Progress in Hazardous Chemicals Handling and Disposal 1972

The Institute of Advanced Sanitation Research, International

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The Proceedings of the Third Symposium on
Hazardous Chemicals Handling and Disposal

The Institute of Advanced Sanitation Research, International

Robert H.L. Howe, Ph.D.
Senior Fellow - Chief Edito.

Twenty Dollars

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FOREWORD

The Third Symposium on Hazardous Chemicals Handling and Disposal was convened on April 11, 12 and 13, 1972 at Stouffer's Inn, Indianapolis, Indiana. Approximately 140 people were registered. The theme address was given by Dr. Arthur G. Hansen, President of Purdue University. Dr. Hansen spoke on "The Need of Academic Support for Establishing Reasonable Environmental Standards." He stressed that we have the talent and manpower in the universities to help in solving environmental problems and establishing reasonable standards and "without their active involvement the future will be a good deal dimmer than it might otherwise appear." His emphasis was on the intercooperation of academic, industrial and governmental endeavor in solving environmental problems and the total need for such cooperation.

A detailed discussion on the "Separation of Fluids by Porous Materials" was presented by Mr. George V. Jordan. He stressed the mechanics and the required conditions of the fluid properties for the successful separation.

Mr. John S. Eckert presented to the audience a paper entitled "Handling and Disposal of Dangerous and Toxic Substances Using Packed Wet Scrubbers." He spoke on the limitations of the various scrubbers in relation to the efficient handling and disposal of the toxic substances.

Mr. G.R. Davies and his coauthors discussed "Controlled Centrifugal Separation of Liquids." Several interesting examples were cited and a number of theoretical and applicative developments were discussed.

A paper, "Removal of Toxic Organic Chemicals by Filtration-Adsorption" was delivered by Mr. J.L. Rizzo. Again, the theoretical reasoning and applicative information were presented to the audience.

Mr. Richard M. Simpson presented a detailed paper, "Separation of Organic Chemicals from Water." He explained that the separation can be accomplished by ion-exchange resins and particularly also by absorbent polymers.

"Pyrodecomposition of Liquid Industrial Wastes" was the title of a paper presented by Mr. Melvin Dadd. He discussed the various aspects of the burning of liquid industrial wastes and presented a number of operational experiences and costs.

Mr. Ray A. Witschey discussed in great detail the consideration of proper refractory materials for the incineration of chemicals in his carefully prepared presentation, "Refractory Practice for Thermal Oxidation of Chemical Liquids and Gases." This consideration should be made before burning any chemical liquid or gas.

Dr. Robert H.L. Howe presented a paper, "The Removal of Toxic Organic Chemicals by a Specific Flotation Technique", in which both theoretical derivation and applicative information were given.

A very important paper, "Chemical Engineering in Chemical Process Safety", was presented by Dr. W. Henry Tucker. He discussed the safety in chemical processes and particularly in chemical engineering. More than forty case studies were discussed. Attendance at this discussion helped in solving many safety problems for the audience. The paper is a must for all chemists and chemical engineers (and safety experts too) to read and understand.

Dr. Robert A. Baker delivered his Buswell-Porges Award presentation, "Analytical Methodology in Implementing Environmental Standards", in which he stressed the limitations of analytical procedures and methods. He cautioned the unconditional acceptance of any analytical data without proper understanding of the "what," "why," "how," etc.

"Potassium Permanganate Control of Certain Organic Residues in Air and Wastewater" was the title of a paper presented by Mrs. Catherine E. Anderson. She explained the reason why permanganate was used and also described some useful considerations for the control of organic residues in air and wastewater.

Mr. G. Frederick Hanna entertained the audience with a very detailed paper, "Odor Classification of Organic Chemicals." It was agreed by all present that this paper is quite informative for those concerned with odor control and air pollution control.

