# COURSE CODE: EMT 309

# COURSE TITLE: ENVIRONMENTAL GEOSCIENCES

## COURSE GUIDE

NATIONAL OPEN UNIVERSITY OF NIGERIA

## Introduction

Environmental Geosciences is a two credit unit course. It will be available to all students to take as a core course for the award of B. Sc. (Hons) in Environmental Sciences and Toxicology. It is also appropriate for those interested in understanding geoscientific relationships in the environment.

Environmental geoscience is an interdisciplinary and multidisciplinary course among the various disciplines of sciences such as: ecology, biology, chemistry, physics, plant science, zoology, mineralogy, petrology, geology, petroleum science, soil science, and agricultural sciences).

## Course Aim

The main aim of this course is to advance our understanding of earth science and related natural and man-made hazards as agents of pollution of the environment.

## Course Objectives

To achieve the stated aim above, this course aims to address the following set objectives:

1. Define the meaning of environmental geosciences
2. Explain geoscientific processes on the environment
3. Discuss some environmental hazards and associated environmental concerns

## Working through the Course

The Course on Environmental Geosciences is multidisciplinary. You would need to apply the knowledge of basic sciences of biology, chemistry and geography. You are required to spend time in reading this course material. Some of the terms are technical and require that you settle down to digest them. Be conscious of the fact that you are part of the environment. For your ease, the course is broken into modules and units. You may need to belong to a tutorial group and also be part of the facilitation services provided at your study centre.

## Course Materials

You will be provided with a study guide to ease your understanding of this course. Also take time to visit the internet and the list of references provided in this study guide. You will have to access the subject matter from the various platforms, discussions and tutorials.

## Modules/Study Units

The following are the modules and study units that you are required to go through in Environmental Geosciences:

**Module 1**
Unit 1: Scope and meaning of Environmental Geoscience
Unit 2: The Concept of the Earth's surface as the home of man

**Module 2**
Unit 1: Atmosphere
Unit 2: Atmospheric Processes
Unit 3: The Hydrosphere and the Biosphere
Unit 4: The Lithosphere and Processes of Sculpturing the Earth's surface

**Module 3**
Unit 1. Endogenous Hazards
Unit 2: Exogenous Hazards

**Module 4**

Unit 1: Prospection, Exploration and Mining

## Assessment

There are two aspects of assessment of the course. First, is the tutor-marked assessment which helps to check the level of understanding of the course by the student. The student has time to prepare for this on a scheduled date by the university. Three (3) tutor-marked assessments each with 10 per cent marks making a total of 30 per cent will be required in a semester. This means the TMA's will contribute 30 per cent of the final marks for the course. Be diligent and focused and avoid any form of discouragement, distraction or laziness. Second, is the written examination at the end of the semester which will constitute 70 per cent of the final grade for the course.

# COURSE CODE: ESM 309

# COURSE TITLE: ENVIRONMENTAL GEOSCIENCES

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**NATIONAL OPEN UNIVERSITY OF NIGERIA**

**MODULE 1**

## Unit 1: Introduction to Environmental Geoscience

**Contents**



### 1. Introduction

Environmental Science is the study of the interrelationships between living (biotic) and non-living (abiotic) things in a particular location at a point in time. It is scientific for you to observe the natural events around you and understand the changes and to some extent factors responsible for such changes. This study will be extended to understanding changes in the environment in areas you may only read about. The natural environment (Fig 1) is easily modified (Fig 2) in the process of development. The environmental science first identifies the changes and then tries to answer how and why?

Figure 1.1 The Natural Environment (Source: ESM 102, Ahove, 2003)

Figure 1.2. An Example of a modified environment (Source: ESM 102, Ahove 2003)

## 2. Objectives

At the end of this unit you should be able to:

1. Identify the biotic and abiotic things around you
2. Discuss the interrelationship between biotic and abiotic things
3. Explain the concept of the earth's surface as the home of man

## 3.0 Main Content

### 3.1 Meaning and Scope of Environmental Geoscience

Environmental geosciences studies the changes in the earth around us. These include the atmosphere, ocean and the solid earth (lithos or geos) and the interactions between them. These interactions are continuous and symbiotic and they determine the habitability of the planet.

Environmental geoscience is both multidisciplinary and interdisciplinary. It covers the field of physical, biological and information sciences (including ecology, physics, zoology, mineralogy, geology, plant science etc.). The fields of physical and biological sciences are therefore very important in environmental geosciences.

The Physical Sciences relevant to environmental geosciences include geography, biology, chemistry, geology, mineralogy and geophysics. Geography is concerned with the study of all physical features of the earth's surface including its climate and the distribution of plants, animals and human life. Geology is the study of the earth; its structure, composition and history. Mineralogy is the study of the naturally occurring inorganic substances that have definite chemical composition and physical character/structure. Geophysics, on the other hand, studies the internal structure of the earth. Biological Sciences study all forms of life, including their classification, physiography, chemistry and interactions. In this regard, the biological sciences include ecology, plant science and zoology. The environment therefore represents a scientific laboratory where physical and biological (or biotic and abiotic) activities interplay. The result is a creation of biodiversity over long periods of expansion or contraction which may in extreme/hash cases be followed by periods of mass extinction.

