PREFACE

In the curricular structure introduced by this University for students for Post-Graduate degree programme, the opportunity to pursue Post-Graduate course in Subjects introduced by this University is equally available to all learners. Instead of being guided by any presumption about ability level, it would perhaps stand to reason if receptivity of a learner is judged in the course of the learning process. That would be entirely in keeping with the objectives of open education which does not believe in artificial differentiation.

Keeping this in view, study materials of the Post-Graduate level in different subjects are being prepared on the basis of a well laid-out syllabus. The course structure combines the best elements in the approved syllabi of Central and State Universities in respective subjects. It has been so designed as to be upgradable with the addition of new information as well as results of fresh thinking and analysis.

The accepted methodology of distance education has been followed in the preparation of these study materials. Co-operation in every form of experienced scholars is indispensable for a work of this kind. We, therefore, owe an enormous debt of gratitude to everyone whose tireless efforts went into the writing, editing and devising of proper lay-out of the materials. Practically speaking, their role amounts to an involvement in 'invisible teaching'. For whoever makes use of these study materials would virtually derive the benefit of learning under their collective care without each being seen by the other.

The more a learner would seriously pursue these study materials, the easier it will be for him or her to reach out to larger horizons of a subject. Care has also been taken to make the language lucid and presentation attractive so that may be rated as quality self-learning materials. If anything remains still obscure or difficult to follow, arrangements are there to come to terms with them through the counselling sessions regularly available at the network of study centres set up by the University.

Needless to add, a great deal of these efforts are still experimental—in fact, pioneering in certain areas, Naturally, there is every possibility of some lapse or deficiency here and there. However, these do admit of rectification and further improvement in due course. On the whole, therefore, these study materials are expected to evoke wider appreciation the more they receive serious attention of all concerned.

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Netaji Subhas Open University
Post Graduate Degree Programme
Choice Based Credit System (CBCS)
Subject : P.G. Environmental Science (PGES)
Course : General Practical
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Netaji Subhas Open University

P.G. Environmental Science
PGES-P205

Course : General Practical
PGES-P205

Contents	

# Unit-1 ☐ Identification of Common minerals and Rocks

Structure

Minerals

Minerals are the geological treasures that underpin the Earth's solid foundation, each with its unique chemical composition, crystalline structure, and distince properties. These mineralogical wonders are abundant in our natural environment and are essential components of our planet's geology. As we embark on a journey to explore common minerals, we will uncover a world teeming with both aesthetic beauty and scientific intrigue. From the glimmering allure of gold to the rugged resilience of quartz, and from the iridescent splendour of opals to the utilitarain strength of granite, these minerals hold an integral place in our daily lives. Moreover, we will discuss the classification of common minerals based on their physical properties, crystal structures, and chemical compositions, providing you with insights into how geologists and mineralogists indentify and categorize these natural wonders.

whether you are a geology enthusiast, a student exploring the intricacies of Earth science, or merely intrigued by the remarkable substances that form the bedraock fo our planet, this journey into the world of common minerals promises to be an illuminating and enriching experience. It will deepen your appreciation for the geological wonders that surround us and shed light on therir enduring importance in our daily lives and our understanding of the Earth's history.

Rock

The earth's crust is composed of rocks. A rock is an aggregate of one or more minerals. Rock may be hard or soft and in varied colours. For example, granite is hard, soapstone is soft. Gabbro is black and quartzite can be milky white. Rocks do not have definite composition of mineral constituents. Feldspar and quartz are the most common minerals found in rocks.

7

Types of Rocks

| Igneous | Sedimentary | Metamorphic |
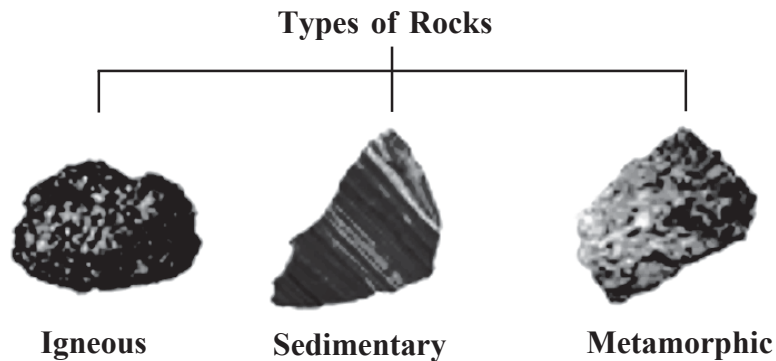
Definition of different types of rocks

Definition or Rocks: Rock can be defined as a material made of mineral particles bonded together. Rock is a hard and clastic substance. Therefore, rocks are aggregate of minerals. Rocks are classified according to their origin—

(a) **Igneous Rock:** The Latin word 'Ignis' means fire. Igneous rocks are actually of fiery origin. They are made by the cooling and solidification of hot molten, material either magma within the earth's crust or lava or the earth's surface.

Eg. Granite, Basalt, Dolerite. Igneous rocks are of two types— i) Extrusive rock ii) Intrusive rock.

(b) **Sedimentary Rock:** The Latrin word 'Sedere' means 'Setting down'. Deposition of eroded materials of pre-existing rocks by natural agents like river glacier, wind at distant places below the river, lake, sea or oceans under water in layers and solidification of these sediments (deposited particles) in layers from sedimentary rocks.

Eg. Coal, Shale, Sandstone, Limestone, Conglomerate, Laterite. Sedimentary rocks are either of classic or non-classic origin.

(c) **Metamorphic Rock:** The Greek word 'meta' means 'altered' and 'morpho' means form. Due to temperature or pressure a pre-existing either igneous or sedimentary rock changes into a new form of rock which is called metamorphic rock.

Eg. Slate, Phyllite, Quartzite, Gneiss, Marble, Schist. Metamorphic rock can be either foliated or non-foliated.

1.1 Identification of common minerals

1.1.1 Aim

To give knowledge to the learners to identify different types of Common minerals along with their distinct characters.

1.1.2 Introduction

The earth is composed of various kinds of elements and these elements are in solid form in the outer layer of the earth and in hot and molten form in the interior. About 98 per cent of the total crust of the earth is composed of eight elements like oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium (Table 1), and the rest is constituted by titanium, hydrogen, phosphorous, manganese, sulphur, carbon, nickel and other elements.

Table 1 : The Major Elements of the Earth's Crust

Sl. No.	Elements	By Weight (%)
1.	Oxygen	46.60
2.	Silicon	27.72
3.	Aluminium	8.13
4.	Iron	5.00
5.	Calcium	3.63
6.	Sodium	2.83
7.	Potassium	2.59
8.	Magnesium	2.09
9.	Others	1.41

The elements in the earth's crust are rarely found exclusively but are usually combined with other elements to make various substances. These substances are recognised as minerals. Thus, a mineral is a naturally occurring inorganic substance, having an orderly atomic structure and a definite chemical composition and physical properties. A mineral is composed of two or more elements. But sometimes single element minerals like sulphur, copper, silver, gold, graphite *etc.* are found.

Though the number of elements making up the lithosphere are limited they are combined in many different ways to make up many varieties of minerals. There are at least 2,000 minerals that have been named and identified in the earth crust; but

almost all the commonly occurring ones are related to six major mineral groups that are known as major rock forming minerals.

The basic source of all minerals is the hot magma in the interior of the earth. When magma cools, crystals of minerals appear, and a systematic series of minerals are formed in sequence to solidify so as to form rocks. Minerals such as coal, petroleum and natural gas are organic substances found in solid, liquid and gaseous forms respectively.

1.1.3 Definition of Minerals:

Mineral is an inorganic homogeneous substance usually crystalline with a defined chemical composition. Therefore, minerals are natural body without organic particles.

E.g. Mica, Talc, Quartz, Feldspar, Gypsum, Hematite, Magnetite, Calcite, Chalcopyrite, Galena, Bauxite.

1.1.4 Physical Characteristics:

(i) *External crystal form*—determined by internal arrangement of the molecules—cubes, octahedrons, hexagonal prisms, etc.

(ii) *Cleavage*—tendency to break in given directions producing relatively plane surfaces—result of internal arrangement of the molecules—may cleave in one or more directions and at any angle to each other.

(iii) *Fracture*—internal molecular arrangement so complex there are no planes of molecules; the crystal will break in an irregular manner not along planes of cleavage.

(iv) *Luster*—appearance of a material without regard to colour; each mineral has a distinctive luster like metallic, silky', glossy etc.

(v) *Colour*—some minerals have characteristic colour determined by their molecular structure—malachite, azurite, chalcopyrite etc. and some minerals are coloured by impurities. For example, because of impurities quartz may be white, green, red, yellow etc.

(vi) *Streak*—colour of the ground powder of any mineral. It may be of the same colour as the mineral or may differ—malachite is given and gives green streak; fluorite is purple or green but gives a white streak.

(vii) *Transparency*—transparent; light rays pass through so that objects can be seen plainly; translucent—light rays pass through but will get diffused so that objects cannot be seen; opaque—light will not pass at all.

(viii) *Structure*—particular arrangement of the individual crystals; fine, medium or coarse grained; fibrous—separable, divergent, radiating.

(ix) *Hardness*—relative resistance being scratched; ten minerals are selected to measure the degree of hardness from 1-10.

They are: 1. talc; 2 . gypsum; 3. calcite; 4. fluorite; 5. apatite; 6. feldspar; 7. quartz; 8. topaz; 9. corundum; 10. diamond. Compared to this for example, a fingernail is 2.5 and glass or knife blade is 5.5.

(x) *Specific gravity*—the ratio between the weight of a given object and the weight of an equal volume of water; object weighed in air and then weighed in water and divide weight in air by the difference of the two weights.

1.1.5 Some Major Minerals and their Characteristics

Feldspar: Silicon and oxygen are common elements in all types of feldspar and sodium, potasium, calcium, aluminium etc. are found in specific feldspar variety. Half of the earth's crust is composed of feldspar. It has light cream to salmon pink colour. It is used in ceramics and glass making.

Quartz: It is one of the most important components of sand and granite. It consists of silica. It is a hard mineral virtually insoluble in water. It is white or colourless and used in radio and radar. It is one of the most important components of granite.

Pyroxene: Pyroxene consists of calcium, aluminum, magnesium, iron and silica. Pyroxene forms 10 percent of the earth's crust. It is commonly found in meteorites. It is in green or black colour.

Amphibole: Aluminium, calcium, silica, iron, magnesium are the major elements of amphiboles. They form 7 percent of the earth's crust. It is in green or black colour and is used in asbestos industry. Hornblende is another form of amphiboles.

Mica: It comprises of potassium, aluminium, magnesium, iron, silica *etc.* It forms 4 percent of the earth's crust. It is commonly found in igneous and metamorphic rocks. It is used in electrical instruments.

Olivine: Magnesium, iron and silica are major elements of olivine. It is used in jewellery. It is usually a greenish crystal, often found in basaltic rocks. Besides these main minerals, other minerals like chlorite, calcite, magnetite, hematite, bauxite and barite are also present in some quantities in the rocks.

Metallic Minerals: These minerals contain metal content and can be sub-divided into three types—

(i) Precious metals: gold, silver, platinum etc.

(ii) Ferrous metals: iron and other metals are often mixed with iron to form various kinds of steel.

(iii) Non-ferrous metals: include metals like copper, lead, zinc, tin, aluminium etc.

Non-Metallic Minerals: These minerals do not contain metal content, Sulphur, phosphates and nitrates are examples of non-metallic minerals. Cement is a mixture of non-metallic minerals.

1.1.6 Identifying characters of Minerals:

(a) Talc:

(i) White/ Whitish grey/ Grey, silky luster, low specific gravity.

(ii) Less than 2.5, soapy feeling

(b) Mica:

(i) Muscovite — i. Colour white, silver, pearly luster, very low specific gravity.

                    ii. Hardness < 2.5, transparent and translucent mineral.

(ii) Biotite — i. Black coloured, pearly luster, very low specific gravity.

                    ii. Hardness < 2.5, transparent and translucent mineral.

(c) Gypsum:

(i) White/Grey colored, sub-pearly luster, low specific gravity.

(ii) Hardness < 2.5, translucent mineral.

(d) Quartz:

(i) White/Greyish white, vitreous luster.

(ii) Hardness 6, crystalline mineral.

(e) Feldspar:

(i) Albite/Plagioclase — i. White/Grey, sub pearly luster, high to moderate specific gravity.

                    ii. Hardness > 5, 2D Clevage.

    (ii) Orthoclase —   i. Reddish white/Pink color, sub peurly luster, high to moderate specific gravity.

                                          ii. Hardness > 5, 2D Cleavage

(f) Hematite:

  (i) Reddish brown (outer surface), Black inner surface, sub metallic luster, very high specific gravity.

  (ii) Hardness 5.5 to 6.5, very low magnetism, gives cherry red streak.

(g) Magnetite:

  (i) Iron black colored, submetallic to earthy luster, high specific gravity.

  (ii) Hardness 5.5 to 6.5, highly magnetism, gives black streak.

(h) Calcite:

  (i) White colored, vitreous luster, low to moderate specific gravity.

  (ii) 3D Cleavage, react with HCl.

(i) Bauxite:

  (i) Creamy/ Whitish cream/ Grey/ Earthy lustre, low to moderate specific gravity.

  (ii) Non crystalline mineral, Pisolitic masses.

(j) Chalcopyrite:

  (i) Golden yellow/ yellow/ Green, metallic luster, high specific gravity.

  (ii) Hardness > 3.5 to 4, Greenish black streak, gives smell when HCl is applied.

(k) Gelena:

  (i) Steel black/ Iron black colored, metallic luster, very high specific gravity.

  (ii) Hardness > 5.5, lead grey streak.

(l) Tourmaline:

  (i) Silver or greenish black coloured, metallic lustre moderate specific gravity.

  (ii) Hardness > 6, prismatic crystalls with rounded shape.

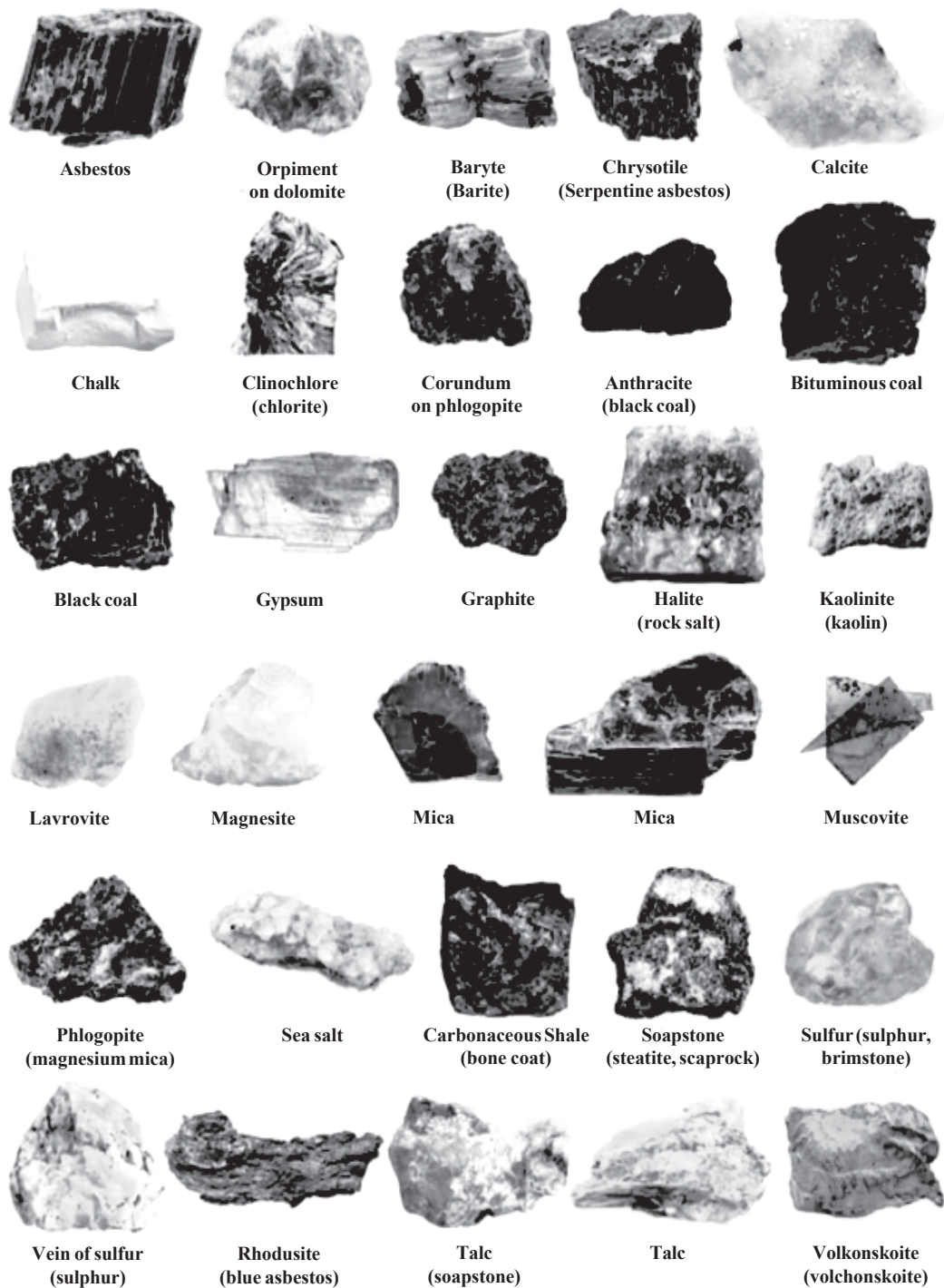|				
Asbestos	**Orpiment on dolomite**	**Baryte (Barite)**	**Chrysotile (Serpentine asbestos)**	**Calcite**
Chalk	**Clinochlore (chlorite)**	**Corundum on phlogopite**	**Anthracite (black coal)**	**Bituminous coal**
Black coal	**Gypsum**	**Graphite**	**Halite (rock salt)**	**Kaolinite (kaolin)**
Lavrovite	**Magnesite**	**Mica**	**Mica**	**Muscovite**
Phlogopite (magnesium mica)	**Sea salt**	**Carbonaceous Shale (bone coat)**	**Soapstone (steatite, scaprock)**	**Sulfur (sulphur, brimstone)**
Vein of sulfur (sulphur)	**Rhodusite (blue asbestos)**	**Talc (soapstone)**	**Talc**	**Volkonskoite (volchonskoite)**

Figure 1: Representation of different types of minerals.

