LESSON PLAN

COURSE NO: SSAC – 242

Course Title: Problematic Soils and their Management

Course Credits:2 (1+1)

SEMESTER IV (New)

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Course Title: Problematic Soils and their Management(B. Sc. (Agri.)
Course No. : SSAC- 242Semester: IV (New)   Credit:2 (1+1)

Teaching Schedule

a) Theory

Lecture No.	Topic	Weightage (%)
1-2	**Soil degradation: Concept, types, factors and processes. Soil quality and soil health: definition and concept, Soil Quality Indicators.Characteristics of healthy soils.**	**6**
3-4	**Distribution and extent of waste land and problematic soils in India and Maharashtra.Categorization of problem soils based on soil properties.**	**6**
5-6	**Saline soils, alkali Soils, saline-alkali soils, degraded alkali soils, coastal saline soils: definition, formation, characteristics, effect on plant growth reclamation and management. Acid and Acid Sulphate Soils: definition, formation, characteristics, effect on plant growth, reclamation and management.**	**12**
7-8	**Calcareous Soil: definition, formation, characteristics, effect on plant growth, reclamation and management.**	**8**
9	Eroded soils and Compacted Soils: definition, formation, characteristics, effect on plant growth, reclamation and management.	6
10	Submerged Soils and flooded Soils: definition, formation, characteristics, effect on plant growth, reclamation and management.	10
11	Polluted soils: definition, sources and their remediation.	10
12	Water pollution : definition, sources and their remediation	6
13	Quality of Irrigation water and its suitability for irrigation	6
14	Utilization of Saline and sewage water in Agriculture	6
15	Remote sensing and GIS in diagnosis and Management of Problem soils	6
16	Multipurpose tree species and Bioremediation of Soils	6
17	Land capability classification and Land suitability Classification	6
18	Problematic Soils under different Agro-ecosystem	6

b) Practical

Experiment	Topic
1 & 2	Preparation of saturation paste extract.
3	Determination of pHe and ECe.
4 & 5	Determination of cations(Ca,Mg, Na and K) and computation of SAR
6 & 7	Determination of ESP of soils.
8	Determination of ESP of soils.
9	Determination of calcium carbonate from soil.
10	Determination of lime requirement of acidic soil.
11	Collection of irrigation water and sewage water.
12	Determination of Ph and EC from irrigation water.
13 & 14	Determination of cations (Ca, Mg, Na and K) from irrigation water.
15 & 16	Determination of anions (CO_3, HCO_3, Cl and SO_4) from irrigation water and computation of RSC and SAR.
17	Determination of BOD and COD.
18	Satellite image analysis by visual method.

Suggested Reading

1) Richards L. A. 1954. Diagnosis and Improvement of Saline and Alkali soils.United State Department of Agriculture.
2) Maliwal, G.L and Somani L.L. 2010.Nature Properties and Management of saline and alkali soils.Agrotech Publishing Academy, Udaipur.
3) Mahendran *et al* Soil Resource Inventory and Management of problematic soils.Agrotech Publishing Academy,Udaipur.
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7) Dey,P. and Gupta S.K.2012. Diagnostics, Remediation and Management of Poor Quality Waters: Lectures for Summer School by R.L.Meena, S.K.Gupta, R.K.Yadav and D.K.Sharma.2011.Salinity Management for Sustainable Agriculture in Canal

Commands.Published by CSRI.,Karnal.
8) Twenty five Years of Research on Management of Salt Affected Soils & Use of Saline Water in Agriculture.1998.Published by CSRI, Karnal.
9) Patil V.D. and Mali, C.V.2007 Fundamentals of Soil Science,Aman PublicationMeerut.
10) Das, D.K.Introductory Soil Science.
11) Brady,N.C. 2016.The Nature and Properties of Soils.15 edn.
12) The Chemisty of Soil – Firman Bear
13) Text Book of Pedology Concepts and Applications-J.Sehgal
14) FAO United Nations Soils Portal.
15) Fundamentals of Soil Science- ISSS Publication.
16) Management of Degraded Lands and Soil Health-Verma,Trivedi,Singh and Tomar
17) Management of Saline Soils and Waters –S.K.Gupta and I.C.Gupta
18) Management of Salt affected Soils and Waters- L.L.Somani and K.L.Totawat

Lesson Plan1-2

Topic:Soil degradation: Concept, types, factors and processes. Soil quality and soil health: definition and concept, Soil Quality Indicators.Characteristics of healthy soils.