## 3.2 The Concept of the Earth's Surface as the home of Man

The Earth is the third planet from the Sun. For now the earth is the only astronomical object that habours human life. The Earth interacts with other objects in space especially the Sun and Moon which act as natural satellites to it. The Earth revolves round the Sun in 365.25 days. The Earth is surrounded by the atmosphere, oceans or hydrosphere and the lithosphere. The wind, water and ice around the planet shape it. This set up is important and significant for life on earth (Fig. 2). Life first appeared in the oceans in the first billion years of the Earth's history. Life in whatever form has undergone changes in many forms from one evolutionary stage to another. This makes the Earth a dynamic planet. Historically, over 99% of all species that ever lived on earth are extinct.

Humans depend on the biosphere for survival. From the point of creation, Adam and Eve were kept in the Garden of Eden and lived a vegetarian life. As at today, many humans are partially or wholly vegetarian (that is, they do not eat meat but depend only on vegetables as their sources of proteins and vitamins). This supports the view that life is dependent on the biosphere.

Felling of trees for ornamental works, construction of houses and bridges are a few examples of the support biosphere has given to the development of the society in the bid to make man be at home in his environment. The biosphere has thus sustained man economically and made him comfortable. This interaction however leads to sculpturing takes place with the felling of trees and consequent disruption and destruction of the biodiversity.

Agricultural activities involving provide food necessary to sustain the home. Extraction of metal and non-metal minerals from the earth has led to the development of the land vested with them.

## 4.0 Summary

Environmental geoscience is the study of the earth particularly the interrelationships between the lithosphere, hydrosphere and biosphere. The earth is the third planet. It is surrounded by the atmosphere and the hydrosphere. In it is the biosphere which is sustained by the lithosphere/geosphere. Farming, mining, tree felling, urbanization, use of chemical fertilizers and weathering and erosion of the rocks/soils act together or individually to sculpture the surface of the earth which man uses.

## 5.0 Conclusion

Environmental geoscience is both multidisciplinary and interdisciplinary between the physical sciences. It is the sum total of physical and chemical activities in a place at a particular time. Man has acted in many ways such as tree felling, agricultural activities, mining and urbanization to sculpture the surface of the earth. The various agencies of change in the environment such as wind, water and ice interact to cause the deterioration of the environment by weathering and erosion.

## 6.0 Tutor-Marked Assignments

1. Distinguish between biotic and abiotic things
2. List five disciplines that are important in environmental geoscience
3. What makes the geoscience environment is a scientific laboratory?
4. Briefly comment on the activities make the earth the home of man

## Reference/Further Reading

Ahove Michael Adetunji (2003). The Nigerian Environment. NOUN Course material for ESM 102, 219p.

**Module 2**

**Unit 1: The Atmosphere and Atmospheric Processes**

**Contents**



## 1.0 Introduction

The easiest assumption is to think of the atmosphere as anything above the ground or earth. This is because the unaided eye will not see far enough beyond the clouds to understand the various layers of the atmosphere. But the atmosphere is a little more complex and plays a role of providing cover and actually controls the temperature of the activities on earth.

## 2.0 Objectives

At the end of this unit you are expected to:

1. Understand the stratification of the atmosphere
2. Explain atmospheric processes
3. Discuss the strategic role man plays on earth

## 1. Main Content

The atmosphere surrounds the earth and helps to moderate the extremes of heat and cold on it (Okebukola, 1997). On the basis of temperature, the atmosphere is composed of the troposphere stratosphere, mesosphere and the thermosphere.

These exist as layers around the earth (Figs 3 & 4). Their thickness around the earth varies from day to day and the distance from the pole.

Figure 3.1. Layers of the atmosphere. [Wikipedia, 2017]

Figure 3.1. The Layers of the Earth's Atmosphere (Wikipedia, 2017)

## Troposphere

The **Troposphere** is the lowest part of the atmosphere. It hosts humans and also accommodates the biosphere (plants and other organisms). It contains almost all (75 %) of the water vapour which forms the clouds and rain).

In the troposphere, the weather gets colder as the distance above the earth increases (the higher, the colder). The change in temperature is about 6.5 $^{o}$ C per kilometer but the daily change of temperature with height fluctuates. Air higher up is cooler than air lower down. Birds and airplanes use the troposphere.

## Stratosphere

Immediately above the troposphere is the Stratosphere. It extends up to a height of 50 km. The temperature remains almost the same in the lower part of this layer up to the height of 20 km. After this, the temperature increases slowly with increasing height. The presence of ozone gas in the upper zone of the Stratosphere leads to increases in temperature in the layer.

The fact that air blows horizontally makes the lower layer of this zone also ideal for flying of aircraft.

The upper limit of the stratosphere is known as Stratopause. It has a layer of ozone gas measured in Dobson Units.

## Mesosphere

Above the Stratosphere is Mesosphere. It extends from the height of 50 km to 80 km. In this layer, the temperature starts decreasing with increasing altitude and reaches up to – 100 $^{o}$C at the height of 80 km. Meteors or falling stars are found in this layer. The upper limit of the mesosphere is known as Mesopause.

## Thermosphere

This layer is located above the Mesopause between 80 and 400 km. Abundant in this layer are electrically charged particles known as ions, hence, it is known as the **ionosphere**. The layer of ions in this zone reflects radio waves from the earth back thus enabling radio broadcasting. Generally the temperature increases with height.

