Syllabus
Foundation Course in Environmental Science

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Tutorial – PAPER 4 - Foundation Course in Environmental Science

- What is environmental science?

Environmental science is an interdisciplinary academic field that integrates physical, biological and information sciences (including ecology, biology, physics, chemistry, zoology, mineralogy, oceanology, limnology, soil science, geology, atmospheric science, 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 Enlightenment. Today it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems.

- Ecology and environmentalism

Ecology is the actual study of living systems and the way that various organisms and flora and fauna interact and support one another. It is not nearly as focused on individual organisms or the past history of various organisms but much more on the present and the way various organisms interact.

Environmentalism is focused on the preservation of or conservation of various types of environments or ecosystems. It is much less scientific and much more

- Formation and structure of the Earth

The interior structure of the Earth is layered in spherical shells, like an onion. These layers can be defined by their chemical and their rheological properties. Earth has an outer silicate solid crust, a highly viscous mantle, a liquid outer core that is much less viscous than the mantle, and a solid inner core. Scientific understanding of the internal structure of the Earth is based on observations of topography and bathymetry, observations of rock in outcrop, samples brought to the surface from greater depths by volcanoes or volcanic activity, analysis of the seismic waves that pass through the Earth, measurements of the gravitational and magnetic fields of the Earth, and experiments with crystalline solids at pressures and temperatures characteristic of the Earth's deep interior.

The structure of Earth can be defined in two ways: by mechanical properties such as rheology, or chemically. Mechanically, it can be divided into lithosphere, asthenosphere, mesospheric mantle, outer core, and the inner core. Chemically, Earth can be divided into the crust, upper mantle, lower mantle, outer core, and inner core. The geologic component layers of Earth are at the following depths below the surface:

Depth		
Kilometres	Miles	**Layer**
0–60	0–37	Lithosphere (locally varies between 5 and 200 km)
0–35	0–22	… Crust (locally varies between 5 and 70 km)
35–60	22–37	… Uppermost part of mantle
35–2,890	22–1,790	Mantle
210-270	130-168	… Upper mesosphere (upper mantle)
660–2,890	410–1,790	… Lower mesosphere (lower mantle)
2,890–5,150	1,790–3,160	Outer core
5,150–6,360	3,160–3,954	Inner core

The layering of Earth has been inferred indirectly using the time of travel of refracted and reflected seismic waves created by earthquakes. The core does not allow shear waves to pass through it, while the speed of travel (seismic velocity) is different in other layers. The changes in seismic velocity between different layers causes refraction owing to Snell's law, like light bending as it passes through a prism. Likewise, reflections are caused by a large increase in seismic velocity and are similar to light reflecting from a mirror.

- The formation of rocks, minerals, and geologic structures

When the Earth and other planets accreted around 4.5-4.6 billion years ago, they contained a mixture of all the elements, and the relative abundances probably reflected the cosmic abundances indicated by spectroscopic studies. What happened to that mixture once the Earth started to heat up and differentiate? Basically, whenever chemical elements (atoms) are brought together there is a tendency for them to react with each other and to form compounds. How this works exactly is the subject of thermodynamics or physical chemistry, a subdiscipline of chemistry. Thermodynamics allows us to calculate the outcome of chemical reactions when we bring certain substances together.

What kind of compounds form in a given mixture of elements depends in part on their relative abundance, and in part on whether a given combination produces an energy-releasing reaction (exothermic, for example when gasoline combines with oxygen and explodes), or whether it requires energy input to react (endothermic, for example the synthesis of ammonia from nitrogen and hydrogen).

The material that was displaced into the mantle during formation of the iron core contained abundant oxygen, silica, magnesium, iron, aluminum, and calcium (plus smaller quantities of a range of other elements) and under the pressures and temperatures that prevail there, chemical reactions (following the laws of thermodynamics) produce compounds that are known as olivine and pyroxene. During formation of the crust, other compounds, in particular feldspars and quartz were common reaction products. The atoms and molecules in these compounds are present in compound-specific proportions, and they are not randomly distributed. Instead, they show very specific geometric arrangements. These compounds that make up the crust and mantle are commonly known to us as minerals.

Minerals, the building blocks of rocks, are inorganic solids with a specific internal structure and a definite chemical composition (varies only within a narrow range). They can form under a variety of conditions, such as:

- A) during the cooling of molten materials (steel, from lavas, igneous rocks).
- B) during the evaporation of liquids (salt, sugar, reference to evaporites)
- C) the cooling of liquids (saturated solution)
- D) at high temperatures and pressures new crystals may grow in solid materials (diamonds from coal, metamorphism)

- Weathering

Weathering is the breaking down of rocks, soil, and minerals as well as wood and artificial materials through contact with the Earth's atmosphere, waters, and biological organisms. Weathering occurs in situ (on site), that is, in the same place, with little or no movement, and thus should not be confused with erosion, which involves the movement of rocks and minerals by agents such as water, ice, snow, wind, waves and gravity and then being transported and deposited in other locations.

