1 **Introduction to**
Environmental Geology, 5e
Chapter 19
Geology, Society, and the Future

2 **summary in haiku form**
Ten thousand years thence
big glaciers began to melt -
called "global warming."

3 **Case History**
Radon Gas: The Stanley Watrus Story
- In December of 1984, scientists discovered that radon (a radioactive gas) from soil and rock may enter the home and possibly present a serious health hazard
- Stanley Watras lived in Boyertown, PA, the radiation level of the indoor air at his house was 3,200 pCi/l, 800 times higher than the level of 4 pCi/l, a threshold set by the EPA
- Held the highest record in early 1980s, until a home in Whispering Hills, New Jersey, reached a radiation level of 3,500 pCi/l
- Increased awareness of the radon gas problem in the United States since 1985

4 **Environmental Geology and Society**
Overall challenges
- How to balance between economic development and healthy environmental sustainability
- How to form an ecologic equilibrium by meeting the divergent needs of a convergent society
- Ultimate goal for the future: Creating a harmonious state between the general environment and human society

5 **Geology and Environmental Health**
- Disease: An imbalance from poor adjustment of an individual to the environment
-
- Toxicology: Study of poisons/toxins and potential effects on people and ecosystems, as well as associated clinical, economic, industrial, and legal problems
-
- Carcinogen: Toxin that causes cancer
-
- Disastrous effects from minute amount of toxin measured in ppm, ppb, mg/l or pCi/l (radioactive toxin)

6 **Lead in the Environment**
- Lead: An extremely toxic heavy metal causing serious health problems
-
- Effects: Anemia, mental retardation, palsy, and even behavior problems
-
- Lead poisoning: Geologic, cultural, political, and economical factors involved
-
- Sources: In past used in gasoline, paints, some moonshine whiskey, and other products
-
- Widespread lead poisoning suggested for the reason behind the fall of the Roman Empire

7 **Geologic Factors of**
Environmental Health
- Soil: Foundation for agriculture, homes, and industries
-
- Water: Used for drinking, agriculture, and industries
-
- Air: Indispensable for life
-
- “Natural” or “virgin” or “pure” environment not necessarily good as widely perceived

- Human activities: Detrimental or beneficial processes for the environmental quality

8 **Chronic Disease and the Geologic Environment**

- Geologic processes: Operating at geologic time scale
- Diseases: Occurred and measured at biologic time scale
- Fact: Some regional and local variations in chronic diseases
- Challenges: Cause-and-effect hypothesis not specific enough, difficulties in obtaining reliable and comparable data, hard to differentiate environmental causes versus genetic factors
- Know much less about geologic (biogeochemical) influences on chronic disease

9 **Heart Disease and the Geologic Environment**

- Heart disease: Coronary heart disease (CHD) & cardiovascular disease (CVD)
- Possible link between water chemistry and heart disease
- Higher rate of heart disease in communities with relatively soft water, based on studies in Japan, England, Wales, Sweden, and the United States
- Uncertain relationships between water hardness and heart disease, other possible factors

10 **Heart Disease and the Geologic Environment (2)**

- Soft water is more acidic than hard water and may, through corrosion of pipes, release into the water trace elements that cause heart disease
- Some other characteristics of soft water may contribute directly to heart disease
- Some substances dissolved in hard water may help prevent heart disease
- More research is needed

11 **Heart Disease and the Water**

Figure 19.2

12 **Cancer and the Geochemical Environment**

Carcinogenic materials

- Naturally occurring in air (radon gas), soil, and water
- Human activities: Industrial products and processes
- Industrial waste: Threats to water and air quality
- Potential problems with present water treatment using chlorine

13 **Radon Gas**

- Colorless, odorless, and tasteless
- Released from uranium-bearing rocks
- Exposure to radon gas of elevated concentration leading to higher risk of lung cancer, EPA estimated lung cancers death related to exposure to radon gas
- Exposed to both radon gas and tobacco 10 times as hazardous as exposed to either one

- No definitive conclusion on cause-and-effect relationship between lung cancer and radon gas

14 **Geology of Radon Gas**

- The actual amount of radon that reaches the surface of the Earth is related to the concentration of uranium in the rock and soil
- Some regions of the United States contain bedrock with an above-average natural concentration of uranium, PA, NJ, and NY etc.
- Geologic structures, such as shear zones, fracture zones, and faults, commonly enriched with uranium
- The amount of radon gas, escaping from bedrock and soil particles, influenced by water content.
- Movement of radon gas from fractures in rock and pore spaces in soil facilitated by relatively low moisture content

15 **How Radon Gas May Enter Homes**

Figure 19.C

16 **Reducing Concentrations of Radon**

- Improve the home ventilation
-
- Locate and stop the entry point of radon gas to homes
-
- Construct a venting system
-
- Recognizing the whole picture and knowing that the problem solvable