## Exosphere

The Exosphere is the uppermost layer of the atmosphere. It is the lightest of the layers of the earth due to the near absence of gases.

## 3.2 Atmospheric Processes

As noticed in the description of the layers of the atmosphere, the atmospheric processes are:

1. Water evaporation in the troposphere. Evaporation is the loss of water in the liquid state to the gaseous state as a result of changes in temperature. For example, evaporation is higher at the equator with high temperature when compared with that at the poles with lower temperature. Similarly, when temperature of surface of streams, rivers, oceans, seas and lakes and from soils increases they lose water to the atmosphere by evaporation. When loss of water takes places from leaves, barks of trees, it is called transpiration.

2. Climate changes within and between the layers of the atmosphere. The emission of greenhouse gases into the air has caused climate changes such as temperature rise in the troposphere.

3. Radiation from sun and the concentration of ions in the thermosphere (ionosphere) contribute to climatic changes in the atmosphere.

4. Rainfall and clouding in the troposphere. The evaporation of water vapour from the surface of the earth saturates as clouds in the air. When the level of saturation becomes heavy, the air becomes cooler and the clouds become bigger and begin to precipitate.

5. Global warming within the stratosphere. This is a phenomena which lead to the sudden rise in the earth's temperature occasioned by the absorption of infrared radiation emitted by the earth surface by certain gases in the atmosphere. Global warming is enhanced by industrialization, burning of fossil fuels in automobiles and generators, the excessive use of chemical fertilizers used in agriculture, exploitation of natural resources, deforestation, urbanization and development of cities etc. Industrialization by the developed nations (Canada, U.S.A, U.K., Japan, Germany, France, Italy etc.) has resulted in greenhouse effect and depletion of ozone layer.

6. Geoscientific actions. The Lithosphere is connected with both the biosphere, hydrosphere and the troposphere. The interactions between these are interwoven. For example, surface waters are evaporated and or lost from plants and trees by transpiration to form clouds in the troposphere which precipitate and again recharge the earth. Precipitation or rainfall may weaken chemical bonds and cause weathering and fracturing of rocks.

### 3.3 Hydrologic Processes and the Biosphere

The hydrosphere is the wet or water saturated portions of the earth. This is synonymous with the hydrologic cycle which is the continuous circulation of water throughout Earth and between Earth's systems.

In the hydrologic cycle water evaporates from the oceans; condenses in the atmosphere as clouds; falls as precipitation; absorbed by the land through a process of infiltration; stored in the aquifers and, after some period of time, makes its way back to the oceans to begin the cycle again.

The atmosphere receives water from the combined process of evaporation from moist soils and bodies of water such as oceans and rivers and streams, and transpiration from the barks of trees and stromata of leaves. This process known as evapotranspiration puts a great deal of water into the atmosphere.

At various stages, water moves through the atmosphere, the biosphere, and the geosphere, in each case performing functions essential to the survival of the planet and its life-forms.

The surface water, though vital to humans and other living things, makes up only about 0.0001% of the total volume of water on Earth indicating that far more is underground and in other compartments of the environment.

When rain falls and water is unable to infiltrate, it becomes runoff. Runoff may be flood usually called ‘flash flooding’ if infiltration is hindered in an

area due to the large volume of water available compared to what may be absorbed into the earth. Thus, water may either infiltrate or become runoff, but as long as it remains close to the surface, it will experience evaporation (Fig. 3.1).

Figure 3.1 The Hydrologic Cycle (Source: Wikipedia)

Evaporation uses the energy from the Sun to change liquid water into gaseous form, transporting it as a vapor into the atmosphere (Fig. 3.1). Thus, the water is returned to the air, where it condenses and resumes the cycle we have described.

Water is important to life. For example, the human body is almost entirely made of water. The biosphere which consist of all plants and other organisms that exist in the rocks and soils are dependent on water without which they will die. Thus, the biosphere, which combines all living things and all

recently deceased things, is connected intimately with the hydrosphere. This is why the biosphere and the hydrosphere are intimately interrelated. Life is closely related to the presence of water. For now, the earth is the only planet with water and therefore the only planet with life. If and when life is found on another planet, that planet also would contain water. Evidence began to gather towards the end of the twentieth century that Mars contains ice crystals on its surface. Further study is, however, on-going on this discovery.

It is amazing to note that the largest portion of water on earth is hidden in the geosphere in the upper portion of earth's crust i.e. the lithosphere. The volume of water available on earth has remained relatively constant over the last three billion years i.e. since the Precambrian ages. The losses are gained such that there is always a balance in the amount of water available for human use at any point in time in human history.

### 3.4 The Lithosphere and Processes of Sculpturing the Earth's surface

The lithosphere is the solid part of the earth which interacts directly with the biosphere, hydrosphere and the atmosphere. The processes that sculpture the earth's surface are plate movement (which shall be discussed later in this course material), weathering and erosion by wind, glacier or water, and deposition by wind, water and ice. These processes have the capacity to sculpture the earth's surface. The processes produce landforms such as valleys, plateaus, mountains, hills, loess or glaciers which are natural features of landscape.

