ENGS-37
INTRODUCTION to
ENVIRONMENTAL ENGINEERING
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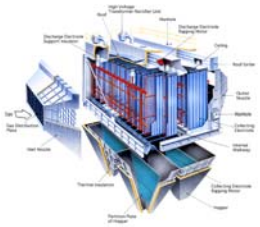


"Pollution" by Tom Lehrer (1965)

"Time was when an American about to go abroad would be warned by his friends or the guidebooks not to drink the water. But times have changed and now a foreigner coming to this country might be offered the following advice.

If you visit American city,
You will find it very pretty.
Just two things of which you must beware:
Don't drink the water and don't breathe the air.

Pollution, pollution,
They got smog and sewage and mud.
Turn on your tap and get hot and cold running crud.

See the halibuts and the sturgeons
Being wiped out by detergents.
Fish gotta swim and birds gotta fly,
But they don't last long if they try.

Pollution, pollution,
You can use the latest toothpaste,
And then rinse your mouth with industrial waste.

Just go out for a breath of air,
And you'll be ready for Medicare.
The city streets are really quite a thrill.
If the hoods don't get you, the monoxide will.

Pollution, pollution,
Wear a gas mask and a veil.
Then you can breathe, long as you don't inhale.

Lots of things there that you can drink,
But stay away from the kitchen sink.
The breakfast garbage that you throw in to the Bay,
They drink at lunch in San Jose.

So go to the city, see the crazy people there.
Like lambs to the slaughter,
They're drinking the water
And breathing <cough> *the air."*

A river on fire!!!

Photo credit: NOAA

The Cuyahoga River in Ohio was so heavily polluted with hydrocarbons that it caught on fire several times.

The largest river fire was in 1952 (picture above) causing significant damage to boats and a riverfront office building.

Fires erupted on the river several more times including 22 June 1969, when the fire caught the attention of the media. Time magazine described the Cuyahoga as a river that "oozes rather than flows" and in which a person "does not drown but decays."

So, yes, we have had problems, some quite acute, and we subsequently established the U.S. Environmental Protection Agency (EPA) in 1970 and passed several major pieces of legislation, notably:
- the Clean Air Act (1970, significantly amended in 1990),
- the Clean water Act (1972, with amendments in 1977 & 1987), and
- the Resource Conservation & Recovery Act (1976).

But it will never be perfect.
We need, among others, some ENVIRONMENTAL ENGINEERS.

In your opinion, what does an environmental engineer do?

Definition:

Environmental engineers protect the health and well-being of the public by minimizing the release and impact of pollutants into the air, land, and water.

(Mines & Lackey, 2009, page 2)

More comprehensive definition:

The environmental engineer is a professional trained in the art of applying scientific principles and technological means to avoid or reduce forms of pollution by human activities.

This includes possessing a knowledge of past and current engineering practice and an ability to innovate. Further, s/he is a *professional*, meaning that s/he is not only applying knowledge but also bearing responsibility and using judgment.

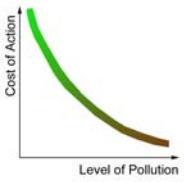
What is Environmental Engineering?

The discipline is largely defined by problems rather than by technical/scientific methods.

Typical activities (read "jobs"!):
- Clean-up of a contaminated site (= fixing the past),
- Control by treatment of a dirty effluent (= dealing with the present),
- Prevention of pollution (= planning for the future).

This requires much breadth and interdisciplinarity:
- Systems thinking, various engineering disciplines, even non-engineering disciplines.

Challenges:
- Increase in population and affluence → increasing amounts of waste
- Tendency to move one waste from one phase to another
  (*ex*. air to water or water to solid waste)
- Prevention harder than treatment
- Environmental benefit versus economic burden (trade-off).



Environmental remediation

= fixing the past by cleaning up contaminated areas after wastes have been released into the environment.

http://www.lenoci.hu/projects.htm

Environmental remediation typically focuses on toxic and hazardous substances and involves far higher costs than those associated with effluent treatment prior to discharge. There are also legal expenses associated with litigation, often concerning responsibility.

Environmental remediation involves chemical reaction, physical separation, or a combination of these, and may be carried out either by removing contaminated material for treatment/disposal at a separate location or in some cases may be accomplished in place ("*in situ*") without such removal.

Treatment and transportation of hazardous materials is a highly regulated activity in the U.S. and many other countries.

Effluent-treatment technology

= handling the present by designing devices that treat effluents that would otherwise pollute the environment.

http://www.indiamart.com/enhanceenvirotech/

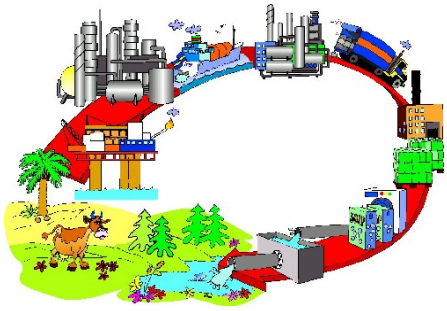
Effluent-treatment technologies involve reaction, separation, or a combination of these, and may be considered for pollutants arising in all phases of matter: gaseous, liquid, and solid.

Frequently, a given effluent treatment technology can be applied to wastes arising from a wide diversity of processes. Thus for example, the design principles for an activated sludge treatment system are largely the same whether the system is treating domestic sewage or wastewater after manufacture of chemicals, paper, or food products.

