FILL UP THE BLANK

Pedology

1. A young soil would have mostly_______ processes operating within the profile
2. As a soil progresses through the young, mature and old stages of differentiation, the depth of the A horizon _______ and ___
3. Soil profile horizon formed as a result of intense eluviation processes and be typical of Spodosol is ______
4. Soils developed under grass vegetation will differ from those developed under forest vegetation mainly due to the _______
5. Traveling from a cool, wet climate to warm, wet climate one would likely leave _______ and encounter _______
6. Profiles exhibiting high levels of organic matter accumulation occur in climates with _____ temperatures and ____ rainfall
7. The migration of clay particles from top soil to sub soil is called as __
8. The soil zone lighter than the zone above or below it is the ________ horizon
9. Soils in which order lack any diagnostic horizons is _______
10. The lightest colored Epipedon is called as _____
11. ________ diagnostic horizons is a product of Illuviation
12. Soil order would most likely exhibit the greatest visual differences within soil profile is ___
13. Soil order typical of a cool, dry climate is ______
14. _______ order is characterized by soil possessing an E Horizon
15. The soil horizon not found in the profile of Entisol is _____
16. The official USDA definition of soil is based on _______ and ________
17. Soils possessing _____ epipedon would be the darkest
18. The most distinguishing difference between aqults and aquepts is probably _______
19. Subsurface diagnostic horizons would be most appropriate for soils in cool, humid regions is ________
20. Illuviation of fine mineral matter forms ________ diagnostic horizon
21. Organic matter accumulation would be greatest under _______ climatic conditions
22. _____ horizon will be present in a mature soil profile but not in a young profile
23. ______ subsurface diagnostic horizon found in Alfisol and resulting from Illuviation
24. The major difference between Spodosol and Ultisols is _________
25. A Mollic Epipedon is an example of a / an ______
26. The major difference between Inceptisol and Ultisols is ________
27. Soil of tropical regions that are highly weathered and show little differentiation belong to the order ________
28. Soils are placed in taxonomic orders on the basis of ________
29. The last major horizon to appear during soil development is the _____
30. The soil classification system we have studied is a good example of _________
31. A primary difference between a Mollisol and a Spodosol will be _______
32. The E horizon in a soil profile will be located between the _ and _ horizons
33. Carbonation would be most active in soil belonging to _______ soil order
34. The process that creates an Argillic horizon is called _______
35. The more infertile soils are likely to be in ________ order

36. ______ diagnostic horizons would most likely to be in an Aridisol
37. ________ soil order would most likely show the most differentiation within the profile
38. _________ soil order would most likely contain the most acid soil
39. _________ soil order contain none of the mineral diagnostic horizons
40. Hydration, hydrolysis and carbonation are most intense in ______ horizon
41. If soil formation processes that transform soil profile characteristics are highly active, the profile is said to be ______
42. ______ soil order is not necessarily linked with certain climatic requirements but is likely to be found in all climates
43. _______ Properties should be used when describing members of the soil order Spodosol
44. __________ order would have properties dominated by physical weathering processes
45. _______ feature would best tell a soils age
46. _______ soil profile horizon is the last to form
47. Illuviation causes the formation of ________ diagnostic horizon
48. _________ diagnostic horizon is noted for its accumulation of clay particles
49. The principal soil zone used to distinguish soils in the order Mollisol from soils belonging to other orders is the ___
50. Soils in ________ order would be dominated by minerals that are the most resistant to weathering breakdown
51. The effect of physical weathering would be most noticeable in ___ horizon
52. _______ diagnostic horizon develops as a direct result of eluviation and Illuviation process
53. _____soil order lacks in development of a diagnostic subsurface horizon, is found in all climates, and under almost any vegetation
54. ______ epipedon description fits soils that exhibit very little accumulation of dark colored humic materials
55. Exfoliation is a weatherable process that would be most prevalent in _____ orders
56. ______ horizon is lacking in Entisol
57. ______ sub surface diagnostic horizons would be most appropriate for Aridisol
58. Weathering deposition of clays in the B horizon forms _____ diagnostic horizon
59. The lightest colored epipedon is called _______
60. _______ soil order would most likely exhibit the greatest visual differences within the profile
61. A soil profile with an abundance of weatherable minerals and minimal differentiation would most likely be a/an ___ order
62. ___ soil order would be most prevalent in climates that support the most extensive weathering potential
63. ______ diagnostic horizons develops as a direct result of excess sodium accumulation
64. The hottest, wettest climatic conditions of the tropical and sub-tropical creates soils belonging to ____ order
65. Compared to a young or mature soil, an old soil profile exhibits the maximum amount of ______
66. ________ horizon would typically become Argillic horizon in a mature profile
67. ________ type of Native Vegetation is most commonly associated with formation of soils of the Alfisol Order

68. __________sequence of horizons could be expected to be found in a well-developed (mature), unplowed Alfisol soil profile
69. _______ is the soil forming factor most dominant in the formation of Gelisol soils
70. The most dominant soil forming factor at work in the formation of Histosol is usually ____
71. An ashy-gray E horizon is common to ________ order
72. Accumulation of salts leads to ______ horizon
73. In the soil, kankar is formed due to ________
74. According to USDA soil taxonomy, the number of soil suborders is ______
75. Gleyed layers in soil profile are formed due to _____
76. Gilgai indicates _________
77. The pioneering work on the 7th Approximation of soil taxonomy was done by _______
78. Soils characterizing with high content of swelling clays and wider cracks in dry season belongs to _______ order
79. Russian approach to soil classification was based on ________
80. The diagnostic surface horizon is called as _______
81. Man-made surface horizon is known as _____
82. The suborder coming under Spodosol order is _________
83. The order which is commonly seen in temperate regions is ______
84. Volcanic soils are grouped under the order _____
85. Pedogeneic turbulence results in the soil of the order _______
86. The formative element " arg' in the soil sub order denotes _______
87. Soils with Ochric epipedon and Argillic endopedon are grouped under the order ______
88. Intensity of weathering in Oxisol is __________
89. Soils with more than 30% organic matter comes under _______ order
90. Soil taxonomy has______ category
91. The coating of ped faces is called as _____
92. The subsoil pan due to the cementation by silica is ___________
93. Hydromorphic soils have ______ horizon
94. In vertic Haplusterts, the formative element vertic denotes ______
95. Accumulation of Illuvial organic matter is represented by the notation _______
96. The first scientific classification of soils was proposed by the Russian scientist ______
97. Soil order hierarchy is from ________ to ___-
98. Marbut classified iron. and Aluminium accumulated soils as ______
99. _________ is the first American to establish the soil profile as the fundamental unit of soil study
100. The diagnostic surface horizon in the soil classification system is called the ____
101. The most modern system of soil classification is called as ________
102. The Vertisol are characterized by the presence of _____ and ____ in Illuvial horizon
103. The Histic Epipedon is associated with ____ order
104. An Ochric horizon is an _______
105. The shrink- swell process results in the development of ________ relief in mineral black soil
106. Mollic Epipedon is ________ colored and contains ____ organic matter
107. Oxisol contains high amount of _____ oxides in surface horizon
108. Soils characterized with high content swelling clays and wide deep cracks in dry season will fall under _____ order

109. Tarai(grassland) soils comes under ________ order
110. The process of accumulation of clay in the B horizon is called _______ and indicated by symbol _____
111. Soils that are dry more than 50% of the year and no Mollic Epipedon is called as _____
112. Calcic horizon is developed due to accumulation of_______-
113. The diagnostic horizon oxic occur in ________ soil
114. Black soils of India belongs to ______ order
115. The desert soils comes under _______ order
116. The number of soil orders found in Tamilnadu is ___
117. The soil having Argillic horizon with high BSP comes under _______ order
118. The formative element of Ultisol is ________
119. The psamments comes under _______ order
120. Marbut classified the soil as ____ and ________- type
121. The natric horizon occur due to the presence of _______-
122. The honey comb structure and Plinthite layer is located in _______ soil
123. Dokuchaev classified the soil into Zonal , Azonal and _________
124. When a soil is submerged for major part of the year, taxonomically it is called as _____
125. The diagnostic horizon present in Spodosol is _______-
126. Peaty and marshy soils belong to _____-- order
127. ____ order occupies largest area in India
128. The parent material from which black soils are developed is ________-
129. Pedogeneic process of translocation of Sesquioxide from A to B horizon due to acid leaching is called as ________
130. A vertical section of a soil profile mounted for display is called as_____
131. The sub soil horizon symbol " g" denotes _______
132. The formative element for soil order Oxisol is ____
133. Soils with Argillic horizon with base saturation < 35% belong to _______order
134. The lowest unit of soil taxonomy is _____
135. ____ is the fundamental unit of soil classification
136. Histosol is characterized by their high _____ content
137. A humus rich layer of forested soils containing mixed organic and mineral matter is known as ____
138. The sub soil horizon symbol " h' denotes ____-
139. Soils with high swelling clays which crack upon drying belongs to the soil order_____
140. Slickenside is common in _____ soils
141. The dominant soil group in Tamilnadu is ___
142. The soil which is completely wet throughout the year comes under ____SMR
143. Gleying and mottles are found in ______ SMR
144. _______ SMR is noticed in Mediterranean climate
145. The SMR noticed between Ustic and Aquic is _____
146. When greater part of the year is moist, then SMR is ______
147. When greater part of the year is dry, then SMR is ______
148. When mean annual temperature is more than 22^0C, the STR is _____
149. When mean annual temperature is less than 0^0C, the STR is _______
150. The limitation in Dokuchaev 's genetic system of soil classification is _______
151. Basic principles followed in coining names in soil taxonomy was proposed by _____

152. ______ is the basic system of soil classification used now for interpreting soil survey

Soil Survey

1. For detailed soil survey, a profile is taken for every ______ Km
2. The base map used in reconnaissance soil survey___
3. The base map used in detailed soil survey is ______
4. Soil type is given on the basis of its _____
5. Soil colour is measured by using _____
6. Munsell colour chart is described by ______
7. The land capability classes suitable for cultivation is ______
8. The toposheets used as base map for soil survey are in the scale of ____
9. The headquarters of NBSS and LUP is located at _______
10. The soil mapping unit used in RSS is_____
11. An organized list of map units is called as _______
12. In LCC IIes, es refers to ______
13. Cadastral is the base map used for _____
14. Soil types and phases is a _________
15. A legend is a Organized list of ______
16. As per erosion hazard e3 is classified under____
17. The systematic examination, description, classification and mapping of soil of an area is known as ________
18. The predominant clay mineral in black soil is ______
19. Among the major soil groups of India oldest one is ________
20. Under conditions of high rainfall and high temperature, soils formed is_______
21. The survey undertaken to carryout for special purpose like dam construction is _____
22. The type of survey under taken for priority areas is _________
23. The LCC consists of three categories capability classes, capability subclasses and ______
24. Limitation of using land for irrigation___________ with _____ increase in capability classes
25. Soil suitability classes for irrigation was developed by_______
26. Storie index of soil rating is obtained by the product of four factors ___, ____, ________ and ________
27. The grouping of land units into defined classes based on its capabilities is called as ___
28. There are ____ land capability classes
29. The productivity soil rating given by Riquer et al is based on ______ number of soil factors
30. The methods of soil survey are ____ and _______
31. The study and mapping of soils of the area in the natural environment is called as ____
32. A group of about 3 to 10 different soils that occur together and are not separated because of scale limitation is called as __________.
33. A __________ is a group of soils found together in a landscape but differing in internal drainage class because of their slope position.
34. When making a soil survey, soil scientists dig soil pits primarily for the purpose of identifying __________

35. A typical field soil profile description is written in a standard format and for each horizon in the profile includes information such as _______________.
36. The Language of Soils is the description at _________ level
37. _______ is the first step in soil classification
38. AB horizons denotes zone of ______ between master horizons
39. One horizon scattered with another horizon is called as ______
40. Two or more genetically unrelated (contrasting) materials are present in a profile is called as _________
41. Roman letters as prefixes to the master horizons (e.g : IC, IIB & IIC) indicates _________
42. Bt, Bh is an example of ____________ horizon
43. Smallest volume that can be called a soil is known as _______
44. _________ soil body is homogeneous at a series level
45. The _________ is the vertical section of soil upon which classification is based
46. Control section - used for the _________ category of soil.
47. For mineral soils in general, the control section extends up to ___ depth from the upper boundary of C horizon
48. The area enclosed by a boundary is called as _________
49. Any unit describing the spatial distribution of soils which can be mapped is called ______
50. The _________is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile except for the texture of the surface soil
51. The basic unit of soil mapping is _________
52. _________ are used to map two or more series that are commonly intermixed on similar landforms in detailed county soil maps.
53. Soils of established series differing in some properties of the series is known as _______
54. Soils components which occupy less than 20 % of the mappable area is called i______
55. _________maps shows field boundaries and field or revenue survey number, however they lack the topographical features (contours, elevations)
56. _______ maps shows physical features and also show contours and elevation above mean sea level
57. The relationship between distances on a map and distances in real life is referred to as ______
58. The base map which shows the location of individual holding, ponds ,road and streams and not the physiographic features and contours lines is ____
59. Frequency of field observation in high intensity detailed survey is ____
60. The expression of name of soil series followed by the texture of the surface layer referred as ___________
61. In _________ survey method, the surveyor chooses the observation points
62. Scale of map of high intensity detailed survey is _____
63. The frequency of observation in semi detailed soil survey is _____
64. For establishing a soil series , a minimum area of ______ acres is required
65. ______ is the mapping unit , classified based on the environmental characters of the soil series namely slope , erosion, stoniness
66. The variants will be proposed as a new series during _____ soil survey
67. Soil profile is _______ dimensional feature
68. The normal dimension of a soil profile is _____

69. Horizons or layers are studied in _________ dimensions
70. Nomenclature for the soil horizon of parent material , excluding bed rock from which solum is believed to have formed is _____
71. The type of survey undertaken to prepare resource inventory of large areas is _______
72. The type of survey , where in base map , cadastral or village map is used is ___
73. The type of survey undertaken for developing correlation between physiographic units and soils is _____
74. The type of survey undertaken for macro planning for varied agro based development programmes is ______
75. Mapping unit consisting of two or three soil series occur in repeated geographical pattern which cannot be demarcated due to scale limitation is _______
76. The mapping units namely soil series, association or complex are used in _________ soil survey
77. Mapping unit consisting of area which have little or no soil to support any vegetation and used only after proper reclamation is ________
78. For selection of area for more intensive study by rapid reconnaissance soil survey is ______-
79. For regional planning by reconnaissance soil survey , scale map of map used is ____
80. For district planning by semi detailed soil survey , scale of map is _____
81. The scale of map used for village / watershed planning by low intensity detailed soil survey is ____
82. The parameter that is studied in the field first and later confirmed by laboratory analysis is ____
83. Cutans, the thin shiny surface either on pits or in pores is _____

Remote Sensing

1. The spectra wavelength range for visible region is ________
2. Weather satellite is a _______
3. An example of active sensor is _____
4. Photographic camera operates in ______ region
5. Vegetation discrimination can be done in _____ spectral region
6. Geosynchronous satellites are launched at an altitude of _______
7. Sun synchronous satellites are launched at an altitude of ________
8. In FCC, water bodies are observed as ____ colour
9. The headquarters of NRSA is located at_______
10. The source of EMR is _______
11. The extent of overlap in the photographs of adjoining flight strip should be ____
12. The extent of overlapping in the photographs taken in the same strip should be _____
13. Large scale aerial photographs will be in the range of _______
14. Aerial photographs taken with camera pointing perpendicular to the plumb line is known as ______
15. Landsat is a _________
16. In vertical aerial photograph, the minimum forward overlap is ____
17. The region of electromagnetic spectrum in which there is very less absorption of radiation is called as _____
18. The major principal windows available for remote sensing are ___, _____, _______ and ______

19. The remote sensing satellites are _____ and _____ type
20. An example of passive remote sensor is ______
21. An example of active remote sensor is ______
22. The sensor used in the visible region is _____
23. The sensor used in the infra-red region is _______
24. The sensor used in the microwave region is _______
25. The spectral range used for discrimination of water bodies is ______
26. The spectral range used for soil discrimination is _____
27. The platforms used for remote sensing are _____ and _______
28. An example of stationary satellite is _______
29. The satellite data products are available in the form _____ and ____
30. Interpretation of pictorial image data is done by____ and _______ ways
31. In India, the earth receiving station is located at ________
32. The overlapping of successively formed photos in the same strip is known as ____
33. The overlapping photographs of adjoining flight strips is called as ____
34. The relationship between distance on a map or photo and the actual ground distance is referred to as ____
35. The large scale photograph will be in the ratio of _____
36. The small scale photograph will be in the ratio of ___
37. As photographs taken with the camera set obliquely as the plane travels horizontally are called as ____
38. The important feature of aerial photographs is ___
39. Stereoscopes are _____ and ________ type
40. The assembly of photos with strict scale or size relation which can be used as a real map is called as _____
41. The assembly of photos without any scale or size relation is called as _____
42. ________ photos are required to get stereoscopic coverage
43. The distance from the middle of the camera lens to the focal plane is known as________
44. A _________ photograph is taken with the camera pointed as straight down as possible
45. The photograph taken with the camera inclined about 30° from the vertical is called as____
46. The _______ photograph is taken with the camera inclined about 60° from the vertical
47. Remote sensing is classified into three types with respect to the wavelength regions; viz. visible , thermal infrared and ______
48. Remote sensing based on energy resource are _____ and ______
49. The energy matter interaction of four types viz., transmission, scattered , absorption and _____
50. Every object has a repeatable characteristic reflectance pattern which can be used to represent it and is called ______
51. The percent reflection of objects with wavelength is called as _______
52. ____ and _____ region of EMS is useful to study the condition of the plants
53. Ability of the sensor to distinguish between signals or spatially similar is called as ______
54. All types of remote sensing system has four types of resolution are spatial, spectral, radiometric and _______
55. The measure of smallest distance between the objects that can be resolved by sensor is known as ________

56. The smallest band or part of the EMS in which the objects are distinguishable is known as _______
57. The frequency of remote sensing system which record the data over the same place is known as ______
58. The smallest slice of the band or portion of the EMS that can be made between the objects is called as ______
59. Device to detect the electro-magnetic radiation reflected or emitted from an object is called as _______
60. A scanning system that collects data at different band is called as ________
61. _________ will detect and emit energy in thermal infrared
62. The scanners are of two types ____ and ________
63. The vehicles or carriers for remote sensors are called the _____
64. Selection of a platform is based on _______ and _______
65. The data acquired by the sensor suffers from ______ and ________ errors
66. The term _____ is used for any pictorial representation of the data
67. Two-dimensional array of discrete picture elements called ____
68. Computer-based manipulation and interpretation of digital images is called as ___
69. Each pixel stores ___ measured by the sensor
70. The image of single band is called as ______
71. The expansion of FCC is __________
72. In FCC, vegetation is shown in _______ colour
73. Photos taken by the aircraft from the distance above the ground level.is known as _______
74. Larger-scale photos (e.g. 1/25000) cover small areas in ______
75. _________ photos required to have stereoscope coverage

Problem soils

1. The Russian term solon chalk belongs to ______
2. Denitrification process is favoured in _______ soil
3. Rock phosphate is generally recommended for application in ____
4. Volatilization loss of nitrogen will be more in _____
5. The amendment used for reclamation of acid soil is ______
6. Phosphorus fixation is prominent in ________ soil
7. Addition of _________ fertilizers causes acidity
8. The diagnostic horizon associated with alkali soil is _______
9. The area under salt affected soils is______
10. Anions which are responsible for saline soils are _____
11. Calculated amount of gypsum necessary to add to reclaim sodic soil is known as ______
12. The microbe which is tolerant in acid soil is ______
13. In sodic soil, soil structure is _______
14. Pyrite can be used for amending __________ soil
15. ESP will be more than 15 in _______ soil
16. Gypsum requirement of soil is used for ameliorating problems of ______
17. Amelioration of acid soil is based on _________
18. Arid climate favors the genesis of _______
19. When the ESP is more than 15, _____ of clay occurs
20. SAR is given by the formula _______
21. Instantaneous P fixation takes place with applied available P fertilizer in ________ soil

22. The micronutrient which is largely available in alkali soil is _______
23. Availability of iron in soil is more in _______ soil
24. In sodic soil, infiltration rate is ________
25. The acid soil is formed due to leaching of ________
26. The $CaCO_3$ equivalent of any liming material is known as the ________
27. ____ amendment is used in alkali soil having alkaline earth carbonate
28. _______ is the micronutrient not found in acid soil
29. _____ ion is the cause of soil dispersion
30. In acid soil equilibrium exists between ____ and ______ ions
31. The sodic soil is characterized by high content of exchangeable ___ and _____ permeability
32. _____ soil responds to application of lime
33. Acid soils are formed under _______ area
34. The two major processes involved in the development of acid soils are ___ and ____
35. ___ type of texture is found in acid soil
36. P fixing capacity is high in ____ and _______ soil
37. Saline soils are characterized by the presence of pH___, EC____ and ESP _____
38. Saline soils is also called as _____
39. Gypsum requirement is calculated by_____ formula
40. ______ is the first step in the reclamation of saline soil
41. Alkaline soil is rich in _____ type of clay mineral
42. In acidic soil, available P is fixed as ________ and _______
43. In calcareous soil, available P is fixed as _______
44. The potential acidity is ______ with active acidity
45. In soil ___ and ____ acts as a buffer system
46. Phosphate fixation in acid soil occur through _____
47. Acid soils are formed from _____ parent rock
48. ____ is an acid tolerant crop
49. Acid sulfate soils is also called as _______
50. Saline soils are usually barren, but ____ soils
51. _____ method is employed for lime requirement of acid soils
52. _______ method is employed in the gypsum requirement of alkali soil
53. Alkali soils are also called as ______
54. Destruction of soil structure in sodic soil is due to the presence of _____ ion
55. The loss of nitrogen in alkali soil is through ______ process
56. The osmotic pressure in saline soil is ___
57. Area under acid soil in India is ____-
58. As soil acidity increases, nitrogen fixation by microbes gets ____
59. The physiological browning disease is caused to presence of excess _____ ions
60. The lime requirement is related to both ____ and ______ capacity
61. Lime increases soil pH by converting H+ ions into ____
62. To get Ca and Mg, ________lime stone is added
63. A liming material should be selected on its ____ value, degree of ____ and ___
64. ___ soils contain free $CaCO_3$
65. The salinity problem in the black soil areas is due to _____
66. The expansion of CSSRI is ________