The shape of the earth may undergo slow processes such as drought, weathering and erosion or rapid/violent processes such as landslides, volcanic eruptions, earthquake, tsunamis and flooding. These processes which are exogenous (surface) and endogenous (within rock), respectively, will be discussed in further details later in this course material.

Sculpturing takes place with felling of trees and consequent disruption and destruction of the biodiversity. Agricultural activities also contribute to the sculpturing. For example, the use of chemical fertilizers act to pollute both the

hydrosphere and the biosphere. The pollution enhances weathering and erosion and also affects the growth and biodiversity of the area.

The efforts of man to develop and expand settlement patterns have had the hardest effect on the sculpturing of the earth as the home of man. Urbanization is normally accompanied by felling of trees without commensurate effort attempt to re-plant. This is one of the worst direct effects of sculpturing of the earth's surface.

The desire and need for development has led to the excavation of the earth for industrial, metal and non-metal minerals from the surface and beneath the earth. These have also sculpture the surface of the earth and in many ways led to deforestation, destruction of biodiversity, farmlands and homes. The economic benefits, however, out way the damages such that environmental reconstruction is made possible during and after the mining activities.

The activities of man mentioned above cause weathering and erosion on the surface of the earth. Weathering is the disintegration of rocks due to the actions of water, wind or man. This weakens or destroys the bond(s) between the elements that make up the mineral in the rock with the consequence that wind or water will cause removal of parts of the rock at intervals.

## 4.0 Conclusion

The atmosphere is classified into the troposphere, stratosphere, mesosphere, thermosphere and exosphere, some of these have sublayers. The hydrosphere is the wet or water saturated portions of the earth. This is synonymous with the hydrologic cycle which is the continuous circulation of water throughout Earth and between Earth's systems. Water in the lithosphere and biosphere undergo evaporation and transpiration under the sun to condense as cloud and thereafter precipitate as rainfall. Erosion, weathering, drought, extreme heat, urbanization and absence of planning have contributed to the sculpturing of the earth's surface.

**5.0 Summary**

The Earth is the third planet and perhaps the only planet with life. It is surrounded by the atmosphere, hydrosphere and biosphere. These are interrelated and work symbiotically in many respects. The surface of the earth has suffered from erosion, weathering, drought, flood, earthquakes, tsunami, agricultural and industrial activities that have individually and collectively worked to re-sculpture the earth.

## 6.0 Tutor-Marked Assignment

1. Attempt a classification of the atmosphere
2. Discuss the interrelation between the atmosphere, biosphere, and lithosphere.
3. List any three ways the surface of the earth undergo sculpturing

## 7.0 References

Okebukola, P. A. O. Understanding our Environment. Paper presented at the Monthly Seminar of the Centre for Environment and Science Education, Lagos State University, March, 1997. In Ahuve M. A. N. (2001) Environmental Management and Educattion: An Introduction: Lagos Goldenpen Books

**MODULE 3**

## Introduction

Environmental hazards are those natural and man-induced (anthropogenic) processes which create an accident or extreme event or damage to all organisms in the ecosystem. The hazards on a large scale become disasters in terms of damages done to the biotic world.

Natural hazards are earthquakes, volcanic eruptions and their derivatives, tsunamis, cyclones and floods. Man-made or anthropogenic events that facilitate or may be responsible for environmental hazards include deforestation, poverty, overpopulation, and crimes. Rapid growth in population puts pressure upon natural resources which will manifest in deforestation, and droughts. Farmers will require the addition of chemical fertilizers and pesticides to achieve bumper increase in agricultural production from which chemical pollution takes place. Underground and surface mining may cause intense pollution of atmosphere and hydrosphere.

Hazards may be natural or anthropogenic. Natural hazards may be 'Planetary' or 'Extra-planetary'.

Planetary hazards may be: **Endogenous (Terrestrial)** which includes earthquakes, tsunamis, volcanic eruptions and landslides, or **Exogenous (Atmospheric)** hazards such as cyclones, lighting, hailstorms, floods, droughts, cold waves etc.

Anthropogenic hazards could be:

1. Physical hazards (landslides caused by felling of trees, soil erosion due to overgrazing)
2. Chemical hazards (linked to release of toxic chemical elements in the air, water, soils, leakage of radioactive elements from nuclear reactors sudden outburst of poisonous gases from chemical factories),
3. Biological hazards involving bacteria, viruses, insects, plants, birds, animals, and humans including sudden rise in population of species in a given habitat.

The disasters/damages associated with these hazards are sometimes colossal and remedies may be short term or long term.

## Unit 1: ENDOGENOUS HAZARDS

**Contents**



### 1. Introduction

Natural hazards that occur within the earth which are not within the control of humans are called endogenous hazards. Some of these are earthquakes and associated volcanic activities, tsunami, plate movements that drive the continents and within continent fracturing, intrusions and extrusions.

### 2. Objectives

At the end of this unit, you should be able to:

1. Identify endogenous hazards
2. Discuss controls of endogenous hazards
3. Readily explain hazards and possible remedies.

