ACTION OF WATER IN LIMESTONE AREAS

Introduction

- Underground/ground water refers to water that exists/derived below the surface of the earth.
- It's contained in the available air spaces, cracks and joints in the soil and in the rocks beneath the surface which are above an impermeable layer

Sources of underground water

(i) **Rainwater:** - which infiltrates and percolates into the lower parts of rocks.
(ii) **Melt water**: - which infiltrates the ground and eventually percolates through the rocks
(iii) **Lake and sea water**: - may enter the ground by seepage and percolates through the rocks to become underground water.
(iv) **Magmatic water** – this is the water that gets trapped in the rocks beneath the surface during volcanism. It's also called **plutonic water.**

Ways in which underground water may reach the surface of the earth

a) Through wells drilled into artesian basin.
b) Capillary action i.e. upward movement of water through the rocks by capillary. The rocks should be permeable i.e. they should have pores (porous) or have cracks/joints (pervious) e.g. limestone and chalk
c) Springs – occur in areas where saturated rock layer is exposed to the surface.
d) Through streams

Zones of underground water

Diagram

Water table: - this is the upper surface of the zone of saturation of underground water in permeable rocks. Water table can be permanent or temporary. Permanent water table is the lower level reached during the dry season and is permanently saturated. Temporary water table refers to the highest level nearer to the surface reached during the rainy season
Zone of permanent saturation: - this is the region where all the rock pores/air spaces are permanently filled with water. It is also known as phreatic zone
Zone of intermittent saturation: - here, the water content fluctuates according to season. During the rainy season, the rocks are saturated while in the dry period the layer is unsaturated.
Zone of non-saturation: - this is found immediately below the earth's surface (permeable layer). It is where the water never remains in the pores for long to saturate the rocks. The top part of this zone is called the *soil water belt.*
Aquifer/aquafer: - this is the layer of permeable rock that can hold water in its mass and allow it to pass through

Factors influencing the existence of underground water

Much of groundwater originates from the surface of the earth. Occurrence of ground water thus depends on factors that influence the rate of infiltration such as;

1. **Amount and nature of precipitation.**
   The amount of rainfall that infiltrates into the ground depends on the type, amount and intensity of the rainfall. Light rain which falls over a long period of time infiltrates longer compared to a heavy downpour which is short-lived hence saturates the surface thus blocking the passages through which water infiltrates. Also, areas with reliable rainfall have more underground water than those with unreliable rainfall.
2. **Gradient of slope**
   Steep slopes reduce infiltration, as much water is lost through surface run-off while on gentle slopes, water remains longer on the ground allowing infiltration.
3. **Amount of Vegetation cover**
   Presence of vegetation cover increases the rate of infiltration as they slow down the speed of surface run-off, holding water for a longer time. Bare surfaces increase surface run-off.
4. **Nature of rocks**
   Permeable rocks allow water to enter and pass through them. The more the permeability of surface rocks, the higher the rate of infiltration. A permeable rock can be pervious or porous. Pervious rock is one with cracks, fractures, joints or fissures through which water enters and passes. Some rocks like clay and unjointed chalk are porous and allow water to enter them but don't allow water to pass through them. This is because on absorbing water, clay particles expand thus narrowing the air spaces between them.
5. **Level of saturation of the ground**
   Dry, porous soil allows much infiltration. While high amount of water in the soil reduce the rate of infiltration as the air spaces are filled up with water sealing off any further percolation.
6. **Rate of evapotranspiration**
   A high rate of evapotranspiration that is caused by low moisture content in the atmosphere reduces the amount of water available for absorption into the soil.

Springs

- This is a point on the earth's surface where underground water flows naturally onto the land surface.
- It occurs where the water table is exposed on the surface along a slope
- It can be permanent or intermittent
- Springs occur in the following ways
  a) Where a permeable rock overlies an impermeable rock. A spring occurs where the two rock layers meet the earth's surface

     Diagram

  b) Where an aquifer lies on the upper side of a dyke which out-crops. A spring may form at the line where the dyke and the aquifer intersect.
  c) At the foot of a steep scarp slope underlain by impermeable rock layers

     Diagram

d) Where there is well jointed rocks e.g. limestone are saturated to the level of the water table. The water guided by the joints flow out of the junction with impermeable rock and runs down the hill side as a spring. Such springs are called Vauclusian springs