67. The dominant N loss mechanism from urea in sodic soil is ___
68. The total area of salt affected soils in India is about______
69. Hydrolysis of _____ and _____ in alkali soils is responsible for their high pH
70. The basic principle in the reclamation of saline soil is ___
71. ___ and ________ is the first step in reclamation of saline soil
72. The fraction of water that must be leached through the root zone to control soil salinity at specified level is known as _____
73. ____ and ________ are the prerequisites for reclamation of alkali soil
74. Amount of liming material that must be added to raise the pH to a desired value is called as _____
75. Calculated amount of gypsum necessary to add to reclaim sodic soil is known as ___
76. In acid soils, ___ and __ elements are in toxic levels
77. Those soils with pH less than 6.5 and which respond to liming may be considered as___
78. Phases of soil acidity are _______, exchangeable and reserve
79. Nitrification ________ with increase in soil acidity
80. Beneficial effects of liming on crop growth are often related to neutralization of _______ and not directly to the change in pH.
81. In saline soils, plants may appear ________ stressed
82. In coastal soils, salinity is due to __________
83. Crusting or hard settings of soil is noticed in ______ problem soil
84. Fluffy soil is usually observed in ________ soil
85. The fluffy soil is characterized by high ______ and _______
86. In crusted soils, the soil structure becomes ______
87. Soil crusts is observed in _________ soil
88. Very slow permeable soils is associated with ____ type of texture
89. Soil breeding technique is recommended for _________ soil
90. Subsurface hard pan is opened by ploughing with ______
91. Crust strength of a soil can be measured by________ test
92. The crust of the soil is formed due to destruction of _______ by _______
93. Chisel ploughing will amend _______ soil
94. Highly permeable soils are associated with ____ soil
95. In India, area under physical constraints in one form or the other is ____
96. Compaction effect on soil through action of rainfall and later drying up of particles is known as ______
97. Sub surface hard pan is caused due to _______of clay
98. Light textured soils are associated with ___ type of physical constraint
99. ______ and _______ technology is recommended for high permeable soils
100. The bulk density in highly permeable soil is usually ___
101. The physical constraint associated with black soil of Vertisol is ___
102. The permeability and hydraulic conductivity in very slow permeable soils is _____
103. ____ practice is recommended to avoid impact of raindrops to cause soil crusting
104. In soil crust, the aggregate stability is ____
105. Infiltration , hydraulic conductivity will be ____ in fluffy soil
106. Rolling of 400 kg stone roller for 8 pauses is recommended for ____ soil

Quality of irrigation water

1. Quality of irrigation water depends primarily on __ and _______ off the water

2. Irrigation water contains dissolved salts which are in the _____ form
3. RSC of irrigation water is 2.3meql^{-1}, water is said to be____
4. Magnesium hazard in irrigation water is expected when Mg /Ca ratio is ____
5. The alkalinity hazard of irrigation water is known by assessing _____
6. SAR of irrigation water will give ___ type of hazard
7. Salinity hazard of irrigation water is obtained on analyzing ___ property of water
8. Alkali waters contain ___ and ____ ions in varying proportion
9. RSC is given by the formula____
10. RSBC was proposed by ______
11. If SAR of given water is 8.5, the water is said to be_____
12. Long term use of high alkaline water induces ___ problems in soil
13. SCAR is calculated when the value of EC is _____ and Mg/Ca ratio is ___
14. Sodicity hazard is evaluated based on ________

Pedology

1	Addition	32	A and B
2	Increases, decreases	33	Aridisol
3	E horizon	34	Illuviation
4	Vegetation	35	Oxisol
5	Alfisol, Ultisols	36	Natric/calcic /Gypsic/salic
6	Low, Low	37	Oxisol
7	Leaching	38	Spodosol
8	E	39	Histosol
9	Entisol	40	A
10	Ochric	41	Young
11	Argillic	42	Entisol
12	Oxisol	43	Strongly expressed E horizon
13	Entisol	44	Aridisol
14	Spodosol	45	Profile differentiation
15	B	46	B
16	Pedology and Edaphology	47	endopedon
17	Mollic	48	Argillic
18	Profile differentiation	49	A
19	Spodic	50	Oxisol
20	Argillic	51	R
21	Temperate	52	Argillic
22	B	53	Entisol
23	Argillic	54	Ochric
24	Vegetation	55	Aridisol
25	Epipedon	56	B
26	age	57	Calcic/salic/Gypsic/Natric
27	Oxisol	58	Argillic
28	Diagnostic horizon	59	Ochric
29	B	60	Oxisol
30	Pedology	61	Inceptisols
31	Vegetation	62	Aridisol

63	Natric	94	Sub group
64	Oxisol	95	Bh
65	oxides	96	Dokuchaev
66	B	97	Order to soil series
67	Deciduous forest	98	Pedalfers
68	A-E-B -C	99	Marbut
69	Climate	100	Epipedon
70	climate	101	USDA
71	Spodosol	102	Slicken sides and wedge shape
72	Salic	103	Histosol
73	Calcium carbonate	104	epipedon
74	47	105	Micro relief
75	Water stagnation	106	Dark , high
76	Micro relief	107	Sesquioxides
77	Kellogg, Baldwin and Thorp	108	Vertisol
78	Vertisol	109	Mollisol
79	Genetic	110	Argillic, Bt
80	epipedon	111	Aridisol
81	Plaggen	112	Calcium carbonate
82	Humods /Aquods/ Orthods/ cryods	113	Laterite soil
83	Spodosols, Alfisols, Ultisols, Entisols, and Inceptisols.	114	Inceptisol or vertisol
84	Andisols	115	Aridisol
85	Vertisol	116	five
86	Illuvial clay	117	Alfisols
87	Alfisol	118	Ult
88	Maximum	119	Entisol
89	Histosol	120	Pedalfers and pedocals
90	6	121	ESP> 15
91	Cutans	122	Laterite soil
92	Duripan	123	Intrazonal
93	Gleyed horizon	124	Aquic

125	Spodic	138	Illuvial humus
126	Spodosol	139	vertisol
127	Inceptisol	140	Black soil
128	Basalt	141	Red soil
129	podsolization	142	Aquic
130	Monoliths	143	Aquic
131	Gleyed	144	Xeric
132	Ox	145	Udic
133	Ultisols	146	Udic
134	Soil series	147	Aridic
135	pedon	148	hyperthermic
136	Organic matter	149	pergelic
137	Spodic layer	150	Climate and vegetation
151	Thorp and smith	152	Soil taxonomy

Soil survey

1	¼ to ½	18	Smectites
2	Toposheets	19	Alluvial
3	Village or cadastral	20	Laterites
4	Texture	21	DSS
5	Munsell colour chart	22	DSS
6	Hue value, chroma	23	Capability unit
7	I to IV	24	1 to 6
8	1"= 8 miles	25	Sys (1976)
9	Nagpur	26	A x B x C x X
10	Soil series, soil association /complex	27	LCC
11	Legends	28	8
12	LCC sub class	29	Nine
13	DSS	30	Free and grid survey
14	Soil mapping unit	31	Soil survey
15	Map unit	32	Soil association
16	IV class	33	Catena
17	Soil survey	34	soil units

35	Morphological properties	61	Free survey
36	Family	62	1:5000 or 1:10000
37	Soil horizon	63	1 per 100 ha
38	Transistion	64	2000 acre
39	Mixed horizon	65	Soil type
40	Lithological discontinuity	66	DSS
41	Lithological discontinuities	67	3D
42	Sub ordinate	68	3 x 2 m
43	Pedon	69	horizontal
44	Polypedon	70	C
45	Control section	71	RSS
46	Series	72	DSS
47	1.5 m	73	SDSS
48	Soil delineation	74	RSS
49	Soil map unit	75	Soil associations or complexes
50	Soil series	76	RSS
51	Soil series	77	Miscellaneous soil type
52	Soil association	78	Detailed soil survey
53	Soil variant	79	Small-scale
54	Inclusion	80	1: 250,000
55	Village map	81	4inch to one mile
56	toposheets	82	texture
57	Map scale	83	Clay slickensides
58	Cadastral map		
59	4 per ha		
60	Soil type		

Remote sensing

1	0.4-0.7µm	31	Shadnagar
2	Geostationary satellite	32	Forward lap
3	Radar	33	Side lap
4	Visible	34	Scale
5	0.45 - 0.52µm	35	1:1000/1;5000
6	36,000 km	36	1;50000 to 1;250000
7	300-1000 km	37	Oblique
8	Black	38	Stereoscopic vision
9	Hyderabad	39	Mirror and lens
10	Sun	40	Controlled mosaic
11	30%	41	Uncontrolled mosaic
12	60%	42	Overlap
13	1:10000 or 1: 5000	43	Focal length
14	Vertical	44	Vertical
15	Satellite	45	Low oblique
16	60%	46	High oblique
17	Atmospheric windows	47	Microwave
18	VIS, NIR, TR and Microwave	48	Passive and active
19	Geo synchronous and Sun synchronous	49	Reflection
20	Photographic camera	50	Spectral signature
21	Radar	51	Spectral reflectance curve
22	Panoramic /vidicon camera	52	VIS and NIR
23	Scanners	53	Resolving power/ resolution
24	SLAR (side looking airborne radar)	54	temporal
25	0.76 to 0.90µm	55	Spatial
26	0.63 to 0.69µm	56	spectral
27	Aircraft and satellite	57	Temporal
28	Weather/ communication satellite-INSAT	58	radiometric
29	Hard copy as aerial photograph and digital format	59	sensor
30	Visual and digital	60	Multi spectral Scanner

61	Thermal scanner	69	Digital number
62	Across and along track scanner	70	Panchromatic
63	Platform	71	False colour composite
64	Altitude and IFOV	72	Red
65	Radiometric and geometric	74	Detail
66	image	73	Aerial photograph
67	Pixel	75	Overlap
68	Digital image processing		

Problem soils

1	Solonchalk	24	low
2	Sodic soil	25	Bases
3	Acid soil	26	Neutralizing value or equivalent acidity
4	Alkaline soil	27	Gypsum/sulphur/ferrous sulfate
5	lime	28	Molybdenum
6	Acid soil	29	Sodium
7	Nitrogenous	30	H^+ and OH^{-1}
8	Natric	31	Sodium , low
9	8.3 Mha	32	Acid
10	Chloride and sulfate	33	rainfall
11	Gypsum requirement	34	Laterisation and Podzolization
12	Fungi	35	Coarse texture
13	Columnar	36	Acid and calcareous
14	Sodic	37	7-8.5, > 4dSm^{-1}. ESP <15
15	sodic	38	White alkali
16	Alkaline soil	39	$\frac{\text{ESP(initial)} - \text{ESP(final)}}{100} \times \text{CEC}$
17	Lime requirement	40	Leaching and drainage
18	Salt affected soil	41	Montmorillonite
19	Dispersion	42	Iron and aluminium phosphate
20	$\frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$	43	Tricalcium phosphate
21	Acid soil	44	Equilibrium
22	Molybdenum	45	Clay and Humus
23	Acid soil	46	Anion exchange

47	Acid igneous rock-	77	Acid
48	Tea/coffee. Rubber	78	Active
49	Kari soils/ cat clays	79	Decreases
50	Productive	80	Aluminium
51	Buffer	81	Water
52	Saturated calcium sulfate	82	Sea water
53	Black alkali	83	Sodic
54	Sodium	84	Paddy
55	Volatilization	85	High infiltration and hydraulic conductivity
56	High	86	Deteriorated
57	4.9 Mha	87	Red soil
58	Reduced	88	Clay /fine textured
59	Fe and Mn	89	Highly permeable soil
60	pH and buffering	90	Chisel plough
61	OH^{-1}	91	Modulus rupture
62	Dolomite	92	soil structure and dispersion of clay particles
63	Neutralizing value, finesse, purity	93	Subsurface hard pan
64	Calcareous	94	Coarse textured
65	Impeded drainage	95	79 M ha
66	Central soil salinity research institute	96	Soil crust
67	Volatalization	97	Illuviation
68	7 M ha	98	High permeable
69	OH^{-1} and sodium	99	Clay mixing, 400 kg stone roller
70	Removal excess salts to a desired level in root zone	100	Very low
71	Leaching , drainage	101	Very slow permeable
72	Leaching requirement	102	Very low/low
73	Amendment, leaching	103	mulching
74	Lime requirement	104	Poor
75	Gypsum requirement	105	High
76	Fe and Al	106	Fluffy

Quality of irrigation water

1	Concentration and composition
2	Ionic
3	Moderate safe
4	<50
5	RSC, RSBC
6	Sodicity
7	Electrical conductivity
8	Carbonate and bicarbonate
9	$(CO_3^{2-} + HCO_3^{-}) – (Ca^{2+} + Mg^{2+})$
10	Gupta(1984)
11	Safe
12	Sodic
13	> 5 dSm-1, >1
14	SAR

DEFINITIONS

1) **Soil survey:** Soil survey is study and mapping of soils in the field in their natural environment. (or)
   It is the systematic examination, description, classification and mapping of soils of the area
2) **Map scale**: The ratio between the distances measured on a map (d) and the same Distance measured on the ground (D)

$$S = \frac{d}{D}$$

3.) **Soil map**: A map showing the distribution of different kinds of soils in relation to the major geographical features of an area
4) **Soil mapping unit**: Any unit describing the spatial distribution of soils which can be mapped.
5) **Base map**: Map on which information may be placed for purpose of comparison or geographical correlations
6) **Soil series:** The soil series is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile except for the texture of the surface soil
7) **Soil associations:** A grouping of soils of different kinds, which may or may not be from the same order, which occur in same area
8) **Soil complex:** When different types or series of soils occur in small areas in an intricate pattern, they cannot be separately mapped. Such a presentation on a soil map is called a soil complex

9) **Catena:** Soils from same developed parent material may differ in their drainage or relief. This relationship on the basis of difference in drainage and relief is known as catena
10) **Legend:** It is list of defined mapping units with their symbols
11) **Soil survey interpretation:** Kellogg (1966) defined soil survey interpretation as predictions of soil behaviour for specific land and management practices
12) **Soil productivity:** Capacity to produce a certain quantity of harvest per hectare per year, expressed as a percentage of optimal productivity, which would provide a suitable soil in its first year of cultivation
13) **Soil survey report**: It is the ultimate product and forms the essence of all field Investigations. It provides good and complete information that could be used by many end users
14) **Pedology:** Area of specialization of soil science which studies the soil and its Weathering profile
15) **Soil classification**: Categorization of soils into groups at varying levels of generalization can be termed as soil classification.
16) **Diagnostic horizon:** Soil layer containing a combination of characteristics typical of that kind of soil.
17) **Soil taxonomy:** The comprehensive soil classification system is called as soil taxonomy which is the science or principles of classification.
18) **Remote sensing**: Remote sensing is multidisciplinary activity which deals with the inventory, monitoring and assessment of natural resources through the analysis of data obtained by observations from remote platforms.

    (Or)

    It is the acquisition and measurement of data/information on some properties of a phenomenon, object or materials by a recording device not in physical, intimate contact with the features under surveillance

    (Or)

    Science and art of obtaining information about something from a distance and analysis of collected data to obtain information about the objects, areas or phenomenon under investigation.
19) **Atmospheric windows**: Those areas of the spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called atmospheric windows
20) **Passive remote sensing**; It record energy that is emitted, scattered or reflected from natural sources
21) **Active remote sensing**: Satellite provide their own source of electromagnetic radiation which is then reflected or scattered and the signal is collected by the system
22) **Spectral signatures**: The variation in reflectance according to the wavelength is called spectral signature
23) **Resolution**: Ability of a remote sensor to distinguish between signals that are spectrally or spatially similar

24) **Spatial resolution**: The measure of the smallest distance between the objects that can be resolved by the sensor

25) **Spectral resolution**: The smallest band or portion of EM spectrum in which the objects are distinguishable

26) **Sensors:** Device to detect the electro-magnetic radiation reflected or emitted from an object is called a "remote sensor" or "sensor". Cameras or scanners are examples of remote sensors

27) **Multiple scanners**: A scanning system used to collect data over a wide variety of wavelength ranges

28) **Platforms:** The vehicles or carriers for remote sensors are called the platforms

29) **Remote Sensing Satellites:** Satellite with remote sensors to observe the earth is called a remote-sensing satellite, or earth observation satellite.

30) **Geostationary satellite**: A geostationary (GEO=geosynchronous) orbit is one in which the satellite is always in the same position with respect to the rotating Earth

31) **Digital Image Processing:** Computer-based manipulation and interpretation of digital images

32) **Pixels**: Images that we see on a computer screen are made up of picture elements called pixels

33) **Aerial photographs**: They are the photos taken by the aircraft from the distance above the ground level

34) **Focal length:** The distance from the middle of the camera lens to the focal plane (i.e. the film

35) **Large Scale:** Larger-scale photos (e.g. 1/25000) cover small areas in greater detail. A large scale photo simply means that ground features are at a larger, more detailed size

36) **Small Scale:** Smaller-scale photos (e.g. 1/50000) cover large areas in less detail. A small scale photo simply means that ground features are at a smaller, less detailed size.

37) **Overlap:** It is the amount by which one photograph includes the area covered by another photograph, and is expressed as a percentage.

38) **Stereoscopic Coverage:** The three-dimensional view which results when two overlapping photos (called a stereo pair), are viewed using a stereoscope**.**

39) **Vertical photographs:** Photographic image taken from an aircraft or similar high-level elevated platform where the camera direction is at right angles to the ground beneath and the face of the film is more or less parallel to the ground surface.

40) **Oblique photographs**: Photographic image taken from an aircraft or similar high-level elevated platform where the camera direction is at an angle to the ground beneath.

41) **Aerial mosaic:** Aerial mosaics are made by assembling and maintaining individual aerial photographs to form continuous photographic image of an area.

42) **Stereoscopic vision:** Three-dimensional vision produced by the fusion of two slightly different views of a scene on each retina.

43) **Soil crusting**: It is a phenomenon associated with deterioration of soil structure where the natural soil aggregates brake and disperse. When on drying soil particles come together to form dense and strong soil layers known as soil crusts.

44) **Fluffy soil**: It is observed in the paddy soils where the working of soil by bullocks will be difficult and is characterized with high infiltration, hydraulic conductivity but with low BD.

45) **Low permeable soil:** The soils are almost impermeable under saturated conditions and develop deep and wide cracks on drying. .The very slow permeability is observed in black soils of Vertisol order

46) **Highly permeable soil:** The light textured soil is highly susceptible to the percolation losses of water and leaching losses of nutrients. Low WHC, poor retentive capacity for nutrients, high percolation loss of water, fast evaporation rate are the major features of light textured soil.

47) **Soil hardening**: It is largely due to physical process brought out either directly by compaction effects of through action of rainfall and later drying up of compacted oriented particles.

48) **Acid soil:** Those soils with pH less than 6.5 and which respond to liming may be considered as acid soils.

49) **Active acidity**: It refers to the activity of hydrogen ions in the aqueous phase of a soil.

50) **Reserve acidity:** It refers to the hydrogen & aluminium ions held on the soil colloids.

51) **Neutralizing value:** The ability to neutralize acids expressed in terms of calcium carbonate equivalent. Calcium carbonate is the standard by which other materials are measured (100%)

52) **Lime requirement:** Amount of liming material that must be added to raise the pH to a desired value is called as lime requirement.

53) **Salt affected soil**: A soil which contain excess amount of salts, excess amounts of exchangeable sodium or both an excess amount of salts and exchangeable sodium

54) **Saline soil:** Classified as saline when they contain a high enough concentration of soluble salts to interfere with normal growth and development of salt-sensitive plants. The soil should have EC > 4 dSm^{-1}, pH <8.5 and ESP<15

55) **Sodic soils**: Soils with high levels of exchangeable sodium (Na) and low levels of total salts are called sodic soils. The soil should have EC <4 dSm^{-1}, pH >8.5 and ESP>15

56) **Leaching:** Leaching is defined as the process of transporting soluble salts by downward movement of water in the soil by the application water.

57) **Leaching requirement** (**LR**): It is defined as that fraction of water that must be leached through the root zone to control salinity at specified level.

58) **Problem soil:** The soils which owe characteristics that they can not be economically used for the cultivation of crops without adopting proper reclamation measures are known as problem soils.

59**)** **Instantaneous field of view (IFOV**): A measure of the spatial resolution of a remote sensing imaging system. It is the most common measure of spatial resolution and can be defined as that area on the ground that is viewed by the instrument from a given altitude at any given time

60) **Soil resource inventory**: Soil survey, or more properly, soil resource inventory, is the process of determining the pattern of the soil cover, characterizing it, and presenting it in understandable and interpretable form to various consumers (or)

SRI meant to secure information needed to manage soil sustainability, protect water quality, vegetation communities and wildlife communities

61) **Pedon**: Smallest volume that can be called a soil. Must be large enough volume of soil to be observable and to exhibit a full set of horizons.

62) **Polypedon:** Group of contiguous (adjacent and in close contact with) similar pedons bounded on all sides by not soil or by pedons of unlike characters.

63) **Control Section:** The control section is the vertical section of soil upon which classification is based. It is necessary to provide a uniform basis for soil classification

64) **Mixed horizons:** One horizon scattered within another horizon. B/A mixed A & B; B is matrix for A , E/B E is matrix for B.

65) **Lithological discontinuities:** Two or more genetically unrelated (contrasting) materials are present in a profile. Indicated by the use of Roman letters as prefixes to the master horizons (e.g : IC, IIB & IIC).

66) **Transition horizons:** AB type: dominated by properties of one master horizon but having subordinate properties of another

67) **Land-use planning:** It is the process of regulating the use of land in an effort to promote more desirable social and environmental outcomes as well as a more efficient use of resources (or)

LUP refers to the rational and judicious approach of allocating available land resources to different land using activities and for different functions consistent with the overall development vision/goal of a particular area

68) **Global position system**: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world

69) **Geographic information system:** Geographic information system (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data

70) **Deflaction :** The process of lowering land surface by wind erosion is called as Deflaction

71) **Sand dunes –** Sand dune, any accumulation of sand grains shaped into a mound or ridge by the wind under the influence of gravity

72) **Ill drained soil**: Ill drained simply refers to the soils ability not to allow water to pass through at a reasonable rate.

73) **Polluted soil**: Soil pollution is defined as the change in physical, chemical and biological conditions of the soil through man's intervention resulting in degradation in quality. **Or** Soil pollution is the reduction in the productivity of soil due to the presence of soil pollutants

74) **Acid Sulphate Soils:** Acid sulphate soils are drained coastal wetland soils that have become acid ($pH<4$) due to oxidation of the pyritic minerals in the soil. **(or)**

Soils formed from weathering of sulphide bearing parent materials which results in the formation of extreme low pH (< 3.0) and precipitation of sulfate salts

75) S**oil Moisture Regime:** Soil moisture regime is the soil property that expresses the change in soil moisture over time as determined by soil and climate

76) **Soil Temperature Regime:** It is the soil property that expresses the change in temperature of soil over time. In tropical soils, the change is minimal, the difference between summer and winter soil temperatures being less than 5^0C

DESCRIPTIVE ANSWERS

PEDOLOGY

Writ short notes on the following

1) **Soil resource inventory**

Soil survey, or more properly, soil resource inventory, is the process of determining the pattern of the soil cover, characterizing it, and presenting it in understandable and interpretable form to various consumers. The objectives of soil resource inventory to 1) Characterize and classify the soils into units based on their morphological, physical and chemical properties and map them on a standard scale. 2) Developing a database on soils at Panchayat level.3) Assessing the potentials and constraints of the soil. 4) Evaluating the soils by various interpretative groupings. 5) Suggesting land use strategies for enhancing agricultural production. The importance of soil resource inventory are a) Gives detailed information about various properties of soil. b) Gives potential and limitation of particular soil. c) SRI information is in sufficient detail for application scientist, engineers to specific area of concern. d) Information is sufficient to place soil in taxonomic class. e) Information about soil properties and land is vital for making decisions on proper land use management, environmental protection, and land use planning. f) To motivate for systematic soil surveys and interpretations, maps of soil properties required by empirical models.

