



SAFE USE OF CHEMICALS

A Practical Guide

T. S. S. Dikshith



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SAFE USE OF CHEMICALS

A Practical Guide

*To my parents,
Gowramma and Turuvekere Subrahmanya Dikshith
and to
my wife, Saroja Dikshith*

A hundred times every day I remind myself, that my inner and outer life depended on the labors of other men, living and dead, and that I must exert myself in order to give in the same measure as I have received and am still receiving.

Albert Einstein

Preface

Let noble thoughts come to us from every side.

Rigveda (1-89-1)

Chemical substances have become an essential part of human activities. Proper use of chemical substances help human society protect itself from hunger, thirst, famine, disease, and infection with good grains, fruits, and vegetables. Synthesis, formulations, and proper use of newer drugs and pharmaceuticals have offered the benefits of improved health care to society. In short, proper and judicious application of a variety of chemical substances has improved the quality of life. In contrast, improper use or misuse of chemical substances has resulted in health disorders and fatalities. Furthermore, improper use has caused chemical disasters both at the workplace and in the environment.

Societal development requires use of chemical substances with pragmatism, as well as proper and good management. The users of chemical substances must be well aware of the implications of improper use of a chemical substance by itself or in combination with another chemical. In fact, all chemical substances are toxic and there is no absolute safety. It is the manner of use of a chemical substance that brings either good or danger to the user, to the immediate workplace, and to the society at large.

Improper use and waste disposal of chemical substances endangers human health and causes environmental pollution and chemical disasters. The adverse health effects of chemical substances depend on many factors, including the toxicity of the candidate chemical, the duration or period of exposure, and the exposed individual's age and health status, among others. To contain the adverse health effects of chemical substances, the user must be aware of the properties and mechanisms of action. The term "toxic industrial chemical" refers to a variety of chemical substances used in industry and in various processes. Any chemical substance can be toxic or harmful to human health in some dose. Toxic industrial chemicals are known to pose risks when they are stored in large quantities in one location. An act of sabotage or an accident can result in large-scale release of toxic chemicals or their degraded products; when those living nearby breathe this air they may develop health disorders. The environment also may become polluted. Examples include a chemical explosion at Seveso, Italy, that released chlorine gas from a large tank into the surrounding air; the Love Canal disaster in Niagara Falls in the late 1970s; and the Bhopal, India, tragedy in 1984. Chemical industries along rivers and lakes or in densely populated or environmentally sensitive areas have created critical situations.

Societal progress and development depend on the knowledge and proper use of chemical substances using a pragmatic approach—certainly not by misuse or reckless imposition of bans on chemical substances. There are no safe chemical substances. Huge amounts of time, money, and human effort have been spent to identify

newer molecules for human use. These chemical molecules have been identified, synthesized, and formulated for human use in the form of drugs, pesticides, preservatives, and many other useful products. Misuse or negligence during the use and management of chemical substances will not achieve human safety. Today, imparting proper education, suitable guidance, and good training to students, workers, and society at large is very necessary to assuring human safety. The global requirement of the day is to achieve economic progress for the developing as well as the developed parts of the world.

The purpose of this book is to provide and promote basic and elementary knowledge about chemical substances, irrespective of workplace, laboratory, factory, field, or home. Timely availability of knowledge protects the health of workers by reducing the possibilities of chemical disasters. This book offers a comprehensive, integrated, speedy, and easy tool for the management of a number of chemical substances commonly used, handled, stored, and transported by a large population. The list of chemical substances includes but is not limited to industrial solvents, pesticides, metals, air pollutants, toxic gases, and drugs. The book also offers guidance to students, basic scientists, toxicologists, industrial workers, professionals, risk assessors, and regulatory agencies. Because chemical substances are ubiquitous and their application universal, these individuals often require a single standardized, comprehensive book of data for reference. The author has made every effort to collect and collate information from different published sources about a large number of chemical substances. Essentially, this book provides ready information to users at times of need.