Diagram

Wells

- These are holes sunk/dug into permeable rock to reach the water table. Water from the underground seeps out of the water table

Diagram

Artesian Basin and artesian wells

- Artesian basin is a layer on the earth's crust in which one or more aquifers are enclosed above and below by an impermeable layer
- The whole system of rocks around the basin forms a broad syncline or depression with one or both ends of the permeable rock are exposed on the surface to allow rain water to percolate.
- If a well is sunk into the aquifer on an artesian basin, water will normally come to the surface by hydraulic pressure so long as the mouth of the well is below the water table.
- Such a well is called an ***Artesian well.***

Diagram

Ideal conditions for formation of artesian well

a. The aquifer must outcrop in a region which is a source of water e.g. a rainy area or beneath a lake/must be exposed in an area of sufficient rainfall
b. The aquifer must be sandwiched between impermeable rocks so that it can retain *water.*
c. The aquifer must dip towards a region where the land surface is lower than it is at the exposed end of the previous formation
d. The mouth of the well must be lower compared to the intake area to allow the water to be forced to the surface by pressure with no need of pumping.

- Examples of artesian basins are the London and Australian artesian basins

Problems associated with availability of underground water.

(i) Over-exploitation due to population pressure. Reduced rainfall and polluted rivers make many people turn to groundwater thus reducing what is available.
(ii) Global warming has led to high evaporation rates. This has reduced underground water sources.
(iii) Pollution from agro-chemicals has led to a lot of chemicals in the water that percolates to the ground.
(iv) Destruction of water catchments areas interferes with hydrological cycle and reduced the amount of rainfall. Consequently, underground water has also been reduced.

Significance of underground water

(i) Springs are sources of many rivers e.g. Yala that provides water for domestic, industrial and irrigations uses among others
(ii) Wells, springs, boreholes, oases, provide water for domestic and industrial uses e.g. Mzima Springs provide water to Mombasa Town.
(iii) Ground water provides water for irrigation farming e.g. cotton, bananas in Taveta grown using water from Mzima Springs.
(iv) A line of springs at the foot of an escarpment can attract settlements.
(v) At the mouth of many hot springs, valuable minerals salts may be deposited and mined to earn revenue, create employment opportunities
(vi) In areas under volcanic influence, underground water is heated by hot magma to form geysers and hot springs that are sources of geothermal power and tourists attraction – earn foreign exchange

Action of water in limestone areas

- **Karst region** is a limestone region where action of water has created unique features on the surface as well as underground.
- The resultant landscape is called ***karst scenery*** and it applies to any area of limestone landscape that has developed similar features to those of karst region
- The creation of these features is mainly due to the following two main reasons;
  - Limestone is highly impervious because of the clear joint bedding
  - Limestone is soluble in ordinary river water and rain water.

Characteristics of a karst landscape

- It has thin soils
- The landscape lacks surface drainage
- Has poor/scrub vegetation as well as some shrubs and grasses with stunted growth
- The surface is rocky and rugged i.e. consists of numerous outcrops of bare rugged rocks
- It has a subterranean network of underground drainage , caves and caverns
- exhibits numerous residual hills and solution hollows
- It has deep steep sided dry valleys.

N/B: Give three reasons why there are few settlements in a karst landscape.

- *The areas are rocky/ have a rugged surface.*
- *They have thin soils*
- *There is inadequate water supply/lack adequate water supply*

Factors influencing the development of karst scenery

a. The surface rocks and the rocks below should be thick limestone, dolomite or chalk (soluble in water)
b. The rocks should be resistant and well jointed
c. A hot and humid weather to accelerate weathering processes
d. Water table in the limestone rocks should be deep below the surface to allow the rocks above to form conspicuous features

Features of action of water in limestone areas

- Reaction between limestone rock and rain water leads to the development of various features in the karst region. Such features can be surface or underground

Surface features in limestone areas

- Rain water reacts with carbon (iv) oxide to form a weak carbonic acid. This carbonic acid reacts with calcium carbonate in the limestone and chalk rock to form a bicarbonate (calcium bicarbonate) soluble in water
- The calcium bicarbonate dissolves causing the joints in the rock to widen and the limestone surface to become rugged
- This leads to formation of the following features: -