- Coasts, estuaries, sea levels

An estuary is a partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea.

Estuaries form a transition zone between river environments and maritime environments. They are subject both to marine influences—such as tides, waves, and the influx of saline water—and to riverine influences—such as flows of fresh water and sediment. The inflows of both sea water and fresh water provide high levels of nutrients both in the water column and in sediment, making estuaries among the most productive natural habitats in the world.

Most existing estuaries formed during the Holocene epoch with the flooding of river-eroded or glacially scoured valleys when the sea level began to rise about 10,000–12,000 years ago. Estuaries are typically classified according to their geomorphological features or to water-circulation patterns. They can have many different names, such as bays, harbors, lagoons, inlets, or sounds, although some of these water bodies do not strictly meet the above definition of an estuary and may be fully saline.

The banks of many estuaries are amongst the most heavily populated areas of the world, with about 60% of the world's population living along estuaries and the coast. As a result, many estuaries suffer degradation by many factors, including sedimentation from soil erosion from deforestation, overgrazing, and other poor farming practices; overfishing; drainage and filling of wetlands; eutrophication due to excessive nutrients from sewage and animal wastes; pollutants including heavy metals, polychlorinated biphenyls, radionuclides and hydrocarbons from sewage inputs; and diking or damming for flood control or water diversion

- Energy from the Sun

Every day, the sun radiates (sends out) an enormous amount of energy. It radiates more energy each day than the world uses in one year. Solar energy is a renewable energy source.
The sun’s energy comes from within the sun itself. Like most stars, the sun is made up mostly of hydrogen and helium atoms in a plasma state. The sun generates energy from a process called nuclear fusion.

During nuclear fusion, the high pressure and temperature in the sun's core cause nuclei to separate from their electrons. Hydrogen nuclei fuse to form one helium atom. During the fusion process, radiant energy is released. It can take 150,000 years for energy in the sun's core to make its way to the solar surface, and then just a little over eight minutes to travel
the 93 million miles to Earth. The radiant energy travels to the Earth at a speed of 186,000 miles per second, the speed of light.
Only a small portion of the energy radiated by the sun into space strikes the Earth, one part in two billion. Yet this amount of energy is enormous. The sun provides more energy in an hour than the United States can use in a year! About 30 percent of the radiant energy that reaches the Earth is reflected back into space. About half of the radiant energy is absorbed
by land and oceans. The rest is absorbed by the atmosphere and clouds in the greenhouse effect.
In addition to supplying a large amount of energy directly, the sun is also the source for many different forms of energy. Solar energy powers the water cycle, allowing us to harness the energy of moving water. Solar energy drives wind formation, allowing us to use wind turbines to transform kinetic energy into electricity. Plants use solar energy in the process of hotosynthesis. Biomass can trace its energy source back to the sun. Even fossil fuels originally received their energy from the sun.

How We Use Solar Energy
People have harnessed solar energy for centuries. As early as the seventh century BCE, people used basic magnifying glasses to focus light from the sun to make fire. Over a century ago, a scientist in France used a solar collector to make steam to power an engine. Solar water heaters gained popularity in the early 1900's in the southwest United States. Today, people use solar energy to heat buildings and water and to generate electricity. In 2014, solar energy accounted for just over 0.4 percent of U.S. energy consumption – less than one percent! The top producing solar energy states include many of the sunny, warm states in the western United States

- The greenhouse effect

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without its atmosphere.

If a planet's atmosphere contains radiatively active gases (i.e., greenhouse gases) the atmosphere will radiate energy in all directions. Part of this radiation is directed towards the surface, warming it. The downward component of this radiation – that is, the strength of the greenhouse effect – will depend on the atmosphere's temperature and on the amount of greenhouse gases that the atmosphere contains.

- The evolution, composition, and structure of the atmosphere

The atmosphere of Earth is the layer of gases, commonly known as air, that surrounds the planet Earth and is retained by Earth's gravity. The atmosphere of Earth protects life on Earth by absorbing ultraviolet solar radiation, warming the surface through heat retention (greenhouse effect), and reducing temperature extremes between day and night (the diurnal temperature variation).

By volume, dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapor, on average around 1% at sea level, and 0.4% over the entire atmosphere. Air content and atmospheric pressure vary at different layers, and air suitable for use in photosynthesis by terrestrial plants and breathing of terrestrial animals is found only in Earth's troposphere and in artificial atmospheres.