2) **Soil horizons**

It is first step in soil classification. Soil horizons consists of master horizon which includes O.A.E.B.C and R As soils age, they may develop more horizons than the basic master horizons. Some of these layers are between the master horizons both in position and properties. These layers are identified by the two master letters, with the dominant one written first. Thus, an AB layer lies between the A and B horizons and resembles both, but is more like the A than the B.

Changes within master horizon for which there is no sub horizon designation which is indicated by number after letters eg. A1 A2 for color change within A

Mixed horizons: One horizon scattered within another horizon. B/A mixed A & B; B is matrix for A , E/B E is matrix for B. etc….

Lithological discontinuities (e.g., soil has A, E, B horizon formed on one parent material and a second soil formed on another) and it is indicated by Numbers before letters II B

Subordinate Distinctions within Master Horizons It is due to translocation of materials from A horizon to **B** horizon. The name and symbol is given based on the type of material accumulated in lower layers. For eg Bt means argillic horizon due to illuvial clay

Vertical Subdivisions: Characterized by similar master and/or subordinate properties separated by "degree" for eg Bt1, Bt2, Bt3

3. **Pedon and Polypedon:**

Smallest volume that can be called a soil. Must be large enough volume of soil to be observable and to exhibit a full set of horizons. Three dimensional. Hexagonal in shape. Area ranges from 1 to 10 m2 upon soil variability. Unit for soil sampling. Includes the rooting zone of most native perennial plants.. Lower limit of pedon for survey. Permits reliable information on soil properties. Lateral dimensions should be large enough. Limitations of pedon soil mapping. It has a very small extent, so can't show any 'macro' landscape features like landform (slope, curvature), landscape position, surface stoniness, erosion. It does not exhibit any spatial variability

Polypedon

Group of contiguous (adjacent and in close contact with) similar pedons bounded on all sides by not soil or by pedons of unlike characters. Real physical soil body with a minimum area of > 1 sq. km and an unspecified maximum area. Real soil bodies - classify into series and higher categories. Polypedon- in Soil Taxonomy as a unit of classification. The polypedon is the soil body, homogeneous at the series level. Big enough to exhibit all the soil characteristics considered in the description and classification of soils

4. **Control section**

The control section is the vertical section of soil upon which classification is based. It is necessary to provide a uniform basis for soil classification. In general, pedons should be sampled at least to the depth of the control section. The properties of the material beneath the control section are important for many interpretive purposes. Therefore, the underlying material should be examined and its properties recorded whenever possible.

There are several control sections in Soil Taxonomy

Subgroup, great group, suborder, order

– Moisture

• Family

Particle-size classes or their substitutes, Mineralogy , Cation-exchange activity, Temperature, Calcareous and reaction classes, Classes of coatings, Classes of permanent cracks, The family category provides information for engineering use and agronomic use.

• Series control section

Series Control Section (SCS) -vertical section of soil - distinguishing series with families. Upper limit of SCS is below the plough or surface layer (20 – 25 cm). Lower limit is extended up to the zone of biological activity (up to 1.0 m/ 1.5 m.)

Mineral soils

For mineral soils in general, the control section extends from the mineral surface either to 25 cm below the upper boundary of the C, IIC, or permafrost table, or to a depth of 2 m, whichever is less

Organic soils

The control section for Fibrisols, Mesisols, and Humisols extends from the surface either to a depth of 1.6 m or to a lithic contact. It is divided into tiers, which are used in classification. The tiers are layers based upon arbitrary depth criteria.

5. **Soil mapping units**

It is an area of soil that is delineated from adjacent soil on a map (or) Any unit describing the spatial distribution of soils which can be mapped. Soil mapping units may be simple, consisting of one type of soil or complex, consisting of two or more types of soil. These are identified by a unique symbol, color or name. Soil maps generally contain more than one map unit. The various soil mapping unit used in soil survey are: a) Soil series b) Soil Types and c) Soil Phases. d)Soil complex, soil association, catena , variant, inclusions, undifferentiated and miscellaneous

Soil series:

The soil series is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile except for the texture of the surface soil. The soils within the series are essentially homogenous in all soil profile features. The series brings the units of mapping together in an organized manner to help us to remember soil properties and the relationship among soils. Soil series are differentiated on the basis of significant variation in morphological features of soil profile.

It is give a geographical name either of the place where it was first recognized eg Madukkur series, Irugur series, Pattukottai series, Noyyal series

Soil types:

The soil type is a sub division of soil series based on the texture of the surface soil. Soil type consists of the series name plus the textural class name of A horizon

eg Knd- Cl

Series A horizon texture

The soil type is the lowest and most nearly homogenous unit in the natural system of classification. A soil type may include defined variation in slope, stoniness, degree of erosion or the depth of rock; To be allowed within a soil type, soils cannot vary in these features beyond a range of significance to the genesis of the natural soil.

They mainly indicate differences of practical significance. Phases are sub division of any category of soil classification in respect of slope, erosion, stoniness and salinity.

Soil complexes and soil associations

Naturally occurring groupings of two or more soil series with different use and management requirements which occur in a regular pattern across the landscape, but that cannot be separated at the scale of mapping that is used. Soil complexes are used to map two or more series that are commonly intermixed on similar landforms in detailed county soil maps. Soil associations are utilized in more general and less detailed regional soil maps.

Soil variant

Soils of established series differing in some properties of the series. They are indicated as variant in reconnaissance. These soil will be proposed as new series in detailed soil survey

Inclusions

Soils components which occupy less than 20 % of the mappable area is called inclusions

Undifferentiated

Mapping unit consisting of a number of taxonomic units Merged so that separation into different units are impossible at any reasonable mapping scale

Miscellaneous land types

These include areas which are having little or more soil to support any vegetation unless they are reclaimed.

6. **Detailed Soil Survey**

In this survey boundaries of soil are delineated from observation by actual traverses throughout the course of the boundary. Soils are examined in detail and at close intervals in an area to detect differences that can be significant in their use and management. Detailed soil survey are conducted to furnish information required for a proper assessment of soil properties, terrain features, erosional aspects and related factors that can help in working out the use capability and management practices for conservation of soil and better production of crops and maintenance of soil fertility. The pedons are examined at the intervals of ¼ to ½ km or close depending upon soil heterogeneity. Intensive agriculture and cropping pattern. With the help of auger, variations in the texture of surface, subsurface, soil colour, depth are noted and demarcated. Pedons are examined and sampled for detailed studies of soil. The base map used are cadastral maps (1:8000 or 1:4000) or aerial photograph (1:10000). The soil mapping unit is soil types and phases. Detailed soil survey is laborious, time consuming and expensive.

7. **Aims and objectives of soil survey**

The aim of soil survey is to provide comprehensive information about soils .Provide soil resource inventory of that area. The purpose of soil survey is both fundamental and practical (applied) in nature. Fundamentals include understanding of soils and expanding the knowledge about genesis, development, classification and nomenclature .Applied part include the interpretation of soil data for use in agriculture, pasture development, forestry, engineering, urban development, recreation and others. It helps transfer of technology under different soil conditions, bringing new areas under agricultural uses, tax appraisal. The objectives of soil survey include recognizing soils and defining their important characteristics. To classify soils into mapping units. To show the distribution of each class on maps. To furnish basic data for making interpretation as to the adaptability of soil for agriculture or other purpose.

8. **Difference between RSS and DSS**

ITEMS	RSS	DSS
Base Map	Toposheets	Cadastral
Scale	1inch = 1 mile	8 or 16inch= 1 mile
Mapping units	Series or soil associations	Soil types and phases
Examination of pedon	3-6 km	640 acre
Nature	Less expensive and less time consuming	More expensive and time consuming
Nature of survey	Preliminary survey	Detailed survey
Purpose	To know broad idea about soil groups	To have minute detail to put soil for best use

Plotting soil boundaries	Soil boundaries are not wholly traversed	Soil boundaries are wholly traversed
Auger sampling	½ to 1 km	¼ to ½ km
Intensity of survey	Low	High
Scale of mapping	Small	Large
Level of planning	District	Village or block

9. Differences between soil series and soil type

Property	Soil series	Soil type
Kind of map	RSS	DSS
Soil mapping unit	RSS	DSS
Definition	The soil series is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile except for the texture of the surface soil	The soil type is a sub division of soil series based on the texture of the surface soil
Position in soil taxonomy	The soils within the series are essentially homogenous in all soil profile features	The soil type is the lowest and most nearly homogenous unit in the natural system of classification
Identification	It is given a geographical name either of the place where it was first recognized	The soil type consists of the series name plus the textural class name of A horizon
Distinguishing feature	Soil series are differentiated on the basis of significant variation in morphological features of soil profile	A soil type may include defined variation in slope, stoniness, degree of erosion or the depth of rock

10 Storie index of soil rating

Stories index (1933) of soil rating is a function of 4 major factors:

A-Physical profile

B- Surface Texture

C- Slope

X- Drainage, fertility and erosion

Storie index soil rating is obtained by multiplying the four factors as follows

A x B x C x X

Each factor is rated in percentage ranging from 0 to 100%. Thus index is expressed in percentage .It is a inductive method. With this index, general agricultural soil uses can be evaluated (hence it is a soil-capability evaluation method. Accordingly there are six classes or grades:

1) Grade-1 (Excellent)-Soil that rate between 80 and 100% .It is suitable for wide Variety of crops

2) Grade-2 (Good)-Soil that rate between 60- 79% and suitable for most crops

3) Grade-3 (Fair) – Soil that rate between 40-59% and it has fair quality with less Wide range of suitability than grade 1&2

4) Grade -4(Poor) - Soil that rate between 20 to 39% and have narrow possibilities for Agriculture

5) Grade- 5 (V. Poor)- Soil that rate between 10 to 19% and have very limited use except for pasture

6) Grade- 6(Non-Agriculture) - Soil that rate less than 10% include tide land, steep Broken land etc

11 **Productivity Index of Riquier et al. (1970)**

The basic concept of this method is that agricultural-soil productivity, under optimal management conditions, depends on the intrinsic characteristics. This is a multiplicative parametric method to evaluate soil productivity, from a scheme similar to the Storie index. Productivity rating includes both productivity and productivity potential. Here productivity means actual productivity of the soil referred as “P” and productivity potential means, it is the productivity of the soil including all possible remedial measures and referred as “P”. The quotient between the productivity and the potentiality is called the improvement coefficient. (P// P). The evaluation is made for three general types of use: agricultural crops, cultivation of shallow-rooted plants (pastures), and deep-rooted plants (fruit trees and forestation). The determining factors of soil depth are: wetness, drainage, effective depth, texture/structure, and base saturation of the adsorbent complex, soluble-salt concentration, organic matter, cation-exchange capacity/nature of the clay and mineral reserves Productivity is expressed as the product of all these factors expressed in percentages.

Five productivity classes are defined:

Class P1 = excellent; (65-100) P/ - I

Class P2 = good, for all types of agricultural crops ;(35-64) P/ II

Class P3 = medium, for marginal agricultural use, suitable for non-fruiting trees; (20-34) P/ --III

Class P4 = poor, for pasture or forestation or recreation; (8-19) P/ -IV

Class P5 = very poor or null, soils not adequate for any type of exploitation (0-7) P/ V

12 **Soil Fertility Capability Classification (FCC)**

This was proposed by Buol *et al.*, (1975) and modified by Sanchez et al. (1982) to evaluate soil fertility. In this system, three levels or categories were established. The first, the type, was determined by the texture of the arable layer, or of the first 20 cm, if this is thinner. Its denomination and range are: S, sandy (sandy and sandy loam); L, loams <35% clay (excluding sandy and sandy loam); C, clayey > 35% clay; O, organic > 30% organic matter to 50 cm or more. The type of substrate is the second level and is used when there is a significant textural change in the first 50 cm of the soil. It is expressed with the same letters, adding “R” when a rock or a hard layer is found within this depth. The third level is comprised of the modifiers, which are the chemical and physical parameters that negatively influence soil fertility. These are numerous and are represented by lower-case letters. In the denomination of the soil class, the principle limitations for use are directly represented. For example, for an Orthic Solonchak, the FCC class that represents it is LCds, which signifies that it is a soil susceptible to severe erosion (L), limited drainage (C), dry soil moisture regime (d) and with salinity (s).

13 **Soil Site Suitability Evaluation for Crop Growth**

Each plant species require definite soil and site conditions for its optimum growth. Soil resource maps, based on several parameters can aid in predicting the behavior and suitability of soils for growing crops and forest or other plantations crops once the suitability criteria is established. FAO proposed the following suitability. There are two orders (S- suitable, N- Non- suitable) which reflect the kind of suitability. There are 3 classes (S1-S3) under order S and 2 classes (N1 and N2) under the order N reflecting degree of suitability within order. The subclasses reflect the kinds of limitations c- climate, t- topography, w-wetness, n- salinity, f- fertility, s- physical.

Sys and Verheye (1975) proposed capability index (Ci) based on nine soil parameters for soil suitability for crop growth. Ci =A x B x C x D x E x F x G x H x I Where

A= soil texture, B=$CaCO_3$, C= gypsum, D=salinity, E= sodium saturation, F=drainage, G=Soil depth, H=epipedon and I= profile development

Sys(1976) proposed the following scheme for evaluating the degree of limitation ranging from 0(suggesting no limitation and having Ci> 80 or more) to 4(suggesting very severe limitation with Ci 30 or less)

No limitation (0) Ci- 80 or more, quality optimal for plant growth

Slight limitation (1) Ci- 60-80, nearly optimal for plant growth

Moderate limitation (2) Ci- 45-60, moderate influence on decline crop yield

Severe limitation (3) Ci 30-45, productivity will be less economical

Very severe limitation (4) Ci < 30 limitation decrease yield below profitable level

A schematic relation is presented below:

Limitation Level	Class levels
0/no	S1
1/ slight	S1
2/ moderate	S2
3/ severe	S3
4/ Very severe	N1 and N2

15. **Give the frame work of Land Irrigability Classification of soils**

The objective is to evaluate the suitability of the mapped soils for sustained use under irrigation. The soil units are first grouped together into soil irrigability classes, according to their kind and degree of limitations for sustained used under irrigation. Special attention is given, in irrigability classification to three factors. They are

i. The drain ability of the land

ii. Predicted effect of irrigation water on salinity and alkalinity status of the soils

iii. Cost of land development

LIC is the interpretation at land and soil characters for potential irrigation. It enables to demarcate the area suitable for irrigation. It has three categories viz.,

i. Land irrigability class (LIC)

ii. Land irrigability sub class (LISC)

iii. Land irrigability units

There are six LIC classes which are numbered 1 to 6. The limitations increase with increase in LIC number.

LIC – 1 → Land that has no limitation for sustained irrigation.

LIC – 2 → Land that have moderate limitations for sustained irrigation.

LIC – 3 → Land that have severe limitations for sustained irrigation.

LIC – 4 → marginally suited for sustained irrigation.

LIC – 5 → temporally suitable (Needs further investigations)

LIC – 6 → Unsuitable for irrigation

LIC are worked out based on soil irrigability class (SIC), topography and drainage. There are five soil irrigability classes indicated by letters A to E

SIC – A → none to slight soil limitation for sustained irrigation

SIC – B → Moderate soil limitation for sustained irrigation

SIC – C → Severe soil limitation for sustained irrigation

SIC – D → Very severe limitation for sustained irrigation

SIC – E → unsuitable for irrigation

16 **Give an account of land capability classification of soils**

The land capability classification is a broad grouping of soils based on their limitations and is designed to emphasis the hazards in different kinds of soils. It serves as a guide to assess suitability of the land for cultivation, grazing and forest plantation. The grouping of soils into capability classes and sub classes is done on the basis of their capability to produce crops and pasture plants without deterioration over a long period of time. The criteria used in assessing a land unit are the physical land properties and the degree of limitation as a function of severity with which crop growth is inhibited. It is mainly based on a) The inherent soil characteristics b) The external land features and c) The environmental factors that limit land. The factors which determine the capability of a soil are a)Depth of soil b)Texture and structure of soil c)Permeability d) Relief as expressed by slope e) Extent of erosion f) Susceptibility to overflow and flooding and degree of wetness g) Presence of salt, alkali and other unfavorable chemical factors like pH and gypsum h) Severity of climate.

The capability classification consists of three categories namely a) Capability classes b) Capability sub classes and c) Capability units

Capability classes

In all eight capability classes are recognized. The soils having greatest capability for response to management and least limitations are grouped in class – 1 and those with little capabilities and greatest limitations are grouped in class VIII. With in a capability class, the soils are similar only with respect to degree of limitations in use for agricultural purpose or hazards to soil when it is so used.

Salient features of land capability classes

Land suitable for cultivation

Class I (green)

Very good cultivable, deep, nearly level productive land with almost no limitation (or very slight hazard). Soils in this class are suited for a variety of crops, Need no special management practices for cultivations; shown as green on maps.

Class II (Yellow)

Good cultivable land on almost level plain or on gentle slopes that have slight limitations of soil depth, salinity, texture, or erosion that reduce the choice of plants. Recommendations is to cultivate with precaution; need simple management practices; shown as Yellow on maps.

Class III (Brown)

Moderately – good cultivable land on almost level plain or on moderate slope. These soils have limitation(s) of moderate erosion, soil depth, soil salinity, soil texture... Recommendations are to cultivate with careful management practices; need intensive care; shown as brown on maps.

Class IV (Pink)

Fairly – good land or almost level plains or moderately – steep slopes. Suitable for occasional or limited cultivation; generally unsuitable for growing a variety of crops because of strong or very strong soil salinity, shallow depth, erosion, fine texture or poor or excessive drainage. Suitable for selected crops and for pasture. Such soils may not be economical to cultivate as they need intensive soil conservation and management practices; shown as pink on maps. Land unsuitable for cultivation but suitable for permanent vegetation (grazing)

Class V (Dark grey)

Land not suitable for arable farming, but very suitable for grazing; have limitations for use of implements due to stony or rocky and marshyness; shown as dark gray on maps.

Class VI (Orange)

Non – arable land, well suited for grazing or forestry use. Have moderate limitations, such as steep slope, server erosion. Limited soil depth, strongly gypsiferous, stony or sand – dune areas. Shown as orange on maps.

Class VII (Red)

Fairly – well suited for grazing or forestry; not cultivable. Have severe limitation, such as very steep land subjected to erosion or very shallow, stony soils having not enough available moisture for cultivation. Need careful management for grazing and forestry; shown as red on maps.

Class VIII (Purple)

Non – arable, extremely rough, rocky, arid, wet or extremely saline land, suited only for wild life or recreation. Have very severe limitation, it is shown as purple on maps

Capability sub classes

The capability sub classes are based on kind of dominant limitation such as wetness or excess water (W), climate (C), soil (S) and erosion (e). The sub classes are mapped by adding limitation symbols to the capability class number. For example II e, III w. Therefore, the sub classes indicate both degree and kind of limitations. There are no subclasses in class I land.

Capability units

These are further sub divisions of capability sub classes. A capability unit includes soils which are sufficiently uniform in their characteristics, potentialities and limitations and require fairly uniform conservation treatments and management practices.

17 **How soil maps are prepared? How soil survey reports are written? Explain the various factors to be considered in writing the report**.

A soil map is designed to show the distribution of soil types or other soil mapping units in relation to other prominent physical and cultural features of the earth surface. The units may be shown separately or as soil association named and defined in terms of taxonomic units. Soil survey maps indicate a. Soil types, b. Water resources, c. Streams and canal, d. Reservoirs, e. buildings, f. Roads, g. Topography, h. Hills, I. valley, j. Contours, h. Degree of slope. The production of a soil map typically consists of the following steps:

1. Collection of background information including base maps, aerial photographs and geological maps which will indicate what soils are likely to be present and where they are likely to change.
2. A reconnaissance survey of the different facets of the area to be mapped, on the basis of which the soil classes to be mapped can be determined and a draft mapping legend constructed.
3. Systematic mapping of the area
4. Redefining boundaries and final map drawing
5. Full description of typical profiles
6. Preparation of accompanying report and any interpretative work eg. Crop suitability, land classification irrigation suitability.

Precision of a soil map depends on its scale. As the scale increases the maps are likely to be more detailed. The value of a soil map for a given purpose depends on the relationship between the minimum size of each mapping unit and minimum size of areas of interest. The lines between mapping units are called soil boundaries. Drawing boundaries between areas of different soils is one of the problems found by the surveyors. In reality different soil merges into one another often, over a considerable distance. In this transition zone there will be soils namely intergrades with similarities to both kinds of soils being mapped. In such a case the surveyor could almost certainly draw boundary between the two mapping units more or less through the middle of the transition zone. Extra observations are needed at suspected boundaries. Soil maps at scales of 1:25,000 have been made as a result of detailed field work. Soils of India are 1:50,000 map units and are usually based on soil series, complexes phases.

Soil survey report is the ultimate product and forms the essence of all field investigations .It provides good and complete information that could be used by many end users. The writings must be simple, direct, positive statements, wherever technical terms are used to clarify the points, terms must be clearly defined. Good reports need lot of working and reworking.

Outline of the report

It consists of two parts a) Memoirs and b) Maps

It describes the area surveyed, kind of soil shown on the map and interpretation suitability of crops, specific problems and their management. A good report will have description of the mapping unit, discussion on management problems and yield predictions.

