Part 1

Introduction to Environmental Science and Engineering

UNIT 1 What is Environmental Science?

Environmental science is a multidisciplinary academic field that integrates physical, biological and information sciences (including but not limited to ecology, biology, physics, chemistry, zoology, mineralogy, oceanology, limnology, soil science, geology, atmospheric science, geography and geodesy) to the study of the environment, and the solution of environmental problems. Environmental science emerged from the fields of natural history and medicine during the Enlightenment①. Today it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems. Related areas of study include environmental studies and environmental engineering. Environmental studies incorporate more of the social sciences for understanding human relationships, perceptions and policies towards the environment. Environmental engineering focuses on design and technology for improving environmental quality in every aspect. Environmental scientists work on subjects like the understanding of earth processes, evaluating alternative energy systems, pollution control and mitigation, natural resource management, and the effects of global climate change. Environmental issues almost always include an interaction of physical, chemical, and biological processes. Environmental scientists bring a systems approach to the analysis of environmental problems. Key elements of an effective environmental scientist include the ability to relate space, and time relationships as well as quantitative analysis.

Environmental science came alive as a substantive, active field of scientific investigation in the 1960s and 1970s driven by (a) the need for a multi-disciplinary approach to analyze complex environmental problems, (b) the arrival of substantive environmental laws requiring specific environmental protocols of investigation and (c) the growing public awareness of a need for action in addressing environmental problems. Event that spurred this development included the publication of Rachel Carson's landmark environmental book *Silent Spring*② and helped increase the visibility of environmental issues and create this new field of study.

Terminology

In common usage, “environmental science” and “ecology” are often used interchangeably, but technically, ecology refers only to the study of organisms and their interactions with each other and their environment. Ecology could be considered a subset of environmental science, which also could involve purely chemical or public health issues (for example) ecologists would be unlikely to study. In practice, there is considerable overlap between the work of ecologists and other environmental scientists.

Components

Atmospheric sciences focuses on the Earth’s atmosphere, with an emphasis upon its interrelation to other systems. Atmospheric sciences can include studies of meteorology, greenhouse gas phenomena, atmospheric dispersion modeling of airborne contaminants, sound propagation phenomena related to noise pollution, and even light pollution.

Taking the example of the global warming phenomena, physicists create computer models of atmospheric circulation and infra-red radiation transmission, chemists examine the inventory of atmospheric chemicals and their reactions, biologists analyze the plant and animal contributions to carbon dioxide fluxes, and specialists such as meteorologists and oceanographers add additional breadth in understanding the atmospheric dynamics.

Ecology is the study of the interactions between organisms and their environment. Ecologists might investigate the relationship between a population of organisms and some physical characteristic of their environment, such as concentration of a chemical; or they might investigate the interaction between two populations of different organisms through some symbiotic or competitive relationship. For example, an interdisciplinary analysis of an ecological system which is being impacted by one or more stressors might include several related environmental science fields. In an estuarine setting where a proposed industrial development could impact certain species by water and air pollution, biologists would describe the flora and fauna, chemists would analyze the transport of water pollutants to the marsh, physicists would calculate air pollution emissions and geologists would assist in understanding the marsh soils and bay muds.

Environmental chemistry is the study of chemical alterations in the environment. Principal areas of study include soil contaminationand water pollution. The topics of analysis include chemical degradation in the environment, multi-phase transport of chemicals (for example, evaporation of a solvent containing lake to yield solvent as an air pollutant), and chemical effects upon biota.

As an example study, consider the case of a leaking solvent tank which has entered the habitat soil of an endangered species of amphibian. As a method to resolve or understand the extent of soil contamination and subsurface transport of solvent, a computer model would be implemented. Chemists would then characterize the molecular bonding of the solvent to the specific soil type, and biologists would study the impacts upon soil arthropods, plants, and ultimately pond-dwelling organisms that are the food of the endangered amphibian.

Geosciences include environmental geology, environmental soil science, volcanic phenomena and evolution of the Earth's crust. In some classification systems this can also include hydrology, including oceanography.

As an example study of soils erosion, calculations would be made of surface runoff by soil scientists. Fluvial geomorphologists would assist in examining sediment transport in overland flow. Physicists would contribute by assessing the changes in light transmission in the receiving waters. Biologists would analyze subsequent impacts to aquatic flora and fauna from increases in water turbidity.