### 4. Main Content

### 3.1 Earthquakes/Volcanic Activities

An earthquake is a sudden motion of the ground surface, ranging from a faint tremor to a wild motion capable of shaking buildings apart and causing gaping fissures to open in the ground. It is caused by an abrupt release of slowly accumulating stress. In other words, earthquake is a form of energy of wave motion transmitted to the surface of the earth through the focus. The intensity of energy released by an earthquake is measured by the Richter scale, after the name of the scientist C.F. Richter (1935). Although the scale ranged between 0 and 9, it has no upper limit of number because it is a logarithmic

scale. Another scale used for measuring the intensity of earthquakes is Mercalli scale.

The intensity of earthquake depends on a variety of factors e.g. magnitude, distance from the epicenter, acceleration, duration, amplitude of wave, type of surface, water table, nature of the geometrical of the concerned region and nature and type of constructions.

The accumulated stress within the earth causes disequilibrium in that part of the crust. The release of the stress may cause any of the following: volcanic eruption, faulting and folding, up warping and down warping, hydrostatic pressure of manmade water bodies like reservoirs and lakes.

Plate tectonic theory has been suggested to explain the occurrence of earthquake. According to the Plate tectonic theory, the earth is composed of slowly but continuously moving plates having the upper Continental Crust overlying the lower Oceanic Crust. The major plates are: Eurasian plate, Indian plate, American plate, African plate, Pacific plate and Ataractic, amid many minor plates. The underlying convective currents originating deep within the earth move the plates.

Studies of plate boundary movements indicate that the tectonic events may be creative (divergent), destructive (subduction) and conservative (strike - slip). The creative or divergent plate boundaries are associated with volcanism and faulting while the destructive plates are dominated by orogenic activities in which mountain building, subsidence and folding are common. The strike-slip boundaries may manifest minor faults and lesser levels of deformation compared to the creative and destructive plate boundaries.

Obviously, earthquakes are more associated with divergent (accretion) and subduction zones than the strike-slip plate boundaries. For example, earthquakes occurring along the mid-Atlantic ridge, mid-Indian Oceanic ridge and east Pacific Ridge are situated along divergent zones while earthquakes of the Western margin areas of North America and South America are due to subduction of the American Plate below the Pacific Plate. Similarly, the subduction of the African Plate below the European Plate and the subduction of Indian Plate below the Asian Plate are responsible for the earthquakes at

the mid-continental belts. This also explains the earthquakes along the Himalayas and the associated foothill zones.

At the global level, there are three major earthquake zones. These are:

1. Circum-pacific belt surrounding the Pacific ocean

2. Mid-continental belt representing epicenters of east African fault zone and

3. Mid-Atlantic belt representing the earthquakes located along the mid-Atlantic Ridge and its offshoots.

According to Lallan Singh (2010), the narrow belts of epicenters coincide almost exactly with the crest of mid-Atlantic, the east Pacific and other oceanic ridges where plates generally separate. Earthquake epicenters are aligned along transformed faults, where plates slide past each other.

Earthquakes cannot be prevented from occurring but they can be monitored and predicted. The management includes:

1. The earthquake zones should be avoided for settlement and construction of developmental structures

2. Erection of earthquake resistant buildings in earthquake prone zones. This is done either by keeping weak spots in the house to absorb vibration or by keeping pads or floats beneath the buildings.

3. Wooden houses should be preferred in earthquake prone seismic areas.

4. Usage of reinforced concrete columns to support long walls.

5. The footing of structures should have reinforcements.

6. Early prediction

Volcanic ashes and dusts from volcanic eruptions, undesirable substances due to fracture and faults caused by the seismic events associated with earthquakes are active agents of pollution. Like the earthquake itself, the movement of these pollutants can only be monitored and managed, they cannot be prevented.

### 3.2 Tsunami

A **tsunami** is a **tidal wave** or a **seismic sea wave** in a water body caused by the displacement of a large volume of water, generally in an ocean or a large lake. It is usually associated with earthquakes, volcanic eruptions and other underwater explosions (*Barbara Ferreira, 2011.* Unlike normal ocean waves generated by wind, or tides, which are generated by the gravitational pull of the Moon and the Sun, a tsunami is generated by the displacement of water (NASA, 2016).

Tsunami waves do not resemble normal undersea currents or sea waves because their wavelength is far longer. Rather than appearing as a breaking wave, a tsunami may instead initially resemble a rapidly rising tide (Tsunami 101, 2018)
Tsunamis generally consist of a series of waves that may last from minutes to hours and could be arriving in a so-called 'internal wave train' (*Fradin, Judith Bloom and Dennis Brindell (2008).* Wave heights of tens of meters can be generated by large events. Although the impact of tsunamis is limited to coastal areas, their destructive power can be enormous, and they can affect entire ocean basins.

The 2004 Indian Ocean tsunami was among the deadliest natural disasters in human history, with at least 230,000 people killed or missing in 14 countries bordering the Indian Ocean.

Tsunamis have a small amplitude (wave height) offshore, and a very long wavelength (often hundreds of kilometers long, whereas normal ocean waves have a wavelength of only 30 or 40 meters),[30] which is why the latter generally pass unnoticed at sea, forming only a slight swell usually about 300 millimeters (12 in) above the normal sea surface. A tsunami can occur in any tidal state and at low tide can still inundate coastal areas.