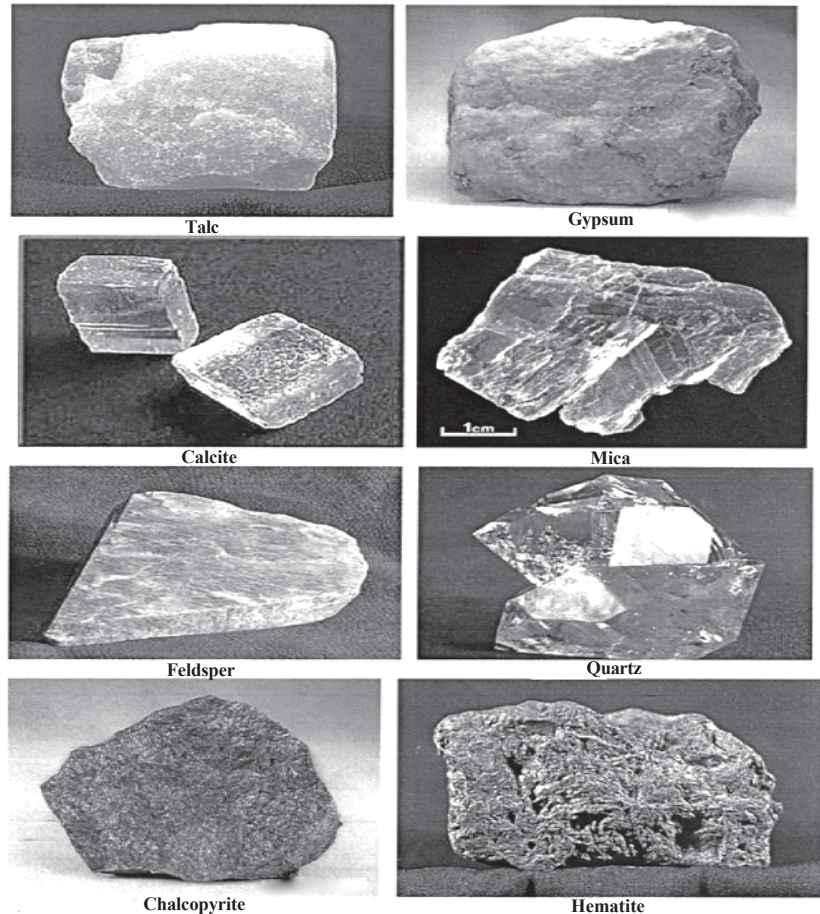*Figure 1.5: Different types of minerals'*
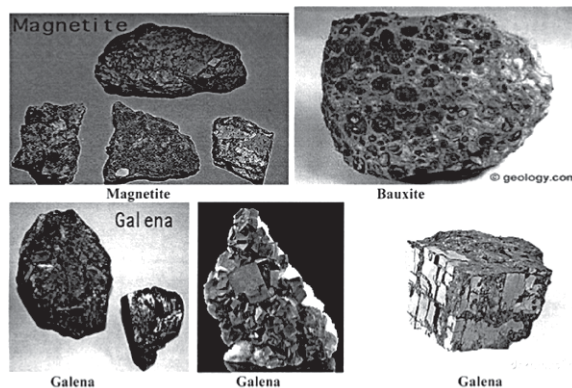

Figure 2: Different types of minerals
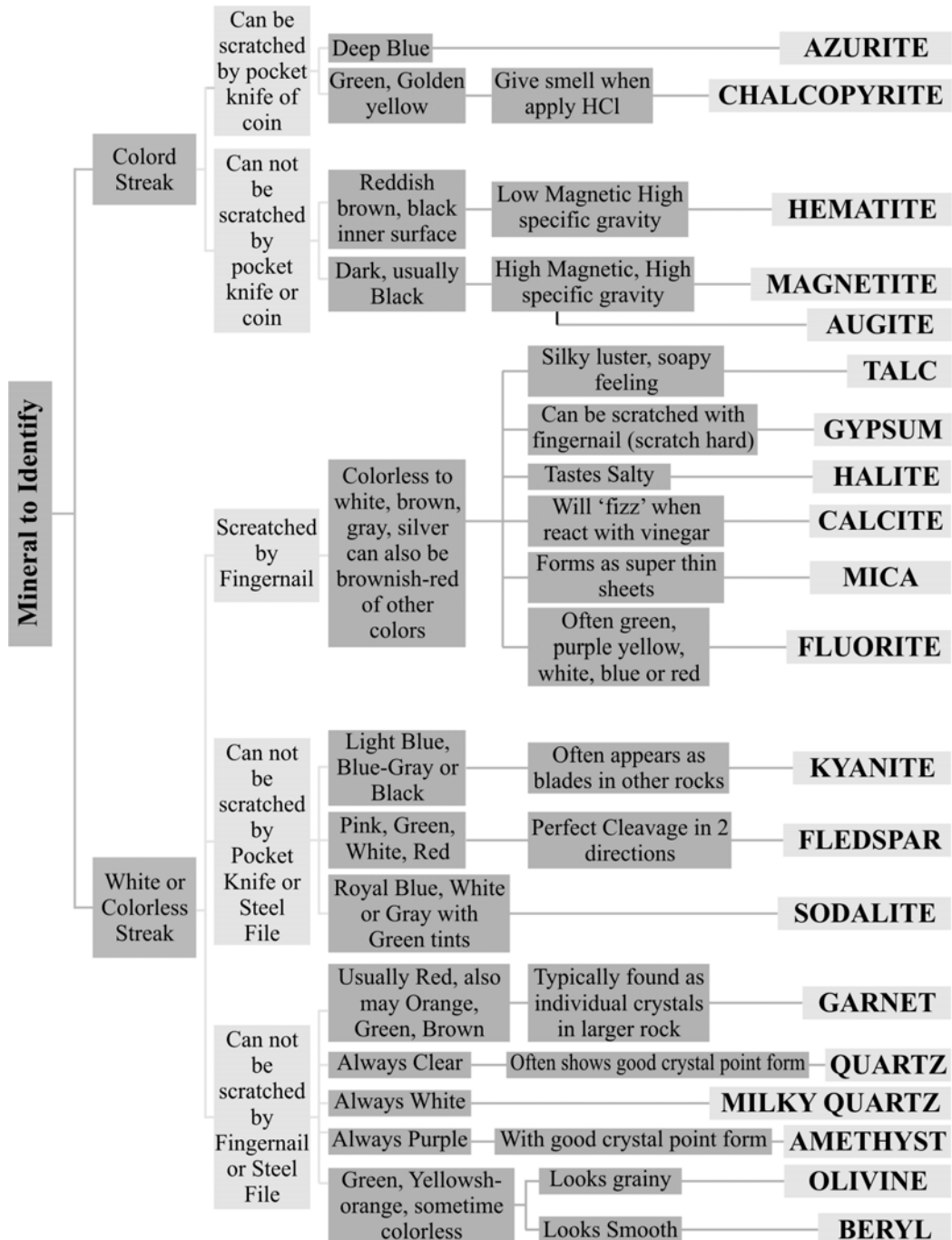

Figure 3: Different types of minerals

Figure 4: Mineral identification chart

1.2 Identification of Igneous rocks

1.2.1 Aim

To give knowledge to the learners to identify different types of igneous rocks along with their distinct characters.

1.2.2 Introduction

A rock is a substance made up of one or more different minerals. Thus, an essential part of rock identification is the ability to correctly recognize the major (or most abundant) mineralswithin a given rock sample. This is often described as the rock's mineralogy. Another important component in rock identification is to correctly interpret the rock texture. Technically, texture is the size, shape, and grain-to-grain relationships between minerals in a rock. For the purposes of this and the next two labs, texture really implies genesis, or how the rock formed. All rocks canbe placed into one of three major rock groups based on their texture; igneous, sedimentary or metamorphic rocks. Recognition of the texture of a rock allows one to properly place the rock into its appropriate rock group.

Igneous rocks form from the cooling and crystallization of molten rock. When minerals grow directly from a liquid the boundaries between adjacent minerals tend to penetrate each other, forming a very strong, interlocking pattern similar to that of pieces in a jigsaw puzzle. Given this and the fact that igneous rocks are composed of relatively hard silicate minerals, igneous rocks are very hard rocks that have been used as important building materials by people for thousands of years.

1.1.3 Mineralogy of Igneous Rocks

All igneous rocks originally form from partial melting of the earth's crust, or even, the earth's upper mantle. Since both crust and upper mantle are composed largely of silicate minerals (minerals that contain both silicon and oxygen) igneous rocks also consist mostly of silicate minerals. In the early 1900's a Canadian Petrologist by the name of N. L. Bowen first published the sequence of silicate minerals and the order in which they crystallize from a magma. This sequence of minerals is now referred to as Bowen's Reaction Series (Figure 5). Bowen also proposed that a single magma body (a single liquid) may be capable of producing different types of igneous rocks through a process called fractional crystallization. As a magma body raises towards the surface minerals that crystallize from the magma may sink to the bottom of the magma chamber (or fractionate) and be left behind by the raising liquid. This

would change the chemistry of the raising liquid causing it to crystallize different minerals on its way toward the surface. In this way a very hot, very deep magma body would first crystallize olivine, which would sink to the bottom and be left behind. The raising and cooling magma body would then crystallize augite and calcium-rich pla-gioclase, which would sink and be left behind. Next would come hornblende and calcium-sodium plagioclase, then biotite and sodium-rich plagioclase and finally, as the magma nears the surface, the last minerals in Bowen's sequence would crystallize out from the largely cooled and solidified magma body.

The major silicate minerals can be identified by first placing them into subclasses based on the arrangement of Si-O tetrahedra and metals present in the silicate mineral. For the purpose of this lab it is more convenient to classify the various silicate minerals based on their chemical composition. Ferromagnesian silicate minerals are those that contain high amounts of the metals iron, magnesium and/or calcium in them. These metals tend to make ferromagnesian silicates dark in color (dark gray to black). So igneous rocks that contain high percentages of ferromagnesian silicates tend to be dark colored. Nonferromagnesian silicate minerals are those that contain little or no iron, magnesium or calcium in them. Instead, they tend to have sodium, potassium and/or aluminium in their chemical make up. These metals produce silicate minerals that have light colors (white, light gray or pink). Igneous rocks that contain high percentages of nonferromagnesian silicates tend to be light colored.

Bowen's Reaction Series

Crystallization Temperature
~1200° C   *Olivine*
      Augite   *Calcium Plagioclase*
       Hornblende   Calcium-Sodium Plagioclase
        Biotite   Sodium Plagioclase

          Orthoclase
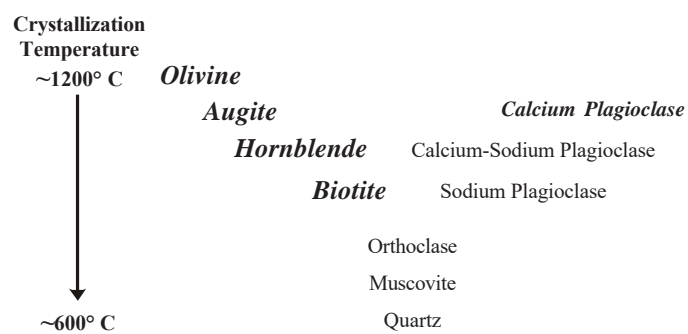   Muscovite
~600° C   Quartz

Figure 5: The Bowen's Reaction Series with ferromagnesian silicate minerals in bold-italic text and nonferromagnesian silicate minerals in normal text.

1.1.4 Identification of Igneous Rocks

Identification of igneous rocks involves determining the major minerals (mineralogy) of the rocks and their texture. Determination of the mineralogy is aided by the color of the rock. Remember that ferromagnesian silicates are dark colored minerals and nonferromagnesian minerals are light in color. Very dark colored rocks (sometimes called ultramafic igneous rocks) consist primarily of the mineral olivine and are dark green. Dark colored rocks (mafic igneous rocks) are dark gray to nearly black. Both ultramafic and mafic igneous rocks consist entirely of ferromagnesian silicate minerals. Medium colored igneous rocks (or intermediate igneous rocks) contain about half ferromagnesian silicates and about half nonferromagnesian silicates. Coarse-grained intermediate igneous rocks are said to have a "salt and pepper" appearance. Light colored igneous rocks, those dominated by nonferromagnesian silicates are called felsic igneous rocks and are either pink or light gray.

All igneous rocks that form from the slow cooling of magma are collectively called Plutonic igneous rocks. Because of the slow cooling, all Plutonic igneous rocks have a coarse-grained or phaneritic texture.

All igneous rocks that form from the quick cooling of lava are collectively called volcanic igneous rocks. Volcanic igneous rocks that form from lava flows generally have a porphyritic or a mixed coarse-grained (phenocrysts) and fine-grained (groundmass). In addition, basalt lavas tend to be rather gassy and so some basalt rocks may have a vesicular texture. Any time lava cools so quickly that no minerals get a chance to form then glass can be created. Some glasses are nonvesicular (obsidian) and some glasses may have been very gassy (scoria or pumice). Compacted volcanic ash or very hot volcanic ash that wields itself together due to extreme heat has a pyroclastic texture and is called tuff. All glasses, whether nonvesicular, vesicular or ash, contain no minerals.

Rock Color	Major Mineralogy	Plutonic Igneous Rocks (cooled from magma)	Volcanic Igneous Rocks (cooled from lava)		
		Phaneritic Texture	Porphyritic Texture	Vesicular & Glassy Texture	Pyroclastic Texture
Very dark Colored (Ultrama-fic)	Olivine	DUNITE	KIMBERLITE (rate)	RARE	RARE
dark Colored (Mafic)	Pyroxene Calcium Plagioclase	GABBRO	BASALT or VESICULAR BASALT	OBSIDIAN (dense glass, no vesicules) SCORIA (50% vesicules) PUMICE (90% Vesicules)	TUFF (Compacted or wielded volcanic ash)
medium colored (Intermedi-ate)	Hornblende Ca-Na Plagioclase	DIORITE	ANDESTIE		
light colored (Felsic)	Biotite Sodiume Plagioclase Orthoclase Muscovite Quartz	GRAY GRANITE (no orthoclase) PINK GRANITE (with orthoclase)	RHYOLITE		

(a) Granite

    i. Light coloured with spots of white, pink and black. Moderate to coarse grained, moderate to high specific gravity.

    ii. Composed of quartz, feldspar, and mica. It is a hard, compact, massive.

(b) Basalt

    i. Dark black/grayish black, very fine grained, moderate to high specific gravity.

    ii. Composed of pyroxene and biotite. It is hard massive and compact.

(c) Dolerite

    i. Dark coloured, moderate grained, moderate to high specific gravity.

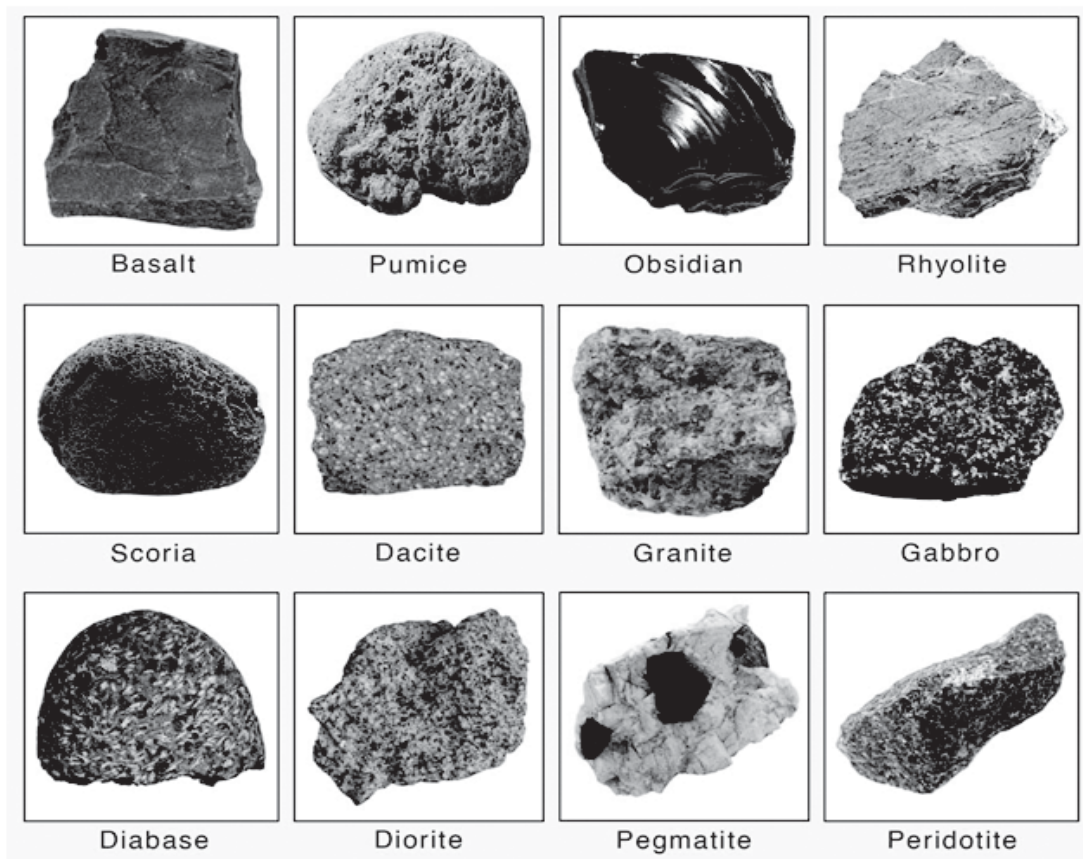   ii. Composed of pyroxene, and feldspar. It is hard, massive and compact having interfingering texture.