The information on each chemical substance is concise and easy to understand. It includes the chemical name with CAS (Chemical Abstracts Service) number, the International Union of Pure and Applied Chemistry (IUPAC) name, molecular formula, synonyms and trade names, use and exposure, toxicity and health effects, whether it is carcinogenic, exposure limits, and methods of proper storage and disposal, with relevant references. Tables and appendices provide additional information. In certain chapters of this book, chemical substances are listed in alphabetical order to facilitate speedy and easy access for the reader; the classifications of chemical substances are included separately.

It is important to state here that this compilation does not discourage the use of chemical substances. Chemical substances are essential and, when they are used properly, societal development and improvement of the quality of life are possible. This book educates students, semiskilled workers in different occupations, householders, and other users about the basic realities of chemical substances, the responsibilities associated with using them, and the immediate short- and long-term consequences of improper use and negligence during handling.

The author is fully aware of the fact that, in spite of his efforts to present an up-to-date and comprehensive compilation in one place, many gaps must have occurred. The book seeks to provide an integrated, yet simple description of chemical substances commonly used, handled, stored, and transported by workers and householders. The salient features of the book include:

information on general fundamentals as well as about specific hazards and effects of chemical substances;
information about the basics of exposure and response to chemical substances in the work environment;
evaluation of toxic responses in different body systems; and
general perspectives on the problem of chemical exposure and its possible health effects.

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Contents

Preface.....	xi
Acknowledgments.....	xv
The Author.....	xvii

Chapter 1 Introduction 1

1.1 Chemical Substances and Poisoning of Humans.....	2
1.2 General Safety Guidelines	3
References	4

Chapter 2 Chemical Substances and Categorization 5

2.1 Introduction.....	5
2.2 Chemicals and Categorization	5
2.2.1 Industrial Solvents	5
2.2.2 Metals and Metal Compounds.....	6
2.2.3 Pesticides.....	6
2.2.4 Toxic Dust, Fumes, Gases, and Vapors.....	7
2.2.4.1 Fumes and Dust of Metals.....	7
2.2.5 Asphyxiates.....	8
2.2.6 Corrosive Substances	8
2.2.7 Irritants	9
2.2.7.1 Eye and Skin Irritants.....	9
2.2.7.2 Lung and Respiratory Irritants.....	9
2.2.8 Neurotoxic Chemicals.....	10
2.2.9 Oxidizing Agents	10
2.2.10 Carcinogens, Mutagens, and Teratogens.....	12
2.2.11 Chemicals and Fire Hazards.....	12
2.3 Conclusion.....	12
References	12

Chapter 3 Elements of Toxicology and Chemical Safety 15

3.1 Introduction.....	15
3.2 Toxicology Studies	15
3.2.1 History of Toxicology	16
3.2.2 Branches of Toxicology	19
3.2.3 Types of Toxicological Studies	21
3.2.3.1 Acute Toxicity	21
3.2.3.2 Chronic Toxicity.....	22
3.2.4 Influencing Factors.....	25