Land/Soil degradation: refers to decline in a soil's inherent capacity to perform environmental and socio-economic functions.

Degraded soil: Soils having unfavorable physicochemical and biological condition that it is unsuitable for agriculture production unless reclaimed.

Types of land degradation: Grouped in six classes 1. Water erosion 2. Wind erosion.3. Soil Fertility decline.4. Salinization 5. Water logging 6. Lowering of the water table.

1. **Water erosion** : Covers all forms of soil erosion by water, including sheet and rill erosion and ravening. Human-induced intensification of land sliding caused by vegetative clearance.
2. **Wind erosion**: Refers to loss of soil by wind, occurring primarily in dry regions.
3. **Soil fertility decline**: Refers to what is more precisely described as deterioration in soil physical, chemical and biological properties.
4. **Water logging**: Refers the lowering in land productivitythrough the rise in ground water close to the soil surface .
5. **Salinization**: is used in the broad sense,to refer to alltypes of soil degradationbrought about by the increase of salt in the soil.
6. **Lowering of the water table**: It is self-explanatory form of land degradationbrought about through tube well pumping of ground water for irrigation exceeding the

natural recharge capacity,

Causes of degradation:

1.Deforestation 2. Overgrazing 3.Agricultural practices 4.Over exploitation of the vegetative cover and 5.Industrial activities.

Processes of soil degradation that result in degradation of soil physical properties include:

1.Surface crusting and compaction through the impact of raindrops, animal hooves and farm machinery;

2.Loss of topsoil structure through excessive tillage and loss of soil organic matter;

3.Sub-soil compaction due to the passage of heavy farm machinery and/or ploughing to a constant depth.

Processes that result in degradation of soil hydrological properties include

1.Water logginginvolving a rise in the water table close to the soil surface due to poor irrigation practices, or loss of deep rooted vegetation whose water needs would have kept the water table low; and

2.Aridification involving a decrease in soil moisture availability, typically due to reduced rain water infiltration following deterioration in the soil's physical structure.

Processes that result in degradation of soil chemical properties include:

1.Decline in the number and availability of soil nutrients (N,P,K, secondary and trace elements) e.g. through leaching, gaseous losses, removal in harvested products etc.

2.Chemical imbalances and toxicities e.g. through application of inappropriate types and quantities of fertilizer, pesticides etc.;

3.Changes in soil pH (acidification or alkalinization);

4.Stalinization(build up of salts through poor irrigation practices in crop lands and poor grazing practices in grasslands);

5.Chemical pollution from over use of agro-chemicals, plastic mulches or poor management of industrial and mining wastes.

Processes that result in degradation of soil biological properties include:

1.Reduction in the numbers or activity of beneficial soil organisms such as bacteria, rhizobia, mycorrhiza, earth worms, termites etc;

2. Increase in the numbers and activity of harmful soil organisms such as nematodes, parasitic weeds etc.

Soil quality can be defined as the fitness of a specific kind of soil, to function within its capacity and within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (Karlen et al. 1997, Arshad and Martin 2002).

Soil health defined as the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, maintain or enhance the quality of air and water, and promote plant, animal and human health (Doran et al. 1996, 1998, Doran and Zeiss 2000).