Figure 6: Different types of igneous rocks [Source: https:// www.sciencefacts.net/igneous-rocks.html]

Table 2: Keys to identify the Igneous rocks

Grain Size	Usual Color	Other	Composition	Rock Type
Fine	Dark	Glassy appearance	Lava glass	Obsidian
Fine	Light	Many small bubbles	Lava froth from sticky lava	Pumice
Fine	Dark	Many large bubbles	Lava froth from fluid lava	Scoria
Fine or mixed	Light	Contains quartz	High-silica lava	Felsite
Fine or mixed	Medium	Between felsite and basalt	Medium-silica lava	Andesite
Fine or mixed	Dark	Has no quartz	Low-silica lava	Basalt
Mixed	Any color	Large grains in fine-grained matrix	Large grains of feldspar, quartz, pyroxene or olivine	Porphyry
Coarse	Light	Wide range of color and grain size	Feldspar and quartz with minor mica, amphibole or pyroxene	Granite
Coarse	Light	Like granite but without quartz	Feldspar with minor mica, amphibole or pyroxene	Syenite
Coarse	Litht to medium	Little or no aukali feldspar	Plagioclase and quartz with dark minerals	Tonalite
Coarse	Medium to dark	Little or no quartz	Low-calcium plagioclase and dark minerals	Diorite
Coarse	Medium to dark	No quartz; may have olivine	High-calcium plagioclase and dark minerals	Gabbro
Coarse	Dark	Dense; alwayas has olivine	Olivine with amphibole and/or pyroxene	Peridotite
Coarse	Dark	Dense	Mostly pyroxene with olivine and amphibole	Pyroxenite
Coarse	Green	Dense	At least 90 percent olivine	Dunite
Very coarse	Any color	Usually in small intrusive bodies	Typically, granitic	Pegmatite

1.3 Identification of Sedimentary rocks

1.3.1 Aim

To give knowledge to the learners to identify different types of sedimentary rocks along with their distinct characters.

1.3.2 Introduction

The word 'sedimentary' is derived from the Latin word sedimentum, which means settling. Rocks (igneous, sedimentary and metamorphic) of the earth's surface are exposed to denudational agents and are broken up into various sizes of fragments. Such fragments are transported by different exogenous agencies and deposited. These deposits through compaction turn into rocks. This process is called lithification. In many sedimentary rocks, the layers of deposits retain their characteristics even after lithiflcation. Hence, we see a number of layers of varying thickness in sedimentary rocks like sandstone, shale etc.

Depending upon the mode of formation, sedimentary rocks are classified into three major groups: (i) mechanically formed—sandstone, conglomerate, limestone, shale, loess *etc.* are examples; (ii) organically formed—geyserite, chalk, limestone, coal *etc.* are some examples; (iii) chemically formed—chert, limestone, halite, potash *etc.* are some examples.

1.3.3 Identifying characters of some sedimentary rocks

(a) Shale:

(i) Yellowish green/ Grey/ Brown/ Greenish brown.

(ii) Very fine grain size, moderate specific gravity.

(iii) Composed of clay minerals, gives smell of clay when water is applied, it is non clastic rock.

(b) Sandstone:

(i) White, light yellowish white, mixture, reddish brown in color.

(ii) Medium to fine grain, moderate specific gravity.

(iii) Composed of sand and quartz, clastic surface, rough surface.

(c) Limestone:

(i) Black/ Grey/ Greyish white/ Mixture/ Reddish Brown, medium to fine grain, moderate specific gravity.

(ii) Composed of calcite, non clastic and reacts with HCl, can be scratched by knife.

(d) Conglomerate:

  (i) Yellowish brown/ White/ Pinkish white, coarse grain, moderate specific gravity.

 (ii) Composed of pebbles, sand/ quartz, clastic texture.

(e) Laterite:

  (i) Brown, orange, reddish brown, red, medium grained, moderate to high specific gravity.

 (ii) Composed of bauxite, limestone, quartz, vesicular structure with spots of nodules, clastic rock, very rough surface.
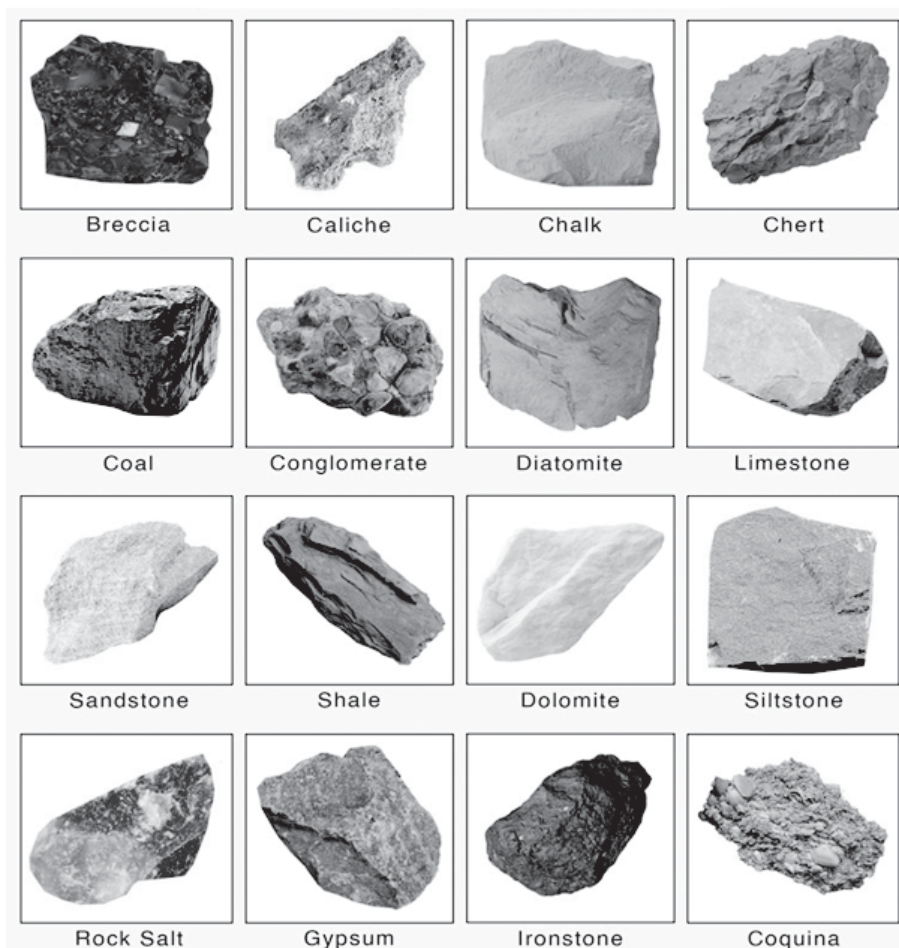

Figure 7: Different types of sedimentary rocks
[https://www.sciencefacts.net/sedimentary-rocks.html]

Table 3: Keys to identify the Sedimentary rocks

Hardness	Grain Size	Composition	Other	Rock Type
Hard	Coarse	Clean quartz	White to brown	Sandstone
Hard	Coarse	Quartz and feldspar	Usually very coarse	Arkose
Hard or soft	Mixed	Mixed sediment with rock grains and clay	Gray or dark and "dirty"	Wacke/ Greywacke
Hard or soft	Mixed	Mixed rocks and sediment	Round rocks in finer sediment matrix	Conglome- rate
Hard or soft	Mixed	Mixed rocks and sediment	Sharp pieces in finer sediment matrix	Breccia
Hard	Fine	Very fine sand; no clay	Feels gritty on teeth	Siltstone
Hard	Fine	Chalcedony	No fizzing with acid	Chert
Soft	Fine	Clay minerals	Splits in layers	Shale
Soft	Fine	Carbon	Black; burns with tarry smoke	Coal
Soft	Fine	Calcite	Fizzes with acid	Limestone
Soft	Coarse or fine	Dolomite	No fizzing with acid unless powdered	Dolomite rock
Soft	Coarse	Fossil shells	Mostly pieces	Coquina
Very soft	Coarse	Halite	Salt taste	Rock Salt
Very soft	Coarse	Gypsum	White, tan or pink	Rock Gypsum

1.4   Identification of Metamorphic rocks

1.4.1 Aim

To give knowledge to the learners to identify different types of metamorphic rocks along with their distinct characters.

1.4.2   Introduction

The word metamorphic means 'change of form'. These rocks form under the action of pressure, volume and temperature (PVT) changes. Metamorphism occurs when rocks are forced down to lower levels by tectonic processes or when molten magma rising through the crust comes in contact with the crustal rocks or the under-lying rocks are subjected to great amounts of pressure by overlying rocks. Metamor-phism is a process by which already consolidated rocks undergo recrystallisation and reorganisation of materials within original rocks.

Mechanical disruption and reorganization of the original minerals within rocks due to breaking and crushing without any appreciable chemical changes is called dynamic metamorphism. The materials of rocks chemically alter and recrystallise due to thermal metamorphism. There are two types of thermal metamorphism—**contact metamorphism** and **regional metamorphism**. In contact metamorphism the rocks come in contact with hot intruding magma and lava and the rock materials recrystallise under high temperatures. Quite often new materials form out of magma or lava are added to the rocks. In regional metamorphism, rocks undergo recrystallisation due to deformation caused by tectonic shearing together with high temperature or pressure or both. In the process of metamorphism in some rocks grains or minerals get ar-ranged in layers or lines. Such an arrangement of minerals or grains in metamorphic rocks is called **foliation** or **lineation**. Sometimes minerals or materials of different groups are arranged into alternating thin to thick layers appearing in light and dark shades. Such a structure in metamorphic rocks is called banding and rocks displaying banding are called **banded rocks**. Types of metamorphic rocks depend upon original rocks that were subjected to metamorphism. Metamorphic rocks are classified into two major groups—foliated rocks and non-foliated rocks. Gneiss, granite, syenite, slate, schist, marble, quartzite *etc*. are some examples of metamorphic rocks.

1.4.3 Identifying characters of some Metamorphic rocks

(a) State

    (i) Greenish black/Grey, fine grained, moderate specific gravity.

    (ii) Composed of clay, prominent foliation, gives metallic sound under Hammer blow.

(b) Phyllite

    (i) Greenish grey/ Grey/ Green, moderate specific gravity.

    (ii) Composed of chlorite and mica, foliated rock, fine to medium grain size.

(c) Quartzite

    (i) White/ Ash/ Grey/ Brownish grey, low to medium grained, low to moderate specific gravity.

    (ii) Composed of sand, quartz sharp edge, non foliated.

(d) Gneiss

    (i) Alternate band of light and dark colored, medium grained, moderate specific gravity.

    (ii) Composed of mica, quartz and feldspar, non foliated.

(e) Marble

    (i) White/Pink, orangish white, fine to medium grained, low to moderate specific gravity.

    (ii) Composed of limestone, react with HCl, nonfoliated.

(f) Schist

    (i) Silver/ White/ Black/ Green, medium grained, low to moderate specific gravity.

    (ii) Composed of muscovite biotite chlorite, foliated rock, crystalline, quartz, feldspar

Figure 8: Different types of metamorplic rocks [https://www.sciencefacts.net/ metamorphic-rocks.html]

Table 4: Keys to identify the Metamorphic rocks

Foliation	Grain Size	Usual Color	Other	Rock Type
Foliated	Fine	Light	Very soft; greasy feel	Soapstone
Foliated	Fine	Dark	Soft; strong cleavage	Slate
Nonfoliated	Fine	Dark	Soft; massive structure	Argillite
Foliated	Fine	Dark	Shiny; crinkly foliation	Phyllite
Foliated	Coarse	Mixed dark and light	Crushed and stretched fabric; deformed large crystals	Mylonite
Foliated	Coarse	Mixed dark and light	Wrinkled foliation; often has large crystals	Schist
Foliated	Coarse	Mixed	Banded	Gneiss
Foliated	Coarse	Mixed	Distorted "melted" layers	Migmatite
Foliated	Coarse	Dark	Mostly hornblende	Amphibolite
Nonfoliated	Fine	Greenish	Soft; shiny, mottled surface	Serpentinite
Nonfoliated	Fine or coarse	Dark	Dull and opaque colors, found near intrusions	Hornfels
Nonfoliated	Coarse	Red and green	Dense; garnet and pyroxene	Eclogite
Nonfoliated	Coarse	Light	Soft; calcite or dolomite by the acid test	Marble
Nonfoliated	Coarse	Llight	Quartz (no fizzing with acid)	Quartzite

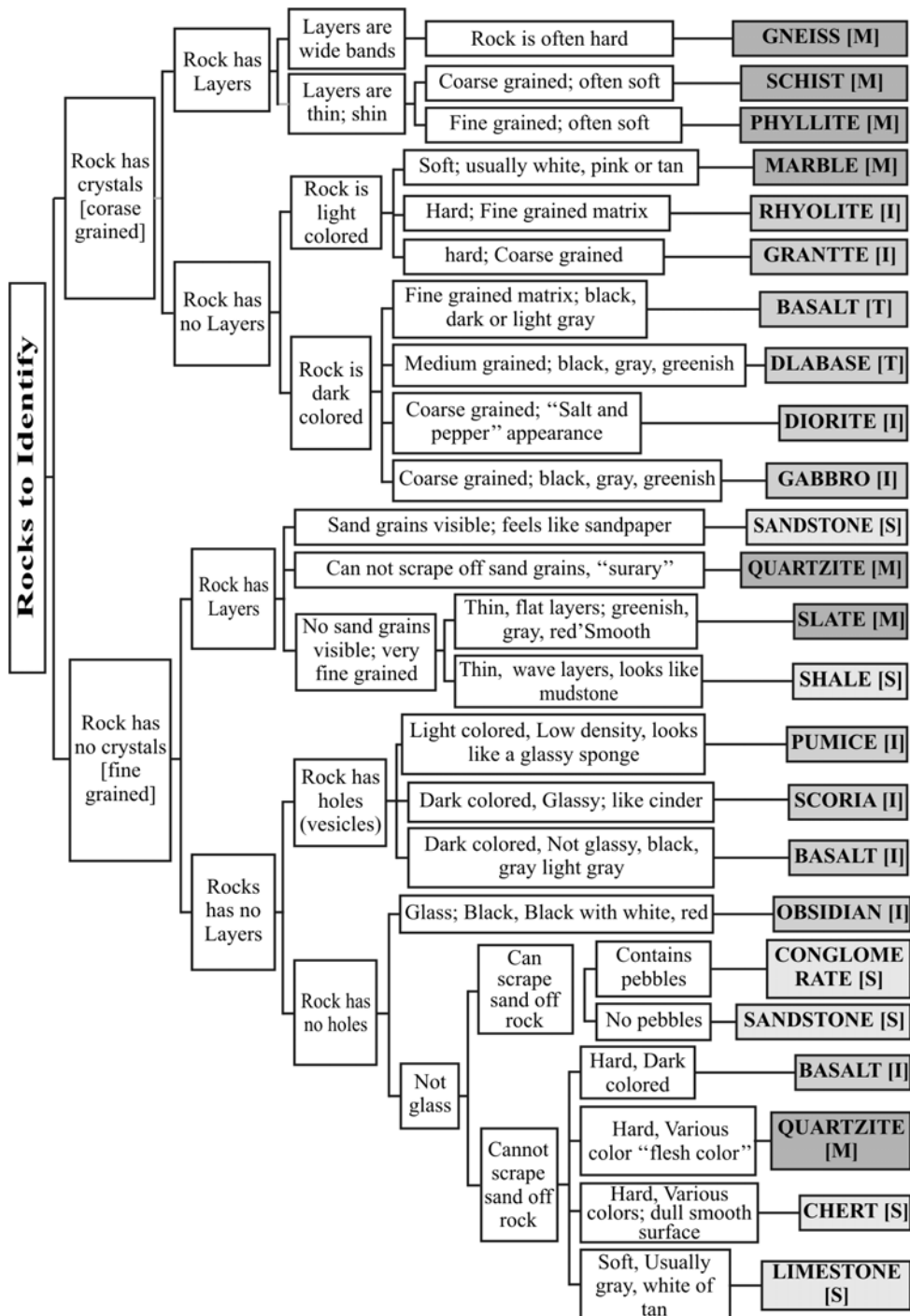| Igneous or Sedimentary Rocks		Metamorphic Rocks
Shale	—	Slate
Sandstone	—	Quartzite
Granite	—	Gneiss
Limestone	—	Marble
Coal	—	Graphite

Figure 9: Rock identification chart

Unit-2 ☐ Meteorological parameters

2.1 Temperature

2.1.1 Aim

This protocol is to provide guideline and the instruction for monitoring the atmospheric temperature.

2.1.2 Introduction

For meteorological purposes, temperature is measured for a number of media. Among them the most common variable measured is the atmospheric temperature (at variable heights). Other variables to be measured are the temperature of the ground, soil, grass minimum and seawater.

The thermodynamic temperature (T), with units of kelvin (K), (also defined as "kelvin temperature"), is the basic temperature variable. The kelvin is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. The temperature (t), in degrees Celsius (or "Celsius temperature") is used for most meteorological purposes. A temperature difference of one-degree Celsius (°C) unit is equal to one kelvin (K) unit.

$$t/°C = T/K - 273.15$$

Meteorological requirements for temperature measurements primarily relate to the following—

- a. The air near the Earth's surface
- b. The surface of the ground
- c. The soil at various depths
- d. The surface levels of the sea and lakes
- e. The upper air.

These measurements are required, either jointly or independently and locally or globally, for input to numerical weather prediction models, for hydrological and agricultural purposes, and as indicators of climatic variability.

