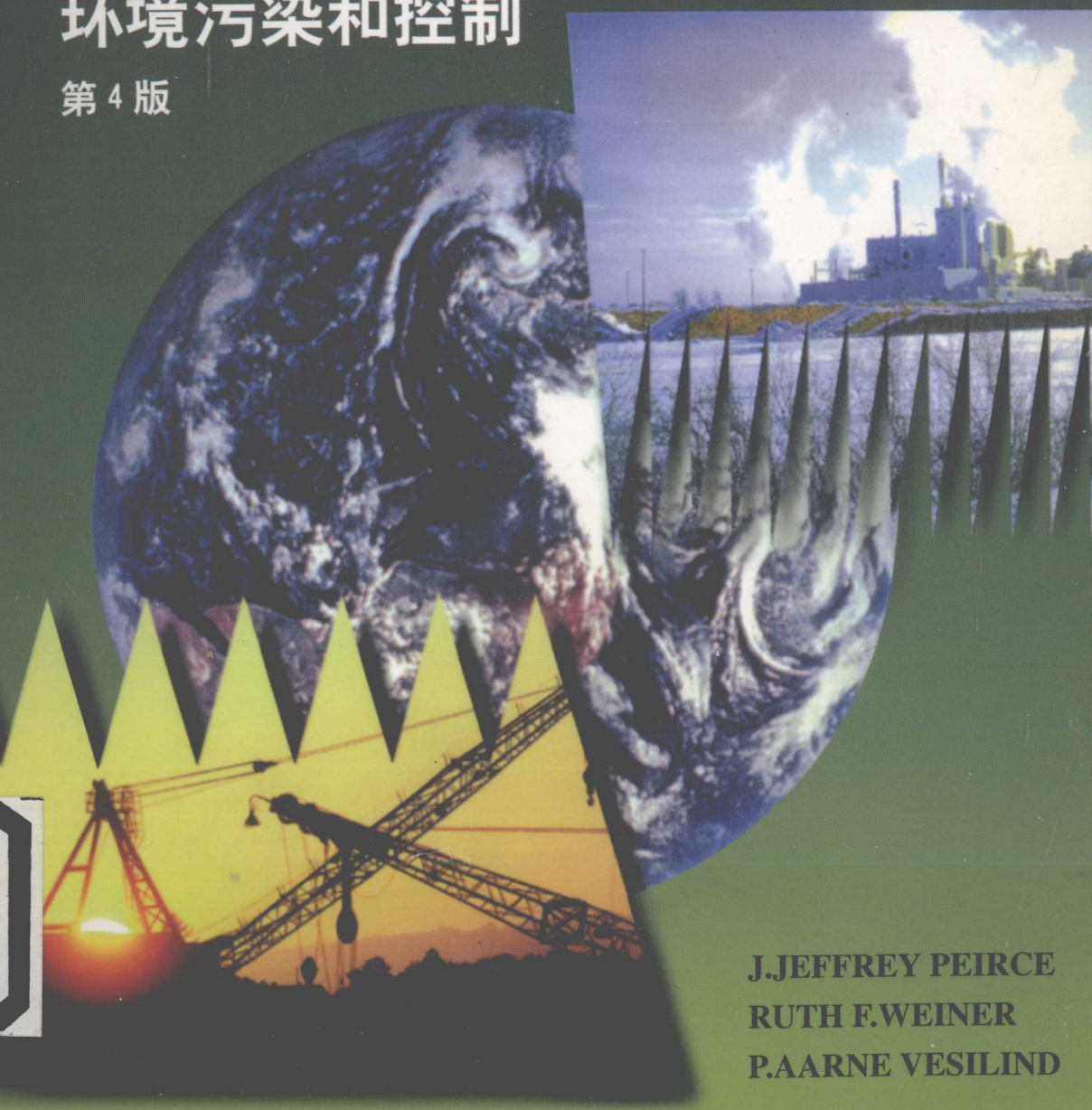
ENVIRONMENTAL POLLUTION and CONTROL

FOURTH EDITION

环境污染和控制

第4版



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To

Elizabeth Davis Rasnic, Shayn, and Leyf
Lisa, Annie, Sarah, and Rachel
Pamela, Steve, and Lauren

Preface

Since this book was first published in 1972, several generations of students have become environmentally aware and conscious of their responsibilities to planet earth. Many of these environmental pioneers are now teaching in colleges and universities, and have students with the same sense of dedication and resolve that they themselves brought to the discipline. In those days, it was sometimes difficult to explain what environmental science or engineering was, and why the development of these fields was so important to the future of the earth and to human civilization. Today there is no question that the human species has the capability of destroying its home and that we have taken major steps toward doing exactly that.