Concept:

To some, the concept of soil quality seems unnecessary and redundant among the soil science profession. After all, "everyone" knows what constitutes good soil and where good soils are found. To others, quantifying soil quality is impossible because of "natural differences" among soil orders and even between the same soil series found in different places. One reason for these opinions is that the process of evaluating soil is not new. As noted by Warkentin (1995), evaluations for crop growth appear in the first written literature and certainly predate those records. Keen (1931) reported on studies made with regard to draft requirements for tillage and the fitness of soils as seedbeds for crop production. Productivity indices based on plant-available water capacity, bulk density, acidity, and a factor for plant root distribution were developed (Pierce et al., 1983, 1984) and used to evaluate soil erosion effects on crop productivity throughout the Midwest. To facilitate the use of soil maps and classification information, soil survey interpretations have been written to predict the behavior of each soil under defined situations.

Why do we need soil quality concept?

1. To address the problems of non agricultural areas of soil (eg. Mine land restoration, urban uses and disposal of urban waste, soil contamination and pollution by industrial activities)

2.To develop appropriate indicators of soil quality in relating to specific soil function

(eg. Agricultural, urban, industrial, recreational, asthetic, environmental and waste disposal)

Soil Health -

Soil quality indicators in soil health assessment

Soil quality indicators to evaluate how well soil functions since soil function often cannot be directly measured. Measuring soil quality is an exercise in identifying soil properties that are responsive to management, affect or correlate with environmental outcomes, and are capable of being precisely measured within certain technical and economic constraints. Soil quality indicators may be qualitative (e.g. drainage is fast) or quantitative (infiltration= 2.5 in/hr).

Ideal indicators should:

1. Correlate well with ecosystem processes.2.Integrate soil physical, chemical, and biological properties & processes.3.Be accessible to many users.4.Be sensitive to management & climate.5.Be components of existing databases.6.Be interpretable

There are three main categories of soil indicators: chemical, physical and biological. Typical soil tests only look at chemical indicators. Soil quality attempts to integrate all three types of indicators. The categories do not neatly align with the various soil functions, so integration is necessary. The table below shows the relationship between indicator type and soil function.

Indicator category	Related soil function
Chemical	Nutrient Cycling, Water Relations, Buffering
Physical	Physical Stability and Support, Water Relations, Habitat
Biological	Biodiversity, Nutrient Cycling, Filtering

Organic matter, or more specifically soil carbon, transcends all three indicator categories and has the most widely recognized influence on soil quality. Organic matter is tied to all soil functions. It affects other indicators, such as aggregate stability (physical), nutrient retention and availability (chemical), and nutrient cycling (biological); and is itself an indicator of soil quality.

Some indicators are descriptive and can be used in the field as part of a health card.

Others must be measured using laboratory analyses. Some examples of indicators that fall into the three broad categories of chemical, physical and biological, are provided below.

Indicator Categories

Chemical indicators can give you information about the equilibrium between soil solution (soil water and nutrients) and exchange sites (clay particles, organic matter); plant health; the nutritional requirements of plant and soil animal communities; and levels of soil contaminants and their availability for uptake by animals and plants. Indicators include measures of: 1. Electrical conductivity 2.Soil Nitrate 3.Soil reaction (pH).

Physical indicators provide information about soil hydrologic characteristics, such as water entry and retention that influences availability to plants. Some indicators are related to nutrient availability by their influence on rooting volume and aeration status. Other measures tells us about erosional status. Indicators include measures of:

1.Aggregate stability.2.Available water capacity.3.Bulk density.4.Infiltration.5.Slaking.6.Soil crusts.7.Soil structure and macropores

Biological indicators can tell us about the organisms that form the soil food web that are responsible for decomposition of organic matter and nutrient cycling. Information about the numbers of organisms, both individuals and species, that perform similar jobs or niches, can indicate a soil's ability to function or bounce back after disturbance (resistance and resilience). Indicators include measures of:

1.Earthworms.2.Particulate organic matter.3.Potentially mineralizable nitrogen4.Respiration.5.Soil enzymes.6.Total organic carbon

Characteristics of healthy soils.

1. Good soil tilth 2. Sufficient supply, but not excess of nutrients.3. Small pollution of plant pathogens and insect pest.4. Large population of beneficial oragnisum.5. Large population of beneficial organism.6. Low weed pressure.