17 **Air Pollution: Geologic Perspective**

- Pollutants in the atmosphere → pollutants in the hydrologic and geochemical cycles
-
- Air pollution: Serious health hazard in many large cities
-
- Effects on human artifacts: Effects of air pollution on buildings and monuments
-
- Aesthetic effects: Reducing visual range and atmospheric clarity

18 **Sources of Air Pollution**

- Stationary
  - Point sources: Discreet and defined location, such as power plant
  - Fugitive sources: From an open area such as construction site, farmland
  - Area sources: Several sources within a well-defined area, such as an urban area
-
- Mobile
  - Moving sources, such as automobiles, aircrafts

19 **Air Pollutants**

- Physical state
  - Gaseous form: SO_2, NO_x , CO, O_3, volatile organic compounds (VOCs)
  - Solid or liquid form: Particulates, PM 10 (less than 10 µm or PM 2.5 (less than 2.5 µm)
  -
- Air Toxins: Pollutants causing cancer or other serious health problems
  -
- Pathway to air
  - Primary pollutants: Emitted directly into the air
  - Secondary pollutants: From the reactions of primary pollutants with atmospheric compounds

20

Table 19.1

21 **Particulate Matter**
- PM 2.5 and PM 10: Diameters less than 2.5 μm and 10 μm respectively
-
- 90 percent particulates from natural resources
-
- Sources: Desertification, volcanic eruption, fire, and farm lands
-
- Industrial sources: Asbestos dust and heavy metals (As, Cu, Pb, Zn)

22 **Urban Air Pollution**
- Air pollution not distributed uniformly, mostly concentrated around urban areas
-
- Sources of pollution: In and around urban areas such as automobiles, industry emission
-
- Form of air pollution: Urban smog
-
- Affected by meteorology and topography

23 **Influence Factors in Urban Air Pollution**
- Sources and emission rates of pollution
-
- Topography: Mountains as barriers for air movement, forming temp inversion layer and promoting pollution over certain areas
-
- Atmospheric conditions: Temperature, cloud cover, and wind affecting the transportation or dispersion of pollutants

24 **Potential for Urban Air Pollution**

Depends on several factors
- Rate of pollutant emissions
- Distance of air mass moving through urban air pollution source
- Speed and duration of the wind
- Height of the mixing layer

25 **Indoor Air Pollution**
- Environmental health hazards at homes and workplaces
-
- A variety of substances: Smoke, chemicals, microbes, and radon
-
- Different sources: Asbestos insulation fibers, wood products, poisonous gases—carbon monoxide and nitrogen dioxide, paint, cleaning chemicals

26 **Waste Management**
- The United States and the rest of the world face a tremendous solid waste disposal problem
-
- Urban waste disposal running out of space, half the cities in the United States
-
- Cost for landfill disposal skyrocketed, $20 billion plus industry
-
- Too much and too many kinds of waste produced in modern societies
-
- Issues about social justice and environmental justice

27 **Integrated Waste Management**
- IWM emerged in 1980s
-
- Including reduction, recycling, reuse, composting, landfill, and incineration

-
- Three Rs approach (reduction, recycle, reuse): Reducing urban refuse by 50 percent
-
- More notable success with recycling, but less successful with reducing waste production

28 **Materials Management**

- Combining sustainable use of materials with resources conservation
-
- New goal: “zero waste” known as industrial ecology
-
- Industrial ecosystem: Producing natural urban and industrial ecosystem through material management, waste from one part of the system as a resource for another part

29 **Materials Management: Extension**

- Eliminating subsidies for extraction of virgin materials, timber, minerals, etc.
-
- Establishing “green building” incentives
-
- Financial incentives or penalties for certain industrial practices for or against the principles of materials management
-
- Financial incentives for the “three Rs” practices

30 **Solid Waste Disposal**

Solid waste (SW)

- Primarily an urban problem
-
- Paper by far the most abundant solid waste
-
- Plastics: 60 percent increase since 1986
-
- Much toxic and infectious wastes: Disposed in large urban landfills

31 **Solid Waste: Sanitary Landfills**

- Defined by the American Society of Civil Engineering, emerged in 1930s
-
- Potential hazards: Leachate entering water system
-
- The concentration of pollutants in leachate much higher than in raw sewage
-
- Uncontrolled production and release of methane gas, growing trend in producing and selling methane as a resource

32 **Landfill Site Selection**

Site selection factors

- Topographic relief
- Location of the groundwater table: Above water table disposal of the waste in the clay soil of low hydraulic conductivity
- Amount of precipitation: Best sites in arid regions
- Type of soil and rock materials at the site
- Location: Away from surface and GW flow system

33 **Landfill Design**

Modern design of the landfills

- Complex system: Multiple-barrier approach
-
- Components: Compacted clay liner or synthetic liner, leachate and methane collection system, and a compacted clay cap

•
• A system of monitoring wells and other devices to ensure intended safe operation