- Oceans, gyres, currents

A gyre in oceanography is any large system of circulating ocean currents, particularly those involved with large wind movements. Gyres are caused by the Coriolis effect; planetary vorticity along with horizontal and vertical friction, determine the circulation patterns from the wind curl (torque). The term gyre can be used to refer to any type of vortex in the air or the sea, even one that is man-made, but it is most commonly used in oceanography to refer to the major ocean systems.

- Weather and climate

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time.

When we talk about climate change, we talk about changes in long-term averages of daily weather. Today, children always hear stories from their parents and grandparents about how snow was always piled up to their waists as they trudged off to school. Children today in most areas of the country haven't experienced those kinds of dreadful snow-packed winters, except for the Northeastern U.S. in January 2005. The change in recent winter snows indicate that the climate has changed since their parents were young.

- Glacials,interglacials,and interstadials

A glacial period (alternatively glacial or glaciation) is an interval of time (thousands of years) within an ice age that is marked by colder temperatures and glacier advances. Interglacials, on the other hand, are periods of warmer climate between glacial periods. The last glacial period ended about 15,000 years ago.

The Holocene epoch is the current interglacial. A time when there are no glaciers on Earth is considered a greenhouse climate state.

An interglacial period (or alternatively interglacial, interglaciation) is a geological interval of warmer global average temperature lasting thousands of years that separates consecutive glacial periods within an ice age. The current Holocene interglacial began at the end of the Pleistocene, about 11,700 years ago.

Stadials and interstadials are phases dividing the Quaternary period, that last 2.6 million years. Stadial are colder periods and interstadials are warmer.

- Dating methods

  Chronological dating, or simply dating, is the process of attributing to an object or event a date in the past, allowing such object or event to be located in a previously established chronology. This usually requires what is commonly known as a "dating method". Several dating methods exist, depending on different criteria and techniques, and some very well known examples of disciplines using such techniques are, for example, history, archaeology, geology, paleontology, astronomy and even forensic science, since in the latter it is sometimes necessary to investigate the moment in the past in which the death of a cadaver occurred.

- Climate change

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have been identified as primary causes of ongoing climate change, often referred to as global warming.

- Fresh water

Fresh water is naturally occurring water on Earth's surface in ice sheets, ice caps, glaciers, icebergs, bogs, ponds, lakes, rivers and streams, and underground as groundwater in aquifers and underground streams. Fresh water is generally characterized by having low concentrations of dissolved salts and other total dissolved solids. The term specifically excludes seawater and brackish water although it does include mineral-rich waters such as chalybeate springs. The term "sweet water" (from Spanish "agua dulce") has been used to describe fresh water in contrast to salt water. The term fresh water does not have the same meaning as potable water. Much of the surface fresh water and ground water is unsuitable for drinking without some form of purification because of the presence of chemical or biological contaminants.

- Irrigation, waterlogging, and salinization

Excess water in the plant root zone restricts the aeration required for optimum plant growth. It may affect the availability of several nutrients by changing the environment around the roots.

Excess salts in the root zone inhibit water uptake by plants, affect nutrient uptake and may result in toxicities due to individual salts in the soil solution. Excess exchangeable sodium in the soil may destroy the soil structure to a point where water penetration and aeration of the roots become impossible. Sodium is also toxic to many plants.

Waterlogging and salinity in the soil profile are most often the result of high water tables resulting from inadequate drainage or poor quality irrigation water. Adequate surface drainage allows excess irrigation and rain water to be evacuated before excess soil saturation occurs or before the water is added to the water table. Adequate subsurface drainage insures that water tables are maintained at a sufficient depth below the soil surface to prevent waterlogging and salt accumulation in the root zone. Salinization of the soil profile is prevented because upward capillary movement of water and salts from the water table does not reach the root zone. Adequate subsurface drainage also allows salts to be removed from the soil profile through the application of excess irrigation water (leaching).

To understand how we may prevent, eliminate or otherwise deal with a waterlogging or salinity problem, we must first understand how crops and soils respond to excess water and salts.

- Biosphere, biomes

The biosphere (from Greek βίος bíos "life" and σφαῖρα sphaira "sphere") also known as the ecosphere (from Greek οἶκος oîkos "environment" and σφαῖρα), is the worldwide sum of all ecosystems. The two joined words are "bio" and "sphere". It can also be termed as the zone of life on Earth, a closed system (apart from solar and cosmic radiation and heat from the interior of the Earth), and largely self-regulating. By the most general biophysiological definition, the biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, geosphere, hydrosphere, and atmosphere. The biosphere is postulated to have evolved, beginning with a process of biopoiesis (life created naturally from nonliving matter, such as simple organic compounds) or biogenesis (life created from living matter), at least some 3.5 billion years ago

A **biome** is a community of plants and animals that have common characteristics for the environment they exist in, and can be found over a range of continents. Spanning continents, biomes are distinct biological communities that have formed in response to a shared physical climate. "Biome" is a broader term than "habitat"; any biome can comprise a variety of habitats.

