that is, that many pollutant control measures appear to be related more to levels of pollutant detectability than to definitive knowledge about the biological effects of given pollutant doses. Certainly, more research needs to be done to determine a scientifically meaningful basis for the regulation of polluted discharges to the environment. But our society can ill afford to wait until all the facts are in before instituting meaningful controls. Pollutant control decisions must be made on the basis of incomplete information.

While some environmental problems (such as problems arising from the discharge of SO_2 from a power plant) are probably more readily eliminated than "understood," other problems which are less easily controlled (such as the buildup of CO_2 and particulates in the global atmosphere) require much more basic research. There is growing concern that man's rapid industrialization may have, in the long term, a serious impact on his global environment. There should be little doubt that basic research is of prime improtance in dealing with this class of problems.

All in all, this volume should point to many an opportunity for the "pure" scientist to become involved with some pressing problems of society.

The editors wish to thank the speakers for their cooperation and Miss Anne Csengery, Mrs. Marion Higa, and Mrs. Charlotte Walker for their excellent job of typing.

Editors:

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April, 1971

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KINETICS OF BIOLOGICAL PROCESSES USED FOR WASTEWATER TREATMENT

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Introduction

Several different types of biological processes are used for wastewater treatment with the most common being the activated sludge process, the trickling filter, anaerobic digestion, and the lagoon as illustrated in Figures 1 through 4. There are several modifications of each process in current use. These modifications consist of variations in such factors as rate of waste application, type of reactor, contacting patterns between the biological and liquid phases, amount and type of recycle, degree of mixing, etc. An extensive body of literature exists for each process and for more detailed information the reader is referred to some of the common textbooks (1,2,3,4) and journals (5,6,7,8) in the environmental engineering field.

Although these processes are simple in concept, in reality they are highly complex biological systems with poorly understood behavior. From a biological viewpoint, most of these processes may be classified as continuous-flow, enrichment cultures of microorganisms with the species of microorganisms predominating being determined by the characteristics of the input wastes and the environmental conditions created through process design and operation. In an individual process there are considerable temporal fluctuations in the species of microorganisms predominating which is not surprising in view of the sizeable variations which occur in the inputs to the process. As would be expected, there are also considerable variations in the quality of the effluent from these processes and gross failures, such as the bulking of activated sludge and "sour" anaerobic digesters, are all too frequent.