The following outline for writing the report is made use by NBSS&LUP

1) Abstract
2) How to use soil survey report
3) Table of contents
4) Introduction
5) General description of the area
    a) Location and extent b) physiography, relief, drainage c) geology d) climate
    e) Natural vegetation f) water supply h) Socio economic condition
6) Land use and agriculture
    a) Present land use b) Agronomic practices c) Forest
7) Soil survey methodology
8) Soils of that area
9) Soil survey interpretations
10) Problems and suggestions

Annexure

1) Morphological descriptions of soil series
2) Index to village wise mapping units
3) Legends for soil symbols
4) Analytical data of representative soil profile samples

The factors to be considered while writing the report are 1) it should be attractive to look in both inside and outside 2) besides text, it should be supported by with good illustrations in the form of photograph, table and diagram 3) It should meet the requirements of different users

18. **What are the functions and uses of soil survey? Discuss the different ways in which soil survey can be conducted over a given region.**

Soil survey as an activity involves soil characterization, classification, correlation, mapping and interpretation and transfer of agro technology. The function and uses of soil survey is both fundamental and practical or applied. As a fundamental, it is to get information about the genesis of the soil. It provides soil resources data for planned land use and resource management .It forms basis for farm planning, provides basis for grassland development, forestry, soil and water conservation, reclamation of salt affected soils, restoration of wastelands, urban development, county and town planning

Soil survey can be carried out in four ways based on purpose, method, intensity of observation, precision of mapping

I. Reconnaissance Soil Survey (RSS)

II. Detailed Soil Survey(DSS)

III. Detailed Reconnaissance Soil Survey (DRSS)

IV. Semi Detailed Soil Survey (SDSS

a) Reconnaissance Soil Survey (RSS)

It is a preliminary survey to detailed soil survey. It is done to get broad idea about major soil groups and their association in a area and to locate soils for more intensive use and locate soils suitable for crops, grazing and forestry. In this survey, boundaries are not wholly traversed but drawn partly by extrapolation. The examination of the pedon is 3-6 km depending upon soil heterogeneity. The scale of mapping is 1:50,000 using toposheets as base map. Soil series an soil associations forms the soil mapping unit.

b) **Detailed soil survey (DSS)**

In this survey boundaries of soil are delineated from observation by actual traverses throughout the course of the boundary. Soils are examined in detail and at close intervals in an area to detect differences that can be significant in their use and management. Detailed soil survey are conducted to furnish information required for a proper assessment of soil properties, terrain features, erosional aspects and related factors that can help in working out the use capability and management practices for conservation of soil and better production of crops and maintenance of soil fertility. The pedons are examined at the intervals of ¼ to ½ km or close depending upon soil heterogeneity. Intensive agriculture and cropping pattern. With the help of auger, variations in the texture of surface, subsurface, soil colour, depth are noted and demarcated. Pedons are examined and sampled for detailed studies of soil. The base map used are cadastral maps (1:8000 or 1:4000) or aerial photograph (1:10000) . The soil mapping unit is soil types and phases. Detailed soil survey is laborious, time consuming and expensive.

c**) Detailed reconnaissance soil survey**

It is the combination of Reconnaissance Soil Survey and Detailed soil survey carried out on an individual area best suited to each of these two kinds. In an area covered by RSS, there may be areas which have limited potentiality for intensive development and there may be large pockets of areas which have the potentiality for the intensive development say irrigation etc., where detailed soil survey are carried out to utilize their potentiality.

a) **Semi Detailed Soil Survey (SDSS)**

It consists of a very detailed survey of some selected strips cutting across many physiographic units and soils. This survey provides information on kinds of soil including problem or degraded soils. It provides a basis for alternative strategies for land use, settlement or agricultural development .According to FAO this survey is referred to "Pre-investment survey".

19. **Define base map .Explain about different base maps**.

It is fundamental requirement for all mapping activity. It is important for surveyor to delineate soil boundaries correctly and conveniently. The base map should be complete in details of features and accurate in their in location to enable the surveyor to delineate soil boundaries more correctly and conveniently. Based on the intensity of mapping, following base maps are used.

Cadastral Maps: It is of scale 1:2640(24”:1 mile) to 1: 7920(8”: 1 mile) or 1:15,840(4”:1 mile) in plain areas and 1: 1200 (52.8” : 1mile) in hilly areas for detailed mapping. Cadastral maps shows field boundaries and field or revenue survey number; however they lack the topographical features (contours, elevations). Advantage in using cadastral map is that soil survey interpretation can be communicated to individual farmers. Cadastral map can be obtained from VAO. It is used in detailed soil survey.

Toposheets: Topographical maps are published in scale of 1:25,000, 1:50,000 and 1:250,000.These maps show not only physical features but also contain topographical details in the form of contours and elevation above mean sea level. These maps have reliable planimetric accuracy facilitating measurement of distances and easy preparation of soil maps. In India it is prepared and published by Survey of India, Dehradun. It is used as base map for reconnaissance soil survey.

Aerial photography: Aerial photographs are taken from cameras fitted in an aircraft and fly over the terrain at a predetermined height depending upon the scale of aerial photograph and focal length of camera. Aerial photographs gives bird's eye view of large areas Aerial photographs ranging in the scale from 1:8000 to 1: 60,000 are used in different types of soil survey.

Satellite Imageries: It is obtained through remote sensing technique. Sensing devices located at distance captures the earth features. The earth features so captured are available in the form of False color composite (FCC) for visual interpretation and in computer compatible disc (CCD) which is amenable for changes by computer through a process called digital image processing. Satellite imageries are available in different scale like 1:10,000, 1: 25000, 1: 50000, 1:250,000, 1: 1000,000. Final scale preparation with help of satellite imageries is supported by ground truth check

20 W**rite a note on methods of soil survey**

There are two methods of soil survey

- Free Survey
- Grid Survey

Free Survey

The surveyor uses his judgment of the objectives of the survey and all the available aerial photos and ground evidence to locate profile pits of the most useful and representative sites. The number of the profile pits depends on the requirements of the survey and the complexity of the soil pattern. The free survey is only feasible in “open” areas, in grass or arable regions. The surveyor uses a lot of observable field marks and taking auger borings in relation to every change of vegetation or edaphic features Aerial photo interpretation will be of immense help in this method**.**

Density of observations

On small scale, the inferred boundaries - soil boundaries

. (1:2, 50,000 or smaller)

On large scale, recognition of several new boundaries
(1:50000 or larger)
Grouping of soils into defined soil units
For large areas (state or country) the mapping is generally undertaken on small scale (1:250,000 or 1:1 M) Ex. Soil resource map of India
Provide information and database on various attributes used for mapping and laboratory investigations. Useful to various consumers Generation of several thematic maps. Helps in determining fertilizers, amendments and other needs for optimizing land use. 5000 ha and above, free survey methodology adopted

Advantages & Disadvantages

Advantages
- Cheaper
- Less number of observation points.

Disadvantages
- Very inaccurate
- Boundary placement is more difficult.

Grid Survey

Observations are made at regular intervals along pre-determined traverses in the survey area. This method is especially useful for large scale high intensity detailed surveys and intensive surveys. However, there is no alternative to grid survey for areas under forest or broken topography where accessibility is difficult and areas where adequate aerial photos or toposheets are not available. It is generally employed in dense forests and swamps where photo interpretation is often of limited usefulness and there is no way of finding one’s position except by measurement. A ‘rigid grid’ pattern of cut traverses is essential with a central baseline, between regularly spaced straight traverses. The grid survey is very tedious, expensive, and time consuming because it takes a lot of time cutting traverses through the forest, chiseling or augering at regular intervals.

Advantages of grid system include;

Traverses provide access between roads in the dense forests, sampling points along the traverses can be located and mapped with accuracy, the direction of the traverses can be arranged to cross the topographical ‘grain’ of the country, the greater part of the field survey can be carried out by soil survey assistants with minimum supervision by the surveyor and the traverse grid provides a uniform sampling point within which it is very unlikely that important soil types will be overlooked

21 **Write briefly on soil map scale**

Scale: The ratio of the distance between two points on a photo to the actual distance between the same two points on the ground (i.e. 1 unit on the photo equals "x" units on the ground).

Another method used to determine the scale of a photo is to find the ratio between the camera's focal length and the plane's altitude above the ground being photographed

Scale may be expressed three ways:

Unit Equivalent, Representative Fraction, Ratio

A photographic scale of 1 millimeters on the photograph represents 25 meters on the ground would be expressed as follows:

Unit Equivalent - 1 mm = 25 m

Representative Fraction - 1/25 000

Ratio - 1:25 000

Two terms that are normally mentioned when discussing scale are**:**

Large Scale - Larger-scale photos (e.g. 1/25000) cover small areas in greater detail. A large scale photo simply means that ground features are at a larger, more detailed size. The area of ground coverage that is seen on the photo is less than at smaller scales.

Small Scale - Smaller-scale photos (e.g. 1/50000) cover large areas in less detail. A small scale photo simply means that ground features are at a smaller, less detailed size. The area of ground coverage that is seen on the photo is greater than at larger scales

22 **Writ short notes on diagnostic horizons**

Epipedon: The diagnostic soil horizon is found in surface and sub-surface soil. The Diagnostic surface horizon is called as Epipedon. There are six epipedons viz., Mollic Umbric, Histic, Ochric, melanic, plaggen and Anthropic

1. Histic- 20-30% O.M in 20 cm
2. Mollic- > 1% OM, > 50% BSP, <250 ppm Citrate soluble P and dark colored
3. Umbric- Similar to Mollic but <50% BSP
4. Ochric- < 1.0% OM and light colored
5. Melanic- Soils obtained in volcanic ash soils
6. Anthropic- Similar to Mollic, > 250 ppm citrate soluble P
7. Plaggen- A man made surface layer > 50 cm thick

Mollic, Umbric and Ochric are found common in all soils: Melanic and Histic are found in specific soil and Anthropic and Plaggen- man made horizon

2) **Endopedon:** It is referred to as sub surface Illuvial horizon. There are 18 Endopedons Available in soil. They are as follows

a) Agric – accumulation of clay and humus just below the plough layer

b) Argillic- Accumulation or enrichment of fine clay and indicated by B_t

c) Natric- Similar to Argillic but Exchange complex is saturated with 15% Na

d) Spodic- accumulation of 2.5 cm thick organic matter and iron and Aluminium oxides

e.) Calcic- Accumulation of > 15% $CaCO_3$- 15 cm thick

f) Gypsic – Accumulation of gypsum >15%- 15 cm thick

g) Salic- Accumulation of soluble salts >15% and 15 cm thick

h) Duripan- A hard horizon cemented with silica

i) Oxic- Highly weathered, mixture of Fe and Al oxides and silicate clay

j) Cambic- Am altered but not highly weathered horizon

23 **Soil moisture Regime (SMR**)

The moistures regimes are defined in terms of the ground water table and in terms of the presence or absence of water held at a tension less than 15 bars in the moisture control section

a) Aquic- Reducing regime, soil is saturated by ground water

b) Torric- Dry for more than half the time

c) Udic- Soil moisture section is not dry for 90 days

d) Ustic- It is between Udic and torric

e) Xeric- winters are cool and moist and summer are warm and dry

24 **Soil temperature regime**

Soil temperature is a measure of the amount of heat or radiation from the sun absorbed by the soil. It is measured in degrees Fahrenheit or Celsius. Soil temperature is determined by air temperature. Temperature like the soil moisture state changes with time and usually varies from horizon to horizon in soil Soil temperature at the surface can change from hour to hour in a daily cycle. The cycle decreases with soil depth and is scarcely measurable below a depth of 50cm in most soils.

25. **Soil classification**

Soil is basic natural resources and diverse and so it is necessary to classify them in a systematic and orderly arrangement. The details and exactness of soil classification depends upon the extent of knowledge about soil. Soil classification is dynamic in nature and keeps on changing and adjusting as the knowledge and understanding of soil increases. The purpose of soil classification is

a) To find out the genesis of soil

b) For planned land use and resource management

c) To have a organized farm planning, suitable cropping system for different types of soil

d) To find out the fertility status of the soil and accordingly recommend suitable fertilizer s for different crops

e) To put the soil into maximum utilization under different systems like forestry, wasteland, and cultivation crops

g) To provide suitable reclamation measures for problem soils

26. **List the Soil Orders with formative elements**

There are twelve orders and it is arranged as follows

I AM A SUVAE HOG

I- Inceptisol -- epts

A- Alfisol - alfs

M- Mollisol - oll

A- Aridiso l - id

S- Spodosol - od

U- Ultisol - ults

V- Vertisol - erts

A- Andosol - and

E-Entisol - ents

H- Histosol - ist

O-Oxisol - ox

G- Gellisol - ell

The twelve soil orders can be grouped under four heads Orders with

a) With unique parent materials (Andisols, Histosol, Vertisol).

b) with unique environnements (Aridisols, Gellisol, Oxisols).
c) by age of **development** (Entisols, Inceptisols, Ultisols).

by unique **vegetative** influence (Alfisol, Mollisols, SpodosolsHH=g) To provide soils suitable for urban development, country and town planning

27 **Soil taxonomy**:

The comprehensive soil classification system is called as soil taxonomy which is the science or principles of classification. The chemical, physical and biological properties of soil are used as criteria for soil taxonomy. The presence or absence of certain diagnostic soil horizons both surface and sub-surface, soil moisture and temperature regimes determines the place of soil in the classification system. The advantages of soil taxonomy are the following

a) It permits the classification of soil rather than soil forming process

b) It focuses on the soil rather than related sciences like geology/ climatology

c) It permits the classification of soil of unknown genesis

d) It permits greater uniformity of classification as applied by a large number of soil scientist

There are six categories in the soil taxonomy in order of decreasing rank and increasing number of differentiate and classes. The categories are 1) Order (12) 2) Sub order (47), 3) Great group (230) 4) Sub group (1200) 5) Family (6600) and 6) Series (16800)

28 **Modern system of soil classification:**

In earlier classification (1938) system, classes were described mainly in qualitative terms and not defined in quantitative terms. This system did not link the classes of its higher categories to the series that were used in soil mapping. All these problems led USDA to develop a new comprehensive system of classification. It was started in the year 1951 and underwent several approximation and finally new natural soil classification system called **"Soil Classification- A comprehensive system- 7th approximation".** It is the modern system of classification and lays more stress on the morphology of soil themselves rather than on the environmental factors. The characteristics of 7th approximate soil classification are many

a) It is natural classification of soil
b) It is based on properties of soil
c) Properties selected were observable or measurable
d) Properties selected were either affected by soil genesis
e) Properties selected had greater significance to plant growth for higher category
f) It is flexible

29 **What do you mean by 7th approximation of soil classification? What are the main features of the system? Name the six categories under this classification**.

The various system of soil classification in the older days (1850-1938) showed major limitation which made them unfit for wider application. The genetic system of soil classification is based entirely on soil genesis. The soil properties change after years of cultivation and influence of environmental factors. Thus classifying soils on the basis of properties presumed to be possessed by them under natural vegetation will not present true picture .The weakness of the older system was overcome by the present system of soil classification. Under the chairmanship of Dr G.D .Smith, New system of soil classification was developed. From 1953 onwards an approximation was prepared and tested.. During the year 1960, a comprehensive soil classification system was developed known as 7th approximation. It is so called because it was approximated seven times. Soil survey staff of USDA proposed classification called Soil taxonomy in 1975.

The main features of the system are

It maintains natural body concept and is based on soil properties

It has unique nomenclature which gives a definite connotation of major characteristics of soil

It is based on soil properties as they are found today

Soil genesis is not ignored. All the physical, chemical biological properties are used in criteria

The six categories under this classification are

a) Order (12)

b) Sub Order (47)

c) Great group (230)

d) Sub group ((1200)

e) Family (6600) and

f)) Series (16800)

30 **Discuss in detail the different orders found in the soils of world**.

The different orders are remembered as follows

I AM A SUAVE HOG

I- I**nceptisol**- The formative element is epts meaning beginning or inception Soils with minimal B horizon development. Usually A-Bw-C. Often in mountainous areas.

A- **Aridiso**l- The formative element is id meaning found in arid climate. Accumulation of soluble salts occurs due to more of evapo transpiration than precipitation. Formation of calcic, Natric, salic, gypsic and duripan horizon is common.. They are productive soil if properly managed.

M- **Mollisol** –The formative element is oll meaning soft. It is dark colored soil noticed under grass land condition. It has mollic epipedon. It is fertile soil due to richness in humus. It is located under cool humid climate.

A-Andisol- The formative element is and. It is weakly to moderately developed soils. It is formed under volcanic ash soils. Allophane is the dominant clay mineral

S- Spodosol – The formative element is od meaning wood ash. It is formed under cool humid climate. The vegetation is acid forest with coniferous type which has got strong leaching property leading to formation of E horizon, The Spodic horizon(Bhs) is noticed in B layer.. It is not naturally fertile. But it can be made productive on proper fertilization.

U- Ultisols- The formative element is ult meaning ultimate. It is old soil with strong B horizon development. They are developed in humid climate, subtropical to tropical temperature. It has Illuvial clay known as Argillic horizon with < 35% base saturation. Fertilization and liming are necessary to produce moderate to high yield.

A- Alfisol – The formative element is alf. It is found under forest soil condition and also in tropical condition. It has Argillic horizon with > 35% base saturation. The b horizon development is moderate. It is naturally productive.

V- Vertisol - the formative element is ert meaning self-churning. These soils have expanding type of clays. It develops cracks on the surface due to alternate expansion and shrinking. It becomes sticky during wet and hard at dry. It has deep A horizon. Pedoturbation is the dominant soil forming process. In the B horizon it has slicken sides (Bss) and wedge shaped structure and clay cutans, shining on the ped surface due to presence of very fine clay. It has micro relief known as gilgai.

E **– Entisol**- The formative element is ent meaning recent soil without any pedogeneic development horizon. It has AC profile. It is called as young soil. It is found in flood plains with texture varying from sand to deposited clays. The agricultural; productivity varies.

H- Histosol- The formative element is ist meaning tissues. It is developed under a water saturated environment called as marshy, bog or peat. It is totally a organic soil with 20-30 % organic matter. There are problems in management. It has Histic epipedon.

O- **Oxiso**l- the formative element is ox. It is highly weathered soil with less than 10% weathered materials. It is found in subtropical to tropical regions. Laterization is the dominant processes. It has accumulation of Fe and Al oxides and forms hard layer known as Plinthite. Laterite soils are formed. It has oxic horizon. Kaolinite clay minerals are dominant. The soils are infertile. High fertilization including micronutrients.

G- **Gelliso**l- Soils with permafrost within 2 m of the surface. Typically have Bf or Cf horizons. It is formed under colder climates

31 **Write a brief essay on the occurrence, distribution and the distinguishing properties of the major soil groups of Tamilnadu**

The soils of Tamil nadu falls under five major orders namely Entisol, Inceptisols, Alfisols, Ultisols and Vertisols.

The Entisol cover an area of 18.3 lakhs hectares which include river alluvium, coastal alluvium and eroded soils**.** The Inceptisols are distributed in all the districts of Tamil nadu and cover an area of 22.1 lakhs hectares. The Alfisols cover an area of 31.4 lakhs hectares and distributed in all districts of Tamil nadu except hilly regions. The Ultisols are distributed in area of 0.36 lakhs hectares and are found in Salem, Dharmapuri, and Niligris. The Vertisols cover an area of 17.9 lakhs hectares and are distributed in all districts except in Niligris and Kanyakumari districts

Entisol: They are characterized by sandy texture or fine textured alternated with sandy layers. They are poor in N, P and organic matter but rich in K and lime. The Base Exchange capacity is on an average 25 cmol (p+) Kg^{-1} and silica Sesquioxide ratio is 12.5. The dominant clay mineral is 2:1 type (illite). The river alluvium is used for the cultivation of wetland crops like rice, sugarcane and banana. Coastal alluvium is made use for casuarinas plantations. The eroded soils are made use for development of pastures. It is distributed in Niligris, North Arcot, Pudukottai, Ramanathapuram, Sivagangai, Cuddalore, Salem, Trichy, Thirunelveli, Tanjore, Coimbatore, Dharmapuri, Kanyakumari, Virudhunagar.

Inceptisols: Moderately deep red brown and black soils are included in this order. The soils are poor in N, P, K and lime. They have moderately well-developed sub soil The soils are rich in kaolinite type of clay mineral The CEC of the soils will be 10 to 15 cmol (p+) kg^{-1}. The soils are cultivated with sorghum, groundnut, cumbu, pulses, tapioca, and chillies.

Alfisols: The soils are very deep reddish in colour and have well developed sub-surface horizons. They have free drainage and pH ranges from 6.5 to 8.0. The soils have low TSS, low in N, P and medium to high in K. The soils are used for cultivation of millets, pulses under dry conditions. Groundnut, cotton, maize, sugarcane and paddy under irrigated conditions

Ultisols: The soils are very deep and highly weathered. The surface soils are darker due to high organic matter. The soils are acidic in reaction. The CEC of soils ranges from 8 to 15 cmol (p+) kg^{-1}. The soils have low amounts of silica and high amounts of sesquioxides and silica sesquioxides ratio is below 1.33. The soils are poor in bases. The soils are cultivated for tea, coffee, cocoa, cold vegetables.

Vertisols: Deep black soils and old alluvial soils are included under this order. The soils are very deep, clayey, calcareous and poorly drained. They develop deep cracks during summer and have kankar nodules in the profile. They contain high amounts of iron, calcium, magnesium but poor in organic matter, N and P but fairly rich in lime and K. The soil pH is alkaline; CEC is 30-70 cmol (p+) kg^{-}. The soils are cultivated for rice, cotton, pulses and sorghum under irrigated conditions.

32 **Discuss briefly the major soil types found in India**

In India, soils are grouped under eight soil orders namely Alfisols, Aridisol, Entisol, Histosol, Inceptisol, Mollisol, Ultisols and Vertisols. In India the maximum area is covered under Inceptisol followed by Entisol, Alfisols, Vertisol and Aridisol. Totally there are 24 sub orders, 85 great group and 246 sub-groups.

Eight major types according to Indian Council of Agricultural Research (ICAR).

1) Alluvial soils 2) Black soils 3) Red soils 4) Laterite soils 5) Desert soils 6) Mountain soils 7) Saline and Alkaline soils 8) Peaty and Marshy soils

Red Soils: They are well drained soils derived from granites. The clay mineral is kaolinite with A horizon being dark reddish brown, B horizon dark brown color. They are poor in N, P, K and with pH varying 7 to 7.5 These soils are light textured with porous structure. Red soils occur extensively in Andhra Pradesh, Assam, Bihar, Goa, Parts of Kerala, Maharashtra, Karnataka, Tamilnadu and West Bengal. Most of the red soils have been classified in the order ' Alfisols' and 'Ultisols. 3.5 lakhs sq.km area.

Laterite Soils: Seen in high rainfall areas, under high rainfall conditions. Silica is released and leached down wards the upper horizons of soils become rich in oxides of iron and aluminum. The texture is light with free drainage structure. Clay is predominant and lime is deficient. pH 5 to 6. With low in Base Exchange capacity, contained more humus and are well drained. They are distributed in summits of hills of Deccan

Karnataka, Kerala, Madhya Pradesh, Ghats regions of Orissa, Andhra Pradesh, Maharashtra and also in West Bengal, Tamilnadu and Assam. Most of the laterite soils have been classified in the order ' ultisols‘and a few under ' Oxisols. Occupies 2.4 Lakhs sq.km.

Alluvial Soils: These are the most important soils from the agriculture point of view. The soils are sandy loam to clay loam with light grey color to dark color; structure is loose and more fertile. The soils are sandy loam to clay loam with light grey color to dark color; structure is loose and more fertile. These soils are distributed in Indo-Gangetic plains. Brahmaputra valley and all most all states of North and South. Most of the alluvial soils have been classified in the orders ' Entisol', ' Inceptisols' and ' Alfisols. There are different types of alluvium depending on the nature and places of their deposition a) Coastal alluvium: influence of sea water and suffer from salinity b) Deltaic alluvium: Heterogeneous type of sediments brought by rivers and deposited at their mouth c)) Lacustrine alluvium: The deposits formed in the lakes Recent alluvium: Deposits by river flowing streams which are of recent origin. 5) Old alluvium: The depth of alluvium is great and will extend more than 100 meters. These water deposited sediments are old, though newer deposits are continuously being added

Black Soils These soils occur in areas ranging from semi-arid to sub humid climates. This is well known group of soils characterized by dark grey to black color with high clay content. They are neutral to slightly alkaline in reaction. Deep cracks develop during summer, the depth of the soil varies from less than a meter to several meters .Poor free drainage results in the soils, base exchange is high with high pH and rich in lime and potash .They may be classified as shallow(< 30 cm depth), medium(30-100 cm) and deep (100-200 cm) black soils. Their limitation fro crop production is because of their poor workability. Major Black soils are found in Maharashtra, Madhya Pradesh, Gujarat and Tamilnadu. Cotton is most favorable crop to be grown in these soils. These soils are classified in the order 'Entisol', Inceptisols’ and ' Vertisols

Desert Soils These soils are mostly sandy to loamy fine sand with brown to yellow brown color, contains large of soluble salted lime with pH ranging 8.0 to 8.5. Nitrogen content is very low. The presence of phosphate and nitrate make the desert soils fertile and productive under water supply. They are distributed in Haryana, Punjab, and Rajasthan. They are classified in the order ' Aridisol' and ‘Entisol’. 1.4 Lakhs sq.km is the area covered under desert soil

Peaty and Marshy Soils These soils occur in humid regions with accumulation of high organic matter. Soils are black clay and highly acidic with pH of 3.5. Formed by accumulation of organic matter. Black in colour. Peaty soils are found more in Kerala and marshy soils are found more in coastal tracks of Orissa, West Bengal and South - East coast of Tamilnadu.