And yet, while much has changed in a generation, much has not. We still have air pollution; we still contaminate our water supplies; we still dispose of hazardous materials improperly; we still destroy natural habitats as if no other species mattered. And, worst of all, we still populate the earth at an alarming rate. The need for this book, and for the college and university courses that use it as a text, continues; it is perhaps more acute now than it was several decades ago.

Although the battle to preserve the environment is still raging, some of the rules have changed. Now we must take into account risk to humans and be able to manipulate concepts of risk management. With increasing population, and fewer alternatives to waste disposal, this problem has intensified. Environmental laws have changed and will no doubt continue to evolve. The economic cost of preservation and environmental restoration continues to increase. Attitudes toward the environment are often couched in what has become known as the environmental ethic. Finally, the environmental movement has become politically powerful, and environmentalism sometimes can be made to serve a political agenda.

In revising this book, we incorporate the evolving nature of environmental sciences and engineering by adding chapters as necessary and eliminating material that is less germane to today's students. We have nevertheless maintained the essential feature of this book—the packaging of the more important aspects of environmental engineering science and technology in an organized manner and the presentation of this mainly technical material to a nonengineering audience.

This book has been used as a text in courses that require no prerequisites, although a high school knowledge of chemistry is important. A knowledge of college-level algebra is also useful, but calculus is not required for an understanding of the technical and scientific concepts.

We do not intend this book to be scientifically and technically complete. In fact, many complex environmental problems have been simplified to the threshold of pain for many engineers and scientists. Our objective, however, is not to impress nontechnical students with the rigors and complexities of pollution control technology but rather to make some of the language and ideas of environmental engineering and science more understandable.

J. Jeffrey Peirce
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Chapter 1

Pollution and Environmental Ethics

"If seven maids with seven mops
Swept it for half a year,
Do you suppose," the Walrus said,
"That they could get it clear?"
"I doubt it," said the Carpenter,
And shed a bitter tear.

—Lewis Carroll

Could the Walrus and the Carpenter have been talking about our earth? And is the situation really this grim? Is it time to start shedding bitter tears, or is there something we can do to control environmental pollution?

The objective of this book is to at least begin to answer these questions. As the title suggests, this book focuses first on the problems of environmental pollution, but then concentrates on methods of control—what we humans can do to prevent and control the pollution of our planet.

We define *environmental pollution* as the contamination of air, water, or food in such a manner as to cause real or potential harm to human health or well-being, or to damage or harm nonhuman nature without justification. The question of when harm to nonhuman nature is justified is a sticky one and is addressed below in the discussion on ethics.

In this first chapter we begin by asking why we seem to have such problems with environmental pollution. Where do these problems originate, and what or who is to blame for what many consider to be the sorry state of the world? Next we discuss our environmental problems within the framework of ethics. We begin by showing how the most basic concepts of environmental pollution that reflect public health concerns are really ethical issues. We then discuss how these ethics have been used to extend the concerns with pollution beyond public health to include the despoliation of the planet, including the extinction of species and destruction of places. All of these problems are still within the context of harm to humans. Finally, we discuss issues that have nothing to do with public health or human well-being, but nevertheless are important to us in terms of environmental quality.