Japan has had the longest recorded history of tsunamis. However, the sheer destruction caused by the 2004 Indian Ocean tusnami event mark it as the most devastating of its kind in modern times, killing around 230,000 people.[19] The

Sumatran region is also accustomed to tsunamis, with earthquakes of varying magnitudes regularly occurring off the coast of the island.[20]
Tsunamis cause underestimated hazards in the Mediterranean Sea and parts of Europe.
Tsunami are related to plate margins and plate movements at the divergent and subduction zones. These areas also are associated with large earthquakes. There are however other areas with large earthquakes that do not cause tsunamis.

Figure 3.1. This image shows the three main types of plate boundaries: divergent (plates mive away from each other); convergent (plates move towards each other), and transform (where plates move away from each other). Image courtesy of the U.S. Geological Survey

Figure 3.2. An example of two plates colliding, one subducting or going under another

1.

Figure 3.3. Plate slips and energy released in the process of subduction produces tsunamic waves

## CONCLUSION

Earthquakes and volcanic activities occur within the Crust. They are closely related to plate movements. Tsunami are **tidal waves** or **seismic sea waves** in a water body caused by the displacement of a large volume of water and may be associated with earthquakes, volcanic eruptions and other underwater explosions.

## TUTOR-MARKED ASSIGNMENT

1. What are earthquakes and how are they different from tsunami?
2. List the types of plate boundaries that are closely associated with earthquakes.

## References


Barbara Ferreira (April 17, 2011). "When icebergs capsize, tsunamis may ensue". Nature. Retrieved 2011-04-27.

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## Unit 2: Exogenous Hazards

**Contents**



### 1.0 Introduction

Flood, cyclone, and drought are common environmental hazards whose sources are external to the lithosphere. Drought and flooding can be controlled/minimized while cyclones are not avoidable but the effects manageable.

### 2.0 Objectives

At the end of this unit, you should be able to undertake the following:

1. Identify areas prone to exogenous hazards in your country
2. Appreciate the need to control environmental hazards in your area
3. Outline the measures that can remediate hazards.

## 4. Main Content

### 3.1 Flood

Flood is the overflowing of a river over its banks and submerging the surrounding areas. It is caused not only due to high precipitation but also due to increased deforestation, poor management of agricultural field, poor drainage system, unplanned urbanization etc.

Flood results in a number of detrimental effects like damaging of houses, buildings, industries etc., damaging of standing crops, lowering of soil fertility, outbreak of epidemics etc. Every year thousands of living organism and huge quantity of properties are lost due to flood in different rivers. Therefore, some preventive measures that may be undertaken to reduce the severity of flood are:

i. Construction of dams and barrages on river beds.
ii. Construction of flood walls embankment and dikes to serve as physical barriers.
iii. Regular dredging and interconnectivity of rivers.
iv. Massive afforestation over denude areas.

v. Awareness regarding the anticipated flood through different mass media.

vi. Construction of artificial channels bordered by dykes in low lying areas to divert water.

## 3.2: Cyclones

According to the American glossary of meteorology, a **cyclone** is a large scale air mass that rotates around a strong center of low atmospheric pressure. Cyclones are characterized by inward spiraling winds that rotate about a zone of low pressure. (*BBC Weather Glossary (2006)*

An extratropical cyclone near Iceland on September 4, 2003 (Source, AGM)

The largest low-pressure systems are polar vortices and extratropical cyclones of the largest scale (the synoptic scale). Warm-core cyclones such as tropical cyclones and subtropical cyclones also lie within the synoptic scale (Orlanski, 1975; David Brand, 1999)

Mesocyclones, tornadoes and dust devils lie within smaller mesoscale (Orlanski, 1975). Upper level cyclones can exist without the presence of a surface low, and can pinch off from the base of the tropical upper tropospheric trough during the summer months in the Northern Hemisphere.

Cyclones have also been seen on extraterrestrial planets, such as Mars and Neptune.

The process of cyclone formation and intensification is called Cyclogenesis.

Baroclinic zones are regions in which a temperature gradient exists on a constant pressure surface. These zones contract and form weather fronts as the cyclonic circulation closes and intensifies. Later in their life cycle, extratropical cyclones occlude as cold air masses undercut the warmer air and become cold core systems. A cyclone's track is guided over the course of its 2 to 6 day life cycle by the steering flow of the subtropical jet stream. Weather fronts mark the boundary between two masses of air of different temperature, humidity, and densities and are associated with the most prominent meteorological phenomena.

Strong cold fronts typically feature narrow bands of thunderstorms and severe weather and may on occasion be preceded by squall lines or dry lines. Such fronts form west of the circulation center and generally move from west to east; warm fronts form east of the cyclone center and are usually preceded by stratiform precipitation and fog. Warm fronts move poleward ahead of the cyclone path. Occluded fronts form late in the cyclone life cycle near the center of the cyclone and often wrap around the storm center.

Tropical cyclogenesis describes the process of development of tropical cyclones. Tropical cyclones form due to latent heat driven by significant thunderstorm activity, and are warm core.

Cyclones can transit between extratropical, subtropical, and tropical phases.

Waterspouts can also form from mesocyclones, but more often develop from environments of high instability and low vertical wind shear. In the Atlantic and the northeastern Pacific oceans, a tropical cyclone is generally referred to as

a hurricane (from the name of the ancient Central American deity of wind, Huracan), in the Indian and south Pacific oceans it is called a cyclone, and in the northwestern Pacific it is called a typhoon.