Saline - Sodic Soils Saline soils contain excess of natural soluble salts dominated by chlorides and sulphates which affects plant growth. Sodic or alkali soils contain high exchangeable sodium salts. Both kinds of salt effected soils occur in different parts of

India like Uttar Pradesh, Haryana, Punjab, Maharashtra, Tamilnadu, Gujarat, Rajasthan and Andhra Pradesh. These soils are classified under ' Aridisol', ' Entisol' and ' Vertisols'.

Mountain Soil Found in hill slopes. Formed by deposition of organic matter from forest. Rich in humus. Poor in Potash and Lime. Areas covered are Assam, Kashmir, Sikkim & Arunachal Pradesh. Crops cultivates in this soil are Tea, Coffee, Spices & Tropical Fruits.

33 **Define land use planning. What is the significance of land use planning?**

Land-use planning is the process of regulating the use of land in an effort to promote more desirable social and environmental outcomes as well as a more efficient use of resources (or)

LUP refers to the rational and judicious approach of allocating available land resources to different land using activities and for different functions consistent with the overall development vision/goal of a particular area

The Goals of land-use planning may include environmental conservation, restraint of urban sprawl, minimization of transport costs, prevention of land-use conflicts, and a reduction in exposure to pollutants. By and large, the uses of land determine the diverse socioeconomic activities that occur in a specific area, the patterns of human behavior they produce, and their impact on the environment

There is need for optimal utilization of land resources. The country can no longer afford to neglect land, the most important natural resources so as to ensure sustainability and avoid adverse land use conflicts. There is a need to cater land for industrialization and for development of essential infrastructure facilities and for urbanization. While at same time, there is need to ensure high quality delivery of services of ecosystem that come from natural resource base and to cater to the needs of farmers that enable food security, both of which are of vital significance for the whole nation. Also, there is a need for preservation of the country’s natural, cultural and historic heritage areas. In every case, there is a need for optimal utilization of land resources

Proper planning of land and its resources allows for rational and sustainable use of land catering to various needs, including social, economic, development and environmental needs. Proper land use planning based on sound scientific and technical procedures, and land utilization strategies supported by participatory approaches empowers people to make decisions on how to appropriately allocate and utilize lands and its resources comprehensively consistently catering to the present and future demands. There is a need for scientific, aesthetic and orderly disposition of land resources, facilities and services with a view to securing the physical, economic and social efficiency, health and wellbeing of communities. There is a need for an integrated land use planning which inter alia includes agriculture industry, commerce, forest, mining, housing infrastructure and urban area settlements, transportation infrastructure to settle claims, counter claims of these activities

Remote sensing

1. **Write short note on Atmospheric windows**;

   Gases absorb electromagnetic energy in very specific regions of the spectrum → they influence where (in the spectrum) we can "look" for remote sensing purposes. Those areas of the spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called atmospheric windows.. The electromagnetic spectrum used in remote sensing are ultra violet < 0.4 µm, visible region - 0 .4 to 0.7µm, reflected infrared region – 0.7 to 2.8µm, thermal infrared region – 2.4 to 20µm and micro wave region- 1 cm to 1 m. Each spectral region has got specific application areas. For example microwave region is used soil moisture studies.

2 **Write brief note on Electromagnetic spectrum**

It is a continuum of all electromagnetic waves arranged according to frequency and wavelength. Remote sensing technology uses the visible, infrared and microwave regions of solar radiations to collect information about the various objects on the earth surface. The EMS ranges from gamma rays to radio waves. The visible region of EMS is used to view objects through our naked eye. For other regions special sensors are used to detect radiations from objects

3 **Passive and active remote sensing**

Remote sensing is classified into passive and active remote sensing based on energy source. Passive remote sensing records energy that is emitted scattered or reflected from natural sources (sunlight). The sensors used in remote sensing are cameras. Active remote sensing is one which provides their own source of EM radiation which is then reflected or scattered, and this signal is detected by sensors. The sensor used in active remote sensing is RADAR.

4 **Platforms**

The vehicles or carriers for remote sensors are called the platforms. Typical platforms are satellites and aircraft, but they can also include radio-controlled aero planes, balloons kits for low altitude remote sensing, as well as ladder trucks or 'cherry pickers' for ground investigations. The key factor for the selection of a platform is the altitude that determines the ground resolution and which is also dependent on the instantaneous field of view (IFOV) of the sensor on board the platform. The platforms used are

Aircraft

- Low, medium & high altitude
- Higher level of spatial detail

Satellite

- Polar-orbiting, sun-synchronous
- 800-900 km altitude, 90-100 minutes/orbit
- Geo-synchronous
- 35,900 km altitude, 24 hrs/orbit stationary relative to Earth

5 **Sensors**

Device to detect the electro-magnetic radiation reflected or emitted from an object is called a "remote sensor" or "sensor". Cameras or scanners are examples of remote sensors. The camera is the sensor in the visible length. In the case of satellite mounted sensors, they are called scanners which sense the objects in the forms of levels of grey in the digital format of the energy reflected. Scanners keep moving from one side to other across the line of flight. Thus scanners record continuously within its range. This varies with different satellites for eg IRS 1A has LISS-1 which scans 148 km of earth surface per scene. Different satellites have different types of sensors depending upon design and based on special needs. The sensors are two types active sensor (RADAR) and passive sensor (Sun)

6 **Multi spectral scanner (MSS)**

A scanning system used to collect data over a variety of different wavelength ranges is called multispectral scanner and is mostly commonly used scanning system MSS system have several advantages over conventional photographs which includes ability to capture data from a wider portion of EM. The general range is from 0.3 to 14μm. The ability to collect data from multiple spectral bands simultaneously. The data collected by MSS system are easier to calibrate and rectify radiometric and geometric errors. The data collected by the MSS system can be transmitted to earth to avoid storage problems. The scanners are two types namely along the track scanner and cross track scanner

7 **Process of remote sensing**

The two basic process involved in the electromagnetic remote sensing are a) Data acquisition b) data analysis.

The elements of data acquisition process are energy sources a) propagation of energy through the atmosphere b) Energy interaction with the earth features c) Retransmission of energy through the atmosphere d) Air borne/ or space borne sensors resulting in the generation of sensor data in pictorial and /or digital form

The data analysis involves examining the data using various viewing and interpretation devices to analysis digital sensor data. Reference data about the resources being study are used. When and where available to assist in the data analysis. With the aid of reference data, the analyst extracts information about types, extent, location and condition of various resources over which the sensor data are collected. This information is then compiled generally in the form of hard copy maps and tables and computer files. Finally the information presented to users who apply it to their decision making process.

8 **Spectral signatures**

The variation in reflectance according to the wavelength is called spectral signature. Different objects receiving the same radiation absorb and reflect different wavelengths of the electromagnetic spectrum, depending on their physical and chemical properties. Two identical objects at unequal temperatures and moisture levels respond differently. Every object has a repeatable characteristic reflectance pattern which can be used to represent it and is called its spectral signature. These signatures are used to identify objects. A graph of spectral reflectance of an object as a function of wavelength is termed as spectral reflectance curve. By observing the reflectance curve, one can identify the objects. Spectral signatures are unique to healthy vegetation where in one can see a peak in the green band indicating the presence of chlorophyll, another peak in NIR which corresponds to leaf structure and another peak in MIR corresponding to water content. This is compared with other plants which are not healthy either due to pest or disease or drought. Similarly water bodies are identified by their low reflection of incident light and incase of soil there will be more reflection of light incident on it and it will appear linear.

9 **Energy matter interaction**

Electromagnetic radiation is only detected when it interacts with matter. When electromagnetic radiation interacts with matter, it may be transmitted, reflected, scattered or absorbed. Transmission allows the electromagnetic energy to pass through matter, although it will be refracted if the transmission mediums have different densities. Reflection, or more precisely spectral reflection, occurs when incident electromagnetic radiation bounces off a smooth surface. Scattering, or diffuse reflection occurs when incident electromagnetic radiation is dispersed in all directions from a rough surface. Absorption occurs when electromagnetic energy is taken in by an opaque medium. Absorption will raise the energy level of the opaque object and some electromagnetic energy will later be re-emitted as long wave (thermal) electromagnetic.

10 **Resolution**

It is defined as the ability of a remote sensor to distinguish between signals that are spatially or spectrally similar. All remote sensing systems have four types of resolution. All remote sensing systems have four types of resolution: a) Spatial b) Spectral c) Temporal d) Radiometric

a**)** Spatial resolution- The measure of the smallest distance between objects that can be resolved the camera

b) Spatial resolution: The smallest band or the portion of electromagnetic spectrum in which objects are seen. Spectral variation vary with objects

c) Temporal resolution- It is called as revisit period time. This resolution used for monitoring the crop growth stages

d) Radiometric remote sensing- It is defined as the smallest: “slice:” of band fraction’
in which the reflectance of a feature may be assigned a digital number.

11 **Remote Sensing Satellites/ Satellite orbits**

Satellite with remote sensors to observe the earth is called a remote-sensing satellite, or earth observation satellite. Remote-Sensing Satellites are characterized by their altitude, orbit and sensor. Satellites can operate in several types of Earth orbit. The most common orbits for environmental satellites are geostationary and polar.

Geostationary Orbits

A geostationary (GEO=geosynchronous) orbit is one in which the satellite is always in the same position with respect to the rotating Earth. The satellite orbits at an elevation of approximately 35,790 km because that produces an orbital period (time for one orbit) equal to the period of rotation of the Earth (23 hrs, 56 mins, and 4.09 secs). By orbiting at the same rate, in the same direction as Earth, the satellite appears stationary (synchronous with respect to the rotation of the Earth). Geostationary satellites provide a "big picture" view, enabling coverage of weather events. This is especially useful for monitoring severe local storms and tropical cyclones**.** Satellites rotate around the equatorial plane and it is used mainly for weather and communication purpose. Eg NOAA, INSAT-1A, 1B, 2A, 2B, 2C, 2D

Polar Orbits

Polar-orbiting satellites provide a more global view of Earth, circling at near-polar inclination (the angle between the equatorial plane and the satellite orbital plane -- a true polar orbit has an inclination of 90 degrees). Orbiting at an altitude of 700 to 800 km, these satellites cover best the parts of the world most difficult to cover in situ (on site). These satellites operate in a sun-synchronous orbit. The satellite passes the equator and each latitude at the same local solar time each day, meaning the satellite passes overhead at essentially the same solar time throughout all seasons of the year.

12 **Data Pre- Processing**

The data acquired by the sensor suffers from number of errors. The errors are due to:

1) Imaging characteristics of the sensor
2) Non- uniformity of illumination
3) Atmospheric effects

} Radiometric errors

4) Scene surface characteristics
5) Stability and orbit characteristics of the platform
6) Motion of the earth and earth curvature

} Geometric errors

Data acquired from the sensor is processed to correct these errors so that inherent quality of the original information scene is brought (Geocoded)

13) **Data Interpretations**

One of the most widespread techniques for data interpretation involves the transformation of the captured data into an image and the visual or computer-assisted analysis of that image. Data interpretation is done by two types a) Visual interpretation of FCC and b) Digital image processing or digital image in the computer screen

Manual (*visual*) Interpretation i.e. by a human interpreter. Imagery displayed in a pictorial or photograph-type format. It is used for extracting information on various natural resources. False color composite (FCC) is used for visual. Image interpretation is dependent upon the analyst’s ability to evaluate the characteristics of an image for size, pattern, shape, tone, shadow, texture, site and scale.

Digital interpretation: Digital Image Processing and Classification enhance data as a prelude to visual interpretation. Automatically identify targets and extract information supplement and assist the human analyst. Computer-based manipulation and interpretation of digital images is called as digital image processing. The basic operations involved are**:** a) Image rectification and restoration, b) Image enhancement, c) Image classification and d) Data merging. Digital interpretation is of two types a) Supervised b) unsupervised. In supervised classification, analyst has ground truth information of that area before he makes identification of the features in the imageries. In the unsupervised classification, the analysts makes demarcation of the earth features on the imageries first based on the statistical approaches and then cross check it by having ground truth. There is possibility of making error which is then corrected in the imageries.

14 **Pixel/images**

The term image is used for any pictorial representation of the data. There are two types of images: a photograph and a digital image. Image – model target features described through the use of spectral reflectance. Software and hardware specially designed to analyze these images give us the ability to see a pictorial rendition of targets. Images that we see on a computer screen are made up of picture elements called pixels. Pixel - picture element having both spatial and spectral properties. The spatial property defines the "on ground" height and width. The spectral property defines the intensity of spectral response for a cell in a particular band Resulting images are made of a grid of pixels. Each pixel stores a digital number (DN) measured by the sensor. Represents individual areas scanned by the sensor. The smaller the pixel, the easier it is to see detail. When only one band of the EM spectrum is sensed, the output device (colorur monitor) renders the pixels in shades of grey (panchromatic). Multispectral sensors detect light reflectance in more than one or two bands of the EM spectrum. These bands represent different data - when combined into the red, green, blue guns of a color monitor, they form different colors

15 **Advantages of remote sensing**

i. Improved vantage point, synoptic view
ii. Broadened spectral sensitivity
iii. Increased spatial resolution
iv. 3-D perspective
v. Capability to stop action
vi. Historical record
vii. Compatibility of data
viii. Rapid data collection
ix. Quantitative analysis
x. Ability to extend ground observation
xi. Cost savings

16. Classification of remote sensing

Remote sensing is classified based on a) Wavelength b) Energy source

Remote sensing is classified into three types with respect to the wavelength regions; (1) Visible and Reflective Infrared Remote Sensing, (photographic remote sensing) (2) Thermal Infrared Remote Sensing (Non- photographic remote sensing) and (3) Microwave Remote Sensing

1. Visible- 0.4 to 0.7µm – sensor camera (black and white)
2. Near visible – beyond red end of visible spectrum – using infrared fil
3. Multispectral – taken in different bands using multiple cameras
4. Thermal infrared – sensed from satellite continuously by scanners and the emitted heat energy from the object can be identified. It is operated between 3 to 14µm
5. Microwave remote sensing- Operates between 0.8m to 1.0mm using radar and microwave radiometers

Two types of remote sensing based on energy source a) Passive remote sensing b) Active remote sensing

Passive remote sensing-The capture of images representing the reflection or emission of EM radiation that have natural source namely sun

Active remote sensing- A system based on the illumination of a scene by artificial radiation and collection of the reflected energy returned to the system. Eg RADAR (Radio detection and ranging).

17 **Components of remote sensing**

The following are major components of Remote sensing System:

a) Energy Source
- Passive System: sun, irradiance from earth's materials;
- Active System: irradiance from artificially generated energy sources such as radar.

b) Platforms: (Vehicle to carry the sensor) (truck, aircraft, space shuttle, satellite, etc.)

c) Sensors :(Device to detect electro-magnetic Radiation) (camera, scanner, etc.)

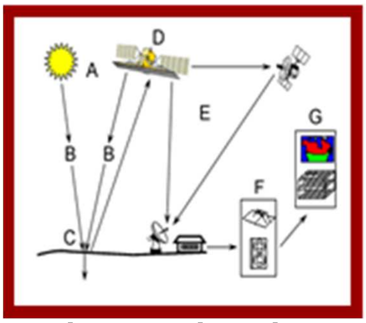
d) Detectors: (Handling signal data) (photographic, digital, etc.)

e) Processing: Handling Signal data) (photographic, digital etc.)

f) Institutionalization: (Organization for execution at all stages of remote- sensing technology: international and national organizations, centers, universities, etc.).

18 **Write brief account of principles of remote sensing**

1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.



2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere as it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere; it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

19. **Write a note on types of images**

Types of images

1) Panchromatic Images

2) True colour composite

3) False color composite

Panchromatic Images

A panchromatic image consists of only one band. It is usually displayed as a grey scale image, i.e. the displayed brightness of a particular pixel is proportional to the pixel digital number which is related to the intensity of solar radiation reflected by the targets in the pixel and detected by the detector. Thus, a panchromatic image may be similarly interpreted as a black-and-white aerial photograph of the area.

Multispectral Images

A multispectral image consists of several bands of data. For visual display, each band of the image may be displayed one band at a time as a grey scale image, or in combination of three bands at a time as a colour composite image. Interpretation of a multispectral colour composite image will require the knowledge of the spectral reflectance signature of the targets in the scene. In this case, the spectral information content of the image is utilized in the interpretation.

Colour Composite Images

In displaying a colour composite image, three primary colours (red, green and blue) are used. When these three colours are combined in various proportions, they produce different colours in the visible spectrum. Associating each spectral band (not necessarily a visible band) to a separate primary colour results in a colour composite image

True Colour Composite

If a multispectral image consists of the three visual primary colour bands (red, green, blue), the three bands may be combined to produce a "true colour" image. For example, the bands 3 (red band), 2 (green band) and 1 (blue band) of a LANDSAT TM image or an IKONOS multispectral image can be assigned respectively to the R, G, and B colours for display. In this way, the colours of the resulting colour composite image resemble closely what would be observed by the human eyes

False Colour Composite

The display colour assignment for any band of a multispectral image can be done in an entirely arbitrary manner. In this case, the colour of a target in the displayed image does not have any resemblance to its actual colour. The resulting product is known as a false colour composite image. There are many possible schemes of producing false colour composite images. However, some scheme may be more suitable for detecting certain objects in the image.

A very common false colour composite scheme for displaying a SPOT multispectral image is shown below:

R = XS3 (NIR band)

G = XS2 (red band)

B = XS1 (green band)

This false colour composite scheme allows vegetation to be detected readily in the image. In this type of false colour composite images, vegetation appears in different shades of red depending on the types and conditions of the vegetation, since it has a high reflectance in the NIR band (as shown in the graph of spectral reflectance signature).

Clear water appears dark-bluish (higher green band reflectance), while turbid water appears cyan (higher red reflectance due to sediments) compared to clear water. Bare soils, roads and buildings may appear in various shades of blue, yellow or grey, depending on their composition.

20 **Write about application of Remote Sensing in Agriculture**

1) **Crop production forecasting**: Remote sensing is used to forecast the expected crop production and yield over a given area and determine how much of the crop will be harvested under specific conditions. Researchers can be able to predict the quantity of crop that will be produced in a given farmland over a given period of time.

2). **Assessment of crop damage and crop progress**: In the event of crop damage or crop progress, remote sensing technology can be used to penetrate the farmland and determine exactly how much of a given crop has been damaged and the progress of the remaining crop in the farm.

3) **Crop Identification**: Remote sensing has also played an important role in crop identification especially in cases where the crop under observation is mysterious or shows some mysterious characteristics. The data from the crop is collected and taken to the labs where various aspects of the crop including the crop culture are studied.

4**)** **Crop acreage estimation**: Remote sensing has also played a very important role in the estimation of the farmland on which a crop has been planted. This is usually a cumbersome procedure if it is carried out manually because of the vast sizes of the lands being estimated.

5) **Crop condition assessment and stress detection**: Remote sensing technology plays an important role in the assessment of the health condition of each crop and the extent to which the crop has withstood stress. This data is then used to determine the quality of the crop.

6) **Identification of planting and harvesting dates**: Because of the predictive nature of the remote sensing technology, farmers can now use remote sensing to observe a variety of factors including the weather patterns and the soil types to predict the planting and harvesting seasons of each crop.

7**)** **Crop yield modelling and estimation**: Remote sensing also allows farmers and experts to predict the expected crop yield from a given farmland by estimating the quality of the crop and the extent of the farmland. This is then used to determine the overall expected yield of the crop.

8) **Identification of pests and disease infestation**: Remote sensing technology also plays a significant role in the identification of pests in farmland and gives data on the right pests control mechanism to be used to get rid of the pests and diseases on the farm.

9) **Soil moisture estimation**: Soil moisture can be difficult to measure without the help of remote sensing technology. Remote sensing gives the soil moisture data and helps in

determining the quantity of moisture in the soil and hence the type of crop that can be grown in the soil.

10**)** **Irrigation monitoring and management**: Remote sensing gives information on the moisture quantity of soils. This information is used to determine whether a particular soil is moisture deficient or not and helps in planning the irrigation needs of the soil.

11) **Soil mapping**: Soil mapping is one of the most common yet most important uses of remote sensing. Through soil mapping, farmers are able to tell what soils are ideal for which crops and what soil require irrigation and which ones do not. This information helps in precision agriculture.

12) **Monitoring of droughts**: Remote sensing technology is used to monitor the weather patterns including the drought patterns over a given area. The information can be used to predict the rainfall patterns of an area and also tell the time difference between the current rainfall and the next rainfall which helps to keep track of the drought.

13) **Land cover and land degradation mapping**: Remote sensing has been used by experts to map out the land cover of a given area. Experts can now tell what areas of the land have been degraded and which areas are still intact. This also helps them in implementing measures to curb land degradation.

14) **Identification of problematic soils**: Remote sensing has also played a very important role in the identification of problematic soils that have a problem in sustaining optimum crop yield throughout a planting season.

15) **Crop nutrient deficiency detection**: Remote sensing technology has also helped farmers and other agricultural experts to determine the extent of crop nutrients deficiency and come up with remedies that would increase the nutrients level in crops hence increasing the overall crop yield.

16) **Reflectance modelling**: Remote sensing technology is just about the only technology that can provide data on crop reflectance. Crop reflectance will depend on the amount of moisture in the soil and the nutrients in the crop which may also have a significant impact on the overall crop yield.

17) **Determination of water content of field crops**: Apart from determining the soil moisture content, remote sensing also plays an important role in the estimation of the water content in the field crops.

18) **Crop yield forecasting**: Remote sensing technology can give accurate estimates of the expected crop yield in a planting season using various crop information such as the crop quality, the moisture level in the soil and in the crop and the crop cover of the land. When all of this data is combined it gives almost accurate estimates of the crop yield.

19) **Flood mapping and monitoring**: Using remote sensing technology, farmers and agricultural experts can be able to map out the areas that are likely to be hit by floods and the areas that lack proper drainage. This data can then be used to avert any flood disaster in future.

20) **Collection of past and current weather data**: Remote sensing technology is ideal for collection and storing of past and current weather data which can be used for future decision making and prediction.