3.2.4.1	Dose–Time Relationship	25
3.2.4.2	Routes of Exposure and Toxicity Tests	25
3.2.5	Parameters of Toxicity	26
3.2.5.1	Parameters and the Safety Evaluation of Chemicals and Drugs	26
3.3	Good Laboratory Practice and Regulations	26
3.3.1	Good Laboratory Practice	27
3.3.2	Toxicology Test Report	28
References	29
Appendix 3.1:	Signs and Symptoms of Toxicity	30
Chapter 4	Industrial Solvents	31
4.1	Introduction	31
4.2	Solvents	32
4.2.1	Flammable and Combustible Solvents	33
4.2.2	Uses of Solvents	34
4.2.3	Exposure to Solvents	35
4.3	Drugs, Pharmaceutical Products, and Residual Solvents	36
4.4	Solvents and Precautions	37
4.5	Education and Training	40
4.6	Toxicity and Health Effects	40
4.7	Neurotoxicity	41
4.8	Solvent Syndrome and Fetal Defects	41
4.9	Workplace Controls and Work Practices	42
4.10	Occupational Exposure Limits	42
4.11	Solvents and Toxicity Profile	42
4.12	Conclusion	71
References	71
Appendix 4.1:	Classes of Different Chemical Substances and Solvents	76
Appendix 4.2:	Health Hazards of Solvents upon Inhalation	78
Chapter 5	Metals and Metal Compounds	79
5.1	Introduction	79
5.2	Discovery of Metals	79
5.3	Different Metals	81
5.3.1	Metals and Alloys	81
5.4	Metal Poisoning and Symptoms	82
5.5	Conclusions	102
References	103
Appendix 5.1:	Metals and Health Disorders in Humans	107
Chapter 6	Pesticides	109
6.1	Introduction	109
6.2	Global Development of Pesticides	110

6.3	Classifications of Pesticides	110
6.4	Uses of Pesticides	113
6.5	Toxicity of Pesticides	114
6.6	Signs and Symptoms of Toxicity.....	114
6.7	Pesticide Management.....	115
6.8	Symptoms of Pesticide Poisoning	118
6.9	Approaches to Reduce Intentional and Suicidal Poisonings.....	120
6.10	The Insecticide Act (1968).....	120
6.11	Regulations.....	121
6.12	Pesticides and Carcinogenicity	122
6.13	Conclusion.....	122
	References.....	123
	Appendix 6.1: Global Development of Pesticides.....	124
	Appendix 6.2: Pesticide Poisoning—Mild, Moderate, and Severe	125
	Appendix 6.3: Pesticide Components, Signs of Toxicity, and Parts of the Body Affected.....	126
	Appendix 6.4: Behavioral and Nonbehavioral Changes Caused by Pesticide Exposure.....	126
	Appendix 6.5: Pesticides and Mammalian Toxicity	126
	Appendix 6.6: Pesticides and Hormone Disturbances in Mammals	129
	Appendix 6.7: Classification of Pesticide Toxicity.....	129
	Appendix 6.8: Organochlorinate Pesticides and Carcinogenicity	130
	Appendix 6.9: Classification of Pesticides and Carcinogenicity	130
	Appendix 6.10: Pesticides Listed in India as Carcinogens	136
Chapter 7	Air Pollutants and Toxic Gases	139
7.1	Introduction.....	139
7.2	Sources of Pollutants and Health Effects.....	139
7.2.1	Air Pollutants	139
	References.....	158
Chapter 8	Chemical Substances and Carcinogenicity	161
8.1	Introduction.....	161
8.2	Carcinogens and Carcinogenesis	161
8.3	Classification of Carcinogens.....	162
8.4	Chemical Substances, Occupations, and Cancer	164
8.5	Children and Pesticide-Induced Cancer.....	167
	References.....	167
	Additional Reading	168
	Appendix 8.1: Known Human Carcinogens	169
	Appendix 8.2: Group B2—Probable Human Carcinogens.....	170
	Appendix 8.3: Group E—Evidence of Noncarcinogenicity for Humans	171
	Appendix 8.4: Classification of Benign and Malignant Tumors in Mammals	172

Chapter 9	Chemical Substances and Neurotoxicity	173
9.1	Introduction	173
9.2	Neurotoxicity	174
9.3	Industrial Chemicals and Neurotoxicity	176
9.4	Monomers	177
9.5	Neurotoxicity and Children	178
9.6	Symptoms of Neurotoxicity	178
9.7	Polyneuropathy	178
9.8	Encephalopathy	179
9.9	Neurotoxicants and Neonates	180
9.10	Conclusion	180
	References	181
	Appendix 9.1: Chemical Substances and Neurotoxicity	183
Chapter 10	Chemical Substances and Nephrotoxicity	185
10.1	Introduction	185
10.2	Chemical Substances and Renal Injury	185
10.3	Symptoms of Nephropathy	186
10.4	Metals and Nephrotoxicity	188
	References	190
Conclusions		191
Chemical Safety Guidelines		193
Safe-Handling Guidelines		193
Minimize Exposure and Reduce Risks		194
Hygiene and Chemical Safety		194
Glossary		197
Appendices		223
Index		283