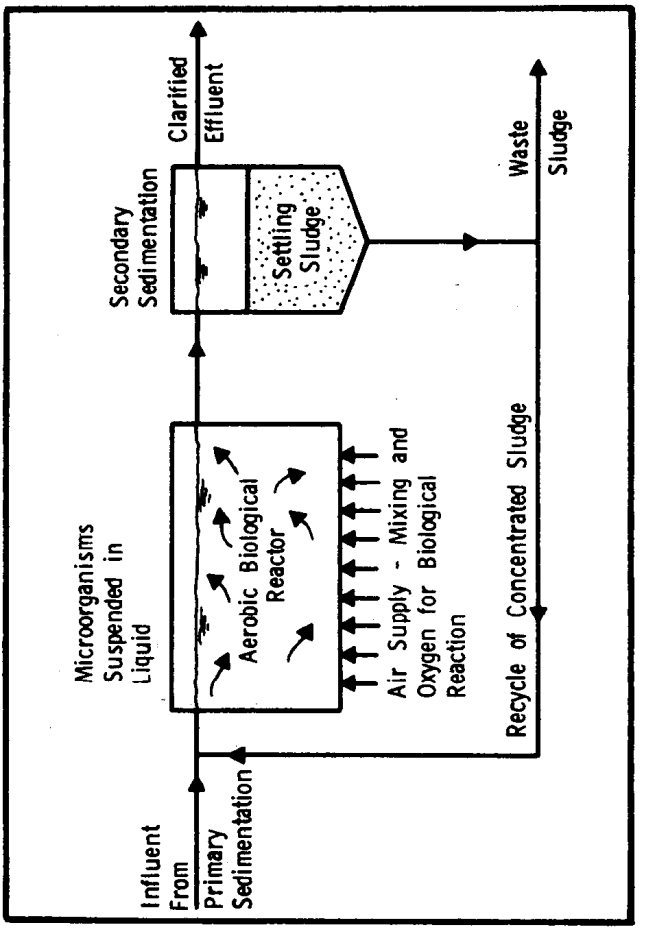

FIGURE 1. THE ACTIVATED SLUDGE PROCESS

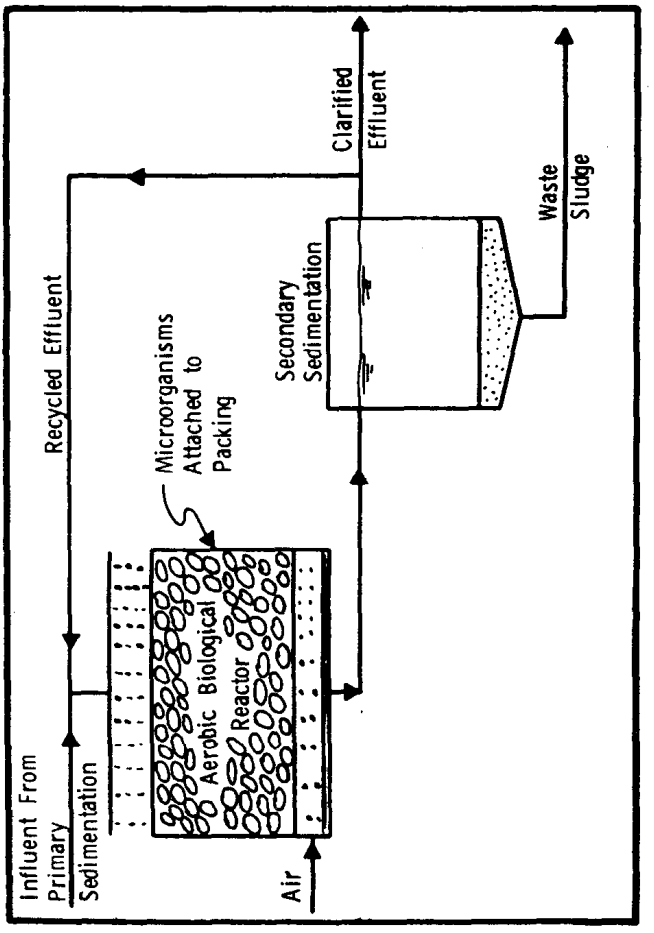

FIGURE 2. THE TRICKLING FILTER PROCESS

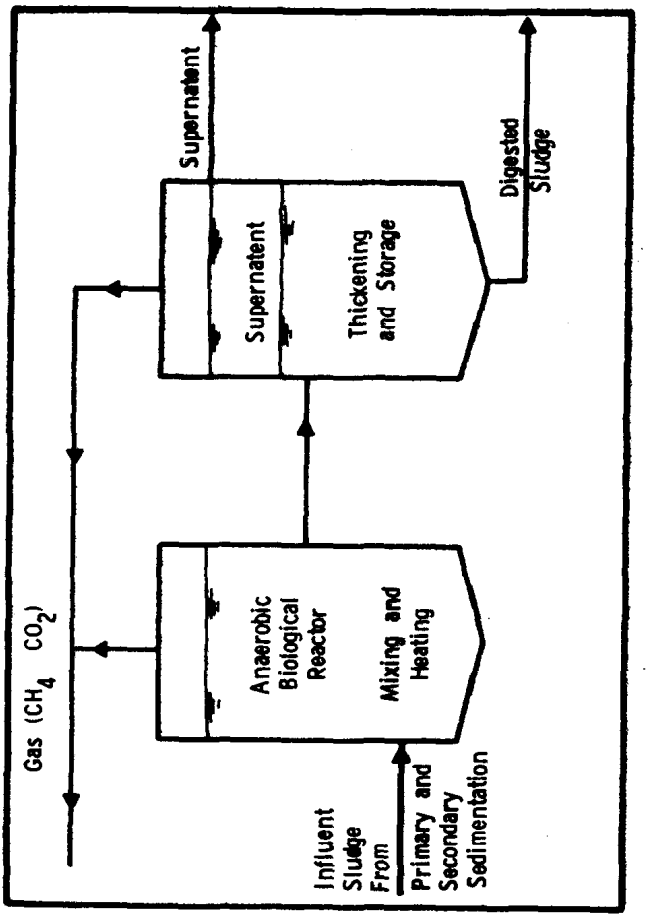

FIGURE 3. THE ANAEROBIC DIGESTION PROCESS