Two panel discussions were enjoyed by the participants. One was "Discussion on the Control of Toxic Materials in Food Industry" with Dr. W.J. Stadelman as the discussion leader. The various topics were presented by Miss Helen L. Scheibner, Mr. Louis F. Schneider, Mr. Frank Fisher, and Dr. Samuel H. Hopper. All the presentations were thought-provoking, comprehensive and many times, assuring.

The other panel discussion was "The Disposal and Burning of Plastic Materials" led by Dr. David L. Brenchley and participated in by Mr. Malvin L. Olson, Mr. Donald L. Sullivan, Dr. Robert H.L. Howe, Mr. Melvin Dadd and Mr. Ray A. Witschey. The different viewpoints discussed and shared with the audience were sincere and challenging.

Dr. Samuel H. Hopper, on behalf of Dr. Lee C. Truman, gave a brief evaluation of the symposium programs. He reported that both Dr. Truman and he were happy about the favorable comments by leaders and participants in the symposium. He urged all to return in 1973 (April 17-19).

In conclusion, the most gratifying result of the symposium was again the unselfish sharing of information in the safe and proper handling and disposal of hazardous chemicals. We hope this volume of the proceedings of the Third Symposium on Hazardous Chemicals Handling and Disposal may further carry the thoughts and useful information from the authors to the concerned readers. To all who helped in planning the symposium programs and to Noyes Data Corporation for the publication of the proceedings, we owe our sincere and heartful thanks.

The Editors – Symposium Proceedings
The Institute of Advanced Sanitation
Research, International

PROGRAM SECRETARY 1971-1972

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**Indicates a Fellow of the Institute*

INTRODUCTION

Robert H.L. Howe, Ph.D.
Symposium Chairman
West Lafayette, Indiana

Distinguished scientists, engineers, doctors and professors, ladies and gentlemen: I am highly honored to serve again as the chairman of the Third Symposium on Hazardous Chemicals Handling and Disposal. The significance of this symposium is its dedication to a renowned chemical process engineering authority, Professor R. Norris Shreve, who agitated a long time ago both about safety and protection in chemical process engineering and for the understanding and reduction of waste control. In addition, ten outstanding scientists and engineers have been admitted to our fellowship and will be honored in appreciation of their accomplishments in their specialized fields and the unselfish sharing of their accrued knowledge.

Another important meaning of this symposium is the fact that there are twenty dedicated individuals present here who have undertaken their assignments since last year's meeting and are prepared to present to us some of their experiences related to the handling and disposal of hazardous chemicals. This represents both long hours and many days of hard work in addition to tremendous amounts of correspondence in order to finalize this program. All of this has been done by each of these people without compensation.

I must make it clear again that our Institute is an independent post-doctoral and professorial fellowship which receives only the voluntary support of our membership. Our programs are supported with the participation of many dedicated individuals at their own expense simply for the great spirit of unselfish sharing of knowledge. It is this mutual understanding which has made possible our gathering here.

I am sure that everyone here will agree with me by looking at the program that our speakers are all qualified specialists in their chosen areas of specialization. I am sure we shall learn much from them.

I urge your patience and attention in order that the information you wish to receive may be offered to you in the most effective manner. Of course, you are invited to contribute questions to complete the exchange of ideas. However, since we intend to include all meaningful questions and answers in the proceedings of the symposium, we urge you to write your questions on the paper to be supplied by the presiding officers rather than ask them verbally.

Introduction

As you all know, the publication of the proceedings is not a simple task. I wish to report to you that the proceedings of the Second Symposium in 1971, published by Noyes Data Corporation, have been available since last October. I must thank the members of our Editorial and Reviewing Board and the Noyes Data Corporation for their prompt completion of their assignments. I have the feeling that they will do the same commendable service in the publication of the proceedings of this symposium.

I must also report on the remarkable cooperation of the co-sponsoring organizations. Without this it would be quite difficult for us to conduct the symposium. In appreciation of their cooperative services, all symposium registration fees became the receipt of Indiana Public Health Association. I hope that this cooperation will continue to serve us.