Lesson Plan 3 and 4

Topic:Distribution and extent of waste land and problematic soils in India and Maharashtra.Categorization of problem soils based on soil properties.

Distribution of salt affected soils in India

According to the estimates of Central soil salinity Research institute (CSRI, Kanal) such soils are occupy about 10 M ha, of which a major fraction (2/3) is sodic in nature and occurs in the indo Gangetic plain, followed bt the Deccan (Paninsula) plateau dominantly supporting Black (Cotton) Soils; the rest (1/3) largely occurring in the semi-ariedand aried coastal regions are saline. The saline –sodic soils recently termed as sodic) of the Indo-ganetic plain receive an annual rainfall ranging from 500-800 mm. The saline soils on the other hand receive an annual rainfall of less than 500 mm except in the coastal area. The worst affected states are Gujrat, Rajasthan, Haryana, U.P. and Bihar (for sodicity) and the coastal region (for salinity).

Table 1 – Distribution of salt affected soils in India.(Lakh ha)

Sr. No.	State	Water Eroded	Wind eroded	Water logged	Saline and alkali soils	Degraded forest soil	Total
1	Andhra Pradesh	74.42	--	3.39	2.40	37.34	117.55
2	Assam	9.35	--	--	--	7.95	17.30
3	Bihar	38.92	--	1.17	0.04	15.62	55.75
4	Gujarat	52.35	7.04	4.84	12.14	6.83	83.20
5	Haryana	2.76	15.99	6.20	5.26	0.74	30.95
6	Himachal Pradesh	14.24	--	--	--	5.34	19.58
7	J & K*	5.31	--	0.10	--	10.34	15.75
8	Karnataka	67.18	--	0.10	4.04	20.43	91.75
9	Kerala	10.37	--	0.61	0.16	2.26	13.40
10	Madhya Pradesh	127.05	--	0.57	2.42	71.95	201.99
11	Maharashtra	110.26	--	1.11	5.34	28.41	145.12
12	Manipur	0.14	--	--	--	14.24	14.38
13	Meghalaya	8.15	--	--	--	11.73	19.88
14	Nagaland	5.08	--	--	--	8.78	13.86
15	Orissa	27.53	--	0.60	4.04	32.27	64.44
16	Punjab	4.63	--	10.90	6.88	0.79	23.2
17	Rajasthan	66.59	106.23	3.48	7.28	19.33	202.91
18	Sikkim	1.31	--	--	--	1.50	2.81
19	Tamil Nadu	33.88	--	0.18	0.04	10.09	44.19
20	Tripura	1.08	--	--	--	8.65	9.73
21	Uttar Pradesh	53.40	--	8.10	12.95	14.26	88.71
22	West Bengal	13.27	--	18.50	8.50	3.59	43.86
23	Union teritories	8.73	--	0.01	0.16	27.15	39.05
	Total (ha)	736.00	129.26	59.86	71.65	358.89	1355.57

Verma *et al* (2015): In Management of Degraded Lands and Soil Health,pp.06

Distribution of Acid soils.

Out of 157 M ha of cultivable land in India, 49 M ha of land are acidic of which 26 M ha of land having soil pH <5.6 and the rest 23 M ha land having soil pH range 5.6-6.5.

Distribution of degraded and wasteland soils in Maharashtra.

Soils: Soils of the state belong to 5 orders and 8 great groups. Entisols (37%),Inceptisols (31%), and Vertisols (26%) are the predominant soils, followed byAlfisols (6%) and Mollisols (<1%). The different great groups are: Rhodustalfs, Haplustalfs, Haplustoll, Ustifluvents, Ustorthents, Halaquepts, Ustropepts, andChromusterts or left as culturable waste; 12% of the cultivated area is irrigated. Croppingpattern includes rice-wheat, rice-mustard and rice-chickpea. Cotton is grown in Vidarbha. Sugarcane is grown in western Maharashtra. Presently soybeanhas been adopted as a cash crop by many farmers. Nashik and Pune districts arefamous for vegetables, onion and grape production.