## 3.3 DROOGHT

Drought is a natural disaster which results as a result of below-average precipitation or rainfall in a given region leading to prolonged shortage in both surface and underground water supply. When this happens, habitats are damage, plants shrink or dry up while shortage of food supply becomes imminent. Droughts therefore may lead to famines and result in the deaths of humans, animals, and plants.

There are four types of drought. They are: meteorological, hydrological, agricultural, and socio-economical.

Signs of drought in a wheat field.(Source: Wikipedia, 2019)

**Meteorological/Climatological Drought**

When there is a prolonged period of low precipitation dry weather patterns dominate the area causing climatological drought. The severity of such droughts depends on the magnitude of the shortfall of precipitation, as well as the duration of the shortfall event.

**Agricultural Drought**

Meteorological drought leads to agricultural drought. An agricultural drought occurs when crop growth in an area is adversely affected due to sustained period of low levels of precipitation. This results in crop failure. It should be noted that poor agricultural practices may lead to changes in soil conditions or soil erosion that will decrease the amount of water available to crops for proper growth in a season. Agricultural droughts are more common in non-irrigated agricultural areas where plant's source of water is largely dependent on prevailing weather conditions.

**Hydrological Drought**

Hydrological droughts occur when water supply becomes scarce due to lower water levels in water bodies likes lakes, rivers, and reservoirs. This also means that water table of underground waters is deeper following the drying-up of the lake, river or reservoir. Often, meteorological droughts precede hydrological droughts since low levels of rainfall and high temperatures may cause water bodies to dry up. A typical example is the drying up of Lake Chad in northeastern Nigeria.

**Socioeconomic Drought**

The food shortfall that follows drought leads to increase in demand for the few available agricultural items/goods. When the demand for an economic good is

greater than its supply due to a water deficit created by shortfalls in precipitation and other weather-related adverse changes, a socioeconomic drought occurs. This is happening in the Lake Chad area. In the Lake Chad area, for example, shortfall in grains, fodder, fish have been recorded and there is inadequate water supply and electricity in the area.

### 3.4 EROSION

Erosion is the action of surface processes that removes a part of soil, rock and or dissolved material by wind, water, ice or by gravity from one location of the earth to the other. It is a dynamic activity that also involves plants, animals, and humans.

Thus erosion is sometimes divided into water erosion, glacial erosion, snow erosion, wind (aeolic) erosion, zoogenic erosion, and anthropogenic erosion (*Apollo, M., Andreychouk, V., Bhattarai, S.S., 2018*).

Erosion may be physical (mechanical) where rocks and soils breakdown into particles that may have undergone some movement from its source and therefore classed as Clastic sediments or chemical where soil or rock material is removed from an area when it dissolves into a solvent (typically water), followed by the flow away of that solution. Eroded sediments or solutes may be transported just a few millimeters, or for thousands of kilometers away from its source.

Anthropogenic activities such as intensive agriculture, deforestation, road construction and urbanization have increased the effect of erosion many folds.

Gully erosion is the most visible effect of erosion in parts of Nigeria underlain by sedimentary rocks while areas underlain by hard basement complex rocks exhibit inselbergs and whalebacks as remnants of erosion.

Water and wind erosion are responsible for about 84% of the global extent of degraded land. Erosion is therefore one of the most significant environmental problems worldwide

If the soil is saturated, or if the rainfall rate is greater than the rate of infiltration into the soil, surface runoff occurs. If the runoff has sufficient flow energy, it will transport loosened soil particles down the slope thus causing sheet erosion (*Food and Agriculture Organization,1965)*.

When erosion produces small, ephemeral concentrated flow paths which function as both sediment source and sediment delivery systems for erosion on hillslopes, Rill Erosion is said to have developed. Rills are active where water erosion rates on disturbed upland areas are greatest. Flow depths in rills are typically of the order of a few centimeters (about an inch) or less and along-channel slopes may be quite steep. This means that rills exhibit hydraulic physics very different from water flowing through the deeper, wider channels of streams and rivers (Nearing, et. al. (1997).

Gully Erosion in Southeastern Nigeria (Source: Igwe, 2012)

Effect of gully erosion on Orlu/Mgbee Road, Southeastern Nigeria (Abdulfatai et. al. 2014

Gully erosion occurs when runoff water accumulates and rapidly flows in narrow channels during or immediately after heavy rains or melting snow, removing soil to a considerable depth (Boardman, John, 2007; J. Poesen *et. al.* 2002; Borah, *et al*. (2008).

## CONCLUSION

Exogenous hazards include cyclones, flood, drought and erosion. With careful planning and meteorology as guide the damages may be controlled or minimized.

## TUTOR-MARKED ASSIGNMENT

1. What makes cyclones exogenous?
2. List some of the steps that may be taken to control flooding.
3. What makes Lake Chad a good example of a lake undergoing drought?
4. Distinguish Gully Erosion from Rill Erosion

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**Module 4**

**UNIT 1: PROSPECTION/EXPLORATION AND MINING**

**Contents**



1.0 Introduction

The search for the riches of the earth and the desire to extract them for the use of man in many developmental projects have been a task man had been tasks that had occupied the business of man since the primitive days. For example, Copper has been in use for at least 10,000 years. It is noted that more than 95% of all copper ever mined and smelted has been extracted since 1900. Also, artifacts of gold have been found dating from the $5^{th}$ millennium BC. The first known networks of gold-producing areas date from the Eqyptian and Nubian times around 2600 BC.
This means that the environment (soils, rock, rivers, glaciers) has been distorted and modified since the primitive man. It is therefore interesting to know what is prospection, exploration and mining.