2.1.3 Measurement of temperature

- Measurement of temperature varied on different parameters

- Measurement of temperature may be required as continuous records or may be sampled at different time intervals

- For climate studies in particular, the temperature measurements are affected by

  - ❖ The state of the surroundings

  - ❖ Vegetation

  - ❖ The presence of buildings and other objects

  - ❖ Ground cover

  - ❖ The condition of and changes in the design of the radiation shield or screen

  - ❖ Other changes in equipment

- It is important to note down the circumstances in which the measurements are taken along with the temperature record. This information is known as the metadata.
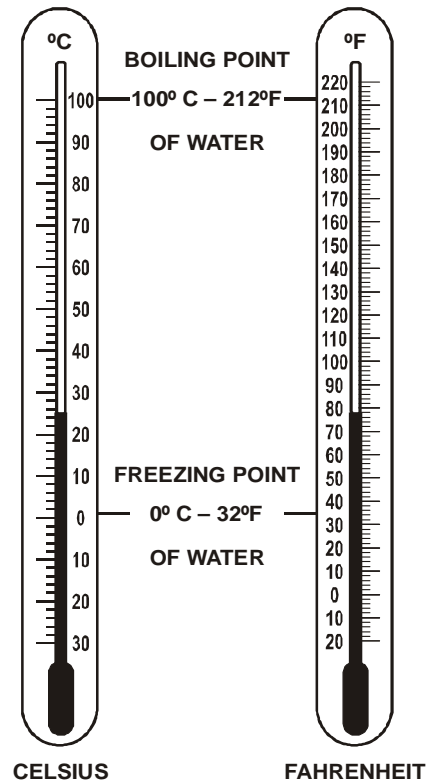

Figure 10: Liquid-in-glass thermometer

2.1.4 Equipment

The major equipments are used to measure the temperature are:

- ❖ Thermometers

- ❖ Liquid-in- glass thermometers

- ❖ Ordinary thermometers (Mercury-in-glass type thermometer)

- ❖ Meteorological thermometers

- ❖ Radiometric thermometers
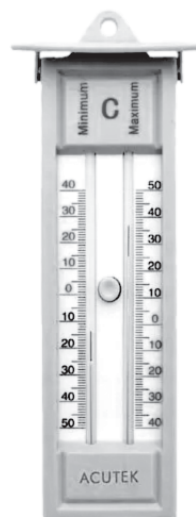
Figure 11: Radiometric thermometers

Figure 12: Meteorological thermometer

2.1.5 Thermometer exposure and siting

Radiation from the sun, clouds, the ground and other surrounding objects passes through the air without appreciably changing it temperature, but a thermometer exposed freely in the open air can absorb considerable radiation and display the values.

2.1.6 Things to be remember

Some important things to be remember during the measurement of the atmospheric temperature which are:

❖ Temperature should be taken in morning, daytime and afternoon and make the average. That will be the day temperature.

❖ During taking temperature thermometer should be under some shade to avoid the extra heating of sun.

❖ Measurement should be done in the open air.

2.2 Atmospheric pressure

2.2.1 Aim

This protocol is to provide guideline and the instruction for monitoring atmospheric pressure.

2.2.2 Introduction

The atmospheric pressure on a given surface is the force per unit area exerted by virtue of the weight of the atmosphere above. The pressure is thus equal to the weight of a vertical column of air above a horizontal projection of the surface, extending to the outer limit of the atmosphere.

The basic unit for atmospheric pressure measurements is the Pascal (Pa) (or Newton per square meter). The atmospheric pressure is measured by the barometers. So barometers are graduated in "millimetres or inches of mercury under standard conditions". Analysed pressure fields are a fundamental requirement of the science of meteorology.

2.2.3 Equipment

For meteorological purpose, atmospheric pressure is generally measured with

- ❖ Electronic barometers
- ❖ Mercury barometers
- ❖ Aneroid barometers or hypsometers

Figure 13: Mercury Barometer

Mercury Barometers

A barometer is the instrument used to measure atmospheric pressure. Pressure tendency can forecast short term changes in the weather.

Aneroid Barometers/ Aneroid Displacement Transducers

The aneroid displacement transducers contain a sensor with electrical properties (resistance or capacitance) that changes as the atmospheric pressure changes. Aneroid barometers have lower accuracy than mercury barometers. These are compact and portable and easier to handle and use.
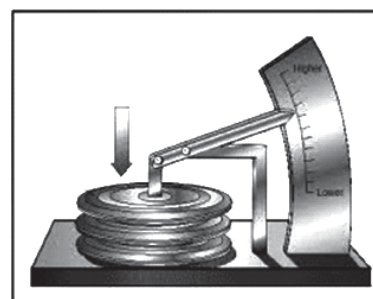

Figure 14: Aneroid Barometer

Digital Piezoresistive Barometers

Today mostly preferred pressure sensor is the piezoresistive sensor. It is cheap, and still delivers a good result. But it has drawbacks, significant power requirements, low output signal, large offset, and temperature dependence.

Figure 15: Digital Piezoresistive Barometers

2.3 Humidity

2.3.1 Aim

This protocol is to provide guideline and the instruction for monitoring and atmospheric humidity.

2.3.2 Introduction

the measurement of atmospheric humidity, and often its continuous recording, is an important requirement in most areas of meteorological activity. The most frequently used quantities in humidity measurements are as follows:

- *Mixing ratio:*

  It is the ratio between the mass of water vapour and the mass of dry air

- *Specific humidity:*

  The ratio between the mass of water vapour and the mass of moist air

- *Relative humidity:*

  The ratio in per cent of the observed vapour pressure to the saturation vapour pressure with respect to water at the same temperature and pressure.

2.3.3 Humidity measurements

Humidity measurements at the Earth's surface are required for meteorological analysis and forecasting, for climate studies, and for many special applications in hydrology, agriculture, aeronautical services and environmental studies, in general. They are particularly important because of their relevance to the changes of state of water in the atmosphere.

2.3.4 Equipment

The instrument is used for measuring the atmospheric humidity is known as a hygrometer. It measures the moisture content in the atmosphere. There is different type of hygrometer measurement methods.

- *Gravimetric hygrometry*

  This method uses the absorption of water vapour by a desiccant from a known volume of air. The gravimetric hygrometer is used for this purpose.

- *The psychrometric method*

  The measurement of atmospheric humidity is an important requirement in most of the areas of meteorological studies. Psychrometry is defined as the measurement of the moisture content of air. Nowadays many humidity measuring devices are available.

Figure 16 Hygrometer

2.3.5 Thing to be remember during the measurement

Some things must be kept in mind during the measurement of atmospheric humidity

- ❖ First of all, measurement must be done in the open environment and surrounding should be noted. Presence of water body in surrounding can rise the atmospheric humidity in local scale.

- ❖ Meter must keep in avoidance of direct sunlight and blowing air to minimize error.

2.4 Wind speed

2.4.1 Aim

This protocol is to provide guideline and the instruction for monitoring the surface wind speed.

2.4.2 Introduction

Wind velocity is a three-dimentsional vector quantity with small scale random fluctuation in space and time. Wind observation and measurement of velocity are required

- For weather monitoring and forecasting

- For wind load climatology for probability of wind damage

- For the estimation of wind energy, and as part of the estimation of surface fluxes

- For visualise the desperation of the pollutants (gaseous) through the air and its distribution as well as direction.

2.4.3 Equipment

An anemometer is a device to measure the wind speed and direction. Wind measurement is significant for detecting surface wind in industrial field. Besides, wind measurement can be applied in environment monitoring and controlling systems, air conditioning system and so on.

There are different types of anemometers is present, for example,

- **Hot Wire Anemometer**

  Hot wire anemomenters use a very fine wire (mm) electrically heated up to above the ambient temperature. Air flowing past the wire has a cooling effect on the wire and through that meter calculate the wind speed. Hot wire anemometer allows accurate monitoring for very low air velocity measurememts.

Figure 17: Hot Wire Anemometer

- **Windmill Anemometer**

   The other form of mechanical velocity anemometer is a windmill type of propeller anemometer. An aerovane that combines a propeller and a tail on the same axis helps to obtain accurate and precise wind speed and direction measurements from the same instrument.

Figure 18: Cup or propeller anemometer

Figure 19: Hand-held anemometer

2.4.4 Methods of measurement and observations

- Wind speed should be reported to a resolution of 0.5 meter per second or in knots (0.515 meter per second) to the nearest unit for every 10 min.

- Wind direction should be reported in degrees to the nearest 10°

- Surface wind is usually measured by a wind vane and cup or propeller anemometer

- Simple hand-held anemometers are also available for this purpose

- The standard exposure of wind instruments over a levelled open terrain is 10 m above the ground

- Two aspects are very important

   - The sensors should be kept away from local obstructions as much as possible

   - The local situation should be well documented

Unit-3 □ Air pollution sampling device and Ambient air quality

3.1 Demonstration of the operating principle of High-Volume Sampler

3.1.1 Aim

To give knowledge to the learners how the high-volume sampler is being operated and the components of the high-volume sampler.

3.1.2 Introduction

High volume samplers are the basic instruments used to monitor Ambient Air Quality. Suspended particles upto 100 microns have emerged as the most critical among all the criteria air pollutants & is caused by number of sources like:

Large, medium & small-scale industries

Road dust construction activities, household fuel cooking, waste burning, vehicular emissions etc.

In order to control the pollution, it is necessary to periodically monitor the air to determine the extent of pollution and to identify the source of emission is designed to meet these needs. That's why, they are in widespread use all over the world to measure air pollution in industrial areas, urban areas, on the shop floor, near monuments and other sensitive areas. The high-volume sampler working on Stokes law for the collection of particulat matter and other gaseous materials.

3.1.3 Principle of operation

In these samplers, airborne suspended particulates (SPM) are measured by passing air at a high flow rate of 1.1 to 1.7 cubic meters per minute through a high efficiency filter paper which retains the particles. The instrument measures the volume of air sampled, while the amount of particulates collected is determined by measuring the change in weight of the filter paper as a consequence of the sampling. The passage for air reaching the filter is designed to prevent heavier settleable dust particles from reaching the filter (by provision of cyclone) thus measuring the concentration of suspended particulate matter (SPM) in the atmospheric air. High-volume air samplers typically sample more than 1500 cubic metres (m) of air over a 24-hour period, while low volume air samplers draw through only 24 m of air, or less.

3.1.4 Components of High-Volume Sampler

- Heavy Duty Blower
- Orifice flow meter: for measures the flow
- Time totalizer: to measure and record the measure time
- Instrument Cabinet
- Filter holder assembly: To hold the filter paper at the right position and ensure maximum suction air pass through the filter paper
- Voltage stabilizer: to guards the apparatus from voltage fluctuation
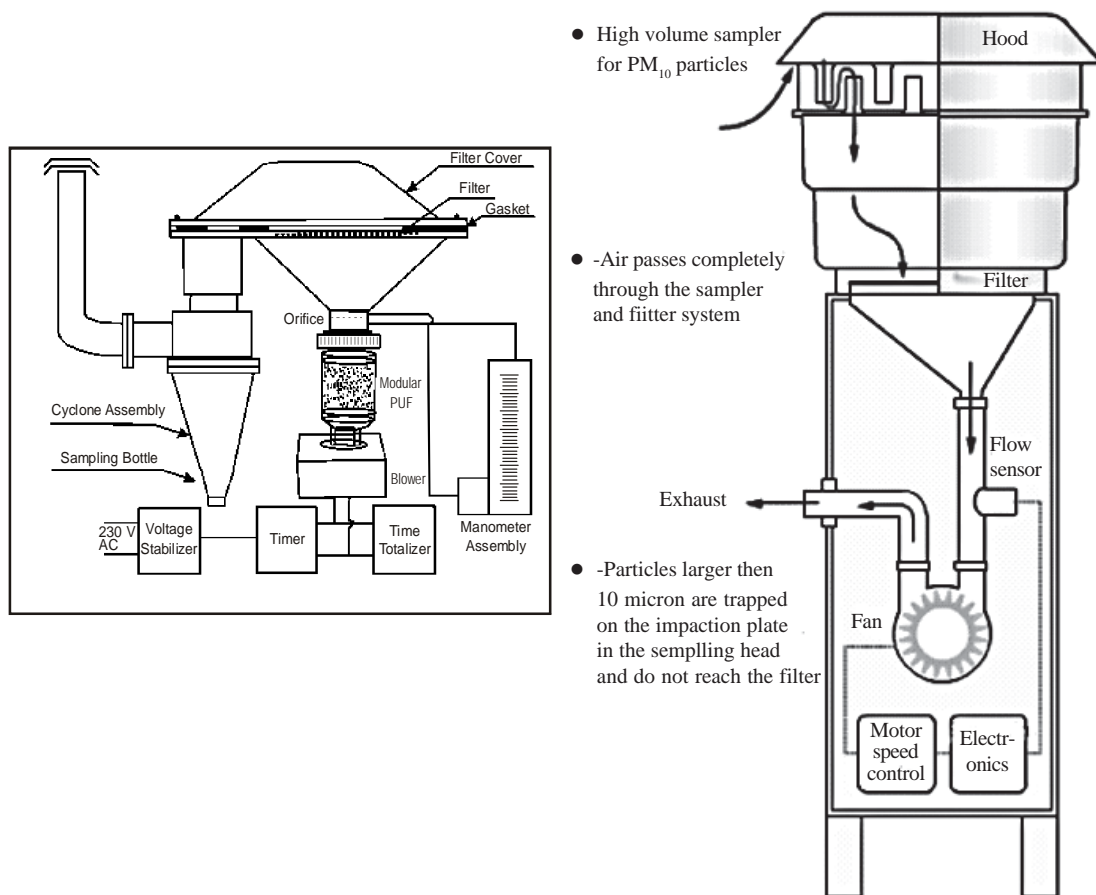- Detachable gable roof: Allows passage of air and protects filter

Figure 20: Schematic diagram of high-volume sampler

3.2 Analysis of sulphur dioxide in ambient air

3.2.1 Aim

This protocol is to provide guideline and the instruction for monitoring and analysis of sulphur dioxide (SO_2) in ambient air.

3.2.2 Introduction

Sulfur dioxide (SO_2) is a colourless, reactive air pollutant with a strong odor. This gas can be a threat to human health, animal health, and plant life. The main sources of sulfur dioxide emissions are from fossil fuel combustion and natural volcanic activity. Sulfur dioxide irritates the skin and mucous membranes of the eyes, nose, throat, and lungs. High concentrations of SO_2 can cause inflammation and irritation of the respiratory system, especially during heavy physical activity. The resulting symptoms can include pain when taking a deep breath, coughing, throat irritation, and breathing difficulties. High concentrations of SO_2 can affect lung function, worsen asthma attacks, and worsen existing heart disease in sensitive groups. This gas can also react with other chemicals in the air and change to a small particle that can get into the lungs and cause similar health effects.

3.2.3 Standard

The national ambient air quality standard for sulphur dioxide is as follows

Pollutant	Time Weighted Average	Concentration [μg/m³]	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area [Notified by Central Government]
Sulphur Dioxide (SO₂)	Annual*	50	20
	24 Hours**	80	80

* Annual: Arithmetic mean of minimum 104 measurements in a year (twice in a week), at a particular site for 24h at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

3.2.4 Methods of Estimation

Modified West & Gaeke method is used to estimate ambient air sulphur dioxide.

3.2.4.1 Principal

Sulphur dioxide from air is absorbed in a solution of potassium tetrachloromercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidationby the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely coloured pararosaniline methylsulphonic acid. The absorbance of the solution is measured by a spectrophotometer at 560 nm.

3.2.4.2 Apparatus and equipment's

The following items are required to analysis of sulphur dioxide in ambient air

- Analytical balance
- Handy air sampler equipped with
  - Vacuum pump capable of maintaining pressure greater than 0.7 atmosphere pressure
  - Flow controller to control the airflow from 0.2 to 1 L/minute
  - Impinger, midget glass impinger that contains absorber
- Spectrophotometer: Capable of measuring absorbance at 560 nm equipped with 1 cm path length cells
- Glass wares: Dark glass was to protect chemicals from sunlight

Figure 21: Handy air sampler

3.2.4.3 Reagents and standards

- **Absorbing Reagent, Potassium Tetrachloro Mercurate, 0.04 M (TCM):** Dissolve 10.86 g mercuric chloride, 0.066 g EDTA and 6.0 g potassium chloride or 4.68 g sodium chloride in water and volume make up to 1 L in a volumetric flask. The pH of this reagent should be approximately 4.0. The absorbing reagent can be used up to six months. Remember this reagent is highly poisonous if spilled on skin, flush it off with water immediately.

- **Sulphamic Acid (0.6%):** Dissolve 0.6 g sulphamic acid in 100 mL distilled water. Remember it must be prepared freshly.

- **0.2 % Formaldehyde:** Dilute 5 mL formaldehyde solution (36-38%) to 1 L with distilled water. Freshly prepare.

- **Purified Pararosaniline Stock Solution (0.2% Nominal):** Dissolve 0.500 gm of specially purified pararosaniline (PRA) in 100 mL of distilled water and keep for 2 days (48 hours).

- **Pararosaniline Working Solution:** 10 mL of stock PRA is taken in a 250 mL volumetric flask. Add 15 mL conc. HCl and make up to volume with distilled water.

- **Iodine Solution (0.01 N):** Place 1.27 g iodine in a 250 mL beaker, add 4 gpotassium iodide and 25 mL water. Stir until all is dissolved, then dilute to 1 litre with distilled water.

- **Starch Indicator Solution:** Triturate 0.4 g soluble starch and 0.002 g mercuriciodide preservative with a little water and add the paste slowly to 200 mL boiling water. Continue boiling until the solution is clear, cool, and transfer to a glass stoppered bottle.

- **Stock Sodium Thiosulfate Solution (0.01 N):** Prepare a stock solution by placing 2.5 g sodium thiosulfate pentahydrate in a beaker, add 0.1 g sodium carbonate and dissolve using boiled and cooled distilled water making the solution up to a final volume of 1 litre.