34

Figure 19.10

35 **Hazardous Waste Management**

• HW: Toxic, inflammable, corrosive, chemically unstable
•
• Approximately 1,000 new chemicals marketed annually
•
• About 50,000 chemicals currently on the market
•
• The United States currently generating more than 150 million metric tons of hazardous waste each year
•
• Uncontrolled or illegal dumping in the past

36 **Hazardous Waste Management**

Table 19.4

37 **HW: Responsible Management**

• Resource Conservation and Recovery Act (RCRA) of 1976
  – Identify hazardous waste and their life cycles
  – Cradle-to-grave control
•
• Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) of 1980 and the Superfund Amendment and Reauthorization Act (SARA) of 1986
  – Superfund for clean up abandoned hazardous disposal sites

38 **HW: Responsible Management**

• Many hazardous chemical waste management
options such as recycling, on-site processing, high temperature decomposition, etc.
•
• Surface impoundment: Monitor risk of air and water pollution
•
• Deep well disposal: Consider earthquake risks
•
• Incineration of hazardous chemical waste
•
• Secure landfill

39 **Hazard Waste: Secure Landfill**

Figure 19.13

40 **Environmental Planning: Site Selection**

• Site selection: Evaluation process to see if the environment supports human activities
•
• Set site-selection criteria: Ensure site developments compatible with both the possibilities and the limitations of the natural environment
•
• Providing geologic info: Crucial info on rock types, rock structure, soil properties, hydrologic characteristics, topography, and hazardous events
•
• Environmental engineering perspectives on testing, design, and prediction

41 **Environmental Impact Analysis (1)**

• 1969 National Environmental Policy Act (NEPA)
•
• Environmental Impact Statements (EIS) for all

federal actions: Potential impact on the quality of the human environment

-
- Scoping: Identifying important environmental issues to be evaluated in detail
-
- Mitigation: Identifying action plans to avoid, lessen, or compensate for anticipated adverse environmental impacts of the project

42 **Environmental Impact Analysis (2)**

- Negative declarations
- Filed when a particular project viewed not to cause a significant adverse environmental impact
-
- Provide detail info to support the contention of no significant negative impact on the environment
-
- Present a complete and comprehensive statement regarding potential environmental problems

43 **Land Use Planning**

- Conversion of agricultural lands to urban development intensifying existing urban environmental problems
-
- Good land-use planning essential for
  - Sound economic development
  - Avoiding hazards and conflicts between different land uses
  - Managing land and resources efficiently
  - Maintaining a sustainable high quality of life

44 **Land Use Planning Process**

- Identify and define issues, problems, goals, and objectives
- Collect, analyze, and interpret data on hazards and resources
- Develop and test alternatives
- Formulate land use plans
- Review, adopt, and implement plans
- Revise and amend plans

45 **Land-Use Planning Process**

Figure 19.15

46 **Scenic Resources**

- Scenery in the United States recognized as natural resource since 1864, when the first park established
-
- Landscapes' varying degrees of scenic value recognized by general public
-
- Growing awareness of and concern for the scenic values of the “everyday” nonurban landscape beyond traditional views of recreation and preservation

47 **Sequential Land Use**

- Sequential land use versus traditional permanent and exclusive land use practice
-
- Conform with the general principle “the effects of land use are cumulative”
-
- Responsible land use: Obligation to future generations and land reclamation after waste disposal or mining

48 **Multiple Land Use**

- Use land for multiple purposes, e.g.,
  - Forests for recreation and timber harvesting

– Reservoirs for irrigation, flood control, fishery, and recreation

- Meet the challenges of maximizing benefits for multiple land-use purposes
- Require well-thought, comprehensive land-use planning

49 **Environmental Law**

- Important for environmental planning implementation and problem solving
- Emerging focus: Emphasis on problem solving, mediation through negotiation
- The process of law: Consultation, negotiation, and mediation have proven more successful than traditional confrontational and adversarial strategies
- Important to recognize the difference between comprehensive collaboration and simple compromise

50 **Geology, the Environment, and the Future**

Avoiding an environmental crisis (Lester Brown)

- Avoid a potential food shortage for the near and intermediate term
- Control global population growth
- Conserve and sustain water resources, especially groundwater
- Control carbon emission and global warming

51 **Attaining Sustainability for the Future**

- Ensure our renewable resources available for future generations
- Evaluate and adjust values and lifestyles
- Set sustainable development as a global issue and priority
- Make a long-term plan: Proactive prevention, rather than reactive problem solving after surprises or shocks

52 **Critical Thinking Topics**

- For the region in which you live, identify potential hazardous wastes that are produced by homes, businesses, and industry or agriculture
- Do you think the steps stated by Lester Brown are necessary to avoid an environmental crisis?
- Discuss how an environmental crisis in China would affect the global environment. What could China do to avoid some of the environmental damages of industrial growth?
- What are the critical relationships between geology, environment, and the future?

53 **Chapter 19 figures follow...**

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97 **End of Chapter 19**