Degraded and Wastelands soil erosion coupled with soil acidity is a major problem in westernMaharashtra, and soil erosion is a major problem in Vidarbha region. In this state, about 8,822 thousand ha (about 29% of TGA) is affected bywater erosion including erosion under open forest. Highly affected districtsare Nashik (836 thousand ha), Ahmednagar (806 thousand ha), Pune (788thousand ha), Solapur (683 thousand ha), Sangli (616 thousand ha), Raigad (570thousand ha), and Ratnagiri (543 thousand ha).Total area under acidic soils (including areas affected by water erosion)covers 269 thousand ha. The Sindhudurg district has an area of 172 thousand ha,followed by Ratnagiri (64 thousand ha) and Kolhapur (21 thousand ha).

Highestareas under sodic soils are found in Ahmednagar district (265 thousand ha). Otheraffected districts are Nashik (40 thousand ha), Aurangabad (31 thousand ha), Pune(26 thousand ha) and Solapur (20 thousand ha).

Problematic Soil: These soils need proper reclamation and management measures for their economical use in crop production. Broadly these soils are grouped in two sets.

First set has problem in physical characteristics and includes highly eroded soils, ravine land, soil on steeply sloping lands, highly permeable coarse textured soil, slowly permeable heavy texture soils, crusting soil and red chalka soils

The second set includes all the soils which have problem in their chemical characteristics. Acid, saline, saline-alkali soil and alkali soil constitute this set.

Classification of problem soils based on properties

Physical Characteristics   Chemical
Characteristics
Highly eroded soils
Sloping lands
Ravine land
Highly permeable coarse textured soil
Slowly permeable heavy texture soils
Crusting soil
Red chalka soils
Peat Soil
Submerged Soils

Acid Sulphate Soils   Acid Soils   Calcareous Soil   Salt Affected
Soil

Saline Soil   Saline- alkali soil   Alkali
soil

Lesson 5 and 6

Topic : Saline soils, alkali Soils, saline-alkali soils, degraded alkali soils, coastal saline soils: definition, formation, characteristics, effect on plant growth reclamation and management. Acid and Acid Sulphate Soils: definition, formation, characteristics, effect on plant growth, reclamation and management.

Alkaline soils:Alkaline soils have pH above 7. Soil alkalinity may be due to high base saturation, particularly with sodium and to the presence of free carbohydrates of calcium and sodium. In soils of arid and semiarid regions, lack of extensive leaching leaves the leaves of bare forming cations quite high. Such soils contain excessive concentration of soluble salts, or exchange sodium or both. Due to which they are regarded as problem soils or soil affected soils. Depending upon the nature of soluble salt such soils are classified into three groups 1. Saline soils 2. Saline-alkali soils (saline-sodic) 3. Alkali soils (sodic soils) (non saline alkali).

Saline soils: Saline soils have electrical conductivity of saturation extract more than 4 dS m^{-1} at 25^0C and exchangeable sodium percentage is less than 15 and the pH is less than 8.5. These soils correspond to Hilgard's (1906) white alkali soils and to solonachak's of the Russian soils scientists. The soluble salts are mainly of Na^+, Ca^{++} and Cl and SO_4^{-2}.

Saline alkali soils: Saline-alkali soils have the electrical conductivity of saturation extract greater than 4 dS m^{-1} at 25^0C and the exchangeable sodium percentage greater than 15 and the pH of the soil about 8.5, contain neutral soluble salts and exch. Na ions. The salts are Cl; Sulphates Ca $^{++}$, Mg^{++}, Na^+,K^+¬¬. There can be all stages with varying degree of dominance of salt content, highpH.