- **Standardized Sulphite Solution for Preparation of Working Sulphite-TCM Solution:** Dissolve 0.30 g sodium metabisulphite ($Na_2S_2O_5$) or 0.40 g sodium sulphite (Na_2SO_3) in 500 mL of recently boiled, cooled, distilled water. Sulphite solution is unstable; it is, therefore, important to use water of the highest purity to minimize this instability. This solution contains the equivalent of 320-400 μg/mL of SO_2

- **Working Sulphite-TCM Solution:** Measure 2 mL of the standard solution into a 100 mL volumetric flask by pipette and bring to mark with 0.04 M TCM. Calculate the concentration of sulphur dioxide in the working solution in micrograms of sulphur dioxide per millilitre. This solution is stable for 30 days if kept in the refrigerator at 5°C. If not kept at 5°C, prepare fresh daily.

3.2.4.5 Sampling

Place 30 mL of absorbing solution in an impinger and sample for four hours at the flow rate of 1 L/min. After sampling measure the volume of sample and transfer to a sample storage bottle.

3.2.4.6 Calibration

The actual concentration of the sulphite solution is determined by adding excess iodine and back titrating with standard sodium thiosulfate solution. To back-titrate, measure, by pipette,

Figure 22: Standard Impinger

- 50 mL of the 0.01 N iodine solution into each of two 500 mL iodine flasks A and B. To flask A (blank) add 25 mL distilled water and into flask B (sample) measure 25 mL sulphite solution by pipette. Lid up the flasks and keep in dark to react for 5 minutes.
- Prepare the working Sulphite-Tetrachloro Mercurate (TCM) solution at the same time iodine solution is added to the flasks.
- By means of a burette containing standardized 0.01 N thiosulfate, titrateeach flask in turn to a pale yellow. Then add 5 mL starch solution and continue the titration until the blue colour disappears.

3.2.4.7 Procedure

Replace any water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber. Mix thoroughly, pipette out 10/20 mL of the collected sample into a 25 mL volumetric flask.

- Add 1 mL 0.6% sulphamic acid and allow to react for 10 minutes to destroy the nitrite resulting from oxides of and make up to 25 mL with distilled water.
- Prepare a blank in the same manner using 10mL of unexposed absorbing reagent. After a 30 min colour development interval and before 60 minutes, measure and record the absorbance of samples and reagent blank at 560 nm.
- Use distilled water, not the reagent blank, as the optical reference

Preparation of Standards

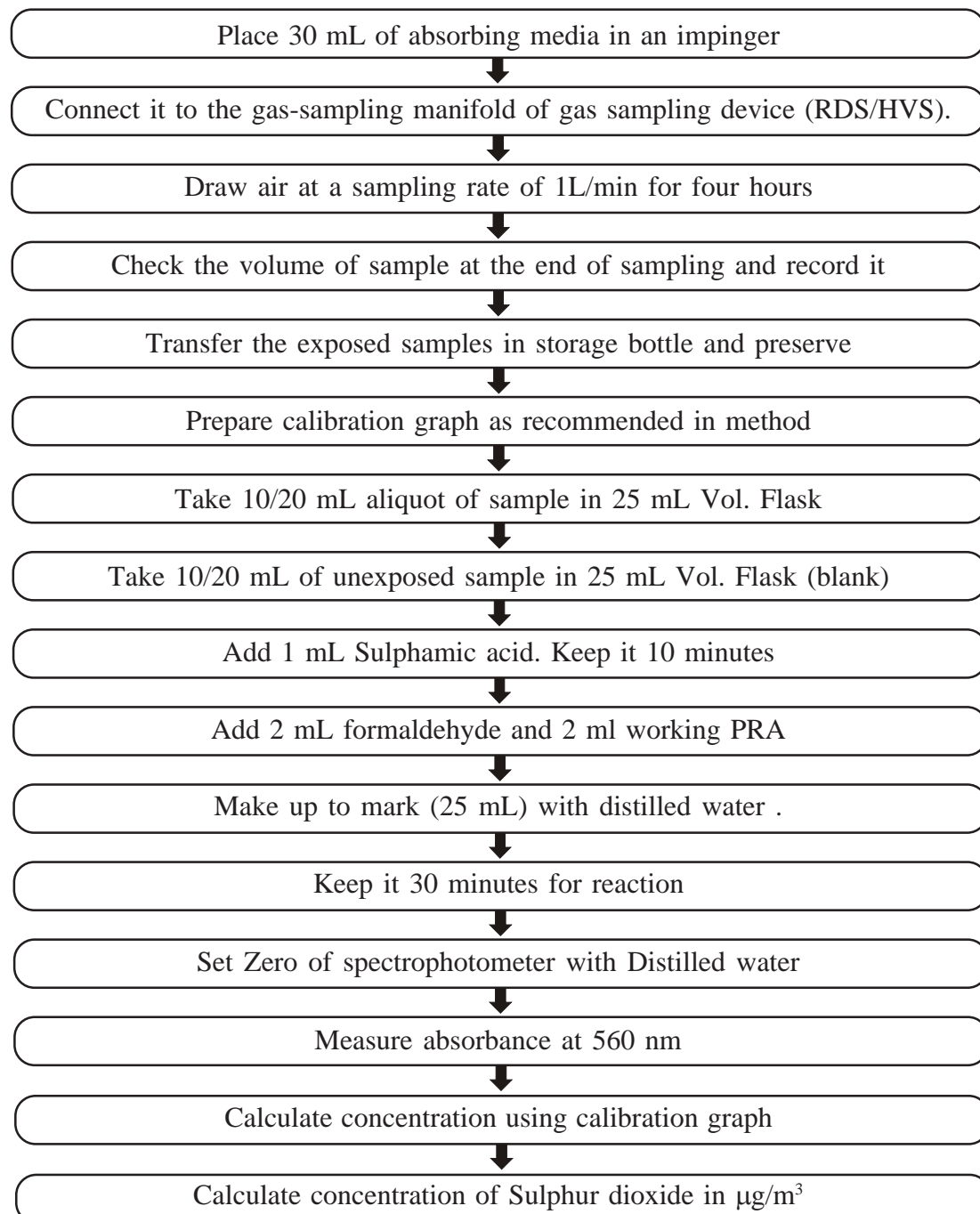- Measure 0.5 mL, 1.0 mL, 1.5 mL, 2.0 mL, 2.5 mL, 3.0 mL, 3.5 mL and 4.0 mL of working sulphite TCM solution in 25 mL volumetric flask.
- Add sufficient TCM solution to each flask to bring the volume to approximately 10 mL. Then add the remaining reagents as described in the procedure for analysis.
- A reagent blank with 10 mL absorbing solution is also need to prepare.
- Read the absorbance of each standard and reagent blank

Plot a curve absorbance (Y axis) versus concentration (X axis). Draw a line of best fit and determine the slope. The reciprocal of slope gives the calibration factor (CF).

Flow Chart for Measurement of Sulphur Dioxide

Place 30 mL of absorbing media in an impinger

⬇

Connect it to the gas-sampling manifold of gas sampling device (RDS/HVS).

⬇

Draw air at a sampling rate of 1L/min for four hours

⬇

Check the volume of sample at the end of sampling and record it

⬇

Transfer the exposed samples in storage bottle and preserve

⬇

Prepare calibration graph as recommended in method

⬇

Take 10/20 mL aliquot of sample in 25 mL Vol. Flask

⬇

Take 10/20 mL of unexposed sample in 25 mL Vol. Flask (blank)

⬇

Add 1 mL Sulphamic acid. Keep it 10 minutes

⬇

Add 2 mL formaldehyde and 2 ml working PRA

⬇

Make up to mark (25 mL) with distilled water .

⬇

Keep it 30 minutes for reaction

⬇

Set Zero of spectrophotometer with Distilled water

⬇

Measure absorbance at 560 nm

⬇

Calculate concentration using calibration graph

⬇

Calculate concentration of Sulphur dioxide in $\mu g/m^3$

3.2.4.8 Calculation

Concentration of sulphate solution

$$SO_2 \text{ Concentration in } \mu g/mL = \frac{(V_1 - V_2) \times N \times K}{V}$$

Where,
V_1 = Volume of thiosulfate for blank, mL

V_2 = Volume of thiosulphate for sample, mL

N = Normality of thiosulphate, 0.01N

K = 32000 (Milliequivalent weight $SO_2/\mu g$

V = Volume of standard sulphate solution, mL

Concentration of Sulphur dioxide ($\mu g/m^3$)

$$SO_2 \ \mu g/m^3 = \frac{(A_s - A_b) \times C_f \times V_s \times V_{an}}{V_a}$$

Where,
A_s = Absorbance of sample

A_b = Absorbance of reagent blank

C_f = Calibration factor

V_a = Volume of air sampled, m^3

V_s = Volume of sample, mL

V_{an} = Volume of aliquot taken for analysis, mL

3.3 Analysis of Nitrogen dioxide in ambient air

3.3.1 Aim

This protocol is to provide guideline and the instruction for monitoring and analysis of Nitrogen dioxide (NO_2) in ambient air.

3.3.2 Introduction

Many chemical species of nitrogen oxides (NO_x) exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide (NO_2). Nitrogen dioxide is soluble in water, reddish-brown in colour, and a strong oxidant. Nitrogen dioxide is an important atmospheric trace gas, not only because of its health effects but also because

   a. it absorbs visible solar radiation and contributes to impaired atmospheric visibility

   b. as an absorber of visible radiation, it could have a potential direct role in global climate change if its concentrations were to become high enough

   c. it plays a critical role in determining ozone (O_3) concentrations in the troposphere because the photolysis of nitrogen dioxide is the only key initiator of the photochemical formation of ozone, whether in polluted or unpolluted atmospheres.

The major source of anthropogenic emissions of nitrogen oxides into the atmosphere is the combustion of fossil fuels in stationary sources (heating, power generation) and in motor vehicles (internal combustion engines). In most ambient situations, nitric oxide is emitted and transformed into nitrogen dioxide in the atmosphere. Oxidation of nitric oxide by atmospheric oxidants such as ozone occurs rapidly, even at the low levels of reactants present in the atmosphere.

3.3.3 Standard

The national ambient air quality standard for nitrogen dioxide is as follows

Pollutant	Time Weighted Average	Concentration [$\mu g/m^3$]	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area [Notified by Central Government]
Nitrogen dioxide (NO₂)	Annual*	40	30
	24 Hours**	80	80

* *Annual: Arithmetic mean of minimum 104 measurements in a year (twice in a week), at a particular site for 24h at uniform intervals.*

** *24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

3.3.4 Methods of Estimation

Modified Jacob and Hochheiser method is used to estimate ambient air nitrogen dioxide.

3.3.4.1 Principal

Ambient nitrogen dioxide (NO_2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO_2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)-ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dyeat 540 nm.

3.3.4.2 Apparatus and equipment

The following items are required to analyse nitrogen dioxide in ambient air

- Analytical balance
- Handy air sampler equipped with
    - Vacuum pump capable to maintain pressure greater than 0.6 atmosphere pressure
    - Flow controller to control the airflow from 0.2 to 1 L/minute
    - Impinger, midget glass impinger that contains absorber
- Spectrophotometer: Capable of measuring absorbance at 540 nm equipped with 1 cm path length cells
- Glass wares: Dark glass were to protect chemicals from sunlight

Figure 23: Handy air sampler

3.3.4.3 Reagents and standards

- **Absorbing Reagent:** 4 g sodium hydroxide dissolved in distilled water and add 1.0 g of sodium arsenite and diluted to 1000 mL with distilled water.

- **Sulphanilamide Solution:** Dissolve 20 g of sulphanilamide in 700 mL of distilled water. Add, with mixing, 50 mL of 85% phosphoric acid and dilute to 1,000 mL. This solution is stable for one month, if refrigerated

- **N-(1-Naphthyl)-ethylenediamine Di-hydrochloride [NEDA] Solution:** Dissolve 0.5 g of NEDA in 500 mL of distilled water. This solution is stable for one month, if refrigerated and protected from light

- **Hydrogen Peroxide Solution:** Dilute 0.2 mL of 30% hydrogen peroxide to 250 mL with distilled water. This solution may be used for one month, if, refrigerated and protected from light

- **Sodium Nitrite stock solution (1000µg NO_2/mL):** Dissolve 0.1g $NaNO_2$ (Assay of minimum 97%) in 100 mL absorbing reagent.

- **Sodium Nitrite working solution (1 µg NO_2/mL):** Dilute 1 mL stock solution to 1000 mL with absorbing reagent, prepare fresh daily.

3.3.4.4 Sampling

Place 30 mL of absorbing solution in an impinger and sample for four hours at the flow rate of 0.2 to 1 L/min. After sampling measure the volume of sample and transfer to a sample storage bottle.

3.3.4.5 Calibration

The actual concentration of the sulphite solution is determined by adding excess iodine and back titrating with standard sodium thiosulfate solution. To back-titrate, measure, by pipette,

Figure 24: Standard Impinger

- 50 mL of the 0.01 N iodine solution into each of two 500 mL iodine flasks A and B. To flask A (blank) add 25 mL distilled water and into flask B (sample) measure 25 mL sulphite solution by pipette. Lid up the flasks and keep in dark to react for 5 minutes.

- Prepare the working sulphite-tetrachloro Mercurate (TCM) solution at the same time iodine solution is added to the flasks.

- By means of a burette containing standardized 0.01 N thiosulfate, titrate each flask in turn to a pale yellow. Then add 5 mL starch solution and continue the titration until the blue colour disappears.

3.3.4.6 Procedure

Replace any water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber, mix thoroughly.
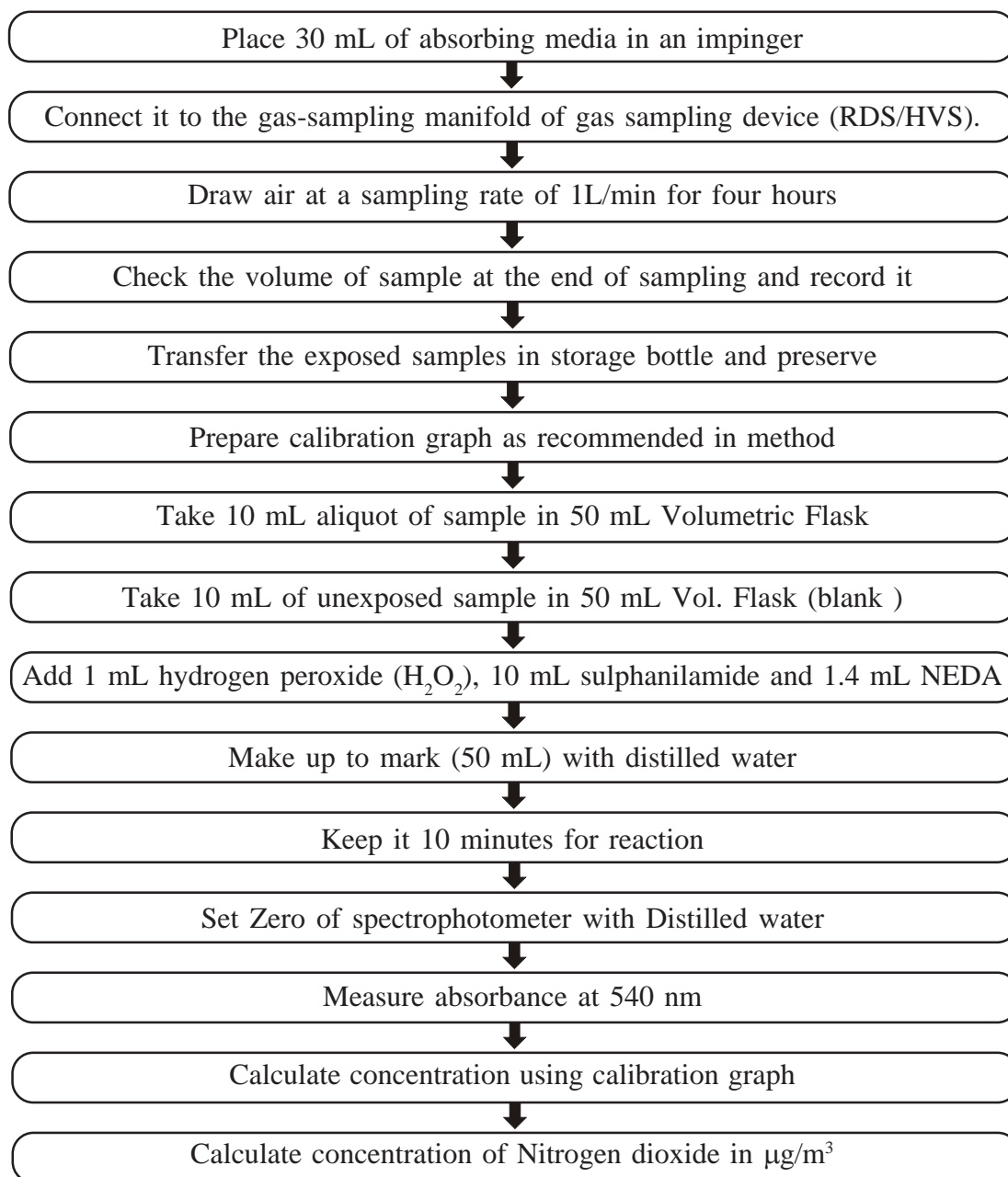
- Pipette out 10 mL of the collected sample into a 50 mL volumetric flask. Pipette in 1 mL of hydrogen peroxide solution, 10 mL of sulphanilamide solution, and 1.4 mL of NEDA solution, with thorough mixing after the addition of each reagent and make up to 50 mL with distilled water.
- Prepare a blank in the same manner using 10 mL of unexposed absorbing reagent. After a 10 min colour development interval, measure and record the absorbance of samples and reagent blank at 540 nm.
- Use distilled water, not the reagent blank, as the optical reference
- Samples with absorbance greater than 1.0 must be re-analyzed after diluting an aliquot of the collected samples with an equal quantity of unexposed absorbing reagent.