2. Objectives

At the end of this unit, you should be able to:

1. Define prospection, exploration and mining
2. Understand the need to properly reclaim the environment after extraction.
3. Outline the measures that can remediate hazards.

## 3 .0 Main Content

### 3.1 Prospection/Exploration

‘Prospection’ and ‘Exploration’ are terms that may be used interchangeably. Many ascribe the early stage of exploration to prospection. This means that the intention and preparatory works done towards exploration, usually for natural resources, is, Prospection.

Exploration is the set of activities undertaken to unravel the existence of natural endowment within the earth. The endowment could be organic (like coal, oil and gas) or inorganic (like gold, cassiterite, tantalite, columbite, diamond, etc.), solid or non-solid. Exploration begins with literature review on the nature of the target endowments, possible locations and consequently field visits, sampling and analyses. Trenching and drilling may be involved in exploration depending on the mode of occurrence or outcrop pattern of the endowment under investigation. These activities take several months/years to conclude on the existence or otherwise of the natural resources in commercial and profit-yielding quantities. Exploration and mining therefore have long gestation period. They are also capital intensive.

The exercise aims is to determine the quality and quantity of the solid mineral or hydrocarbon endowments. This may be extended to groundwater quality and quantity in many instances. In the case of solid minerals, the qualitative assessment

determines the ***grade*** of mineralization while the quantitative assessment determines the ***tonnage***.

Exploration is therefore multidisciplinary and interdisciplinary depending on the target mineral(s). Geologists, geochemists, chemists, biologists may constitute the technical team while administrators, accountants, medical personnel, and lower cadre staff such as security, drivers, may be required in the day to day running of the enterprises.

Exploration activities must be systematic and presented in such a way to win the confidence of would-be financiers or sponsors. All stages must be simply outlined and explained. The primary target of exploration is to produce a bankable document in a feasibility report.

Exploration activities are most times inconclusive and abandoned when the desired goals are not met. This explains the high risk associated with exploration and mining as a business.

Efforts are concentrated at defining the physical and chemical limits of the mineral resources. The physical limits are defined using geology and geophysical studies while the chemical limits are defined by sampling and composition studies of the resource. At the end, grades or chemical composition of the critical elements (metals or industrial) are used to delimit areas of high concentrations (**Reserves**) from those of low concentrations (**Resources**). Careful calculations are made on the reserves with a view that operations must pay for the investments. Once that is done and positive, the operations can move to the next stage of **Extraction or Mining**.

### 3.1 Mining

The removal of natural materials from within the earth is called ‘Mining’. The scale of extraction may vary from resource to resource and from place to place. Only less than 10 per cent of exploration activities goes into the Mining Stage where the minerals are extracted or removed from the earth for use. At this stage, the mineral extraction must pay for all activities leading to its extraction and value addition, where necessary.

Extraction of natural endowments may be underground or surface (open cast) mining method. Controlling the decision on the method of mining to be adopted are: the mode of occurrence, the value of the endowment or degree of enrichment (grade), politics, location, and market factors.

Coal, for example, is extracted both as underground and surface mines at Enugu, Enugu state and Okaba-Okobo areas of Kogi state. As may be observed in the figures below, control of surface and underground water into the mines could be a threat particularly during the rainy season.

Figure 3.1 Photograph of an Open Cast Coal Mining in Okobo, Ankpa Local Government, Kogi State. Here, the Coal occurs as near horizontal layers overlain by thin beds of claystone, siltstone and sandstone. Note the accumulation of water in the excavation site.

Figure 3.2. Overview of the Open Cast Coal Mine at Okobo, Ankpa Local Government Area, Kogi State. At the bottom right corner are coal dumps. Note also water accumulation in the mine site.

Mining for local industrial usage does not require refining in many cases. Examples are: marble and limestone for cement manufacture, alluvial sands and granite quarry for the construction industry.

However, many minerals or ores (metals) in their natural forms require some form of refining or value addition before they are sold at the international market. Examples are cassiterite ($SnO_2$), gold (Au), and molybdenite ($MoS_2$).

Refined Gold Bar (Source: Wikipedia)

Mining may have the following effects on the environment:

1. Distortion the ecosystem
2. Destruction of biodiversity
3. Pollution of underground and surface waters which affect both physical and chemical activities.
4. Relocation of villages, farms
5. Forfeiture of rights to land, ancestral belongings etc.

## CONCLUSION

Prospection and exploration are those set of activities undertaken to determine the chemical characteristics and volume of mineral resources so that reserves that are extractable may be outlined. In the process, the environment is badly destroyed and will require reclamation. This covers a long period of time from the pre-mining, mining and the post mining stages.

## TUTOR-MARKED ASSIGNMENT

1. What is Prospection and how is it different from Mining?
2. Distinguish a Resource from Reserve as used in the extractive industry set up
3. What are the effects on mining on the environment?