Alkali soils: Alkali soils have electrical conductivity of saturation paste extract less than 4 dS m^{-1} at 25^0C and exchangeable sodium percentage more than 15. The pH ranges between 8.5 to 10. These soils correspond to Hilgards Black alkali soils and in some cases Solonetz, of the term used by Russian Scientists. High SAR, Presence of large come of sodium carbonate, type salts, and soils may be alkaline but not necessarily alkali.

Nature and classification of salt affect soils

1. **Saline soils**
2. **Alkali Soils**

a) Saline –Alkali Soil

b) Non saline Alkali Soil

c) Degraded Alkali soils

Characteristics of Salt affected soils

1. **Saline Soils** – Soils contains chloride, sulphates, bicarbonates and sometimes nitrates of sodium.

   ESP is very low (< 15).

   pH varies between 7.5 to 8.35.

   Total soluble salts content is > 0.1 %.

   EC >4 dSm^{-1}.

   These soils remain flocculated condition**.**

Characteristics of Alkali/ Sodic soils

A) Non Saline Alkali Soils

1. ESP is > 15.
2. pH ranges from 8.5 to 10.
3. Total Soluble Salt is < 0.1 %.
4. EC < 4.0 dSm^{-1}.
5. Colloidal complex is deflocculated condition.
6. SAR is > 13.

B) Saline – Alkali Soils

1. ESP is > 15.
2. pH is > 8.5.
3. Total soluble salt > 0.1 %.
4. EC > 4.0 dSm^{-1}.

C) Degraded Alkali Soils

1. pH of surface layer is acidic and lower layer has high pH > 8.5.
2. ESP > 15.
3. EC < 4.0 dSm^{-1}.
4. Black colour and has prism like structure.
5. Soil become compact and has low infiltration.

Formation of Saline Alkali Soils

1. Arid and semiarid region.
2. Poor drainage.
3. High water table.
4. Over flow of sea water over land.
5. Introduction of irrigation water.
6. Salts blown by wind.
7. Saline Nature of parent rock material.
8. Excessive use of basic fertilizers.
9. Humid and semi humid region.

Detrimental Effect of soil Salinity and Alkalinity

1. Saline Soils

A) Absorption of water and nutrients.

B) Salt toxicity.

2. Alkali Soils

A) Dispersion of Soil particles.

B) Physical properties of soil.

C) Availability of plant Nutrients.

Reclamation of Saline and Alkali Soils

Saline Soils

A) **Mechanical Methods**

1. Flooding and leaching down of the soluble salts.
2. Scrapping of the surface soil.

B) **Cultural Methods**

1. Providing proper drainage.
2. To use of salt free irrigation water
3. Proper use of irrigation water.
4. Planting or sowing of seed in the furrow.
5. Use of acidic fertilizers.
6. Use of organic manures.
7. Ploughing and levelling of land.
8. Retardation of water evaporation from the soil surface.
9. Growing of salt tolerant crops.

Alkali Soils

A) Chemical Methods

1. Application of Gypsum and Gypsum requirement.
2. Use of sulphur.
3. Addition of sulphuric acid.
4. Addition of Organic Matter.
5. Addition of molasses.

Cultural Methods / Management practices

Water Management and cropping system are very important.

1. Solution of salt tolerant crops and crop varieties.
2. Adoption of best suited cultural and fertilizer practices.

Salt tolerant crops

High salt tolerant: Barley, Sesabania, rice, sugarcane, oats, berseem, lucern.

Medium salt tolerant: Castor, cotton, sorghum, pearl millet, maize, mustard, wheat.

Low salt tolerant: Pulses, pea, sunhemp, gram, linseed, sesamum.

Scale of conductivity for salt tolerance of plants 0-2 dSm^{-1}

No effect of crops (2-4 dSm^{-1}). Sensitive crop restricted 4-8 dSm^{-1}. Many crops restricted (8-16 dSm^{-1}) Most crops restricted 16-12 dSm^{-1}.Few crops tolerant.