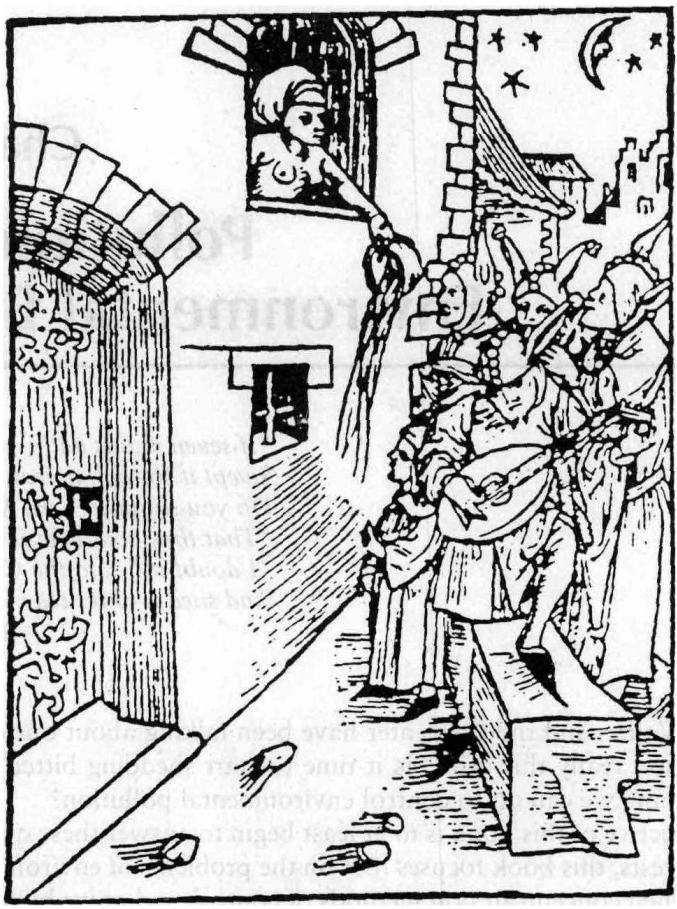

FIGURE 1–1. Human excreta disposal, from an old woodcut. [Source: Reyburn, W., *Flushed with Pride*, London: McDonald (1969).]

THE ROOTS OF OUR ENVIRONMENTAL PROBLEMS

Much of the history of Western civilizations has been characterized as exploitation, destruction, and noncaring for the environment. Why are we such a destructive species? Various arguments have been advanced to explain the roots of our environmentally destructive tendencies, including our religions, our social and economic structure, and our acceptance of technology.

Religion. In the first chapter of Genesis, people are commanded by God to subdue nature, to procreate, and to have dominion over all living things. This anthropocentric view of nature runs through the Judaeo-Christian doctrine, placing humans at the pinnacle of development and encouraging humans to use nature as we see fit.

In his essay, "The Historical Roots of Our Ecological Crisis," Lynn White argues that those who embrace the Judaeo-Christian religions are taught to

treat nature as an enemy and that natural resources are to be used to meet the goals of human survival and propagation. From this dogma (so goes the argument) have developed technology and capitalistic economy, and, ultimately, environmental degradation.

Because the Judaeo-Christian traditions are most prominent in the United States, we often forget that this is not a majority religious tradition in the world. Billions of people embrace very different deities and dogmas, and yet they also live in capitalistic economies with perhaps even greater destruction of environmental quality. So it cannot be just the Judaeo-Christian religions that are to blame.

Remember also that Christianity and Islam both developed at a time when there were a number of competing religions from which to choose. For many, the Christian ideas and ethics derived from the Judaic traditions seemed to fit most comfortably with their existing ethics and value systems, while others chose Islam over other religions. It seems quite obvious that Christianity was not the *reason* for the development of science, capitalism, and democracy, but simply provided an ethical environment in which they flourished (at least in Europe). It seems farfetched, therefore, to blame our environmental problems on our religions.

Social and Economic Structures. Perhaps it is our social structures that are responsible for environmental degradation. Garrett Hardin's "The Tragedy of the Commons" illustrates this proposition with the following story:[1]

> A village has a common green for the grazing of cattle, and the green is surrounded by farmhouses. Initially, each farmer has one cow, and the green can easily support the herd. Each farmer realizes, however, that if he or she gets another cow, the *cost* of the additional cow to the farmer is negligible because the cost of maintaining the green is shared, but the *profits* are the farmer's alone. So one farmer gets more cows and reaps more profits, until the common green can no longer support anyone's cows, and the system collapses.

Hardin presents this as a parable for overpopulation of the earth and consequent resource depletion. The social structure in the parable is capitalism—the individual ownership of wealth—and the use of that wealth to serve selfish interests. Does that mean that noncapitalist economies (the totally and partially planned economies) do a better job of environmental protection, natural resource preservation, and population control?

The collapse of the Soviet Union in 1991 afforded the world a glimpse of the almost total absence of environmental protection in the most prominent socialist nation in the developed world. Environmental devastation in the Commonwealth of Independent States (the former USSR) is substantially more serious than in the West. In the highly structured and centrally controlled communist

[1]Hardin, G., "The Tragedy of the Commons," *Science* 162 (1968): 1243.

system, *production* was the single goal and environmental degradation became unimportant. Also, there was no such thing as "public opinion," of course, and hence nobody spoke up for the environment. When production in a centrally controlled economy is the goal, all life, including human life, is cheap and expendable.[2]