21) **Crop intensification**: Remote sensing can be used for crop intensification that includes collection of important crop data such as the cropping pattern, crop rotation needs and crop diversity over a given soil.

22) **Water resources mapping**: Remote sensing is instrumental in the mapping of water resources that can be used for agriculture over a given farmland. Through remote sensing, farmers can tell what water resources are available for use over a given land and whether the resources are adequate.

23) **Precision farming**: Remote sensing has played a very vital role in precision agriculture. Precision agriculture has resulted in the cultivation of healthy crops that guarantees farmers optimum harvests over a given period of time.

24) **Climate change monitoring**: Remote sensing technology is important in monitoring of climate change and keeping track of the climatic conditions which play an important role in the determination of what crops can be grown where.

25**)** **Soil management practices**: Remote sensing technology is important in the determination of soil management practices based on the data collected from the farms.

26) **Air moisture estimation**: Remote sensing technology is used in the estimation of air moisture which determines the humidity of the area. The level of humidity determines the type of crops to be grown within the area.

27) **Land mapping**: Remote sensing helps in mapping land for use for various purposes such as crop growing and landscaping. The mapping technology used helps in precision agriculture where specific land soils are used for specific purposes

21 **What is the advantage and disadvantages of remote sensing**?

Advantages of remote sensing

1) Improved vantage point that is synoptic view or birds view
2) Broadened spectral sensitivity
3) Increased spatial resolution
4) 3 D perspective
5) Capability to stop action
6) Historical record
7) Comparability of data
8) Receptivity
9) Rapid data collection
10) Quantitative analysis
11) Coverage of inaccessible areas
12) Cost savings

Disadvantages of Remote Sensing

1) Expensive for small areas especially for one time analysis
2) Requires specialized training to interpret images
3) Remote Sensing instruments often become uncalibrated, resulting in uncalibrated Remote sensing data.

22 **Write a brief account of satellite remote sensing and indicate its use in the field of agriculture**

Satellite with remote sensors to observe the earth is called a remote-sensing satellite, or earth observation satellite. Remote-Sensing Satellites are characterized by their altitude, orbit and sensor. Satellites can operate in several types of Earth orbit. The most common orbits for environmental satellites are geostationary and polar

Geostationary satellites

A geostationary (GEO=geosynchronous) orbit is one in which the satellite is always in the same position with respect to the rotating Earth.

The satellite orbits at an elevation of approximately 35,790 km because that produces an orbital period (time for one orbit) equal to the period of rotation of the Earth (23 hrs, 56 mins, and 4.09 secs). By orbiting at the same rate, in the same direction as Earth, the satellite appears stationary (synchronous with respect to the rotation of the Earth). Geostationary satellites provide a "big picture" view, enabling coverage of weather events. This is especially useful for monitoring severe local storms and tropical cyclones. Satellites rotate around the equatorial plane and it is used mainly for weather and communication purpose. Eg NOAA, INSAT-1A, 1B, 2A, 2B, 2C, 2D.

Sun synchronous satellite

Polar-orbiting satellites provide a more global view of Earth, circling at near-polar inclination (the angle between the equatorial plane and the satellite orbital plane -- a true polar orbit has an inclination of 90 degrees). Orbiting at an altitude of 700 to 800 km, these satellites cover best the parts of the world most difficult to cover in situ (on site). These satellites operate in a sun-synchronous orbit. The satellite passes the equator and each latitude at the same local solar time each day, meaning the satellite passes overhead at essentially the same solar time throughout all seasons of the year

The reflectance in a wavelength ranged called as Band is recorded with the help of sensors in digital form. These stored digital numbers are analyzed and processed to reconstruct the land scene

Satellite remote sensing is used very much in the field of agriculture. They are as follows

1) Agriculture, forestry and range
   a) Identify crop, forest and rangeland types
   b) Measure area
   c) Assess condition and estimate yields
   d) Monitor changes
2) Water resources
   a) Lake water quality monitoring
   b) Inventory and mapping of wetlands
3) Monitor land use and change
   a) Urban dynamics
4) Mapping soils, geology, topography

Aerial Photography

23 **Merits and demerits of aerial photography**

The merits are

Aerial photographs show more ground detail, permit three dimensional view of the features. Physical and cultural features are represented infinite detail in aerial photograph. It helps in understanding areas which are inaccessible and cover a large area in a shorter time. Stereoscope vision or the ability to see the depth is possible in aerial photograph

The demerits are

Elevations are not shown. It lacks uniform scale throughout the area because variation in elevation. Differences of scale between adjoining photographs create some minor difficulties. Distance and direction cannot be accurately measured because of distortion due to tilt and displacement

24 **Types of aerial photographs**

a) Related to camera angle – vertical and oblique

A vertical photograph is taken with the camera pointed as straight down as possible. This is a photograph taken with the camera inclined about 30° from the vertical is called as low oblique. The high oblique is a photograph taken with the camera inclined about 60° from the vertical .is known as high oblique

b) Related to film- B/w panchromatic, b/w infrared, colour, colour infrared

c) Related to scale – large (1: 5000) and small scale (1;50000) aerial photographs

Larger-scale photos (e.g. 1/25000) cover small areas in greater detail. Smaller-scale photos (e.g. 1/50000) cover large areas in less detail.

25 **Scale of aerial photographs**

Scale is the ratio of the distance between two points on a photo to the actual distance between the same two points on the ground (i.e. 1 unit on the photo equals "x" units on the ground). Scale may be expressed three ways: Unit Equivalent, - 1 mm = 25 m Representative Fraction1/25 000 and Ratio- 1:25 000.

Two terms that are normally mentioned when discussing scale are:

Large Scale - Larger-scale photos (e.g. 1/25000) cover small areas in greater detail. A large scale photo simply means that ground features are at a larger, more detailed size. The area of ground coverage that is seen on the photo is less than at smaller scales.

Small Scale - Smaller-scale photos (e.g. 1/50000) cover large areas in less detail. A small scale photo simply means that ground features are at a smaller, less detailed size. The area of ground coverage that is seen on the photo is greater than at larger scales.

26 **Overlap**

It is the amount by which one photograph includes the area covered by another photograph, and is expressed as a percentage. The photo survey is designed to acquire 60 per cent forward overlap (between photos along the same flight line) and 30 per cent lateral overlap (between photos on adjacent flight lines).Stereoscopic imagery is the result of overlap, which is the amount by which one photograph includes an area covered by a neighbouring photograph. Air photo coverage is generally designed to provide about

60 percent forward overlap between photographs. This allows stereoscopic, or 3D, viewing when the two overlapping photos are used with a stereoscope. In addition, from 20 to 40 percent lateral (side) overlap is allowed when complete coverage of an area is required. For mapping, inventory and vegetation studies, for example, a survey is flown in a series of to-and-from parallel strips with side overlaps between strips over the entire area

27 **Stereoscopic vision**

Individual aerial photographs are flat in appearance, overlapping pairs can be viewed under a stereoscope and topography of the ground becomes apparent. When viewing two overlapping photographs under stereoscope, one sees the same ground area widely separated position. The right eye is viewing the area in one photograph and left eye the same area in another photograph. The brain so fuses the images that one sees the relief in the photograph. The three-dimensional view which results when two overlapping photos (called a stereo pair), are viewed using a stereoscope is called as Stereoscopic Coverage. There are two types of stereoscopes to view stereoscopic vision viz., lens and mirror type

1) Mirror type: Using the principle of reflection. It has four mirrors fastened in a frame and arranged to transmit the photographic image to the eye by reflection. It gives image nearly free of distortion

2) Lens type or Pocket stereoscope: Using the principle of refraction. It has two magnifying lens mounted on a frame and supported on a stand so that photographs are viewed directly through the lens. It gives a distorted images

28 **Aerial mosaics**

Aerial mosaics are made by assembling and maintaining individual aerial photographs to form continuous photographic image of an area. Two types: a) Controlled b) Uncontrolled

Uncontrolled mosaics:

The uncontrolled mosaic is made simply by matching like images on adjoining photographs without use of ground control. No corrections are made for scale, tilt or displacement. Since the photographs are matched without the geographical control of their position, it is not suitable for mapping.

Controlled mosaics

In the controlled mosaics the photographs are adjusted to ground control

Distances and direction are measurable; photographs are brought to correct scale, corrected for tilt and displacement. Each photograph is matched and adjusted so that points on the photograph fall in their geographic position.

Advantage:

1) Cover large area in one photograph, so fewer sheets is needed

2) It can be used to cover a specific area

3) Controlled mosaic has got better accuracy than the individual photograph

Disadvantages:

1) It cannot be used for stereoscopic study

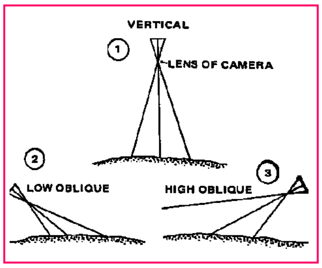
2) Accuracy cannot be always assessed by its appearance

29 **Discuss in detail about types of aerial photographs**

The aerial photographs based on camera angle is classified into a) vertical b) Oblique which is sub divided unto low and high oblique

Vertical.

A vertical photograph is taken with the camera pointed as straight down as possible. Allowable tolerance is usually + 3° from the perpendicular (plumb) line to the camera axis. The result is coincident with the camera axis.



Advantages of vertical over oblique aerial photographs

Vertical photographs present approximately uniform scale throughout the photo but not oblique photos. Because of a constant scale throughout a vertical photograph, the determination of directions can be performed in the same manner as a map. This is not true for an oblique photo because of the distortions. Because of a constant scale, vertical photographs are easier to interpret than oblique photographs. Furthermore, tall objects (e.g., buildings, trees, hills, etc.) will not mask other objects as much as they would on oblique photos. Stereoscopic study is also more effective on vertical than on oblique photographs.

Low Oblique.

This is a photograph taken with the camera inclined about 30° from the vertical

High Oblique.

The high oblique is a photograph taken with the camera inclined about 60° from the vertical).

Advantages of oblique over vertical aerial photographs

An oblique photograph covers much more ground area than a vertical photo taken from the same altitude and with the same focal length. Oblique coverage is possible under cloud layer than by vertical Oblique photos have a more natural view. Tall objects such as bridges, buildings, towers, trees, etc. will be more recognizable. Determination of feature elevations is more accurate using oblique photograph than vertical aerial photographs. Because oblique aerial photos are not used for photogrammetric and precision purposes, they may use inexpensive cameras

30 **Explain the use of aerial photographs in soil survey. How it is conducted? What are the advantages and disadvantages of it over regular field survey?**

Prior to the 1920s or even until 1945, most surveying was done using ground methods, which include: **a. Chain and compass:** location of points using distance and direction from two at least other points. This describes the standard process of triangulation. Prior to the use of aerial photographs, this process was used for survey and mapping, including India and Mt. Everest **b. leveling:** vertical measurements by using a level and viewing a vertical staff. Viewing the level of the staff visible in line with the observer gives a measure of the difference in elevation between the observer and target. **c. Theodolites:**

these instruments enable the determination of vertical angle, distance and azimuth (direction) from observer to target.

Aerial photographs are among the most important, widely available, and commonly utilized kinds of remotely sensed images. They are used for all manner of land resources, cartographic, and appraisal surveys in the public and private sectors. They are often employed as "base maps" upon which thematic data are portrayed. Locating appropriate aerial photographs is a fundamental first step for many land mapping and evaluation projects, and air photos often form the basis for interpretation of other kinds of remote sensing.

Aerial survey consists of 4 parts.

a) Flying b) Photography c) Ground Control and d) Compilation of Map

Photos are taken systematically along a pre-determined flight line. Adjacent flight lines have 30% overlap to ensure no 'gaps' between lines. Successive photos have a 60% overlap, to ensure coverage on at least two photos. By taking two photos that overlap along a flight line , stereoscopic image viewing becomes possible. This is done with a stereoscope or it can be done with trained eyes.

. **Advantages of aerial photography over ground surveying:**

Aerial photography offers an improved vantage point. Aerial photography has the capability to stop action. It provides a permanent recording. It has broader spectral sensitivity than the human eye. It has better spatial resolution and geometric fidelity than many ground-based sensing methods. Combined, these created a huge reduction in fieldwork costs, and a huge increase in how quickly and accurately large areas could be mapped. It can be used with great success for other purposes such as classification of land and soil, geological and archeological investigations etc. The disadvantage of aerial photography is aerial surveying is a highly technical and specialized work and most be carried out by skilled, specially trained and experienced personal. It is mainly made by government organization

31 **Role of remote sensing in soil survey-Discuss**

Soil survey constitutes valuable soil resource inventory linked with the survival of life in the earth. Timely and reliable information on soils with respect to their nature, extent, spatial distribution, and potential and limitations/hazards, namely soil erosion by water and wind, soil salinity and/ or alkalinity, wetness, soil compaction, *etc.*, is very crucial for optimal utilization of available natural resources on a sustained basis. Soil surveys, which hitherto have been conducted through conventional approach The Technological advancement in remote sensing and GIS has been boon for such surveys. By providing synoptic coverage of the earth's surface at regular intervals remote sensing has augmented the efficiency of soil survey programmes.Both aerial and satellite remote sensing offer efficient and timely data for natural resources mapping, as well as for monitoring spatial change patterns over a period of time. Beginning with the Landsat MSS data in early 1970s, space borne multispectral measurements from a variety of sensors, namely Thematic Mapper (TM), SPOT Multi Linear Array (MLA), Panchromatic Linear Array (PLA), Indian Remote Sensing Satellite (IRS) Linear

Imaging Self-scanning Sensor (LISS I, II and III), Wide Field Sensor (WiFS) and Panchromatic (PAN) sensor have been extensively used for carrying out soil surveys of varying intensities. The usefulness of multispectral satellite data in land use and physiographic/soils mapping has been successfully demonstrated by various researchers using visual and digital data Advancements in space technology opened application possibilities of remote sensing in soil mapping. The study reveals that both airborne and space borne data afford greater accuracy, economy and efficiency than the conventional method at reconnaissance level of mapping. The efficiency in terms of time spent on soil mapping by computer techniques, aerial photo-interpretation and conventional method was in the ratio of 1:5:10.

Narrow band imaging spectroscopy in optical and thermal region of electromagnetic spectrum will provide comprehensive insight into various aspects of soil and their properties and to answer the quantitative aspects of soil science, namely, soil mineralogy, soil fertility, soil organic matter, soil moisture and thermal properties of soils provide such information.

32 **Geographic Information System**

A GIS is a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modelling, representation and display of geo referenced data to solve complex problems regarding planning and management resources (or)

A geographic Information System (GIS) is a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the earth

A working GIS integrates five components:

Hardware: Hardware is the computer on which a GIS operates. Today, GIS software runs o a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations

Software: GIS software provides the functions and tools needed to store, analyse, and display geographic information.

Data: Possibly the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources

People: GIS technology is of limited value without the people who manage the system and develop plans for applying it to real-world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform

Methods: whether vector or raster method

Advantages of GIS

- Exploring both geographical and thematic components of data in a holistic way
- Stresses geographical aspects of a research question
- Large volumes of data
- Integration of data from widely disparate sources
- Allows a wide variety of forms of visualization

Disadvantages of GIS

- Data are expensive

- Learning curve on GIS software can be long
- Shows spatial relationships but does not provide absolute solutions
- Origins in the Earth sciences and computer science. Solutions may not be appropriate for humanities research

33 **Explain about Global Positioning Systemic**

GPS, which stands for Global Positioning System, is the only system today able to show you your exact position on the Earth anytime, in any weather, anywhere (OR)

A network of satellites that continuously transmit coded information, which makes it possible to precisely identify locations on earth by measuring distance from the satellites

The parts of GPS include a) Space segment b) Control segment c) User segment

The 24 satellites that make up the GPS space segment are orbiting the earth about 12,000 miles above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are travelling at speeds of roughly 7,000 miles an hour. GPS satellites are powered by solar energy. They have backup batteries on board to keep them running in the event of a solar eclipse, when there's no solar power. Small rocket boosters on each satellite keep them flying in the correct path. The GPS satellites (also called NAVSTAR, the official U.S. Department of defence name for GPS.

Control segment

The second part of the GPS system is the ground station, comprised of a receiver and antenna, as well as communication tools to transmit data to the data center**.** GPS units are made to communicate with GPS satellites (which have a much better view of the Earth) to find out exactly where they are on the global scale of things

34 **How GPS works?**

The principle behind GPS is the measurement of distance (or “range”) between the satellites and the receiver. The satellites tell us exactly where they are in their orbits by broadcasting data the receiver uses to compute their positions.

GPS uses trilateration to determine a user's position. To be able to apply trilateration, we need to know the exact distance that our GPS receiver is from the orbiting satellites to be able to calculate an accurate position. By applying some basic mathematics the receiver can work out this distance.

Distance = Speed x Travel Time

• GPS signals are a radio signal, therefore they travel at the speed of light

• If we know the time the signal was sent and the time the signal was received we can work out travel time.

• By subtracting the sent time from the received time, we can determine the travel time Now we can multiply travel time by the speed of light and we can determine distance

To calculate the travel time, each satellite transmits it's own pseudo code, as illustrated below

To determine distance, both the satellite and GPS receiver generate the same pseudocode at the same time. The satellite transmits the pseudocode which is received by the GPS receiver. The receiver is still producing the pseudocode while the satellite's code is travelling through the sky. The 2 signals are eventually compared and the difference between the 2 signals is the travel time.

Problem soils

1. **Classification of problem soils**

The soils which owe characteristics that they cannot be economically used for the cultivation of crops without adopting proper reclamation measures are known as problem soils. The problem soils are classified based on soil properties

Problem soils are classified into physical constraints or physical problems and chemical constraints or chemical problem. The physical constraints are due to textural and structural condition of soils. It includes a) Surface hard pan, b) Sub surface hard pan, c) Highly permeable soil, d) Very slow permeable soil, e) Soil crusting and f) Fluffy soil.

The chemical constraints are due to presence of salts or beyond permissible limit of nutrients present in exchange complex. It includes a) Acid soil b) Saline soils c) Sodic soil d) Saline sodic and e) Degraded alkali

2. **Soil acidity**

It is a chemical property and it sir estimated through pH. Soil acidity increases with decrease in soil pH. There are three forms or phases of soil acidity. They are a) active acidity b) exchangeable acidity and c) reserve acidity

Active acidity

Refers only to H+ and not Al3+ in the soil solution. pH measures active acidity or the H+ concentration of the soil solution.

Exchangeable acidity

Includes exchangeable Al3+. Includes exchangeable H. Usually there is a small amount in acid mineral soils but it is more abundant in organic soils. It is extracted with a neutral unbuffered salt solution, such as KCl, CaCl2 or NaCl

Reserve acidity

This is comprised of weak acids not replaced by neutral unbuffered salt solution and H+ which bonds with OH-. This is the type of acidity caused by organic matter and bound Al. Bound Al occurs in soils primarily as Al polymers (long chain compounds) and is denoted as Al (OH)xx

3. **Distinguish between active and reserve acidity**

Active acidity	Reserve acidity
1. Acidity refers to the activity of hydrogen ions in the aqueous phase of a soil.	1. Reserve acidity refers to the hydrogen & aluminium ions held on the soil colloids.
2. It is the primary source of soil acidity.	2. It is the secondary source of soil acidity.
3. Small amount of lime is required to neutralize the active acidity.	3. Large amount of lime is required to neutralize the reserve acidity.

4. It is generally much less than reserve acidity. [the no. of adsorbed H ions in the diffuse layer is much greater than those in true solution.]	4. It is commonly for greater than the active acidity. It may be 1000 times greater than the active acidity in a sandy soil and 50,000 or even 100,000 times greater in a clayey soil high in organic matter.
5. Buffering capacity of soil is not dependent on the active acidity.	5. Buffering capacity of soil is directly related to the reserve acidity.

4. **Source of soil acidity**

Humus decomposition results in release of large amounts of acids. There by lowering the pH.

Rainfall: In areas with more than 100 cm rainfall associated with high R.H., Ca, Mg is dissolved in water and leached out due to this base saturation of soil decreases.

Application of elemental sulphur under goes reactions resulting in formation of H2SO4.

Continuous application of acid forming fertilizers like ammonium sulphates or ammonium chlorides results in depletion of Ca by CEC (cation exchange capacity) phenomenon.

Parent Material: Generally rocks are considered as acidic, which contain large amount of silica (SiO_2) when this combined with water, acidity increases

5. **Characteristic feature of acid soil**

   1. pH is less than 6.5
   2. This soil is open textured with high massive Structure.
   3. Low in Ca, Mg with negligible amount of soluble salts.
   4. This soils appear as brown or reddish brown, sandy loams or sands
   5. The acid soils have kaolinitic type of clay minerals
   6. Acid soils have low dispersion and flocculates in a suspension
   7. Acid soils have low population of bacteria and actinomycetes but very high amounts of fungi
   8. P fixing capacity in these soils will be high

6. **Lime requirement**

The amount of lime required to be added to acidic soil to raise the pH to a desired value is known as lime requirement. (or) LR is the amount of good quality agricultural limestone required to establish the desired soil pH range for the cropping system being used. LR is determined in the laboratory using a buffer pH in equilibrium with the soil. The amount of lime to be added depends on a) Efficiency of the liming material b) Lime requirement of crop c) soil pH d) Percent exchangeable Al e) Buffering capacity of soil f) Type of clay g) Desired pH level

7. **Liming of acid soils**

Raising the soil pH to a reaction near neutral or just above that is done by liming. Liming is the best measure to correct soil acidity. Liming means adding to soil any compound containing calcium or calcium and magnesium that is capable of reducing the acidity of the soil. Lime can be applied through several liming materials such as calcic limestone, dolomite limestone, quick lime, hydrated or slaked lime. A satisfactory material for raising the pH should have the following characteristics

a) It should have mild alkalizing effect.
b) It should have a desirable proportion of cations mostly calcium and magnesium
c) It should have favourable effect on soil structure
d) It should not be too expensive

When liming materials are added to soil, the calcium and magnesium compound react with carbon dioxide and the acid colloidal complex. These liming materials replace hydrogen and aluminium tightly held on soil colloidal complex. Adsorption of calcium and magnesium raises the base saturation percentage of colloidal complex which results in soil Al^{3+} and pH

8. **Efficiency of liming**

It depends on

a) Neutralizing value. The ability to neutralize acids expressed in terms of calcium carbonate equivalent. Calcium carbonate is the standard by which other materials are measured (100%).

b) Purity of liming materials - Purity will increase its efficiency

c) Fineness of materials- The finer the material, more rapidly it dissolves into solution and more effective it becomes. Material passing through 60mesh is more effective

d) Method of application- surface application of lime and spread over the entire field and then mixed well. Large quantities of lime in a single application is avoided and it should be applied in two or three split doses. This is generally advocated for strong acid soils.

9. **Beneficial effects of liming**

a) Prevents aluminium toxicity
b) Prevents manganese toxicity
c) Increases P and Mo availability
d) Improves N fixation
e) Improves fertilizer P and K efficiency
f) Enhances soil exploration by roots

10 **Effect of soil acidity on plants**

Direct Affects

1. Plant root system does not grow normally due to toxic hydrogen ions.
2. Permeability of plant membranes are adversely affected due to soil acidity.
3. Enzyme actions may be altered, since they are sensitive to PH changes.