(Selected from "http: //www. en. wikipedia. org/wiki/Environmental_science")

Words and Expressions

multidisciplinary	[mʌltidisə'plinəri]	*adj*. 多学科的
mineralogy	[minə'rælədʒi]	*n*. 矿物学
limnology	[lim'nɒlədʒi]	*n*. 湖沼学
geology	[dʒi'ɒlədʒi]	*n*. 地质学
geodesy	[dʒi'ɒdisi]	*n*. 测地学
interdisciplinary	[intə'disiplin(ə)ri]	*adj*. 跨学科的
enlightenment	[in'lait(ə)nm(ə)nt]	*n*. 启蒙
quantitative analysis		定量分析
perception	[pə'sepʃ(ə)n]	*n*. 感知
alternative	[ɔ: l'tɜ: nətiv]	*adj*. 可替代的
mitigation	[miti'geiʃ(ə)n]	*n*. 减轻
interaction	[intər'ækʃ(ə)n]	*n*. 相互作用

protocol	['prəʊtəkɒl]	*n.* 议定书
interchangeably	[intə'tʃeindʒəbl]	*adv.* 可交换地
subset	['sʌbset]	*n.* 子集
overlap	[əʊvə'læp]	*n.* 重叠
atmospheric dispersion modeling		大气扩散模拟
meteorology	[⌨mi: tiə'rɒlədʒi]	*n.* 气象学
terminology	[⌨tɜ: mi'nɒlədʒi]	*n.* 术语
approach	[ə'prəʊtʃ]	*n.* 方法、途径
phenomena	[fə'nɒminə]	*n.* 现象
airborne contaminants		空气传播污染物
propagation	[⌨prɒpə'ɡeiʃən]	*n.* 传播
circulation	[sɜ: kjʊ'leiʃ(ə)n]	*n.* 循环
infra-red radiation		红外辐射
transmission	[trænz'miʃ(ə)n]	*n.* 传播
inventory	['inv(ə)nt(ə)ri]	*n.* 清单
flux	[flʌks]	*n.* 流量
oceanographer	[⌨əʊʃiə'nɒɡrəfə]	*n.* 海洋学家
dynamics	[dai'næmiks]	*n.* 动力学
concentration	[kɒns(ə)n'treiʃ(ə)n]	*n.* 浓度

symbiotic	[simbai'ɒtik]	*adj.* 共生的、共栖的
stressor	['stresə]	*n.* 胁迫因子
estuarine	['estjʊərain]	*adj.* 江口的、河口的
flora and fauna	['flɔ: rə]&['fɔ: nə]	植物和动物群
marsh	[mɑ: ʃ]	*n.* 沼泽
alteration	[ɔ: ltə'reiʃ(ə)n]	*n.* 改变、变更
degradation	[⌨degrə'deiʃ(ə)n]	*n.* 退化
species	['spi: ʃi: z]	*n.* 物种
emission	[i'miʃ(ə)n]	*n.* 排放、排放物
evaporation	[i⌨væpə'reiʃən]	*n.* 蒸发
solvent	['sɒlv(ə)nt]	*n.* 溶剂
biota	[bai'əʊtə]	*n.* 生物群
habitat	['hæbitæt]	*n.* 栖息地
endangered species		濒危物种
amphibian	[æm'fibiən]	*n.* 两栖动物
contamination	[kən⌨tæmi'neiʃən]	*n.* 污染
arthropod	['ɑ: θrəpɒd]	*n.* 节肢动物
dwelling	['dweliŋ]	*v.* 居住
volcanic	[vɒl'kænik]	*adj.* 火山的

evolution	[⌨i: və'lu: ʃ(ə)n]	*n.* 进化
crust	[krʌst]	*n.* 地壳
hydrology	[hai'drɒlədʒi]	*n.* 水文学
oceanography	[⌨əʊʃə'nɒgrəfi]	*n.* 海洋学
soil erosion		水土流失、土壤侵蚀
surface runoff		地表径流
fluvial geomorphologist		河流地貌学家
sediment	['sedim(ə)nt]	*n.* 沉积、沉淀物
overland flow		坡面流
aquatic	[ə'kwætik]	*adj.* 水生的、水栖的
turbidity	[tɜ: 'bidəti]	*n.* 浊度
organism	['ɔ: g(ə)niz(ə)m]	*n.* 生物

Notes

① the Enlightenment 指 17—18 世纪发生在欧洲的启蒙运动。

② *Silent Spring*《寂静的春天》, 1962 年出版，作者是美国海洋生物学家蕾切尔·卡逊。书中描述了由于农药的大量使用，人类可能将面临一个没有鸟、蜜蜂和蝴蝶的世界。正是这本不寻常的书，唤起了人们的环境意识，开启了全世界环境保护事业。

Exercises

1. Reading Comprehension Check.

Choose the best answer from the options given or fill in the blanks wherever required.

(1) Which of the following is *NOT* included in environmental science? ___________.

A. Biology

B. Chemistry

C. Civil engineering

D. Mathematics

(2) The publication of book ___________ initiated the growing environmental awareness of the public.

(3) According to the passage, computer models are created to simulate ___________.

(4) Describe your understanding on symbiotic or competitive relationship.

(5) The changes of light transmission in the receiving waters is assessed by ___________.

(6) "Population" of organism refer to ___________.

(7) According to the passage, hydrology and oceanography can also be included in _________.

(8) Flora and fauna in the passage can be replaced by ___________.