1 Introduction

Today, almost everyone works or lives with chemicals and chemical products. Over the centuries man has lived in a chemical age, but especially so during the past several decades. Many of the chemical substances can have deleterious effects on animals, humans, and the environment. These substances are capable of causing physical hazards (e.g., fire or explosion) or health hazards (such as systemic toxicity and chemical burns). Improper use of chemical substances causes a wide range of health hazards. It is the responsibility of the user to evaluate each chemical substance and know its potential to cause adverse health effects and pose physical hazards, such as flammability in the workplace. The manufacturers, importers, and distributors of different chemical substances must be sure that containers of hazardous chemicals leaving the workplace are properly labeled with the identity of the chemical and appropriate hazard warnings. In the workplace, each container must be marked with the identity of hazardous chemicals contained in it and must show hazard warnings appropriate for employee protection.

There are several ways to use chemicals wisely. One can reduce both the probability and consequences of accidents to negligible levels. Use of chemical substances is always associated with risks. However, these risks can be minimized with knowledge, proper use, and good practices. In other words, safety from chemical substances depends on knowledge, judicious use, safe practices, appropriate methods of engineering controls, proper use of personal protective equipment, use of minimum quantities of materials, and substitution of a less hazardous chemical substance when possible.

Chemical substances that make up the world around us include more than 100 fundamental elements, such as iron, lead, mercury, carbon, oxygen, and nitrogen. They also include combinations of different elements, acids, and salts. A process of chemical reaction is triggered, making one substance chemically convert into another. Man-made chemical compounds have changed lives. In fact, the twentieth century could well be called the "age of chemistry." Industries, factories, homes, laboratories, fields, farm yards, gardens, and city roads are flooded with aerosols, artificial sweeteners, cosmetics, detergents, dyes, paints, pesticides, pharmaceuticals, plastics, refrigerants, and synthetic fabrics, as well as many other substances. The list of chemical substances is endless. To satisfy the ever growing global demand for these products, the annual production of chemical substances, according to estimates of the World Health Organization (WHO), amounts to about \$1.5 trillion. Further, reports of WHO state that approximately 100,000 chemical substances are now on the market and each year more than 1000–2000 others are added to the list.

This flood of chemical substances, however, invites questions regarding human health and environmental safety. Clearly, society is sailing into uncharted waters.

The public is a part of an experimental generation, and the full effects will not be known for decades to come. The most often affected by chemical substances and pollutants are poor, illiterate, semiskilled workers and people with little or no access to basic information about chemical substances. Many people are not fully aware of the short- and long-term possible health hazards posed by chemical substances to which they are directly or indirectly exposed daily. This increased trend and the manner of exposure to a plethora of chemical substances in workplaces or other environments cannot be ignored.

A Green History of the World points to the need for basic knowledge about chemical substances and proper management of their use. The book states that 20% of California's water wells have pollution levels, including pesticides, above official safety limits. The book states:

In Florida, 1,000 wells have been closed because of contamination. In Hungary 773 towns and villages have water that is unfit for human consumption and in Britain ten per cent of aquifers are polluted above the safety limits set by the WHO, and in parts of both Britain and the United States tap water cannot be given to newborn babies because of high nitrate levels.¹