Indirect Affects

1. Deficiency of Ca and Mg occur by leaching.
2. Al, Mn and Fe available in toxic amounts.
3. All the micro nutrients except molybdenum are available. So 'Mo' deficiency has been identified in leguminous crops.
4. Phosphorous gets immobilized and its availability is reduced.

Activity of Micro Organisms

1. Most of the activities of beneficial organisms like Azotobacter and nodule forming bacteria of legumes are adversely affected as acidity increases.

Nitrification is reduced at lower pH values and Rhizobium activity is increased as the pH value increases

11 **Define acid soil. Describe the factors leading to development of acid soils. How will you reclaim acid soil**?

Those soils with pH less than 6.5 and which respond to liming may be considered as acid soils.

The factors leading to development of acid soils are

1) Leaching due to high rainfall- Soils may turn acidic due to loss of calcium and magnesium salts in areas of high rainfall as in humid regions. It may be explained as follows

$CO_2 + H_2O \longrightarrow H_2CO_3$

$CaCO_3 + H_2CO_3 \longrightarrow Ca(HCO_3)_2 \downarrow$

Soluble

Thus calcium and magnesium is lost in to solution and dominance of H and Al takes place in colloidal complex

2) Acidic parent material- Soils developed from acidic parent material like granite are acidic in nature

3) Presence of silicate clays- Presence of 1:1 clay minerals, allophane and humus also contribute to soil acidity

4) Microbiological action- Humus decomposition results in release of large amounts of acids. There by lowering the pH.

5) Use of fertilizers- Continuous application of acid forming fertilizers like ammonium sulphate or ammonium chlorides results in depletion of Ca by CEC (cation exchange capacity) phenomenon. Application of elemental sulphur under goes reactions resulting in formation of H_2SO_4

6) Acid rain – carbon monoxide, nitrogen oxide and sulfur oxide produced from factories. These gases when dissolved in rain to form sulfuric acid, nitric acid and when it reaches the soil, it turns acidic

7) Pedogeneic process:

- Laterisation: In tropical regions where high rainfall with high temperature causes laterisation which in turn leads to intense weathering and leaching of bases like Ca, Mg
- Podsolization: in area with sub temperate to temperate climate, where organic matter content is high (low temperature and high rainfall)
- Marshy and Peaty condition: With significant amount of under decomposed and partly decomposed O M

Procedure for reclamation of acid soil:

Bring a representative sample of soil from the field to be reclaimed. Determine the pH of soil in soil water extract (1:2). Determine the lime requirement of the soil. Select appropriate liming material. Calculate total quantity of the liming material after having known its neutralizing value of $CaCO_3$ equivalent. Spread uniformly half the quantity of lime on the field and plough/ harrow it into the soil when the soil is in friable condition. Spread uniformly the remaining half of the liming material and mix it thoroughly by disking and harrowing. While mixing, the field should be in proper tilth.

12 **Write a brief note on liming materials**

To be considered a liming material an anion must produce OH - ions to react with H^+ and Al_3^+ ions. It is usually Oxides, hydroxides, carbonates, and silicates of calcium

1. Calcium oxide (CaO)

Common names - burned lime, quicklime, unslaked lime

$CaCO_3$ ===> CaO + CO_2

Advantage is immediate reaction with the soil.

Disadvantage - caustic, difficult to handle and apply

Caking may occur. Through mixing is necessary

2. Calcium hydroxide ($Ca (OH)_2$)

Common names -- slaked, hydrated, builders lime

CaO + H_20 ===> $Ca (OH)_2$

Advantage - quick reaction with the soil

Disadvantage - difficult and unpleasant to handle

3. Calcitic limestone ($CaCO_3$

Dolomitic limestone ($CaMg(CO_3)_2$) Mined from deposits. Quality depends on amount of impurities such as clay. Good handling properties. Reaction time several months

4. Marl ($CaCO_3$)

Unconsolidated deposits of CaCO3. Usually contaminated with clay low in Mg

5. Slag ($CaSiO_3$)

Byproduct of furnaces used for making iron, steel and elemental P

6. Fly ash

Byproduct in thermal and coal industry rich in silica

13 **Acid sulfate soil**

Acid sulphate soils extremely acid soils they have a pH, which is < 4.0 in some layer in the upper 50 cm of the soils profile.

The acidity is due to presence of H_2SO_4 and Fe and Al sulphates.

They are derived from marine sediments high in pyrites, and poor in bases. S oxidation is an acidifying process. The reaction is as follows.

$$2\,S + 3O_2 + 2\,H_2O \xrightarrow{\text{Oxidation}} H_2SO_4$$

$$H_2 + 2O_2 \xrightarrow{\text{Oxidation}} H_2SO_4$$

During the submerged period, sulphates (SO_4^{2-}) in the water are reduced to sulphides (S_2) in which form they are stabilized generally as iron sulphides (Fes). When these areas are drained, the sulphides or elemental (S) are oxidized forming H_2SO_4. The soil pH may drop to level as low as 1 or 2 (highly acidic condition). Obviously plant growth cannot occur under these conditions. Sizable areas of these kinds of soils called cat- clays are found in South East Asia

14 **Discuss the occurrences, formation, characteristics and management of acid sulfate soil ?**

Acid sulphate soils are drained coastal wetland soils that have become acid (pH<4) due to oxidation of the pyritic minerals in the soil. (or)

Soils formed from weathering of sulphide bearing parent materials which results in the formation of extreme low pH (< 3.0) and precipitation of sulfate salts

Soil with sufficient sulphides (FeS2 and others) to become strongly acidic when drained are termed acid sulphate soils or as the Dutch refer to those soils cat clays. When allowed to develop acidity, these soils are usually more acidic than pH 4.0. Before drainage, such soils may have normal soil pH and are only potential acid sulphate soils. Generally acid sulphate soils are found in coastal areas where the land is inundated by salt water. In India, acid sulphate soil is, mostly found in Kerala (kuttanad) and West Bengal (Sunderban).

Land inundated with waters that contain sulphates, particularly salt waters, accumulate sulphur compounds, which in poorly aerated soils are bacterially reduced to sulphates. Such soils are not usually very acidic when first drained in water. When the soil is drained and then aerated, the sulphide (S_2^-) is oxidized to sulphate (SO_4^{-2}) by a combination of chemical and bacterial actions, forming sulphuric acid (H_2SO_4). The magnitude of acid development depends on the amount of sulphide present in the soil and the conditions and time of oxidation. If iron pyrite (FeS_2) is present, the oxidized iron accentuates the acidity but not as much as aluminium in normal acid soils because the iron oxides are less soluble than aluminium oxides and so hydrolyze less.

Characteristics

Acid sulphate soils contain a sulphuric horizon which has a pH of the 1: 1 soil: water ratio of less than 3.5, plus some other evidences of sulphide content (Yellow colour). Such strong acidity in acid sulphate soils results toxicities of aluminium and iron, soluble salts (unless leached), manganese and hydrogen sulphide (H_2S) gas. Hydrogen sulphide (H_2S) often formed in lowland rice soils causing Akiochi disease that prevents rice plant roots from absorbing nutrients

Management of Acid Sulphate Soils

Management techniques are extremely variable and depend on many specific factors viz, the extent of acid formation, the thickness of the sulphide layer, possibilities of leaching or draining the land etc. The general approaches for reclamation are suggested bellow: Keeping the area flooded. Maintaining the reduced (anaerobic). Soil inhibits acid development, the use of the area to rice growing. Unfortunately, droughts occur and can in short time periods cause acidification of these soils. The water used to flood the potential acid sulphate soils often develop acidity and injure crops. Controlling water table. If a non-acidifying layer covers the sulphuric horizon, drainage to keep only the sulphuric layer under water (anaerobic) is possible. Liming and leaching. Liming is the primary way to reclaim any type of acid soil. If these soils are leached during early years of acidification, lime requirements are lowered. Leaching, however, is difficult because of the high water table commonly found in this type of soil and low permeability of the clay. Sea water is sometimes available for preliminary leaching.

15 **Classification of salt affected soils**

Salt affected soil is classified based on three parameters viz., soil reaction (pH), Exchangeable sodium percentage (ESP) and electrical conductivity (EC

Salt affected soil	Electrical conductivity ($dSm^{-1)}$	Soil pH	Exchangeable sodium percentage (ESP)	Soil physical condition
Saline soil	> 4	< 8.5	<15	Normal
Sodic soil	<4	> 8.5	>15	poor
Saline sodic soil	>4	>8.5	>15	Normal

16 **Saline Soils**

Classified as saline when they contain a high enough concentration of soluble salts to interfere with normal growth and development of salt-sensitive plants. A saline is characterized by EC > 4 dSm^{-1}, ESP <15 and pH <8.5. Salinity is measured in terms of electrical conductivity (EC). It is expressed as deciSiemens per meter (dSm^{-1}). The saline soils contain toxic concentration of soluble salts in the root zone. A soluble salt consists of chlorides and sulphates of sodium, calcium, magnesium. Because of the white encrustation formed due to salts, the saline soils are also called white alkali soils. The plant may appear water stressed. Poor germination. Leaf burns and shallow water table

17) **Sodic soils**

Soils with high levels of exchangeable sodium (Na) and low levels of total salts are called sodic soils. A soil with pH > 8.5, ESP>15 and EC> 4 dSm^{-1} are said to be sodic Because of high alkalinity resulting from sodium carbonate the surface soil is discolored to black; hence the term black alkali is used. Due to high sodium content, soil will loose soil structure, crusting or hard setting may occur, low infiltration rate, run off and erosion., dark powdery residue on surface, stunted plants and nutrient deficiencies especially micronutrients are noticed.

18) **What are saline-Sodic Soils?**

These soils have both soluble salts and exchangeable Na. As long as excess salts are present, soils are flocculated and pH is < 8.5. When such soils are leached, soil becomes strongly alkaline due to dominance of Na. Such soils will have pH>8.5, ESP>15 and EC> 4 dSm^{-1}

19) **Degraded alkali soils**

In areas of excess rainfall due to absence of Ca and Mg, part of Exch. Na (in alkali soils) is replaced by hydrogen

$Na\text{-}Soil + H_2O \longrightarrow NaOH + H\text{-}Soil$

$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H2O$

Hydrogen soils so formed undergo degradation to form silicic acid and forms Sesquioxide. Such soils will have acidic pH at the surface and subsurface will have pH > 8.5. Such soils are called degraded alkali soils

20 **How are salt affected soil formed? Give the methods of managing them.**

The salt affected soil is a broad term which consists of saline soil, sodic soil and saline-sodic soil. Salt affected soils are formed by

1.Weathering of rocks and minerals: Chemical weathering leads to formation of soluble salts and gets leached down during rainfall and move upwards due to high temperature and get deposited on the surface on evaporation

2. Hydrolysis of sodium saturated soil complex: When soil exchange sites get saturated with Na, forms sodium carbonate, undergo hydrolysis to form sodium hydroxide, results in increase in pH due to OH-

3. Salty underground water: The ground water of arid regions contains considerable quantities of soluble salts. These salts move upward with water and get deposited when water evaporates

4 .Arid and semi-arid climate: Poor rainfall coupled with high temperature in arid and semi arid climate regions favors formation of saline and alkali soils.

5. Quality of irrigation water: If water available for irrigation contains high amount of soluble salts and if irrigated continuously for some time, then good soils also turn into saline and alkali soils

Management of salt affected soils

a) Saline soils

Removal of excess salt to a desired level in the rooting zone is the basic principle of reclamation of saline soils. Leaching with good quality water followed by adequate drainage are the two essential components of any permanent solution of the salinity problem. Flooding and leaching down of soluble salts is the first step in reclamation

Leaching is defined as the process of transporting soluble salts by downward movement of water in the soil by the application water. Leaching requirement (LR) is defined as that fraction of water that must be leached through the root zone to control salinity at specified level.

Procedure for reclamation

Level the plots, divide into sub-plots of suitable size. Dig a trench (45-60 cm) deep on one side of the plot to remove excess water. Make a strong bund (30-45 cm high) around the plot and flood it with good quality water. Plough the soil for uniform mixing of soil and water to ensure dissolution of soluble salts. Allow the water to stand for 2-3 days. Remove the standing water through the channel in to trench. Add well decomposed organics and raise salt tolerant crops

b) **Sodic soils**

The basic principle underlying reclamation is to adopt those ameliorative measures which replace sodium with calcium in the exchange complex followed leaching of soluble sodium from exchange complex. Use of amendments followed by adequate leaching is prerequisites for any reclamation measure of sodic soils. Because of low cost and easy availability gypsum is used widely for sodic soil reclamation

Soil- Na_2 + $CaSO_4$ $\longrightarrow$ Ca- Soil + Na_2SO_4

Sodium sulfate being soluble it is removed by leaching

Other than gypsum, amendments used are calcium salts, acids and acid forming materials. Iron pyrites in the presence of air and water produces sulfuric acid which reacts with calcium carbonate to form calcium sulfate and the exchange reaction follows

$2FeS_2 + 7O_2 + 2H_2O \longrightarrow 2FeSO_4 + 2H_2SO_4$

$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$

Na-Soil + $CaSO_4$ $\longrightarrow$ Ca- soil + Na_2SO_4

The quantity of gypsum to be applied is found out by Gypsum requirement of alkali soil. Addition of bulky manures, green manures, crop residues will produce weak organic acids creating acid environment. Addition of organics along with gypsum proved to be better amendment for alkali soils. Growing of crops tolerant to sodic soils can ensure reasonable returns during initial years of reclamation. Cropping practice involving green manures/ legume crop is advantage

Procedure for reclamation

Level the lands and divide into sub plots. Dig a trench across the slope of 60-75 cm

Make a strong bund around the plot. Apply required quantity of gypsum/ pyrite as found out by GR and mix it with top soil by ploughing. Flood the plot with good quality water and stand for 2-3 days. Remove the standing water. Raise Dhaincha and plough at appropriate time. Apply 25 kg $ZnSO_4$/ha. Raise rice crop, increase plant density and add 25% extra N. Raise salt resistance crops in the following season by adopting improved agronomic practices.

20 **Trace the genesis of alkaline soils and bring about the various chemical amendments for reclaiming the same**

1) Hydrolysis of sodium saturated soil complex: When soil exchange sites get saturated with Na, forms sodium carbonate, undergo hydrolysis to form sodium hydroxide , results in increase in pH due to OH-
2) Arid and semi-arid climate: Poor rainfall coupled with high temperature in arid and semi arid climate regions favors formation of saline and alkali soils.
3) Quality of irrigation water: If water available for irrigation contains high amount of soluble salts and if irrigated continuously for some time, then good soils also turn into saline and alkali soils

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$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

$Na\text{-}Soil + CaSO_4 \rightarrow Ca\text{-} soil + Na_2SO_4$

3) Sulfuric acid* can be used instead of gypsum on calcareous (CaCO3 containing) soil only. Sulfuric acid dissolves calcium carbonate in the soil

$$H_2SO_4 + CaCO_3 \rightarrow CO_2 + H_2O + CaSO_4$$

4) Elemental sulfur can also be used as an alternative to gypsum on calcareous soils. Soil microbes convert sulfur into sulfuric acid. H_2SO_4 dissolves calcium carbonate and makes gypsum. Conversion to sulfuric acid takes time. Several weeks and faster in warm soils

21) **Briefly describe the characteristics of saline, saline alkali and alkali soils and their formation**

Characteristics

Saline soils are in flocculated state. Their permeability is higher than alkali soils. Their physical condition is good and hence water can pass through them. These soils have white encrust on soils surface. Soluble salts in soils: soil water is held tightly enough by the ions that plants cannot use it (apparent moisture stress). Saline soils characteristically remain moist longer than the rest of the field. Saline soils are usually barren but potentially productive soils

Abnormally high levels of exchangeable sodium (Na+).When enough Na+ is adsorbed, clay particles repel each other. Occurs when the exchangeable Na+ percentage (ESP) is equal to or exceeds 15. Soil pH of sodic soils will often be above 8. Dispersed colloids become oriented as water moves into soil and eventually they plug soil pores. Poor internal drainage resulting in dry subsoil and a moist or wet surface layer. Crops fail because of excess surface water ("drown out") or for lack of water (dry subsoil) even though there may have been adequate rainfall or irrigation If a soil is highly sodic, a brownish-black crust sometimes forms on the surface due to dispersion of soil organic matter. By the time darkened crusts are visible on the soil surface, the problem is severe, and plant growth and soil quality is significantly impacted. Plants growing on sodic soils may appear stunted and often show a burning or drying of tissue at the leaf edges, progressing inward between veins

These soils have both soluble salts and exchangeable sodium. As long as soluble salts are present in excess, the soil is flocculated and pH is less than 8.5. When such soils are leached, their soluble salts content decreases, soil pH become strongly alkaline because of hydrolysis of sodium. If sodium content is increased, soils get deteriorated. The soil will have pH >8.5, ESP>15 and EC>4 dSm^{-1}

Formation

Weathering of rocks and minerals: Chemical weathering leads to formation of soluble salts and gets leached down during rainfall and move upwards due to high temperature and get deposited on the surface on evaporation

1) Hydrolysis of sodium saturated soil complex: When soil exchange sites get saturated with Na, forms sodium carbonate, undergo hydrolysis to form sodium hydroxide , results in increase in pH due to OH-
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22 **What are the effects of saline and sodic soils on plant growth? Explain the methods of reclaiming saline soils**

Sodic soils may impact plant growth by 1) specific toxicity to sodium sensitive plants, 2) calcium deficiencies or nutrient imbalances caused by excessive exchangeable sodium, 3) high pH, 4) dispersion of soil particles, resulting in poor physical conditions in the soil.

Soluble salts can have two types of effect on the growing plants 1) Specific effects due to particular ions they contain being harmful to the crops and 2) general effect due to raising of the osmotic pressure of the solution around the roots of the crop. The salt damage on plants is as follows

1) Physiological drought which is direct osmotic effect
2) Increased hydraulic resistance of roots and leaves
3) Alteration of hormone levels
4) Photosynthetic mechanism
5) Ionic competition , increasing energy use to maintain the Na: K balance

Reclamation of Saline Soils

Removal of excess salt to a desired level in the rooting zone is the basic principle of reclamation of saline soils. Leaching with good quality water followed by adequate drainage are the two essential components of any permanent solution of the salinity problem. Flooding and leaching down of soluble salts is the first step in reclamation

Procedure for Reclamation

Level the plots, divide into sub-plots of suitable size. Dig a trench (45-60 cm) deep on one side of the plot to remove excess water. Make a strong bund (30-45 cm high) around the plot and flood it with good quality water. Plough the soil for uniform mixing of soil and water to ensure dissolution of soluble salts. Allow the water to stand for 2-3 days. Remove the standing water through the channel in to trench. Add well decomposed organics and raise salt tolerant crops

23. **Write short note on Fluffy soils**

It is observed in the paddy soils where the working of soil by bullocks will be difficult. The depth of soil will be such that knee of bullock will be completely covered. Fluffy soil is characterized with high infiltration, hydraulic conductivity but with low BD. In such soils depth has to be reduced so that working of cattle is easily made. It is done by rolling of 400 kg stone for 8 pauses. By rolling it, soil will be compact, there is better aggregation, increase in BD and reduce in HC and infiltration

Genesis of fluffy soil is due to monoculture of rice (rice – rice – rice). Break down of aggregates- structure less mass. Soil particles are always in a state of flux. Mechanical strength is poor. Tamil Nadu – Cauvery deltaic area

24 **Sub soil compaction and its management**

Fine clay and clay is deposited in the sub soil during the process of illuviation. High clay content might have resulted in compaction and formed hard layer when combined with silica and sesquioxides followed by rapid drying, heating and high temperature. 11.34 M ha in India and 2.08 lakhs ha of land in Tamilnadu is affected by subsurface hard pan**.** There is need to break open the hard sub-surface soil by deep tillage to improve water storage besides improvement in root development. Use of chisel plough at 50 cm interval up to 30 cm depth and incorporating paddy husk at 5 t ha^{-1} will break hard pan.

25 **Highly permeable soils**

The light textured soil is highly susceptible to the percolation losses of water and leaching losses of nutrients. Low WHC, poor retentive capacity for nutrients, high percolation loss of water, fast evaporation rate are the major features of light textured soil. 13.75 M ha are affected by high permeability in India. To correct the textural weakness of soil, mixing 5% clay in the top 15 cm increased the crop yield by increasing BD, decreasing HC and infiltration rate and increased moisture retentive capacity. Compacting of sandy soils by passing 400 kg roller (1 meter long) caused increase in BD to 1.60 Mgm-3 from 1.45 Mgm-3, decreased HC and total porosity. Mixing of clay at the rate of 5%or 2% or 1% and compacting to 1.70 Mgm^{-3} minimized percolation losses. Increased retention and uptake of nutrients, less leaching loss of nutrients, increased crop growth and yields

26 **List out various soil physical constraint which limits crop production. Explain in detail about management of soil crust.**

Out of total cultivable area of 140.5 M ha, about 79 M ha has physical constraints in one form or other. The major soil physical constraints are

1) Surface hardening
2) Soils having shallow depth and rocky layer
3) Soils having hard layer or hard pan in the Rhizosphere
4) Highly permeable layer
5) Very slow permeable soil
6) Soil crusting
7) Fluffy soil
8) Undulating and rolling topography

Soil crust is a phenomena a associated with deterioration of soil structure where the natural soil aggregates brake and disperse. If dispersion is followed by drying the soil solids rearrange to crust. When raindrops strike the exposed soil surface, kinetic energy cause disintegration of aggregates and dispersive action of water leaves surface soil into mono grain state. The dispersed particle is carried down the soil with infiltrating water clogging the soil pores. When on drying soil particles come together to form dense and strong soil layers known as soil crusts. Soil crusting is observed in 10.25 M ha in India. Crust can be formed in all types of soil (Red soil specific) of arid and semi-arid regions It has high BD, low non- capillary pore space, low HC, encourages run off and soil loss.. It affects the emergence, early growth of seedlings and largely determines the crop stand. Soil factors that are associated with soil crusts formation include low OM, high salt and exch. Na, low structural stability. Since rain drop is major cause, soil crusting could be avoided by use of surface mulches which prevents dispersion of surface soil and maintains high infiltration, close growing crops and grasses, gypsum, crop rotation, residue management and chemical amendments

27 **Enumerate the genesis, properties and remediation of a) surface hard pan b) Slow permeable soil c) fluffy soil**

Surface hard pan

It is largely due to physical process brought out either directly by compaction effects of through action of rainfall and later drying up of compacted oriented particles. The structure of this layer is sufficiently changed from that of soil mass below. The above layer has high BD, lower macro porosity and greater mechanical strength than soil layers below. The emergence of seedlings is affected. 21.57Mha soil in India is affected by hardening. Incorporation of powdered groundnut shell, FYM, paddy husk increased the yield. Due to prevention of jamming of pore space by finer particles, increase in infiltration rate, increase in HC, better aggregate stability. Soil inversion (mixing of top and bottom layers) along with addition of organics improved the root growth. Due to change in textural composition. Mixing of finer and coarser fractions in different proportion could give good management of soil hardening through its effect on hardness strength, WHC and cracking properties. The ratio of finer and coarser fraction of 3:7 to 4:6 is found to best in reducing the soil hardening.