Finally, I must state that we are highly honored that the distinguished scientist-engineer-educator, Dr. Arthur G. Hansen, President of Purdue University, will be our Symposium Theme Address speaker today. The title of his address is "The Need of Academic Support for Establishing Reasonable Environmental Standards." Dr. Hansen will be introduced by our Senior Fellow and President-Elect of the Institute, Dr. Samuel H. Hopper. I sincerely hope to see you all at the luncheon where Dr. Hansen will present his address.

On behalf of Dr. Lee C. Truman, President of the current term, I welcome you all to the Third Symposium on Hazardous Chemicals Handling and Disposal.

THE NEED OF ACADEMIC SUPPORT FOR ESTABLISHING REASONABLE ENVIRONMENTAL STANDARDS

Dr. Arthur G. Hansen
President, Purdue University
Lafayette, Indiana

There is little doubt that the protection and improvement of our environment is one of the top concerns of the people of this nation. This concern is expressed in the highest levels of government. It is expressed as well in groups that represent every aspect of our national life. It is expressed by the man on the street who voices concern that the air is not clean enough to breathe or that fish can no longer be caught in his favorite stream. As great and evident as this concern might be, dealing with the concern has been a most complex matter.

First and foremost has been the nagging question: "What is the basis for the concern?" On the one hand are groups of people who have looked at a particular aspect of environmental degradation and have issued severe warnings about the future of our planet. They are calling for immediate and stringent controls so that the quality of our life in these United States might be maintained. On the other hand are groups of people who take quite an opposite point of view. These are often people who are economically affected by the establishment of control. They would put forth the claim that we have overemphasized environmental quality and that furthermore, overemphasis on environmental quality will seriously affect the welfare of the nation in other equally significant ways.

Clouding the issue further is a debate as to whether the emphasis should be on a healthful environment with emphasis on man alone or a healthy environment that takes into account entire ecological systems. Those who put the emphasis on man may not be concerned about pollutants of our environment that may affect other forms of life.

Those who support a total healthy environment would claim that it is too short-sighted to support "environmental health" criteria that are too narrowly centered on human health, as is often done. Their point of view is that, ultimately, an ecosystem that is unhealthy will no longer be healthful for humans.

Thus, the arguments rage and emotions run high. There can be little doubt therefore in anyone's mind that the time has come for as much clear thinking on the issues of environmental quality as this country can possibly assemble. The former chairman of the subcommittee on Science, Research and Development of the House Committee on Science and Astronautics, Emilio Daddario, stated the situation quite well. In his opening remarks to a hearing on pollution abatement. He said, and I quote: "We must replace emotional response which comes all too quickly in environmental pollution issues with facts. We must replace an atmosphere of crisis, which is a poor one for decision making, with confidence in cause and effect relationships. We must do out utmost in developing new waste management methods and in removing barriers to their application. We must also help to define the problems through the formulation of realistic standards by which we can judge our current situation, our progress and our needs. It will then be possible for continued economic growth to be accompanied by a high level of quality in the air, water and soil."

Given that the point of view expressed by Mr. Daddario makes good sense, we ask the question: "What particular role can our nation's colleges and universities play in judging our current situation, our progress and our needs and above all else in providing answers to some of our most difficult questions?" It is my belief that the role of the university is to respond to this challenge in two unique ways.

First of all, traditionally the university has been recognized as a social institution that has aided society in an objective pursuit of truth. The pursuit of truth, based on the highest standards of scholarship, has been its hallmark since the university was instituted in the middle ages.

It has served society by being its critic and by being a disinterested observer. Put another way, the university through research and scholarship can provide the needed factual information on which decisions can be made free from emotional constraints.

The second point, and this is the one I particularly wish to express, is that the problems of establishing environmental standards cannot be confined to a single area. The problems that we are dealing with cut across all aspects of our life. In nature they are political, economic, sociological, legal and technological. In the current terminology of the university, they are highly interdisciplinary. At first glance one may question whether the university is the proper type of institution to be dealing with interdisciplinary problems. If there has been a criticism in the past, it has been that the university has been far too greatly concerned with discipline-oriented specialties. Its critics would say that it has contained a multiplicity of ivory towers with windows shut to the outside world. But this, indeed, is no longer the case.