Preparation of Standards

- Measure 1 mL, 2 mL, 4 mL, 6 mL, 8 mL, 10 mL, 12 mL and 15 mL of working nitrate standard solution in 50 mL volumetric flask.
- Fill to 20 mL mark with absorbing solution
- A reagent blank with 10 mL absorbing solution is also need to prepare.
- Then add the other reagents as described in the procedure for analysis
- Read the absorbance of each standard and reagent blank

Plot a curve absorbance (Y axis) versus concentration (X axis). Draw a line of best fit and determine the slope. The reciprocal of slope gives the calibration factor (CF).

Flow Chart for Measurement of Nitrogen Dioxide

Place 30 mL of absorbing media in an impinger

↓

Connect it to the gas-sampling manifold of gas sampling device (RDS/HVS).

↓

Draw air at a sampling rate of 1L/min for four hours

↓

Check the volume of sample at the end of sampling and record it

↓

Transfer the exposed samples in storage bottle and preserve

↓

Prepare calibration graph as recommended in method

↓

Take 10 mL aliquot of sample in 50 mL Volumetric Flask

↓

Take 10 mL of unexposed sample in 50 mL Vol. Flask (blank)

↓

Add 1 mL hydrogen peroxide (H_2O_2), 10 mL sulphanilamide and 1.4 mL NEDA

↓

Make up to mark (50 mL) with distilled water

↓

Keep it 10 minutes for reaction

↓

Set Zero of spectrophotometer with Distilled water

↓

Measure absorbance at 540 nm

↓

Calculate concentration using calibration graph

↓

Calculate concentration of Nitrogen dioxide in $\mu g/m^3$

3.3.4.7 Calculation

Concentration of Nitrogen dioxide (μg/m3)

$$NO_2 \ \mu g/m^3 = \frac{(A_s - A_b) \times C_f \times V_s \times V_{an} \times 0.82}{V_a}$$

Where, A_s = Absorbance of sample

A_b = Absorbance of reagent blank

C_f = Calibration factor

V_a = Volume of air sampled, m³

V_s = Volume of sample, mL

V_{an} = Volume of aliquot taken for analysis, mL

0.82 = Sampling efficiency

3.4 Analysis of Particulate matter (PM$_{10}$) in ambient air

3.4.1 Aim

This protocol is to provide guidelines and the instructions for monitoring and analysis of Particulate matter (PM$_{10}$) in ambient air.

3.4.2 Introduction

Airborne particulate matter represents a complex mixture of organic and inorganic substances. Mass and composition tend to divide into two principal groups: coarse particles mostly larger than 2.5 µm to 10 µm in aerodynamic diameter (PM$_{10}$), and fine particles mostly smaller than 2.5 µm in aerodynamic diameter (PM$_{2.5}$). The larger particles usually contain earth crust materials and fugitive dust from roads and industries. An idealized distribution of ambient particulate matter is shown in the figure **(Figure 25)**. Particulate air pollution is a mixture of solid, liquid or solid and liquid particles suspended in the air. These suspended particles vary in size, composition and origin. It is convenient to classify particles by their aerodynamic properties because:

    a. they govern the transport and removal of particles from the air

    b. they also govern their deposition within the respiratory system

    c. they are associated with the chemical composition and sources of particles.

These properties are conveniently summarized by the aerodynamic diameter, that is the size of a unit-density sphere with the same aerodynamic characteristics. Particles are sampled and described on the basis of their aerodynamic diameter, usually called simply the particle size.
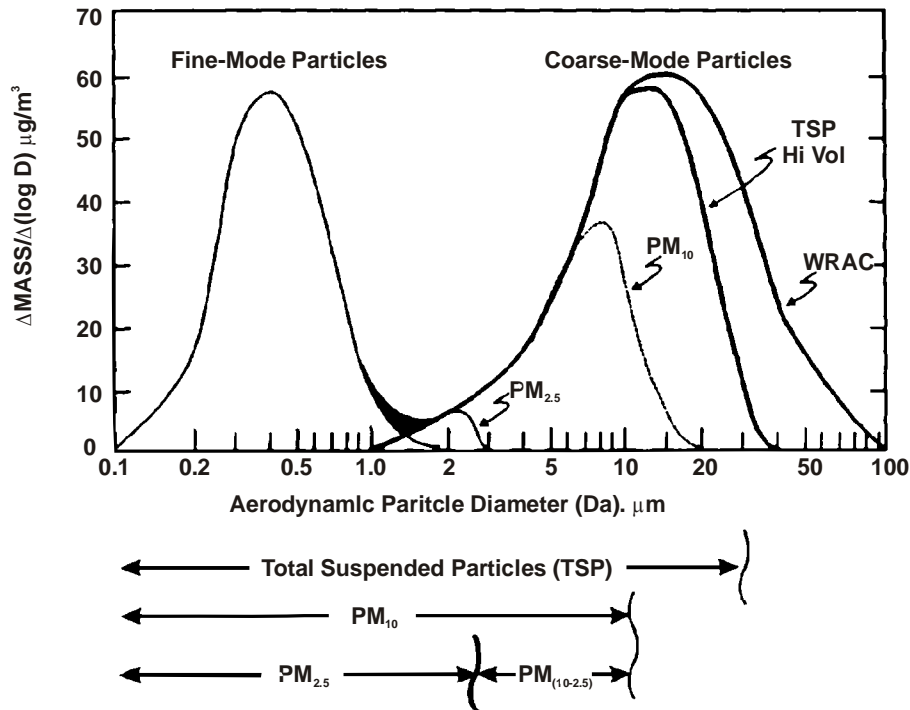
Figure 25: Schematic representation of the size distribution of particulate matter in ambient air (USEPA, 1996)

3.4.3 Standard

The national ambient air quality standards for Particulate matter (PM_{10}) is as follows

Pollutant	Time Weighted Average	Concentration [$\mu g/m^3$]	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area [Notified by Central Government]
Particulate Matter (PM_{10})	Annual*	60	60
	24 Hours**	100	100

* Annual: Arithmetic mean of minimum 104 measurements in a year (twice in a week), at a particular site for 24h at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

3.4.3 Methods of estimation

Gravimetric method is used to estimate the concentration of particulate matter in ambient air.

3.4.3.1 Principal

Air is drawn through a size-selective inlet and through a 20.3×25.4 cm (8×10 in) filter paper at a flow rate of 1132 L/min. Particles with aerodynamic diameter lessthan the cut-point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of particulate matter (PM_{10}) in the designated size range is calculated by dividing the weight gain of the filter paper by the volume of air sampled.

3.4.3.2 Apparatus and equipment's

The following items are required to analysis of particulate matter (PM_{10}) in ambient air

● Analytical balance

● Dryer/ hot air oven

● High volume sampler equipped with

  ○ Size selective inlet for PM_{10}

  ○ Automatic volumetric flow control (airflow controlled to 1132 L/min)

  ○ Top loading orifice kit

Figure 26: High Volume air sampler

3.4.3.3 Reagents and standards

A glass fibre filter paper of size 20.3×25.4 cm (8×10 in)

3.4.3.4 Sampling

Open the inlet and secure it according to manufacturer's instructions. Loosen the faceplate wing nuts and remove the faceplate. Filter paper must be dried in hot air oven and cooled in a decigator. Take the weight of the filter paper and put it into the jacket. Remove the filter from its jacket and centre it on the support screen with the rough side of the filter facing upwards. Replace the faceplate and tighten the wing nuts to secure the rubber gasket against the filter edge. Gently lower the inlet. For automatically flow controlled units, record the designated flow rate [1132 L/min] on the data sheet. Record the reading of the elapsed time meter. The specified length of sampling is commonly 8 hours. During this period, hourly reading of flow rate should be taken. After the required time of sampling, record the flow meter reading, take out the filter media from the sampler, and put in a container or envelope.
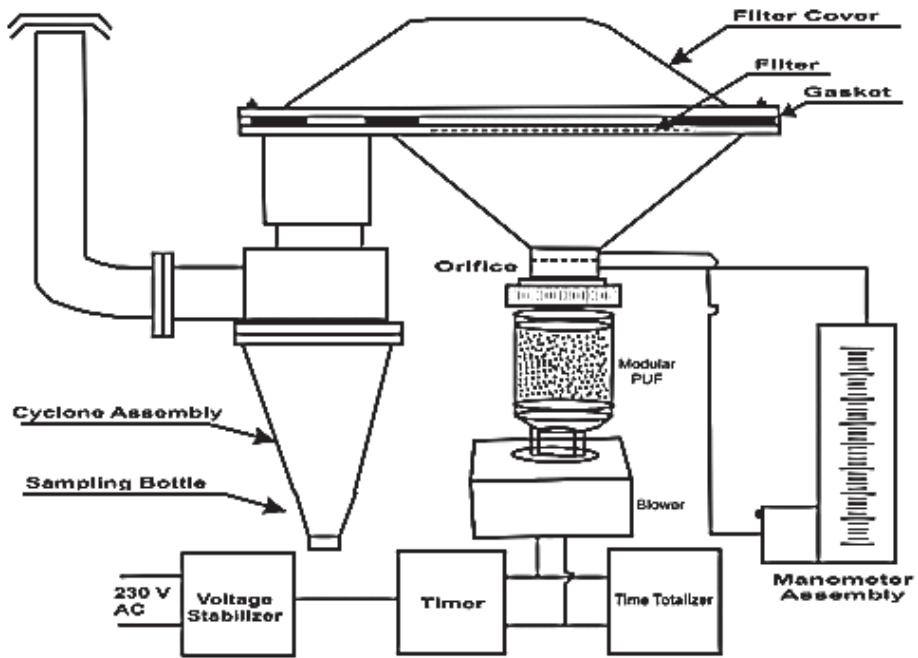
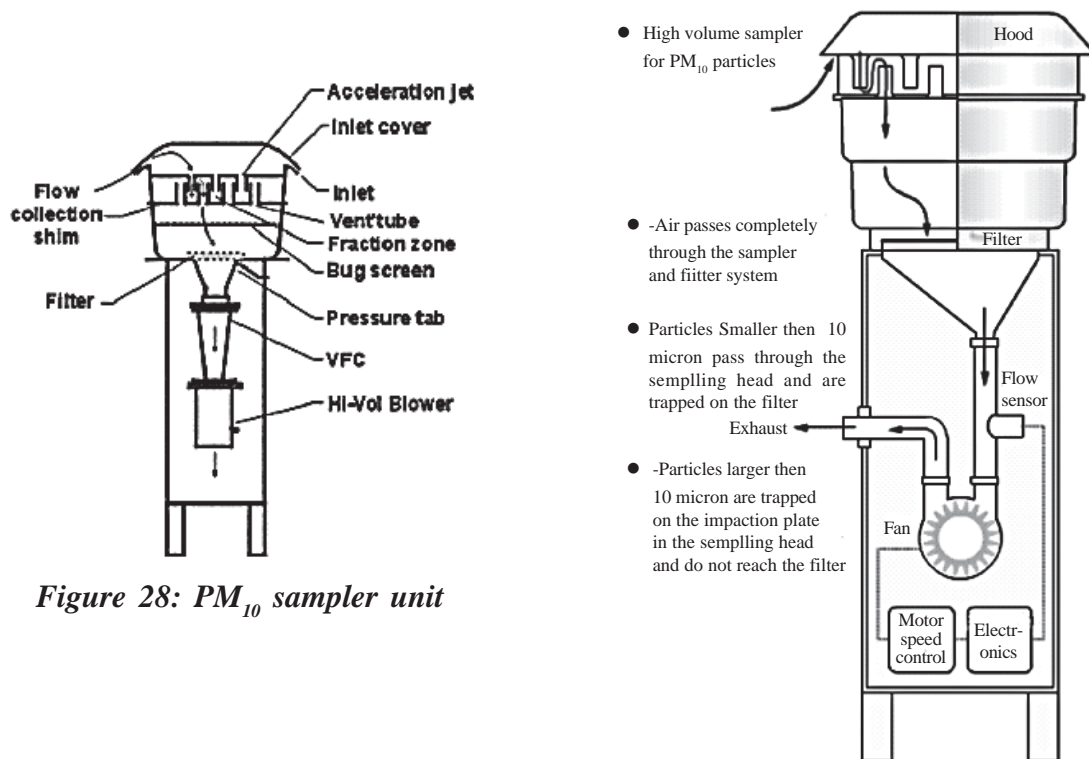*Figure 27: Schematic diagram of high-volume sampler*

Figure 28: PM$_{10}$ sampler unit

- High volume sampler for PM$_{10}$ particles

- -Air passes completely through the sampler and fiitter system

- Particles Smaller then 10 micron pass through the semplling head and are trapped on the filter

- -Particles larger then 10 micron are trapped on the impaction plate in the semplling head and do not reach the filter

3.4.3.5 Calibration

Periodical calibration of the sampler is being done by Orifice Transfer Standard – The PM sampler calibration orifice consists of a 3.175 cm (1.25 in) diameter hole in the end 10 cap of 7.62 cm (3 in) diameter by 20.3 cm (8 in) long hollow metal cylinder. This orificeis mounted tightly to the filter support in place of the inlet during calibration. A small tap on the side of the cylinder is provided to measure the pressure drop across the orifice. A flow rate of 1132 L/min through the orifice typically results in a pressure difference of several inches of water. The relationship between pressure difference and flow rate is established via a calibration curve derived from measurements against aprimary standard such as a Roots meter at standard temperature and pressure. Flow resistances that simulate filter resistances are introduced at the end of the calibrator opposite the orifice by a set of perforated circular disks.

3.4.3.6 Procedure

Inspect the filter for pin holes using a light table. Loose particles should be removed with a soft brush. Apply the filter identification number or a code to the filter if it is not numbered. Dried in hot air oven within 30-40°C and cooled in an airtight desiccator for 24 hours. Take the initial weight of the dried and cooled filter paper (W_i) before sampling. Take the final weight of the filter paper (W_f)

Flow Chart for Measurement of PM$_{10}$

3.4.3.7 Calculation

Concentration of PM$_{10}$ ($\mu g/m^3$)

$$PM_{10} \ \mu g/m^3 = \frac{(W_f - W_i) \times 10^6}{V}$$

Where, W_f = Final weight of filter paper (g)

               W_i = weight of filter paper (g)

               10^6 = Conversion of g to μg

               V = Volume of air sampled, m^3

Check the filter for any physical damages

↓

Mark identification number on the filter

Condition the filter in conditioning room / desiccator for 24 hours

Record initial weight and place the filter on the sampler

Run the sampler for eight hours

Record the flow rate on hourly basis

Remove the filter from the sampler

Keep the exposed filter in a proper container

Record the total time of sampling & average flow rate

Dry the filter paper and record final weight

Calculate the concentration of PM in $\mu g/m^3$

Unit-4 ❑ Measurement of Noise Level

4.1.1 Aim

This protocol aims to be carried out Ambient Noise monitoring on a routine basis or to address public complaints. The objective is to monitor the noise level at a particular site or as described in the complaints. The data generated by the method shall also evaluate with prescribed noise level standards.

4.1.2 Introduction

Noise is typically defined as unwanted sound. Sound which pleases the listeners is music and that which causes pain and annoyance is noise. At the time a sound that is music for some can be noise for others. Machines that have been developed for industrial purposes, for speedy transportation, or household equipment to make life more smoothing by reducing the workload and shaving time most of them produce a sound which becomes noise in different circumstances. It may also be generated from the flashing riverting, rock fall from chutes and funker, air flast etc. From this, we can say that noise is a type of sound with no musical quality, a wrong sound in the wrong place and at the wrong time.

Noise pollution refers to sounds in the environment that are caused by humans and that threaten the health or welfare of human or animal inhabitants.

4.1.3 Noise Rules and Standards

The standards are the statutory values (legally valid) of noise for a specified location and time. Central Government notified the Noise Pollution (Regulation and Control) Rules, 2000 as it is published in the Gazette of India, Extraordinary, Part-II –section 3(ii), vide S.O 123 (E) dated 14.2.2000. In this rule following responsibilities are vested with State Governments, District Magistrate, Police Commissioner, or any other officer, not below the rank of Deputy Superintendent of Police:

1. Enforcement of Noise Pollution control measures and the due compliance of ambient air quality standards in respect of noise.

2. Restriction on the use of Loud Speakers/Public Address system.

3. Restriction on the use of horns, sound emitting construction equipment and bursting of firecrackers.

4. Prohibition of continuance music sound or noise.

5. Authority shall act on the complaint and take action against the violator in accordance with the provisions of the rules.

6. Disallowing sound-producing instruments after 10 p.m. to 6 a.m. except in closed premises.

7. State Government may permit loudspeakers or public address systems during night hours (between 10.00 p.m. to 12.00 midnight not exceeding 15 days in a year).

Table 4.1: Ambient Air Quality Standards in Respect of Noise is notified under Noise Pollution (Regulation and Control) Rules, 2000.

Area Code	Category of Area/ Zone	Limit in dB(A) Leq	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note:

- Day time shall mean from 6 AM to 10 PM
- Night time shall mean from 10 PM to 6 AM
- A silence zone is defined as areas up to 100 meters around such premises as hospitals, educational institutes and courts. The Silence Zones are to be declared by a competent authority.
- Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.
- dB(A) Leq denotes the time-weighted average of the level of sound in decibels on scale A which is relatable to human hearing.
- A "decibel" is a unit in which noise is measured.
- "A", in dB (A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.
- Leq: It is the energy mean of the noise level over a specific period.

4.1.4 Methods of Estimation

4.1.4.1 Principal

The sound produced from any source is stimuli and it can be measured as sound pressure. The sound pressure range varies from 20 µPa- 200 Pa and it can be expressed on a scale based on the log of the ratio of measured sound pressure and a reference standard pressure Sound Level (L),

$$L = Log_{10} \frac{P}{P_0} \text{ (bel)}$$

Were,

P = Measured quantity of sound pressure or sound power, or sound intensity.