2. Describe your understanding on environmental science in English.

3. Translate the following passage into Chinese.

Environmental science came alive as a substantive, active field of scientific investigation in the 1960s and 1970s driven by (a) the need for a multi-disciplinary approach to analyze complex environmental problems, (b) the arrival of substantive environmental laws requiring specific environmental protocols of investigation and (c) the growing public awareness of a need for action in addressing environmental problems. Event that spurred this development included the publication of Rachel Carson's landmark environmental book *Silent Spring* and helped increase the visibility of environmental issues and create this new field of study.

4. List all environment-related sciences mentioned in the passage in English.

Reading Material

Environmental Chemistry and Environmental Biochemistry

Environmental chemistry encompasses many diverse topics. It may involve a study of Freon reactions in the stratosphere or an analysis of PCB deposits in ocean sediments. It also covers the chemistry and biochemistry of volatile and soluble organometallic compounds biosynthesized by anaerobic bacteria. Literally thousands of other examples of environmental chemical phenomena could be given.

Environmental chemistry may be defined as *the study of the sources, reactions,* transport, effects, and fates of chemical species in water, soil, air, and living environments, and the effects of technology thereon.

Environmental chemistry is not a new discipline. Excellent work has been done in this field for the greater part of a century. Until about 1970, most of this work was done in academic departments or industrial groups other than those primarily concerned with chemistry. Much of it was performed by people whose basic education was not in chemistry. Thus, when pesticides were synthesized, biologists observed firsthand some of the less desirable consequences of their use. When detergents were formulated, sanitary engineers were startled to see sewage treatment plant aeration tanks vanish under meter-thick blankets of foam, while limnologists wondered why previously normal lakes suddenly became choked with stinking cyanobacteria. Despite these long standing environmental effects, and even more recent and serious problems, such as those from hazardous wastes, relatively few chemists have been exposed to material dealing with environmental chemistry as part of their education.

Environmental Chemistry and the Environmental Chemist

An encouraging trend is that in recent years many chemists have become deeply involved with the investigation of environmental problems. Academic chemistry departments have found that environmental chemistry courses appeal to students, and many graduate students are attracted to environmental chemistry research. Helpwanted ads have included significant numbers of openings for environmental chemists among those of the more traditional chemical subdisciplines. Industries have found that well-trained environmental chemists at least help avoid difficulties with regulatory agencies, and at best are instrumental in developing profitable pollution control products and processes.

Some background in environmental chemistry should be part of the training of every chemistry student. The ecologically illiterate chemist can be a very dangerous species. Chemists must be aware of the possible effects their products and processes might have upon the environment. Furthermore, any serious attempt to solve environmental problems must involve the extensive use of chemicals and chemical processes.

There are some things that environmental chemistry is not. It is not just the same old chemistry with a different cover and title. Because it deals with natural systems, it is more complicated and difficult than “pure” chemistry. Students sometimes find this hard to grasp, and some traditionalist faculty find it impossible. Accustomed to the clear-cut concepts of relatively simple, well-defined, though often unrealistic systems, they may find environmental chemistry to be poorly delineated, vague, and confusing. More often than not, it is impossible to come up with a simple answer to an environmental chemistry problem. But, building on an ever-increasing body of knowledge, the environmental chemist can make educated guesses as to how environmental systems will behave.

Chemical Analysis in Environmental Chemistry

One of environmental chemistry's major challenges is the determination of the nature and quantity of specific pollutants in the environment. Thus, chemical analysis is a vital first step in environmental chemistry research. The difficulty of analyzing for many environmental pollutants can be awesome. Significant levels of air pollutants may consist of less than a microgram per cubic meter of air. For many water pollutants, one part per million by weight (essentially 1 milligram per liter) is a very high value. Environmentally significant levels of some pollutants may be only a few parts per trillion. Thus, it is obvious that the chemical analyses used to study some environmental systems require a very low limit of detection.

However, environmental chemistry is not the same as analytical chemistry, which is only one of the many subdisciplines that are involved in the study of the chemistry of the environment. Although a "brute-force" approach to environmental control, involving attempts to monitor each environmental niche for every possible pollutant, increases employment for chemists and raises sales of analytical instruments, it is a wasteful way to detect and solve environmental problems, degenerating into a mindless exercise in the collection of marginally useful numbers. Those responsible for environmental protection must be smarter than that. In order for chemistry to make a maximum contribution to the solution of environmental problems, the chemist must work toward an understanding of the nature, reactions, and transport of chemical species in the environment. Analytical chemistry is a fundamental and crucial part of that endeavor.

Environmental Biochemistry

The ultimate environmental concern is that of life itself. The discipline that deals specifically with the effects of environmental chemical species on life is environmental biochemistry. A related area, toxicological chemistry, is the chemistry of toxic substances with emphasis upon their interactions with biologic tissue and living organisms. Toxicological chemistry deals with the chemical nature and reactions of toxic substances and involves their origins, uses, and chemical aspects of exposure, fates, and disposal.

(Selected from "Manahan, Stanley E., *Environmental Science, Technology, and Chemistry, Environmental Chemistry*, Boca Raton: CRC Press LLC, 2000")