Slowly Permeable Soils

The very slow permeability is observed in black soils of Vertisol order. The soils are almost impermeable under saturated conditions and develop deep and wide cracks on drying. They swell and sticky on wetting. It is difficult to manage them unless they are cultivated at the appropriate soil moisture levels with suitable implements. The timely tillage holds key to the successful cropping. Deep black soils have high clay content varying from 50 -70% and lacks good structure. Shortage and excess of water are the twin problems. The slow permeability of the soil could be broken by deep ploughing of sub soils. This encouraged root growth and larger size of roots. Addition of FYM @ 25 tha^{-1} improved the soils

Fluffy soils

Monoculture of rice (rice – rice – rice). Break down of aggregates- structure less mass Soil particles are always in a state of flux. Mechanical strength is poor. Tamil Nadu – Cauvery deltaic area. It is observed in the paddy soils where the working of soil by bullocks will be difficult. The depth of soil will be such that knee of bullock will be completely covered. Fluffy soil is characterized with high infiltration, hydraulic conductivity but with low BD. In such soils depth has to be reduced so that working of cattle is easily made. It is done by rolling of 400 kg stone for 8 pauses. By rolling it, soil will be compact, there is better aggregation, increase in BD and reduce in HC and infiltration

28 **Write a note on eolian soil**

Wind processes are typically referred to as eolian processes, which produce eolian land forms Wind action can be divided into three parts

a) Erosion b) Transportation c) Deposition

Types of Erosion

a) Deflaction b) Abrasion c) Attrition

a) Deflaction

The process of lowering land surface is called as Deflaction. Removal of sediments from surface by wind action. In Latin verb deflatus means blown away

1) Desert pavement

A resistant, pavement like surface created when fine particles blown way and coarse particle like pebbles and gravel are left behind. Protect underlying layers of fine particles from further deflaction by capping them

2) Deflaction hollow

A depression crested by wind erosion. Most deflaction hollow are small, but it can be as large as 1.6 km in diameter

b) Abrasion

The blown particles strike against up standing masses and causes erosion by mechanical Wearing of rocks. The process is same as sandblasting.

There are four features of abrasion

a) Ventifacts b) Yardangs c) Pedestal rock d) Zeugen

c) **Attrition**

Attrition is an erosional process. Rocks and pebbles are carried in the flow of a river. They repeatedly knock into each other, which causes the rocks to erode or to break. As the rocks continue to collide, they erode more and more, getting smaller and smaller until they are only sediment

Transportation

Particles are transported by winds through suspension, saltation (skipping or bouncing) and creeping (rolling or sliding) along the ground

Deposition

When velocity of wind is checked, then deposition started. Eolian deposit is formed

The process by which sediment settles out of the wind that is carrying it, and is deposited in a new location.

The deposition of eroded materials are of two types

a) Sand sheet – horizontal to semi horizontal bodies of sand. It exhibit little or no surface topography

b) Sand seas- Vast region and enormous quantities of sand result in wide variety of sand dunes

29 **What is ill drained soil? Write briefly now to manage it?**

Ill drained simply refers to the soils ability not to allow water to pass through at a reasonable rate. Ill drained soils are associated with heavy clay content. Clay soils are referred as heavy soils. To be classified as clay soil, it should be made up of about 40% clay particles, the finest particles found in soil. Heavy have very hard consistence when dry and very plastic and sticky ("heavy") when wet. Therefore the workability of the soil is often limited to very short periods of medium (optimal) water status. They are imperfectly to poorly drained, leaching of soluble weathering products is limited. This is due to the very low hydraulic conductivity. Proper aeration in the root zone is necessary for development of healthy growth. The crops become stunted with yellowing of leaves when the soil is saturated. In excess water, the plants usually die because of root damage caused by reduced supply of oxygen and accumulation of carbon dioxide with the related effects on the soil plant relationship. The adverse effects are not from direct presence of excess water, because crops will not suffer even in total from direct presence of excess water, because crops will not suffer even in total water culture, if they can get air. the root growth in such cases is also poor due to lack of aeration and they tend to remain largely near the surface and be subject to wilting when the surface becomes dry and even through there may be enough moisture below

How to overcome ill drained condition?

Proper drainage is important because not all plants prefer moist conditions. In nature certain minerals such as sand provide rapid drainage, while heavy minerals like clay can restrict drainage. Poor drainage is easily spotted in areas where water tends to pool following a rainstorm. Drainage can be improved by adding compost or sand. Where proper drainage cannot be achieved through natural means, corrugated piping called tiling may be installed below the growing surface to move moisture away from the plant's roots

30 **Discuss how soils get polluted and how to rectify the soils that are polluted?**

Soil pollution is defined as the change in physical, chemical and biological conditions of the soil through man's intervention resulting in degradation in quality. Or

Soil pollution is the reduction in the productivity of soil due to the presence of soil pollutants

Soil pollutants have an adverse effect on the physical chemical and biological properties of the soil and reduce its productivity. Pesticides, fertilizers, organic manure, chemicals, radioactive wastes, discarded food, clothes, leather goods, plastics, paper, bottles, tins-cans and carcasses- all contribute towards causing soil pollution. Chemicals like iron lead mercury, copper, zinc, cadmium, aluminium, cyanides, acids and alkalies etc. are present in industrial wastes and reach the soil either directly with water or indirectly through air. (E.g. through acid rain). The improper and continuous use of herbicides, pesticides and fungicides to protect the crops from pests, fungi etc. alter the basic composition of the soils and make the soil toxic for plant growth. Organic insecticides like DDT, aldrin, benzene hex chloride etc. are used against soil borne pests. They accumulate in the soil as they degrade very slowly by soil and water bacteria. Consequently, they have a very deleterious effect on the plant growth stunting their growth and reducing the yield and size of fruit. Their degradation products may be absorbed by the plants from where they reach the animals and man through the food chains. Radioactive wastes from mining and nuclear processes may reach the soil via water or as 'fall-out'. From the soil they reach the plants and then into the grazing animals (livestock) from where ultimately reach man through milk and meat etc. resulting in retarded and abnormal growth of man. Human and animal excreta used as organic manure to promote crop yield, pollute the soil by contaminating the soil and vegetable crops with the pathogens that may be present in the excreta. Nitrification, which is the process of forming soluble nitrates from the elemental atmospheric nitrogen or from originally harmless organic materials actually contribute towards water pollution when the nitrates leach out of the soil and accumulate to toxic levels in the water supply.

Soil pollution can lead to water pollution if toxic chemicals leach into groundwater, or if contaminated runoff reaches streams, lakes, or oceans. Soil also naturally contributes to air pollution by releasing volatile compounds into the atmosphere

Control of soil pollution

A number of ways have been suggested to curb the pollution rate. Attempts to clean up the environment require plenty of time and resources. Some the steps to reduce soil pollution are:

• Ban on use of plastic bags below 20 microns thickness.
• Recycling of plastic wastes.
• Ban on deforestation.
• Encouraging plantation programmes.
• Encouraging social and agro forestry programmes.
• Undertaking awareness programmes.
• Reducing the use of chemical fertilizer and pesticides.
• Recycling paper, plastics and other materials.
• Ban on use of plastic bags, which are a major cause of pollution.
• Reusing materials.
• Avoiding deforestation and promoting forestation.
• Suitable and safe disposal of including nuclear wastes.
• Chemical fertilizers and pesticides should be replaced by organic fertilizers and pesticides.
• Encouraging social and agro forestry programs.
• Undertaking many pollution awareness

Quality of Irrigation Water

1. Write short note on Quality of irrigation water

Purpose of assessing water quality is to find out short and long term effect of soluble salts and specific substances at any concentration present in the irrigation water on plant growth and soil properties. From environmental point of view, to study the man's action on the usage of water on environmental health. Water quality is determined according to the purpose for which it will be used. The criteria for assessing irrigation water suitability include chemical, physical and biological characteristics of soils, waters and crops. The characteristic of irrigation water that appears to be most important in determining its quality are the following

1) Salinity hazard(Total concentration of soluble salts)
2) Specific ion toxicity hazard(ionic composition a) major b) Minor
3) Sodicity hazard(Relative proportion of Na to other cations
4) Alkalinity hazard (Bicarbonate conc. As related to conc. of Ca and Mg

2 **What is the significance of conductivity as a parameter of irrigation water?**

It is determined by measuring the total soluble salts. It is measured in terms of electrical conductivity and expresses as dSm^{-1}. It is closely related to sum of cation and anions. Salts (chlorides and sulfates of Ca, Mg, Na, and K) are responsible for salinity. A salinity problem related to water quality occurs if total concentration of salts is high enough in crop root zone to affect growth and yield. Salinity impacts include a) physiological drought b) Increased osmotic potential of soil c) specific ion toxicity d) leaf burn e) nutrient uptake interferences

Classes of water	TDS	Electrical Conductivity
	(mg/l)	(dS/m)*
Class 1, Excellent	<1,000	≤0.25
Class 2, Good		0.25 - 0.75
Class 3, Permissible[1]	1,000 – 2,000	0.76 - 2.00
Class 4, Doubtful[2]		2.01 - 3.00
Class 5, Unsuitable[2]	>2,000	≥3.00

3. SAR of irrigation water

Sodicity hazard is evaluated by two expressions

1) Sodium absorption ratio(SAR) 2) Sodium to calcium activity ratio (SCAR)

Sodium absorption ratio (SAR)

Water may be good for irrigation on the basis of EC, may not be suitable if sodium predominates. Thus if SAR of water is not beyond 15, is considered to be good quality

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

SAR value measures relative concentration of sodium to calcium and magnesium. High concentration of sodium in irrigation water can result in the degradation of well-structured soils. This will limit aeration and soil permeability to water leading to reduced crop growth. At same SAR values with low EC will cause more dispersion of soil compared to high EC waters.

SAR values	Sodium hazard of water	Comments
1-9	Low	Use on sodium sensitive crops must be cautioned.
10-17	Medium	Amendments (such as gypsum) and leaching needed.
18-25	High	Generally unsuitable for continuous use.
≥26	Very High	Generally unsuitable for use.

4 **RSC of irrigation water**

Alkalinity hazard is identified by following two expressions

1) Residual sodium carbonate (RSC) and 2) Residual sodium bicarbonate(RSBC)

Residual sodium carbonate (RSC)

Eaton (1950) gave the concept of RSC. Alkali soils could be developed when irrigation water contains higher amounts of CO_3 + HCO_3 than Ca^{2+} + Mg^{2+}. Calcium and magnesium present in soil is precipitated as carbonates when irrigated with water containing bicarbonates. The sodium reacts with residual bicarbonate to form sodium bicarbonate and converted to sodium carbonate on evaporation.

Classification of water based on RSC is as follows

RSC = $[CO_3^{2}- + HCO_3-] – [Ca^{2+} + Mg^{2+}]$

Category	RSC values(meql-1)
Probably Safe	< 1.25
Marginal safe	1.25-2.5
Not suitable	>2.5

5. **Explain the problems associated with poor quality water**

Poor quality of water is one of the main factors turning good soil into saline or sodic. Several salts dissolved in it, as universal solvent. Irrigation with saline water adversely affects crop growth and productivity. High subsoil water table, aridity, seepage from canals, poor drainage, back water flow, intrusion of sea water also leads to salinity and sodicity. Around 1.5 Mha areas are affected by poor quality water in India. The most affected state is Rajasthan. In world, over 50 million ha are affected by salinity spread over 24 countries

1) Extraction of Water

If excess soluble salts of irrigation water accumulated in crop root zone, crop has difficulty in extracting enough water. Root growth is also suppressed; increasing the difficulty of water uptake. Salinity stress in plants is often called physiological drought. Due to reduced uptake of water and other effects, yields are reduced. The reduction in yield due to salinity is more in warm climate than cool climate.

2) **Soil permeability**

Soil permeability is reduced due to the deflocculation effect of sodium. If permeability is reduced, infiltration of water into and through the soil is reduced. Adequate root penetration is inhibited due to the presence of impermeable soil layer caused by $CaCO_3$ and high exch. Na %. Crusting of seed bed, Water logging, reduced oxygen and nutrient supply to the crops are the problems due to high sodium content relative of Ca & Mg.

3) **Toxicity Symptoms**

More uptake of B, Cl, Na, sulphate and bicarbonate by plant creates toxicity problems. Vegetative growth decrease as osmotic pressure of the soil solution increases. Reduction in growth takes place even without any external toxic symptoms. Increase in salinity, salt injury appears. Thick cuticle, waxy bloom and deep blue-green colour of leaves. At high salt levels, leaf burn appears in barley, sorghum and field beans

4) **Anatomical and Physiological Effects**

Salinity reduces cell division, cell enlargement and protein synthesis. It affects the structure and integrity of plant membranes and causes mitochondria and chloroplast to swell. Sodium and chloride at toxic levels disrupt the structure of the protein molecules. High chloride content hinders the development of xylem tissue.

5) Nutritional Effects

Higher level of certain ions affect the absorption of other nutrient elements. High concentration of sulphate reduces the uptake of calcium enhances the uptake of sodium. This process causes high level of sodium in plants, thus causing sodium toxicity. High concentration of Ca reduces the uptake of K. High concentration of Mg induces Ca deficiency

6) **Soil Microorganisms**

NO_2 & NO_3 producing bacteria sensitive to high salt concentration than NH_4 producing bacteria. Azotobacter is resistance to salt concentration

7) **Other effects**

Excessive vegetative growth, lodging, delayed crop maturity result due to excessive nitrogen in water. White and black deposit on soil due to high salt content and sodium and leaf burn due to using poor quality irrigation water in sprinkler irrigation are some of the problems. Tilth of the soil will be poor due to high exchangeable sodium percentage. Exchgeable Na tends to make moist soil impermeable to air and water & on drying soil becomes hard and difficult to work. The dense crusts formed interfere with germination and emergence of seedlings. Soluble carbonates are in water applied to soil in absence of Ca and Mg in soil, soil becomes alkaline & unfavourable.Na_2CO_3 in irrigation water is toxic to plants

6. **Explain the different parameters/criteria used to assess the quality of irrigation water. How poor quality water can be used for irrigation?**

The different parameters used to assess the quality of irrigation water are

1) Soluble salts (salinity hazard) - It is measured as electrical conductivity. It is primarily used to determine the irrigation water quality. It is expresses as dSm^{-1}. It is closely related to sum of cation and anions. Salts (chlorides and sulfates of Ca, Mg, Na, and K) are responsible for salinity and correlates with osmotic potential. A salinity problem related to water quality occurs if total concentration of salts is high enough in crop root zone to affect growth and yield. The water having EC > 2 dSm^{-1} will be problem to those crops which are sensitive to salinity. Salinity impacts include a) physiological drought b) Increased osmotic potential of soil c) specific ion toxicity d) leaf burn e) nutrient uptake interferences.

2) **Specific ion toxicity**

a) Sodium- The quality of irrigation water based on sodium is expressed as soluble sodium percentage. Its high value indicates soft water and low value indicates hard water. Use of SSP as quality parameter has become obsolete. Now better index called as sodium absorption ratio (SAR) is used developed by Richards (1954). SAR with less than 10 is safe for irrigation and values above 10 are moderate to unsafe.

b) Chloride- EC increases with chloride ion concentration. Chloride is harmful than sulfate. It is found to cause toxicity to certain tree crops.

c) Carbonate and bicarbonate- Higher bicarbonate content compared to calcium is considered harmful, since it precipitates calcium ions.. The effect of bicarbonate along with carbonate is evaluated by index called as Residual sodium carbonate (RSC) and calculated as below

$$RSC = [CO_3^{2-} + HCO_3^-] – [Ca^{2+} + Mg^{2+}]$$

Carbonate is present in trace amounts and does not exceed 1.0 $meql^{-1}$

d) **Magnesium –** Water with low salinity has calcium more than magnesium. It is observed that if Ca: Mg ratio>0.5, harmful effects on soil is noticed. Higher amount of Mg over Ca increases ill effect of sodicity. An index called as Sodium to calcium activity ratio (SCAR) was developed to evaluate Mg hazard

3) **Sodicity hazard**

Water may be good based on EC, may not be suitable if Na exceeds. Irrigation water with SAR not greater than 15 is considered good quality. SAR is given by the formula

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

Higher SAR water causes permeability problem to the soils. Infiltration rate is reduced such that plant is not adequately supplied with water and hence yield of crops is reduced. The application of SAR values to the group of waters which have EC> 5 dSm^{-1} and Mg/Ca ratio > 1 is questionable. So new ratio called as sodium to calcium activity ratio (SCAR) is calculated to find out Na problems

4) **Alkalinity hazard**

Alkalinity hazard is identified by following two expressions

1) Residual sodium carbonate (RSC) and 2) Residual sodium bicarbonate(RSBC)

Alkali soils could be developed when irrigation water contains higher amounts of CO= + HCO_3 than Ca^{2+} + Mg^{2+}. Calcium and magnesium present in soil is precipitated as carbonates when irrigated with water containing bicarbonates. The sodium reacts with residual bicarbonate to form sodium bicarbonate and converted to sodium carbonate on evaporation

Classification of water based on RSC is as follows

$RSC = [CO_3^{2-} + HCO_3^-] – [Ca^{2+} + Mg^{2+}]$

Category	RSC values(meql-1)
Probably Safe	< 1.25
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Not suitable	>2.5

Residual sodium bicarbonate (RSBC)

RSC concept was devised for fresh quality waters which have low EC and SAR. This water seldom contains appreciable amounts of carbonates unless the pH is> 8.5. Since bicarbonate does not precipitate Mg. Gupta (1984) suggested that RSC should be simply calculated as HCO_3 – Ca which is called residual sodium bicarbonate.

Management of poor quality waters

The following measures should be adopted for improvement and management of poor Quality water

1) Pretreatment of water:

If water contains excessive amounts of Na (>70%), bicarbonate (RSC > 5 $meql^{-1}$ or HCO_3> 8 mel^{-1}) and Mg (Mg/Ca ratio >4), It will induce sodicity. Hence water may either pretreated with gypsum by suitable method or gypsum is added directly to soil.

2) Fertilizer management:

Judicious use of fertilizer can increase crop yield in saline water irrigated areas. About 15% additional quantities of fertilizers (N, P) over the normal dose be applied. Ammonium sulfate or CAN is superior to urea due to less loss of N through gaseous loss and pH reducing tendency in root zone. DAP and super phosphate is better than rock phosphate. Response of fertilizers decreases as the salinity and SAR of water increases, so Fertilizers should be added @ 1.25- 1.5 times the normal rate of their application and in split application to improve the yields. Application of zinc @ 20kg ha^{-1} reduces the adverse effect of higher salinity and sodicity.

3) Agronomic management

Salts tend to accumulate closer to the soil surface and tend to move downwards with reclamation and irrigation. Deep ploughing will loosen the sub soil and reduce salinity. Mulching reduces salt accumulation on the surface. Planting technique like sowing on the slope of the ridge than flat sowing. Pitcher or drip irrigation is good when water quality is poor since it keeps soil moist. Quantity of water need for irrigation is calculated based on tolerance limit of crops, degree of salt accumulation in soil and quality of water used

4) Salt tolerance of crops

Sensitive crops like wheat, barley, cow pea, pearl millet totally fail to grow under high saline water. There are certain crops which can grow under high salt stress since it has certain specific characters which offer resistance to grow in saline water. Among leguminous crop Daincha is well known tolerance crop

5) Crop rotation

Crops vary in their water requirement as well as in frequency with which they need water. Crop with long duration of evapo transpiration will enhance much more salt accumulations compared to short duration crops. Crops like rice, alfa alfa, and berseem require frequent helps reclamation irrigation. A best crop rotation not only provided good return but also help to control salinity of growing soil. Generally rice as first crop after burial of green manures followed by an alkali tolerant crops

6) Soil incorporation of organic materials

Organic materials (organic manures and organic wastes) could be incorporated in soil for improving physical properties and lowering the pH, EC and SAR of soil irrigated with saline water. For sodic water, use of FYM along with gypsum is more beneficial

7) Cyclic use with good quality water

Under situation of limiting quantity of good water, saline water can be used for irrigation in conjunction with good water. Pre sowing and first irrigation after germination should be done with good quality water.

8) Treatment with amendments

In water containing excess sodium, gypsum can be used. On addition of gypsum, proportion of sodium to other ions is reduced.

7. **Discuss briefly the management of saline water for irrigation?**

Several physical, chemical and biological soil management measures help facilitate the safe use of saline water in crop production. Some important ones in this regard are: tillage, deep ploughing, sanding, use of chemical amendments and soil conditioners, organic and green manuring and mulching.

Tillage is a mechanical operation that is usually carried out for seedbed preparation, soil permeability improvement, to break up surface crusts and to improve water infiltration. If tillage is improperly executed, it might form a plough layer or bring a salty layer closer to the surface.

Deep ploughing refers to depths of ploughing from about 40 to 150 cm. Deep ploughing to 60 cm loosens the aggregates, improves the physical condition of these layers, increases soil-water storage capacity and helps control salt accumulation when using saline water for irrigation. Crop yields can be markedly improved by ploughing to this depth every three or four years.

Sanding is used in some cases to make a fine textured surface soil more permeable by mixing sand into it, thus a relatively permanent change in surface soil texture is obtained. When properly done, sanding results in improved root penetration and better air and water permeability which facilitates leaching by saline sodic water and when surface infiltration limits water penetration. The method can be combined with initial deep ploughing.

Chemical amendments are used to neutralize soil reaction, to react with calcium carbonate and to replace exchangeable sodium by calcium. Gypsum is by far the most common amendment for sodic soil reclamation, particularly when using saline water with a high SAR value for irrigation. Soil conditioners can have practical applications in seedling establishment when soil is irrigated with saline water of high SAR.

Mineral fertilizers: Salt accumulation affects nutrient content and availability for plants by adverse interactions between the salt present in saline water and fertilizers, decreasing fertilizer use efficiency. Crop response to fertilizer under saline or sodic conditions is complex since it is influenced by many soil, crop and environmental factors. The type of fertilizer applied, when using saline water for irrigation, should preferably be acid and contain Ca rather than Na taking into consideration the complementary anions present. Timing and placement of mineral fertilizers are important and unless properly applied they may contribute to or cause a salinity problem.

Organic and green manures and mulching: Incorporating organic matter into the soil has two principal beneficial effects of soils irrigated with saline water with high SAR and on saline sodic soils: improvement of soil permeability and release of carbon dioxide and certain organic acids during decomposition. This will help in lowering soil pH, releasing calcium by solubilization of $CaCO_3$ and other minerals, thereby increasing EC_e and replacement of exchangeable Na by Ca and Mg which lowers the ESP. When using saline water where the concentration of soluble salts in the soil is expected to be high in the surface, mulching can considerably help leach salts, reduce ESP and thus facilitate the production of tolerant crops. Thus, whenever feasible, mulching to reduce the upward flux of soluble salts should be encouraged.