P_{10} = Reference standard quantity of sound pressure, sound power, or sound intensity (20×10^{-6} Pa)

L= Sound Level in Bels (B)

The sound wave energy is converted into an electrical signal through the micro-phone, then the pre-amplifier boosted it in magnitude. The rectifier converts the AC signals to DC to cause the meddle to display the meter to register the sound pressure level directly in dB. The middle motion is directly controlled by a fast/slow response setting. Sound level meters are designated as small band-held instruments powered by lithium-ion batteries.

Leq

Leq is the statistical value of sound pressure level that can be equated to any fluctuating noise level. *E.g.* a sound of 40 dB last for 5 min, for the next 10 min sound is 85 dB and then followed by a sound of 100 dB for the next 5 min, which will compose a fluctuating noise level, which is indicative of producing the same effect over the entire period of 5+10+5= 20 minutes in dB. This value is called Equivalent continuous equal energy level, Leq.

$$Leq = 10 \sum_{i=1}^{i=n} (10)^{\frac{Li}{10}} \times \frac{ti}{tt}$$

n = number of sound samples,

Li =The noise level of any i^{th} sample,

ti = time duration of ith sample,

tt = total period of the event.

Leq is also defined as the constant noise level, which over a given time, expands the same amount of energy, as is expanding by the fluctuating levels over the same time. A sound level meter that measures the sound pressure level with a "flat" response will indicate the strength of low-frequency sound

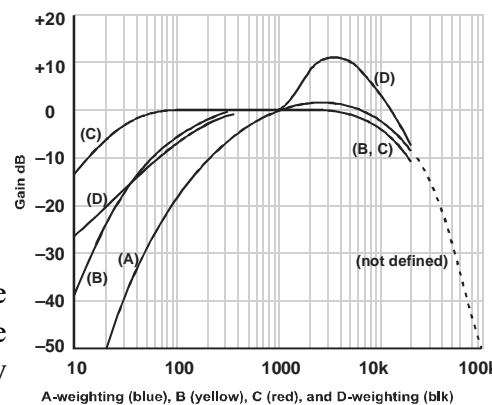A-weighting (blue), B (yellow), C (red), and D-weighting (blk)

Figure 29: A graph of the A-, B-, C- and D-weightings across the frequency range 10 Hz – 20 kHz[https://en.wikipedia.org/wiki/A-weighting#/media/File:Acoustic_weighting_curves_(1).svg]

with the same emphasis as higher-frequency sounds. Therefore, the sound meter is equipped with a frequency-weighting filter.

The human ear does not respond uniformly to sounds of all frequencies being less efficient to low and high frequencies as compared to medium-range frequencies. To obtain a sound level which covers a wide range of frequencies and conforms approximately to the response of the human ear, a frequency weighting filter is used. The resultant sound level obtained is A weighted sound. Therefore, we measure sound level as Leq dB(A).

4.1.4.2 Site selection criteria

The site of an area shall be selected based on the land use pattern as prescribed in the legislation *e.g.* Industrial, Commercial, Residential and Silence Zone. Minimal key points to be maintained:

Figure 30: Sound Level Meter

- The station should be located at the ambient level *i.e.* away from the direct source, away from any vibration and any obstruction.
- Categorize the area with a land use pattern.
- The microphone must be placed 1.2 -1.5 m above the ground level.
- In dry conditions with a wind speed of less than 5 m/s.
- Isolate the instrument from strong vibration and shock.

4.1.4.3 Selection of Noise level meter:

Type 1 integrating sound level meter with free-field microphone with the accuracy of noise measurement as per IEC 804 (BS 6698) Grade I or IEC 61672-1 (2002-05) Class-I or ANSI type I is to be selected for Noise measurement.

4.1.4.4 Noise measuring instrument and method:

The instrument used to measure and evaluate noise is a sound level meter. This instrument is designed to respond in approximately a similar way as the human ear and to give reproducible measurements of sound pressure level. The basic components of a sound level meter include–

- Microphone that converts the sound signal to an equivalent electrical signal,
- Amplifiers: Electrical signal produced by the microphone is very small and it required a preamplifier before processing.
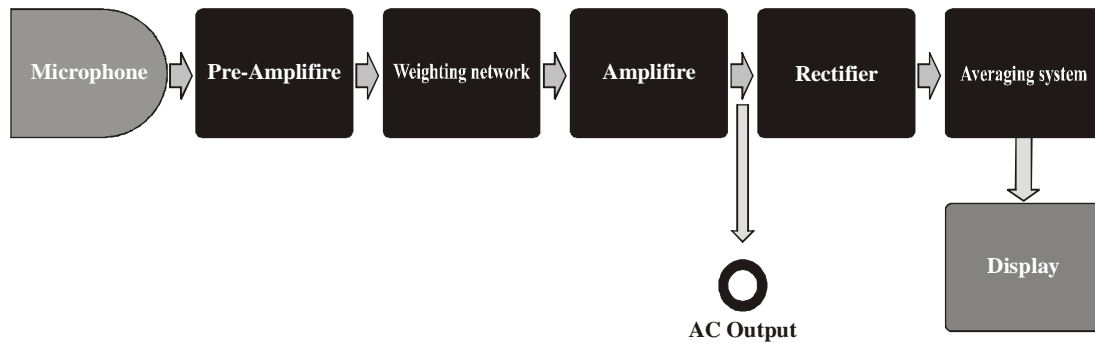- weighting network and
- display meter reading in dB

Figure 31: Diagram of Sound Level Meter working mechanism

4.1.4.5 Calibration

Make sure that the instrument is properly calibrated. Measurements should be accepted as valid only if the calibration level from before and after the noise measurement agrees to be within 1.0 dB. The sound level meter and calibrator will hold a current calibration certificate traceable to national standards.

Start the calibrator and put on 1 kHz frequency calibration on two values 94 dB and 114 dB. If the instrument shows more than ± 0.3 dB differences adjust the calibration. Calibration is done, now the instrument is ready for monitoring.

4.1.4.6 Apparatus and equipment

A sound level meter is required for noise measurement.

4.1.4.7 Procedure

Controlling the equipment as per the model and manufacturer's instructions. But some basic procedures need to be followed.

(a) During ambient noise monitoring sound comes from a different direction, so it is important to fit the microphone to the best possible omni directional characteristics

(b) First determine the proper measuring range selector.

(c) According to various measurements, sounds select the time weighting selector to fast a slow.

(d) Hold the instrument in range and point the microphone at the measured noise source. The sound level meter will be displayed on the dB unit.

(e) The noise measurement equipment will be supervised continuously during the monitoring period and notes will be made of the date, time and prevailing weather conditions

(f) Noise measurements should not be made in fog and rain.

4.1.4.8 Results

Noise can be recorded as:

Description of the Location:					Date:			
Noise Level Meter								
Make								
Model								
Serial No.								
Calibration result of Noise Level Meter								
Calibration	94 dB at 1000Hz				114 dB at 1000 Hz			
Initial								
Final								
Sampling rate								
Sl. No.	Time duration	File No.	**Sound Parameters (dBA)**					
			L_{eq}	L_{10}	L_{50}	L_{90}	L_{min}	L_{max}
1.								
2.								
3.								
4.								
5.								
Average L equivalent dB (A)								
Monitoring team and signature								

Unit-5 ▢ Plankton Collection and Counting

5.1.1 Introduction

The term plankton was first proposed by Hensen in 1887. The word plankton comes from the Greek word planktos, which means "drifter." Their name fits, because planktons are unable to swim by their own or fixed any place in the aquatic system. They drift about in the water, allowing tides, currents, and other factors determine where they go. Although they are very small/ microscopic in size but in the aquatic system, they provide a crucial source of food to many small and large aquatic organisms.

There are two main types of plankton: phytoplankton, which are plants in nature, and zooplankton, which are animals in nature. Zooplankton and other small marine creatures eat phytoplankton and then become food for fish, crustaceans, and other larger species.

Phytoplankton assimilates energy through photosynthesis, the process of using chlorophyll and sunlight to create energy. Like other plants, phytoplankton take in carbon dioxide and release oxygen. Phytoplankton account for about half of the photosynthesis on the planet, making them one of the world's most important producers of oxygen. Phytoplankton rely on nutrients found in their surroundings, such as phosphate, nitrate, and calcium, to thrive.

5.1.2 Collection of Plankton

There are three methods of plankton sampling

A. Bottle Sampler:

Sampling through the bottle sampler is the recommended method to obtain an accurate picture of the quantitative composition of the phytoplankton in the water body. A bottle sampler can obtain the whole size spectrum from large entities. These are ideal for quantitative plankton collections as required quantities of water can be collected from any desired depth of shallow systems like a lake, the near seashore water, estuaries and mangroves. Water samples are generally used from vessels, ships or fish trawlers.
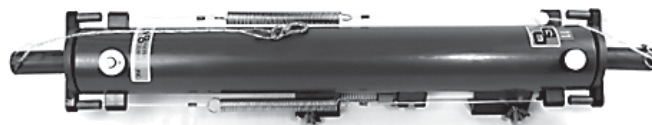

Figure 31: Battle Plankton sampler

B. Plankton pumps:

Plankton pumps are integrating samplers that pump a continuous stream of water to the surface and the planktons can then be rapidly concentrated by continuous filtration. Because the pumps can collect continuously as the tube is lowered through the water column the samples are integrated from the surface to desired depth. This method has its disadvantages, *e.g.*, breaking up colonies, and breaking the body parts of planktons.
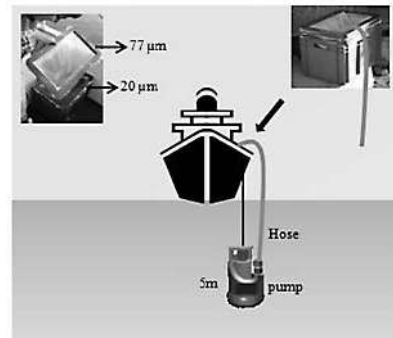

Figure 32: Plankton sampling pumps

C. Plankton nets:

The easiest and quickest way of obtaining a concentrated sample of phytoplankton is to tow a cone-shaped bolting silk net through the water. The wider end of the net is kept open by a metal ring and this is attached to a towing rope. The narrow end of the net is closed by a plastic bucket or tube. When hauling is done through the water, backpressure builds up at the opening, which prevents some water from flowing through the net. A cone-shaped sleeve allows more effective filtering by reducing the volume of water entering the net. Net with fine meshes size of 5 to 25μm for phytoplankton and 200 μm for zooplankton are often used.

The determination of the volume of water filtered through any plankton net is essential for the estimation of the standing crop. The volume of water traversed by the net is determined as an approximate value by the formula

$$V = \pi r^2 d$$

Where   V = volume of the water filtered by the net

r = radius at the mouth of the net

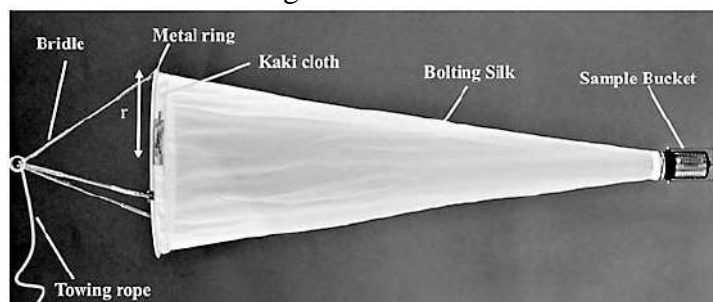d = distance through which the net is towed.

Figure 33: Plankton collection net

5.1.3 Preservation

Preservation is the maintenance of the fixed condition for extended periods of time. Specimens after one week of fixation are used for preservation after thorough washing with distilled water. Formalin (2.5 – 5.0%) is used in the ratio of 1:9 (sample to preservative). pH should be maintained at 7.0. To preserve the natural color of the plankton, fish and crustaceans may preserve in phenolic antioxidants such as 40% emulsifiable concentrate of butylated hydroxytoluene (BHT) or butylated hydroxyamisole (BHA).

5.1.4 Quantitative estimation

Preparation of the sample: -

(a) Take the concentrated sample.

(b) Add 10 mL of Lugol's Iodine and allow it to stand for at least 24 hrs to ensure complete sedimentation (centrifuge if necessary especialy for nanoplankton).

(c) Remove the supernatant liquid with the help of a pipette.

(d) Further concentrate the remaining sample upto 10-100 mL depending on the number of plankton.

5.1.5 Plankton enumeration

Planktons are counted through two different and simple methods.

(a) Drop Count Method:

5.1.5.a.1 Procedure:

(a) Shake the concentrated sample and put quickly one drop on a clean slide with the help of a standard dropper holding it vertically.

(b) Carefully cover the whole drop with a cover slip of suitable size so that the sample does not run out.

(c) Put the slide under microscope and focus one edge of the cover slip.

(d) Count the phytoplankton / zooplankton species.

(e) Shift the slide to the next field.

(f) In this way observe the whole coverglass and work put planktonic estimation atleast for 3-5 drops depending on the density of plankton.

5.1.5.a.2 Observation:

Sl. No.	Name of the Species	No.of the organisms/drop			Average No. of organisms/drop
		1	2	3	
1					
2					
3					
Total					

5.1.5.a.3 Calculation:

The total number of plankton present in a litre of water sample can be calculated using the following formula:

$$\text{Total number of organisms}/L = \frac{A \times V}{v \times L}$$

Where,

A = Number of organisms/drops,

v = Volume of one drop (mL),

V = Total volume of the concentrated sample (mL),

L = Volume of original sample (L)

(b) Sedgwick-Rafter Cell:

It has been named after the inventor of the cell. The rectangular cavity in the slide (50×20×1 mm) contains exactly 1 mL of liquid sample. This method is better suited for the enumeration of larger planktons like zooplankton.

(a) Transfer one mL of well mixed plankton sample using graduated pipette into the sedgewick rafter cell.

(b) Spread evenly in the form of thin layers.

(c) Focus one edge of the cavity and move the slide horizontally, simultaneously counting the organisms till the other edge.

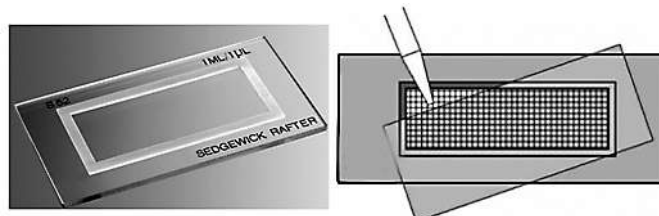(d) Examine this way 3-6 such strips or transects.

Figure 34: Sedgwick Rafter Cell

5.1.5.b.1 Calculation:

The total number of plankton present in a litre of water sample can be calculated using the following formula:

$$\text{Total number of organisms}/L = \frac{n \times v}{V}$$

Where,

n = Average no. of plankton present in 1 mL of plankton sample

v = Volume of plankton concentrate (mL) and

V = Volume of total water filtered (L)

Unit-6 ❑ Demonstration of Vegetation Frequency, Density, Abundance, Cover and Basal Area Dominance, Importance Value Index (IVI) and Phytography

6.1 Introduction

The collective and continuous growth of plants in space is known as vegetation.

A group of several species living together with mutual tolerance and beneficial interactions hi a natural area is known as a community.

Each community is characterised by its species diversity, growth forms and structure, dominance etc. Details of these aspects are studied by a number of characters a parameters. These are used to express the characteristics of a community. Various characters, that are used to characterise a community are broadly classified as – (i) analytical characters and (ii) synthetic characters. The quantitative characters among analytical characters are – frequency, density, abundance, cover and basal area etc.

6.2 Frequency

6.2.1 Introduction

Assessing vegetation frequency helps researchers, land managers, and conservationists monitor ecosystem health, assess changes over time, and make informed decisions about land use and conservation efforts. Understanding vegetation frequency is crucial for various ecological and land management applications. It provides valuable insights into plant community composition, diversity, and ecological processes.

What is Vegetation Frequency?

Vegetation frequency refers to the proportion of sample plots or quadrats in which a particular plant species is present. It is expressed as a percentage and provides information about the abundance and distribution of plant species within a study area.

Why Measure Vegetation Frequency?

Measuring vegetation frequency helps researchers:

- Assess plant community composition.
- Monitor changes hi vegetation over time.

70

- Evaluate the impact of environmental factors.
- Make informed land management decisions.
- Contribute to biodiversity conservation efforts.

Key Terminology

- Quadrat: A square or rectangular sampling area used to assess vegetation within a defined space.
- Sample Size: The number of quadrats or plots selected for data collection.
- Species Frequency: The percentage of quadrats where a particular plant species is present.
- Dominant Species: The plant species with the highest frequency in a study area.
- Subdominant Species: Plant species with intermediate frequencies.
- Rare Species: Plant species with low frequencies.
- Species Richness: The total number of different plant species in a study area.
- Species Evenness: The relative abundance of different species in a community.

6.2.2 Tools and Equipment

i. Vegetation Sampling Frame: A vegetation sampling frame is a physical or virtual boundary that defines the area to be surveyed. It can be a fixed-size frame or a GPS-defined polygon.

ii. Measuring Tape: A measuring tape is essential for setting up quadrats and measuring distances accurately.

iii. Quadrat or Plot: Quadrats are square or rectangular frames used for sampling vegetation. They come in various sizes depending on the research objectives,

iv. Field Notebook: A notebook is used to record field observations, including species presence, location data, and any relevant notes.

v. GPS Unit (optional): A GPS unit can help precisely record the geographic coordinates of sampling sites.

6.2.3 Methodology

- At the initial stage clearly define the boundaries of your study area and consider the environmental factors that may influence vegetation distribution.
- Determine how you will select sample locations. Common methods include random sampling, systematic sampling, or stratified sampling based on habitat types.

- Choose an appropriate sample size based on the study area's size, heterogeneity, and your research goals. Larger sample sizes provide more precise estimates of vegetation frequency.
- Place quadrats systematically or randomly within the study area. Ensure consistent orientation and spacing between quadrats.
- Vegetation Sampling for each quadrat, follow these steps:
    a. Identify and record all plant species present.
    b. Estimate the percentage cover of each species within the quadrat,
    c. Note the location using GPS (if available).
    d. Record any environmental variables (e.g., soil type, sunlight) that may affect vegetation.