Mercury is another useful but potentially toxic chemical. It finds its way into the environment through sources ranging from industrial smokestacks to billions of fluorescent lights. Similarly, lead can be found in many products, from fuel to paint and products of paint. Lead is toxic, especially to children, and prolonged periods of exposure to fumes and emissions of processes using lead can affect a child's IQ.² According to the United Nations Environment Program (UNEP), each year approximately 100 tons of mercury, 3800 tons of lead, 3600 tons of phosphates, and 60,000 tons of detergents enter the Mediterranean Sea as a result of human activities. Understandably, the sea is in crisis, but it is not alone. In fact, the United Nations declared 1998 "the International Year of the Ocean." Worldwide, all oceans are in trouble, particularly because of pollution. While chemical technology has provided us many products and improved the global economy, improper use and waste disposal methods have disturbed human health and caused disasters to the environment. As one newspaper columnist recently said, "Have we made ourselves hostages to progress?"³

1.1 CHEMICAL SUBSTANCES AND POISONING OF HUMANS

Human exposure to a variety of chemical substances and the subsequent poisonings and fatalities have caused significant global concern. In fact, recent reports indicate that as many as 350,000 people died worldwide from unintentional poisoning and more than 94% of fatal poisonings occurred in countries with low- and middle-income populations. While accurate global figures are not available, approximately a million people died as a result of suicide, and possibly as many as a quarter of these deaths resulted from ingestion of chemical substances. Pesticide-related suicides and fatalities have affected a significant percent of the global population. In fact, over

60% of successful suicides in China are the result of pesticide poisoning and over 71% in Sri Lanka.⁴

Overdoses account for a quarter of all suicides in England. Further, the number of people who survive the immediate effects of their overdose long enough to reach medical attention but subsequently die in hospital is unknown. In England, during 1997 and 1999, there were 233,756 hospital admissions for overdose, and 1149 (0.5%) of these ended in death of the patient. Of these deaths, 29% accounted for overdose suicides—7% of total suicides.⁵ Around a quarter of all overdose suicide deaths occur subsequent to hospital admission. Detailed research is required to discover if better preadmission and in-hospital medical management of those taking serious overdoses may prevent some of these deaths. Proper management of chemicals can control the misuse of these chemicals.

In the light of these human health developments, there is an urgent need to educate industrial workers as well as the general public about chemical substances. Also, regulatory systems need to be updated for the collection of compatible data on human poisonings. The Intergovernmental Forum for Chemical Safety (IFCS Forum III) has already discussed these important aspects under Program Area D7 in October 2000 in Salvador da Bahia, Brazil. Collection of compatible data and categorization of chemical substances, types of poisonings, and identity (chemical structure), use, or function of different chemical substances, as well as many other aspects, need to occur to achieve safe use of chemical substances by all.

1.2 GENERAL SAFETY GUIDELINES

Before using a chemical substance, one should ask, “What would happen if...?” The answer to this question requires an understanding of the hazards associated with the candidate chemical substance, equipment, and procedures involved. The hazardous properties of the chemical substance and the intended use dictate the precautions to be observed by the user. Another important distinction is the difference between hazard and risk. The two terms are sometimes used as synonyms; however, “hazard” is a much more complex concept because it includes conditions of use. The hazard presented by a chemical substance has two components: (1) the inherent capacity to do harm by virtue of its toxicity, flammability, explosiveness, corrosiveness, and many other properties; and (2) the ease with which a chemical substance can come into contact with a person or other object of concern. These two components together determine the risk (the likelihood or probability that a chemical substance will cause harm). Thus, an extremely toxic chemical such as strychnine cannot cause poisoning if it is in a sealed container and does not have direct contact with the user. In contrast, a chemical substance that is not highly toxic becomes fatal if a large amount is ingested, so users should never underestimate the risks of chemical substances. Chemical substances such as buffers, sugars, starches, agar, and naturally occurring amino chemicals are considered nonhazardous.

Chemical safety is inherently linked to other safety issues, including laboratory procedures, personal protective equipment, electrical safety, fire safety, and hazardous waste disposal. Specific chemical substances, uses, and possible health effects are discussed in different chapters of this book. The responsibility of workers as well