Distinction needs to be made between so-called *point sources* (such as a power plant) and *distributed sources* (such as traffic and agricultural runoff). Treatment of effluent from distributed sources is far more complicated than that from point sources.

Sustainable Engineering

= planning for the future at the company's scale by consideration of material and energy flows associated with industrial activity.



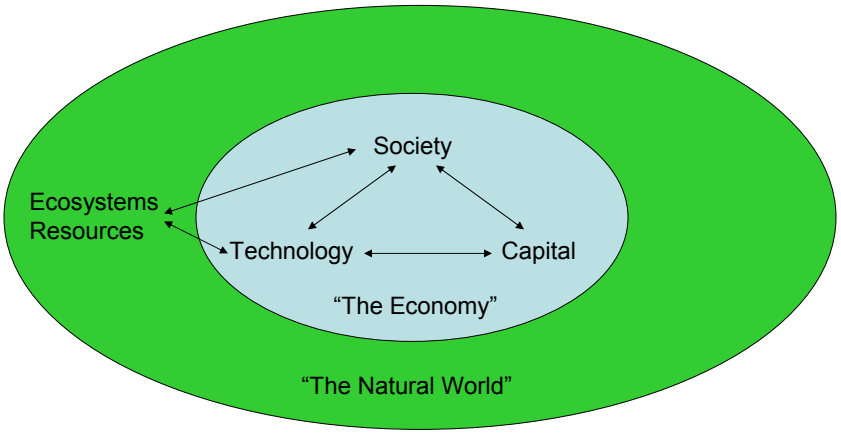
http://www.dantes.info/Tools&Methods/Environmentalassessment/enviro_asse_lca.html

Frequently "industrial ecology" focuses on analyzing the life cycle of a particular product from resource extraction, to manufacture (which may involve multiple steps and is often a primary focus of industrial ecology), use (often by individual consumers), and disposal (including recycling).

The concept of designing products and processes to minimize environmental impacts is a central element of sustainable engineering.

Sustainable Engineering, cont'd

Necessary to the sustainability objective is a global outlook of the *economy* on one hand and of *nature* on the other. Central concerns include the depletion of non-renewable resources on the upstream side and climate change on the downstream side of our industrial activities.



Business as usual won't do. It is unsustainable, both in terms of
- procurement of new resources (upstream end)
- environmental capacity to absorb our consequences (downstream end).

This course is not about convincing you of this. Evidence is shown elsewhere.

Way out? Make our actions, products, industry, *etc*. sustainable, that is, mindful of the future (future human generations, survivability of the rest of the planet).

Consider this:
- Engineers are responsible for the Industrial Revolution.
- The Industrial Revolution has reached across the globe.
- There is a growing set of negative consequences, some local, some global.

Thus, it stands to reason that engineers are called to play a central role in
- amending current technological practices, and
- designing and deploying sustainable technologies.

Note: This does not require a return to the distant past.
A healthy (functional) planet is not necessarily a pristine (untouched) planet.

Table / 1.5

Vocabulary of the Industrial Revolution and Sustainability Revolution

Industrial Revolution	Sustainability Revolution
~~Nonrenewable energy~~ Fossil fuels	Renewable energy
Waste	Efficiency
Climate change	Ecological restoration
Consumption	Resource equity
Accumulation	Social and environmental justice
Toxicity, smog, persistent organic pollutants, endocrine disruptors	Green chemistry
Transportation	Accessibility
Concrete hydraulic channels	Low-impact storm water development, rain gardens
Urban heat island effect	Green roofs
Bioaccumulation	Biodiversity
Industrial design	Green design
Gross national product (GNP)	Index of sustainable economic welfare, environmental sustainability index, genuine progress indicator

Source:
Mihelcic & Zimmerman, 2010

Yet to be defined!

Structure of the course

Context & Motivation
- the role of engineers in sustainability

Preliminaries
- Relevant quantities (concentrations and such)
- Chemical, biological and ecological concepts
- Risk assessment
- Modeling: Material balances & transport processes

Forms of Pollution & Treatment Technologies
- Water pollution → water-treatment technologies
- Air pollution → air-quality technologies

Prevention methods → "Sustainable Engineering"
- Green design
- Green buildings
- Energy conservation & renewable forms of energy

Example of past local problems

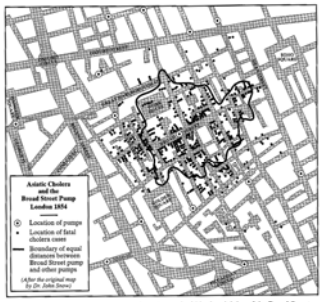


Figure 1.B.1 Map showing cholera victims clustered within the vicinity of the Broad Street pump in London, 1854 (Cosgrove, 1909).

Cholera outbreak in London in 1854. John Snow, medical doctor, tracked the infection to a single well on Broad Street. Solution: He convinced the city officials to remove the pump handle.

Pittsburgh in 1906

Photograph: Hans Deryk/Reuters

Deepwater Horizon oil spill in Gulf of Mexico April-July 2010

Shift in patterns

20th Century Environmental Issues	21st Century Environmental Issues
Local	Global
Acute	Chronic
Obvious	Subtle
Immediate	Multigenerational
Discrete	Complex

(*Source*: Mihelcic & Zimmerman, 2010, page iii)

Major challenges for the 21st Century
(those implicating engineers)

- Fresh water supply (esp. for agriculture)

- Running out of oil
- Climate change

} - Energy

- Mounting solid waste