(a) Grikes and Clints

- These are irregular gullies that traverse limestone surface, separating various limestone blocks called **clints**
- These gullies develop when water action widens and deepens the joints in the limestone rock blocks (clints) standing protruded

Diagram

(b) Swallow/sink holes

- This is a vertical hole in the ground through which rain water/river water disappears into the ground
- The water widens and deepens the joints especially where such joints converge leading to the development of a vertical hole/shaft
- The holes are slowly deepened as the surface water sinks through them to form **swallow** or **sink holes**

(c) Dolines

- This is a round shallow hollow or depression on the surface of a limestone region formed when several small swallow/sink holes merge or enlarge due to continued process of solution
- The swallow hole is widened through solution until the rock blocks between the hollows are completely dissolved to form a **doline**

(d) Uvalas

- These form when continued solution dissolve the rock blocks between dolines leading to their collapse or merger

(e) Poljes

- As the dissolving of limestone continues underground, several uvalas may collapse to form a very large depression in karst scenery called **poljes**
- During the rainy season, the polje may be filled with water to form a temporary lake

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(f) Dry Valleys

- This is part of a river in which water nolonger flows in a karst region
- It forms when river water disappears into the swallow hole

Underground features in limestone areas

(a) Caves and caverns

- These are underground chambers formed in limestone areas due to carbonation and solution process along the joints of limestone rock
- At first, a tunnel forms, continued solution enlarges the tunnel to form a **cave**.
- The process of cave formation may continue, widening and deepening the existing cave to form a **cavern**

(b) Underground streams/rivers

- When water sinks down into impermeable rock layers, underground streams or rivers may form and flow for longer distances until they reappear on the surface as springs
- These streams may be effluent or influent
- Effluent streams are fed by water table over their level while influent streams intersect the water table and flow into it from the ground water reservoir (they are fed by water table below their level)

(c) Stalactites

- These are columns of limestone that hang vertically from the roof of a cave
- They form through deposition of drops of water containing calcium bicarbonate that has seeped through joints and crevices in limestone rock
- The calcite in calcium bicarbonate is deposited due to evaporation and release of carbon (iv) oxide in water
- The drops of calcium bicarbonate therefore crystallize and then deposited at the roof of the cave
- This process is repeated over time with more crystals of calcium bicarbonate being formed
- A column of limestone grows from the roof of the roof of the cave downwards as crystals accumulate to form a **stalactite**

(d) Stalagmites

- These are underground stumpy rock masses that grow from the floor of the cave upwards
- When drops of water containing calcium bicarbonate hangs on the roof of a cave, some water drips onto the floor of the cave
- This water spread out, evaporates and leaves behind crystals of calcium carbonate
- This process continues with time and the crystals grow upwards towards the roof of the cave to form a **stalagmite**

(e) Limestone pillars

- This is a column of limestone that connects the roof and the floor of the cave
- They are formed in the following ways
  - When a stalagmite forms directly below a stalactite, the two grow towards each other and eventually meet forming a continuous column that touches the roof and the floor of the cave called a **limestone pillar**
  - When a stalactite grows from the roof of the cave till it touches the floor of the cave
  - When a stalagmite grows from the floor of the cave upwards till it touches the roof of the cave

Diagram

(f) Karst windows

- Small underground outlets to the surface from the roof of a cave/cavern
- They form due to continuous carbonation by rain water at the surface or rising of the water table due to heavy rain leading to the formation of cavern.
- Continuous growth of the cavern and collapse of its roof leaves a hole called a **karst window** i.e. small outlet from a cave to the surface

(g) Karst bridges

- Karst window enlarges due to continuous collapse until a small part of the roof left known as a **karst bridge.**

Significance of the resultant features of action of water in limestone areas

a. Tourist attraction. The surface and underground features of a karst landscape form scenic beauty which attract tourists who in turn bring foreign exchange e.g. limestone pillars, stalactites, stalagmite, etc.

b. Limestone blocks are used for building houses

c. Limestone is also a raw material in the manufacture of cement.

d. Karst landscape is rugged, rocky hence discourages settlements

e. Limestone from karst region is used as a raw material in the iron and steel industry

f. Collapse of dolines and poljes in water table may lead to formation of lakes in the karst area thus providing water for domestic and irrigation