- Nutrient cycles

A nutrient cycle (or ecological recycling) is the movement and exchange of organic and inorganic matter back into the production of living matter. The process is regulated by food web pathways that decompose matter into mineral nutrients. Nutrient cycles occur within ecosystems. Ecosystems are interconnected systems where matter and energy flows and is exchanged as organisms feed, digest, and migrate about. Minerals and nutrients accumulate in varied densities and uneven configurations across the planet. Ecosystems recycle locally, converting mineral nutrients into the production of biomass, and on a larger scale they participate in a global system of inputs and outputs where matter is exchanged and transported through a larger system of biogeochemical cycles.

- Respiration and photosynthesis

The relationship between photosynthesis and cellular respiration is such that the products of one system are the reactants of the other. Photosynthesis involves the use of energy from sunlight, water and carbon dioxide to produce glucose and oxygen. Cellular respiration uses glucose and oxygen to produce carbon dioxide and water. To emphasize this point even more, the equation for photosynthesis is the opposite of cellular respiration.

Humans, animals and plants depend on the cycle of cellular respiration and photosynthesis for survival. The oxygen produced by plants during photosynthesis is what humans and animals inhale for the blood to transport to the cells for respiration. The carbon dioxide produced during respiration is released from the body and absorbed by plants to help provide the energy they need for growth and development. This is the never ending cycle that sustains life on earth.

- Wildlife conservation

Conservation is the practice of protecting wild plant and animal species and their habitats. The goal of wildlife conservation is to ensure that nature will be around for future generations to enjoy and also to recognize the importance of wildlife and wilderness for humans and other species alike. Many nations have government agencies and NGO's dedicated to wildlife conservation, which help to implement policies designed to protect wildlife. Numerous independent non-profit organizations also promote various wildlife conservation causes.

According to the National Wildlife Federation, wildlife in the United States gets a majority of their funding through appropriations from the federal budget, annual federal and state grants, and financial efforts from programs such as the Conservation Reserve Program, Wetlands Reserve Program and Wildlife Habitat Incentives Program. Furthermore, a substantial amount of funding comes from the state through the sale of hunting/fishing licenses, game tags, stamps, and excise taxes from the purchase of hunting equipment and ammunition, which collects around $200 million annually.

Wildlife conservation has become an increasingly important practice due to the negative effects of human activity on wildlife. An endangered species is defined as a population of a living species that is in the danger of becoming extinct because of several reasons.Some of The reasons can be, that 1. the species have a very low population, or 2. they are threatened by the varying environmental or prepositional parameters

- Pest control

Pest control refers to the regulation or management of a species defined as a pest, and can be perceived to be detrimental to a person's health, the ecology or the economy. A practitioner of pest control is called an exterminator.

- Restoration ecology

Restoration ecology emerged as a separate field in ecology in the 1980s. It is the scientific study supporting the practice of ecological restoration, which is the practice of renewing and restoring degraded, damaged, or destroyed ecosystems and habitats in the environment by active human intervention and action. Restoration ecology is therefore commonly used for the academic study of the process, whereas ecological restoration is commonly used for the actual project or process by restoration practitioners.

- World conservation strategies

The World Conservation Strategy was published by the International Union for Conservation of Nature and Natural Resources (IUCN), United Nations Environment Programme (UNEP) and the World Wide Fund for Nature (WWF) in 1980. Its main objectives are:
(a) to maintain essential ecological processes and life support systems,

(b) to preserve genetic diversity, and
(c) to ensure the sustainable utilization of species and ecosystems.

- Pollution control

Pollution is the introduction of contaminants into the natural environment that cause adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat or light. Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants. Pollution is often classed as point source or nonpoint source pollution.

- Hazardous waste

Hazardous waste is waste that poses substantial or potential threats to public health or the environment. In the United States, the treatment, storage, and disposal of hazardous waste are regulated under the Resource Conservation and Recovery Act (RCRA). Hazardous wastes are defined under RCRA in 40 CFR 261 where they are divided into two major categories: characteristic wastes and listed wastes.

Characteristic hazardous wastes are materials that are known or tested to exhibit one or more of the following four hazardous traits:
ignitability
reactivity
corrosivity
toxicity