If there is any current major trend on university campuses today it is precisely in this area of interdisciplinary studies and in particular systems analyses of very complex societal problems. Sensitivity to social problems has come from both faculty and students and rapid progress is being made. But let us explore this matter further.

There is no doubt that the so-called interdisciplinary approach at most universities has not worked particularly successfully. In some respects this is a consequence of the organizational structure and the usual association of a scholar in a particular department.

It is my feeling, however, that answers to how we handle interdisciplinary activities must be found and lessons already learned more widely applied. What I am implying is that the university, as an instrument of society, must look to the future and provide society with the very best input possible to preserve whatever may be termed our "quality of life." I believe that it is imperative that we launch this effort on a major scale.

Having said all of these things, to what degree can we demonstrate the manner in which a university disciplinary team might approach a problem. To illustrate this point let's consider what the approach might be to a study of toxic contaminants that might in some form affect one aspect of our environment. The steps could be as follows.

1. Identify the toxic contaminants (and magnitude of their release into the environment) resulting from natural processes, agricultural and mining practices, and the manufacture, use and disposal of products and by-products.

2. Develop techniques in analytical chemistry, data on biota highly sensitive to pollutants and knowledge of pollutant concentrating mechanisms in food chains.

3. Identify the environmental sources and sinks, routes, and rates of flow of toxic contaminants.

4. Identify the targets, including man, in the routes of flow, and assess the degree of damage to these targets.

5. Synthesize models of environmental systems which define toxic contaminant transport (mass flux), predict causes and effects, and alternative actions for contaminant control.

6. Identify the changes in molecular species which toxic contaminants undergo in their movement through environmental media.

7. Identify the legal and economic factors which impede or assist environmental pollution by toxic contaminants and assess their impact.

8. Identify public attitudes in "willingness to pay" for environmental quality.

9. Provide data that assist Federal and other governmental regulatory agencies in setting realistic and fair environmental standards.

10. Provide information useful to local and regional decision makers in planning further use of land, water and air resources for habitation, recreation and commerce, including information on environmental decontamination.

In order to carry along a project of this type and complete the steps that I have just outlined, note that the entire resources of a major university would in some way probably be involved. There would be a need for scientists, for engineers and technologists, for people in political science and economics, in sociology, in government, systems analysts, computer specialists, and experts in communicating information. To illustrate further how an interdisciplinary operation can be organized, I would like to remark on the approach that has been used at Purdue.

In November 1965, Purdue University organized an Institute for Environmental Health which has been conducting both research and training concerned with man's environment as related to his health and ecology. It is a research and educational entity within the university comprising a group of teachers, investigators, and students from a number of disciplines who are associated because of a common scholarly and professional concern with the study and control of the interaction of man with his environment. Emphasis has been placed on an interdisciplinary approach to environmental problems and is one with a character to which scientists and students alike are spontaneously being attracted.

The admistrative structure and central concepts of the institute involve a Policy Committee with general management authority, a Director of the Institute, and the Interdisciplinary Study and Advisory Section. The Interdisciplinary Study and Advisory Section has the major responsibility for promoting central concepts and planning. The Institute is made up of members of the present University staff who have had experience in environmental related research and who indicate sufficient interest in cooperative interdisciplinary research and training in this area to contribute all or a portion of their time to research, teaching, and/or the direction of research. This group, approximately 110 in number, forms the basic core staff of the Institute and provides an umbrella of leadership and expertise under which projects are conducted.

The institute does not have facilities of its own, but rather carries on its activities in the educational and research facilities of those departments and schools of the University from which the staff is drawn. A number of interdisciplinary research and training subcommittees made up of different individuals in different departments, depending on the research project, review, coordinate and make recommendations for activating projects.