6.2.4 Calculation

Frequency is expressed as the percentage of quadrats in which a species appears. The formula used is as follows:

$$\textbf{Frequency (F)} = \frac{\text{No. of sampling units in which the species occurred}}{\text{Total no. of sampling units studied}} \times 100$$

If species 'A' occurs in 6 quadrats out of total 10 quadrats studied, the frequency of species 'A' will be

$$\frac{6}{100} \times 100 = 60\%$$

Five frequency classes of plant species have been recognised by Raunkier (1934)

Class	Frequency percentage
A	1-20
B	21-40
C	41-60
D	61-80
E	81-100

Factor required to be remembered:

i. If GPS is used, record accurate GPS coordinates for each quadrat to enable precise mapping and spatial analysis,

ii. Prioritize safety during fieldwork, including knowledge of local hazards, first aid kits, and proper attire.

iii. Transfer field data into a computer database or spreadsheet for analysis. Ensure data integrity.

6.3 Density

6.3.1 Introduction:

Vegetation density assessment is crucial for understanding and managing ecosystems, biodiversity conservation, land use planning, and addressing environmental challenges. It helps in making informed decisions for sustainable resource management and conservation efforts. Vegetation density refers to the degree of plant cover within a defined area. It can be measured in various ways, including plant counts, canopy cover, biomass, or remotely sensed indices such as NDVI (Normalized Difference Vegetation Index).

Why Measure Vegetation Density?

- To assess ecosystem health.
- To monitor changes in land use and land cover.
- To study the impact of climate change.
- To inform conservation and restoration efforts.
- To support urban planning and green space management.

Various factors influence the Vegetation Density of a particular area, such as climate and weather patterns, soil type and fertility, human activities (e.g., agriculture, logging, urbanization), natural disturbances (e.g., fire, flooding), and invasive species.

6.3.2 Equipment

a) Quadrats or plots for ground-based sampling.

b) Clinometers for measuring canopy cover.

c) GPS devices for geolocation.

d) Measuring tapes.

e) Soil sampling kits (if necessary).

6.3.3 Methodology

i. Choose study sites that represent the ecosystem or area of interest. Consider factors such as accessibility, ecological significance, and spatial distribution

ii. Create a detailed plan outlining the data collection method, sampling locations, and frequency. Ensure that the plan aligns with the research objectives

iii. Set up plots of various sizes to sample vegetation. Measure canopy cover, biomass, or other relevant parameters

iv. Document plant species composition

v. Accurately record all collected data, including location, date, and environmental conditions.

6.3.4 Calculation

Density is the numerical strength (number) of individuals in relation to a definite unit space *i.e.,* per unit area. The density of a species is determined by using the formula given below:

$$\text{Density (D)} = \frac{\text{Total number of individuals of a species in all sample plots stdied}}{\text{Total number of sample plots studied}}$$

If there are 7 plants of species 'A' per quadrat of 10m × 10m size for 5 plots, density of 'A' will be $\dfrac{7}{500} \times 1000 = 14$ plants per hectre.

6.4 Abundance

6.4.1 Introduction

Vegetation abundance assessment is crucial for understanding ecosystem dynamics, biodiversity conservation, environmental impact assessment, and ecological research. It enables informed decision-making for sustainable land management and ecosystem preservation. Vegetation abundance refers to the degree of plant cover within a specific area. It can be quantified using various metrics, such as plant density, biomass, or vegetation cover percentage.

Significance of Vegetation Abundance Assessment:

- Facilitates the monitoring of ecosystem health and changes over time.
- Provides valuable data for conservation planning and habitat restoration.
- Supports land management decisions and environmental impact assessments.
- Enhances our understanding of the effects of climate change on vegetation.

6.4.2 Calculation

This is the number of individuals of any species per sampling unit of occurrence. It is calculated as follows:

$$\text{Abundance} = \frac{\text{Total no. of individuals of a species in all sampling units}}{\text{Total no of sampling units studied}}$$

Abundance is categorised into five classes.

Class	Stands per sq. m. quadrat
Rare	1-4
Occasional	5-14
Frequent	15-29
Abundant	30-90
Very abundant	91-100

6.5 Cover and basal area

6.5.1 Introduction

Quantitative values of frequency, density etc. do not provide correct information on the distribution of a species. As different species differ in their growth forms, such values are to be supplemented with other characters like cover and basal area. Cover or herbage cover signifies primarily the area of the ground occupied by the above ground parts of plants, such as leaves, stems as viewed from above. The cover can be measured both as aerial (canopy) cover and as basal cover or basal area.

Vegetation cover refers to the degree to which an area is covered by plant material. It is often expressed as a percentage of the ground surface covered by vegetation. The basal area represents the cross-sectional area of tree stems at breast height (usually 4.5 feet or 1.37 meters above ground level) within a defined area. It is typically measured in square feet per acre or square meters per hectare. Vegetation cover assessment helps monitor land use changes, ecological health, and habitat quality. Besides that, basal area measurement aids in forest management, timber inventory, and carbon sequestration estimation.

6.5.2 Equipment

- Quadrats for assessing vegetation cover, measuring tapes or chains.
- Diameter tapes, calipers, or Biltmore sticks for measuring tree diameter.
- GPS devices for geolocation.
- Clinometers for slope measurements (if needed).

6.5.3 Methodology

i. Select study sites that represent the target ecosystem or habitat. Consider factors like accessibility, ecological significance, and spatial distribution,

ii. Develop a detailed plan outlining the data collection method, sampling locations, and frequency. Ensure alignment with research objectives,

iii. Establish sampling plots or quadrats to assess vegetation cover,

iv. Estimate the percentage of ground covered by vegetation within each plot,

v. Record data for various vegetation types and species composition,

vi. Measure tree diameters at breast height within sample plots,

vii. Calculate the basal area for each plot using the formula for the area of a circle (πr^2).

6.5.4 Calculation

Vegetation Cover: $\dfrac{\text{Area covered with vegetation (sq. ft. or sq. meter)}}{\text{Area of the plot or quardent}} \times 100$

The leaf area index (LAI) is an important device which quantifies the amount of leaf overlap. LAI is a dimensionless quantity which portrays plant canopies.

$$LAI = \frac{\text{Total leaf area} \left[m^2 \right]}{\text{Ground area } m^2}$$

Vegetation type	Leaf area index
Tropical rain forest	10-11
Boreal conifer forest	9-11
Deciduous forest	5-8
Grassland	5-8
Tundra	1-2
Semiarid desert	1

A tree's basal area (BA) is measured using the tree's DBH (diameter of the trunk at breast height) in inches by the following formula:

$$BA = \frac{\pi \times \left(\dfrac{DBH}{2} \right)^2}{144}$$

The factor of 144 is used to convert sq. inches into sq. ft.

In simplified form – BA = $0.005454 \times (DBH)^2$ sq.ft.

The basal area or the area of coverage is used as an index of dominance. The higher the BA or coverage area the greater is dominance. The average BA of one stem multiplied by the density (no. of individuals per unit area) would give the basal cover per unit area.

6.6 Importance value index

6.6.1 Introduction

The Important Value Index (IVI) is a quantitative measure used to assess the relative ecological importance of plant species within a community or ecosystem. It combines measures of a species' relative frequency, relative density, and relative dominance to provide insights into its significance within the community. It helps identify key species that contribute significantly to ecosystem structure and function. It also informs conservation efforts by highlighting species of ecological importance and aids in land management decisions, such as habitat restoration or invasive species control.

Factors Influencing IVI:

- Species richness and diversity.
- Community composition.
- Abundance and distribution of individual species.
- Ecological context (e.g., forest, wetland, grassland).

6.6.2 Equipment

- Field guides and botanical keys for species identification.
- Quadrats or plots for vegetation sampling.
- Measuring tapes, calipers, or rulers for size measurements.
- GPS devices (if applicable).
- Soil sampling tools (if soil data is collected).

6.6.3 Methodology

i. Choose study sites that represent the ecosystem or habitat of interest. Consider factors such as diversity, accessibility, and ecological significance.

ii. Develop a detailed plan outlining data collection method, sampling locations, and frequency. Ensure that the plan aligns with research objectives.

iii. Establish sampling plots or quadrats of appropriate size and record the presence and abundance of plant species within each plot,

iv. Collect relevant data on plant size and other ecological parameters.

6.6.4 Calculation

The IVI is typically calculated using the following formula:

IVI = Relative density + Relative dominance + Relative frequency

Where,

$$Relative\ density\ =\ \frac{number\ of\ individuals\ of\ species}{total\ number\ of\ individuals}\times 100$$

$$Relative\ dominance\ =\ \frac{dominance\ of\ species}{dominance\ of\ all\ species}\times 100$$

$$Relative\ frequency\ =\ \frac{frequency\ of\ species}{sum\ frequency\ of\ all\ species}\times 100$$

The importance value index (IVI) measures how dominant a species is in a given forest area. The IVI of tree species was determined as the sum of relative frequency, relative density and relative dominance.

This may be graphically portrayed in the form of phytograph.

6.6.5 Creation of phytograph

- A circle is made and then divided into four equal parts (A, B, C and D) by two radial lines.
- Three radii (A, B and C) are divided into 100 scales from centre to circumference.
- The fourth radius is divided into 300 scales.
- The three radii with 0-100 scales characterise the values of RF on radius A, RD on radius B and relative dominance on radius C.
- IVI value is put on radius D in 0-300 scale.
- All these points of four radii are joined to get sociological characters and IVI of a species.

6.7 Dominance

Dominance is considered as an analytical character. Number of organisms may not give a correct idea of the species. Few trees in a grassland or few grasses in a forest may be of little value. Situation will be different if we consider area occupied or weight. In dominance cover is included as important. A single tree in grassland may occupy fairly large area and may have much mass.

Unit-7 ❒ Effect of Pesticides of opening and closing of stomata of different crops

7.1.1 Introduction

Though a common plant function, much remains unknown about stomatal conductance, especially at larger ecosystem scales while its associated processes like photosynthesis and, to a lesser extent, transpiration, are largely well studied. This research gap is surprising considering that sophisticated tools exist to rapidly and accurately measure stomatal conductance in the field. Modern infrared gas analyzers (IRGAs), for instance, used to analyze photosynthesis, are also equipped to measure stomatal conductance. Stomatal conductance (gs) is the diffusion of gas, such as carbon dioxide, water vapor, and oxygen, through the stomata of a plant. It also functions as the measure of stomatal opening in response to environmental conditions. Stomatal conductance occurs specifically through the stomata when they are open; The reverse is known as stomatal resistance.
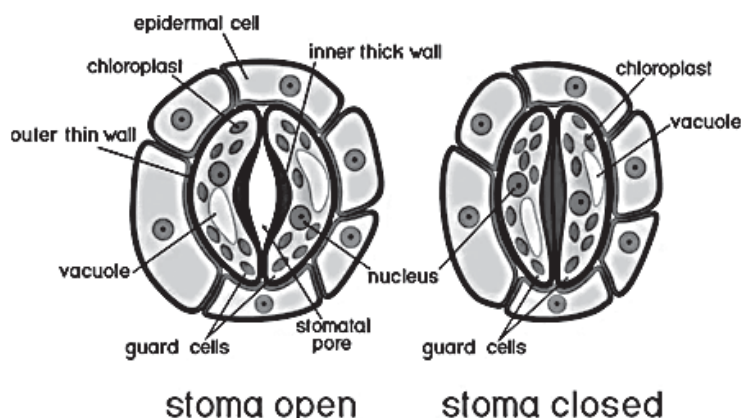

Figure 35 : Structure of stomatal complex with open and closed stoma.

7.2 Understanding Stomata

Stomata are found mainly in the epidermis of leaves, and other parts of the above-ground shoot in vascular plants. The stoma is an aperture formed by two guard cells. Connected to the guard cells are subsidiary cells. When the guard cells are flaccid, they close, and when they are turgid, they open, forming the stomata. See Figure 35

The shape of guard cells varies based on species. Based on the shape of guard cells and the number and arrangement of subsidiary cells, there are many kinds of stomata, some of which are shown in Figure 36.

In most plants, stomata are present on both sides of the leaves. In some, they are found only on one side. The density of stomata can also differ based on species. However, environmental factors can also play a role in determining the number of stomata.

Figure 36: Stomatal traits vary between species. The eudicots (A) Arabidopsis thaliana and (B) Phaseolus vulgaris display kidney-shaped guard cells (colored in green). The grasses (C) Oryza sativa and (D) Triticum aestivum show dumbbell-shaped guard cells (solid green) and specialized subsidiary cells (light green gradient). Clear differences in stomatal size and stomatal density can be observed," Bertolino et al. 2019. (Image credits: https://www.frontiersin.org/article/10.3389/fpls.2019.00225)

7.1.3 Influences of stomatal conductance

Environmental factors can also affect stomatal conductance.

External environmental factors influencing stomatal behavior are as follows:

1 . Light is the primary external factor that determines stomatal conductance, as stomata are activated and open during daylight.

2 . Humidity influences stomatal conductance. Low humidity reduces stomatal conductance to preserve water. Stomata will open in high humidity even if the leaf water content is less.

3 . Soil water and nutrient status will also impact stomatal conductance, which will decrease when soil moisture is less.

4 . Air temperature rises will increase stomatal conductance, independent of plant water status and photosynthesis. While this helps plants cool through evaporation and increases photosynthesis, plants lose more water.

5 . Elevated atmospheric CO_2 concentration decreases stomatal conductance, which can end up reducing photosynthesis.

6 . Salinity stress also reduces stomatal conductance–this is significant as nearly 7% of the global land is saline.

7 . Toxicity of external chemicals also impact on stomatal opening and closing.

The internal and external factors that control stomatal conductance will also interact, so stomatal response can be complex.

7.1.4 Apparatus

- A plant to sample a leaf from
- Clear nail varnish (ideally solvent based)
- Cellotape
- Microscope
- Microscope slides
- Stage micrometer
- Counting device (clicker/ phone app etc.)
- Calculator

7.1.5 Method of measurement

- Select a leaf from a live plant and cut it off the plant
  ❖ Geraniums and spider plants make good subjects for this experiment
- Place the leaf upside down on a flat surface such as a tile or worktop
- Paint clear nail varnish onto the underside of the leaf
- Wait for the nail varnish to dry (approx. 5 minutes)
- Peel off the layer of varnish using sellotape
  ❖ Discard the leaf
- Place the dried varnish impression on a microscope slide
  ❖ A coverslip is not required as this isn't a biological sample, just an impression of one
  ❖ A drop of water is not required either, so long as the sample is laid flat on the slide

- Use the usual steps to focus on the sample
- Adjust the zoom such that a countable number of stomata are visible in the field of view
  - ❖ Between 15 and 100 is ideal
  - ❖ Even if a stoma is partially visible at the edge, still count it as 1
- Count the stomata in that field of view
- Repeat the method after exposure of the toxic chemical (pesticide), and see the opening and closing status of the stomata.
- Measure the opening area of the stomata in both cases using the oculometer

7.1.6 Calibration of the Ocular Micrometre

This is a simple and precise method for measuring objects seen in the microscope. Ocular micrometres are calibrated by comparing the ocular micrometre scale with a calibrated stage micrometre. A calibration procedure must be completed to determine the calibration factor for each objective and each microscope following steps are to be followed to calibrate the ocular micrometre:

1. Insert the ocular micrometre into a 10X eyepiece. The ocular micrometer is divided into ocular divisions (OD).
2. Place the calibrated stage micrometer slide on the stage and focus on the scale. The stage micrometer has a calibrated scale which is divided into 0.1 millimeters (mm) and 0.01 mm units.
3. Adjust the field so the 0 line of the ocular micrometer (OM) scale is exactly superimposed upon the 0.0 line of the stage micrometer (SM) scale.
4. Without moving the stage micrometer, locate the point as far to the extreme right as possible where any two lines are exactly superimposed upon each other.
5. Count the number of divisions (mm) on the stage micrometer between the 0.0 line and the superimposed line to the far right.
6. Count the number of ocular divisions on the ocular micrometer between the 0 line and the superimposed line to the far right.
7. Divide the distance determined in step 5 by the number of ocular divisions in step 6 and multiply by 1000 to give the ocular micrometer units in μm.
8. Repeat steps 3 through 7 for each objective on the microscope.
9. If at any time the ocular micrometer is moved to a different microscope or a new objective is added to the microscope, the calibration procedure must be completed again.
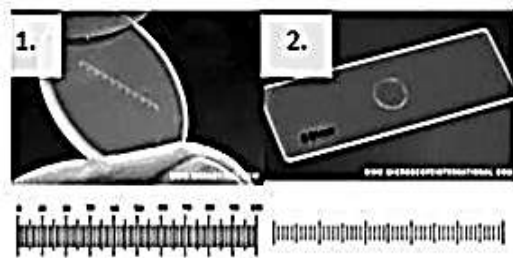
Figure 37: 1. Ocular and
2. Stage micrometer
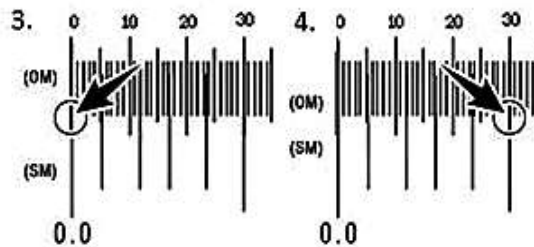
Figure 38: Example of super
imposed Ocularmeter and stage
micrometer

$$\frac{\text{Length seen on stage micrometer}}{\text{\# of divisions counted on ocular micrometer}} \times 1000 = \underline{\quad} \mu m$$

Example:

$$\frac{.30\text{mm}}{30 \text{ units}} \times 1000 = 10 \ \mu m$$

7.7 Result

Difference of the Percentage of stomatal closing and reducing stomatal opening are infer the affect of toxicant/xenobiotics on stomatal conductance and diffusion.