Some less industrialized societies, such as some Native American tribes, the Finno-Ugric people of northern Europe, and the Pennsylvania Amish in the United States, have developed a quasi–steady-state condition. These sociopolitical systems incorporate animistic religion, holding that nature contains spirits that are powerful, sometimes friendly, and with whom bargains can be struck. The old Estonians and Finns, for example, explained to the spirit of the tree why cutting it down was necessary.[3] As another example, Estonians began the wheat harvest by putting aside a shaft of wheat for the field mice. This mouse-shaft (*hiirevihk*) did not appear to have religious significance; it was explained as a means of assuring the mice of their share of the harvest.[4]

These societies were not all environmentally stable, however, nor did they deliberately act to protect their environment. Those that are still in existence coexist with the industrialized societies that have not achieved a steady state, use the products and marketing mechanisms of those states, and lose their young people to societies where there is wider opportunity. Society is the reflection of the needs and aspirations of the people who establish and maintain it. Re-establishment of a nonindustrialized society would be doomed to failure, because such societies have already demonstrated that they do not meet people's needs.

The democratic societies of the developed world have in fact moved consciously toward environmental and resource protection more rapidly than either totally planned economies or the less developed nations. The United States has the oldest national park system in the world, and pollution control in the United States predates that of other developed nations, even Canada, by about 15 years.

So much for blaming capitalism.

Science and Technology. Perhaps the problem is with science and technology. It has become fashionable to blame environmental ills on increased knowledge of nature (science) and the ability to put that knowledge to work (engineering). During the industrial revolution the Luddite movement in England violently resisted the change from cottage industries to centralized factories; in the 1970s a pseudo-Luddite "back-to-nature" movement purported to reject technology altogether. However, the adherents of this movement made considerable use of the fruits of the technology they eschewed, like used vans and buses, synthetic fabrics, and, for that matter, jobs and money.

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[2]Solzhenytsin, A., *The Gulag Archipelago,* New York: Bantam Books (1982).

[3]Paulsen, I., *The Old Estonian Folk Religion,* Bloomington, IN: Indiana University Press (1971).

[4]According to F. Oinas of the University of Indiana.

People who blame science and technology for environmental problems forget that those who alerted us early to the environmental crisis, like Rachel Carson in *Silent Spring*,[5] Aldo Leopold in *A Sand County Almanac*,[6] and Barry Commoner in *The Closing Circle*,[7] were *scientists*, sounding the environmental alarm *as a result of scientific observation*. Had we not observed and been able to quantify phenomena like species endangerment and destruction, the effect of herbicides and pesticides on wildlife, the destruction of the stratospheric ozone layer, and fish kills due to water pollution, we would not even have realized what was happening to the world. Our very knowledge of nature is precisely what alerted us to the threats posed by environmental degradation.

If knowledge is value-free, is technology to blame? If so, less technologically advanced societies must have fewer environmental problems. But they do not. The Maori in New Zealand exterminated the moa, a large flightless bird; there is considerable overgrazing in Africa and on the tribal reservations in the American Southwest; the ancient Greeks and Phoenicians destroyed forests and created deserts by diverting water. Modern technology, however, not only provides water and air treatment systems, but continues to develop ways in which to use a dwindling natural resource base more conservatively. For example, efficiency of thermal electric generation has doubled since World War II, food preservation techniques stretch the world's food supply, and modern communications frequently obviate the need for energy-consuming travel, and computer use has markedly decreased the use of paper.

If technology is not to blame, does it have the "wrong" values, or is it value-free? Is knowledge itself, without an application, right or wrong, ethical or unethical? J. Robert Oppenheimer faced this precise dilemma in his lack of enthusiasm about developing a nuclear fusion bomb.[8] Oppenheimer considered such a weapon evil in itself. Edward Teller, usually credited with its development, considered the H-bomb itself neither good nor evil, but wished to keep it out of the hands of those with evil intent (or what he perceived to be evil intent). The developers of the atomic bomb, although defending the position that the bomb itself was value-free, nonetheless enthusiastically promoted the peaceful uses of atomic energy as a balance to their development of a weapon of destruction. The ethics of technology is so closely entwined with the ethics of the uses of that technology that the question of inherent ethical value is moot. On balance, technology can be used to both good and evil ends, depending on the ethics of the users.

Assessment of the ethics of the use of any technology depends on our knowledge and understanding of that technology. For example, at this writing, scientists are investigating whether or not proximity to the electric and magnetic

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[5]Carson, Rachel, *Silent Spring*.

[6]Leopold, Aldo, *A Sand County Almanac*, New York: Oxford University Press (1949).

[7]Commoner, Barry, *The Closing Circle*.

[8]Newhouse, J., *War and Peace in the Nuclear Age*, New York: Alfred A. Knopf (1988).