I will not take time to refer to the many projects that this particular institute has been working with, except perhaps to refer to one which is directed specifically at the establishment of standards and environmental quality criteria concerning cadmium as a toxic substance. The institute, beyond being interdisciplinary within the university, is also interinstitutional in that in this particular study it involves eight individuals at the Oak Ridge National Laboratory and 27 professors at five different schools. The progress that has been made to date is most significant.

In conclusion I would like to reiterate that the University has significant contributions to make in establishing environmental standards. Through the objectivity of its scholarship and because it has the expertise to solve problems that are truly broad-ranging and interdisciplinary its contributions can be most unique.

It would be my hope that the nation would recognize the value of university support and give it every encouragement. While there are some hopeful signs in this direction, a great deal more needs to be done and I believe quickly.

F.A. Long, of Cornell University, stated the feelings that many of us have when he wrote in a recent editorial in Science Magazine and I quote him: "Pressure the universities, if you will. Castigate their occasionally overly narrow behavior. Insist on changed structures and reward mechanism, but for earth's sake, don't count them out. Without their active involvement the future will be a good deal dimmer than it might otherwise appear."

SEPARATION OF FLUIDS BY POROUS MATERIALS

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INTRODUCTION

In our discussion on the separation of fluids by porous materials we will be dealing with these basic process operations, namely (a) liquid-liquid separation, (b) liquid-gas separation, (c) liquid-solid separation; and two phenomena, namely (a) coalescing, and (b) microfiltration.

Both liquid-liquid separation and liquid-gas separation are most effectively performed by fluid coalescing, whereas liquid-solid separation utilizes the phenomena of microfiltration. We will attempt to describe how these three basic process operations are accomplished through the application of coalescing and microfiltration involving the flow of fluids through fine porous materials.

FLUID COALESCING

The most effective means of carrying out the phenomena of coalescing is controlled fluid flow through selected porous media. The basic principles of fluid coalescing are dependent almost entirely on the fundamentals of capillary physics and surface chemistry. Specifically, we are concerned with the phenomena involved in the flow of fluids through porous material, a study of the interface between the fluids, and the relationship between the phenomena of capillary flow and fluid interfacial structures.

When two immiscible fluids are in contact with each other, the molecules of each fluid exert an attraction upon those of the other fluid at the interface. This molecular attraction reduces the inward pull of each fluid upon the molecules of its own kind present at the fluid interface. A molecule of each fluid present at the interface will be under different forces from a similar molecule located at some distance from the interface. Under such conditions, the fluid interface will have a surface energy. This surface energy is termed the "interfacial tension" in the case of liquid-liquid interfaces, and "surface tension" in the case of a liquid-gas interface. This interface has strength and will resist rupture.

A proper appreciation, utilization, and support of this fluid interface is a fundamental requirement for effective fluid coalescing.

On the basis of the specific process operation and the specific flow phenomena involved, there is very little difference between liquid-liquid coalescing and liquid-gas coalescing. The same basic laws of capillary physics and surface chemistry apply to both systems. As a matter of fact, the same type of porous material is utilized in both systems for effective coalescing. However, for the sake of some clarity and simplicity, the two basic systems will be treated separately.

First off, let us examine a liquid-liquid system. A liquid-liquid system is generally presented in the form of an emulsion. An emulsion is normally defined as a dual phase liquid system in which fine droplets of one liquid are dispersed in a second liquid with which it is completely immiscible or incompletely miscible. The components of an emulsion consist of a continuous or predominate phase and a dispersed phase. The continuous phase is generally, but not necessarily, that phase which is in excess of the dispersed phase. The dispersed phase is generally present in the continuous phase in the form of fine droplets which tend to rise or fall as a result of variation in droplet size and density differences.

Emulsions are generally classified as stable or unstable. The stability of emulsions is determined by the permanence of the dispersed droplets in the continuous phase and if the dispersion remains permanent, then it is considered a stable emulsion.

The important factors which determine the permanence of the dispersion are: (a) the presence of electrical charges on the surface of the dispersion droplets, or (b) encapsulating film around the droplets which is both protective and resistant, but not adhesive.

The basic difference between a stable and an unstable emulsion is the fact that in an unstable emulsion, the interfacial tension value between the two liquids has not been reduced drastically or destroyed entirely; therefore the dispersed droplets can be induced to conglomerate by physical means. Under such conditions, the mechanics of fluid coalescing can be effectively applied for the separation of the liquids that make up the emulsion.

Figure 1 illustrates, schematically, the typical unstable emulsion. The dark areas illustrate the dispersed droplets. The shaded area illustrates a continuous phase with finely divided dirt particles present.

A liquid-gas system is generally defined as a dual phase fluid system in which droplets of a liquid are dispersed in a gas or vapor. The components of a liquid-gas system consist of a predominate phase and a dispersed phase. The continuous phase is generally that phase which is in excess of the dispersed phase. In most cases, the liquid phase is the dispersed phase and the gas is the continuous phase. We will be dealing with systems in which the dispersed phase is present in the form of droplets ranging from 100μ down to approximately 1μ.

Figure 1 will also illustrate a typical gas system during flow conditions. The dark circular areas illustrate the liquid droplets as they would be present in the gas stream in the form of sprays, mists, fogs and fumes. The shaded area illustrates continuous gas phase in which finely dispersed particulate matter is present. In selecting a porous material as the most effective fluid coalescing support, including the conditioning of both liquid-liquid and liquid-gas systems, it is necessary to consider the following facts. Any porous material is pervious to the flow of any fluid under certain conditions, provided the size of the capillary through the porous material is larger than the molecular size of the fluid. Conversely, any porous material is impervious to the flow of any fluid under certain other conditions. The conditions which determine whether a porous material is pervious or impervious to the flow of a fluid depends primarily on the following:

(a) The surface tension value between fluids.
(b) The size of the maximum opening of the porous material.
(c) The degree of wetting, nonwetting or preferential wetting of the porous material by the fluid.
(d) Pressure drop of the fluid system across the porous material.

The specific type of coalescing support, including materials of construction, porosity characteristics, surface conditions, shape and size, depends on the fluid system to be processed and the type of coalescing to be utilized.

Let us now examine the operations involved in liquid-liquid coalescing. Liquid-liquid coalescing generally involves the separation of an emulsion, or more specifically, the removal of the dispersed liquid contaminate from a continuous liquid phase. There are several types of liquid-liquid coalescing requiring different types of coalescing supports.

One type of liquid-liquid coalescing is termed "depth coalescing" in which the liquid-liquid coalescing operating occurs within the porous material and both phases of the liquid system pass through the porous material. The second type of liquid-liquid coalescing is termed "surface coalescing" in which the coalescing operation occurs on the surface of the porous material and only one phase of the liquid system passes through.

Depth type coalescing of emulsions has two distinct duties: (a) the preparation of the dispersed liquid droplets, and (b) the conglomerating of the prepared dispersed droplets. Both of these requirements are effectively carried out by causing the emulsion to pass through comparatively fine rigid type porous materials.

Figure 2 illustrates, schematically, the sequence of operation of depth type liquid-liquid coalescing as it occurs through the porous section of a rigid type coalescing material. Section A indicates, schematically, the normal structure of an unstable liquid emulsion before processing begins. The dark circles illustrate the dispersed droplets of the various sizes. The shaded area illustrates the continuous phase which also includes finely dispersed particulate matter. We should also note that the dark spheres are capsulated with a dirt film which prevents coalescing when collision occurs in this condition.

In Section B, the emulsion is illustrated, schematically, as it would to through exaggerated openings of the porous material. Note that during this travel through the openings of the porous material, two basic actions occur: (a) The encapsulated dirt film is removed by the filtering action of the porous material. At this point, the dispersed droplets are literally polished and the particulate matter removed from the surface of the dispersed phase droplet