Formation of saline-alkali soils

1. The salts are accumulated in some surface soils of arid and semiarid regions.
2. These soils are formed due to combined process of salinization (Process of accumulation of neutral soluble salts) and alkalization (Process whereby exchangeable sodium content is increased).
3. Leaching of sodic soil will raise pH, unless calcium and magnesium salts are high in soil pH increases occurs due to removal of neutral soluble salts and exchangeable sodium hydrolyses and sharply increase OH ions concentration, pH rises above 8.5.

Effects of plant growth

Plants suffer due to high salinity as well as due to high alkalinity. High alkalinity resulted in dispersion of clay.

Reclamation of saline alkali soils :

Sodium from exchange complex should be removed, then washing of salts with good quality water.

Formation of alkali or sodic soils (None saline alkali)

Three distinct stages in the evaluation of alkali soils are :

1. Salinization 2. Saline alkali soil 3. Alkalinisation of the exchange complex. Salt accumulation is the first stage. Major cation is sodium. The process in the formation of sodic soil is the result of exchange of cations in soil solution with those present on the exchange complex of the soil. The conditions which result in increase of SAR of soil solution lead to the formation of sodic soil. Sodic soils occur generally in relatively low lying with insufficient natural drainage. The displayed calcium from the exchange complex precipitates at a high pH. The process repeated over long period results in the formation of sodic soils.

Reclamation of sodic or Alkali soils

The problem of sodic soil is the high ESP. Replacement of exchangeable sodium by calcium and leaching out of sodium salts from root zone are important. Use of amendments and adequate drainage and leaching are basic requirements for reclamation of sodic soils. Scrapping and growing salts tolerant crops are not suitable for reclamation of alkali soils.

Amendments used for reclamation of sodic soil

1. Soluble calcium salts : Gypsum and calcium chloride – Reaction with equation.
2. Acids or acidic formers :Sulphur, Sulphuric acid, iron sulphates, iron pyrites with equations.

Gypsum requirement :

The amount of gypsum required to be added to a sodic soil to lower the ESP to desired value is known as gypsum requirement (Milliequivalent of Ca/100 g of soil).

Management practices :

1. Proper choice of crop viz. salt tolerant crops
2. Green manuring and orgnaic manures.
3. Proper crop rotation
4. Optimum use of good quality irrigation water

Effect of alkali soil on plant growth

1) Loss of desirable soil structure
2) Effect of physical properties viz. Reduced drainage, aeration and microbial activity.
3) Reduced solubility and availability of macro and micro nutrients.

Coastal saline soil:is the soil which its amount of salinity is high enough to be dangerous for economic crops. Such soil is found in the coastal area where the sea is reached.

Problems existing in coastal saline soils:

1. The lands are subjected to the influence of tidal waves and periodical inundation by tidal water.

2.Shallow water table enriched with salts contributes to increase in soil salinity during winter andsummer months.

3.Heavy rainfall except in some part of Gujarat.

4. Poor surface and subsurface drainage conditions.

5. Lack of good quality irrigation water during dry period in certain areas.

Development of soil salinity in coastal lands

The processes responsible for the development of soil salinity in coastal areas are :

1. Sea water inundation is one of the processes by which soil salinity develops in the coastal regions.

2. Use of saline ground water for crop production also causes soil Stalinization in many areas.

3.Whereever ground water is saline, high water table during the post monsoon season, brings up dissolved salts in the root zone through capillary rise.Salinization process is most active during the summer season.

4.Deposition of wind borne salts.

Management of coastal saline soils

1.Soil management – a. Soil erosion b.Leaching of salts

2.Engineering management – a.Height of embankments b.Structural design of sea dikes c.Embankment construction d.Other activities.

3.Water management – a. Surface drainage b.Storage and recycling on rain water for summer cultivation c. Tapping the creeks d. Use of ground water for crop production.

4.Crop management – a. Cropping system b.Farming system c.Agronomic and cultural practices d. Improved irrigation practices e. Mulching

5. Fertility Management – Nitrogen, phosphorus, Potassium and micronutrients etc

Acid Soils – A soil having dominance of hydrogen (H^+) and aluminium (Al^{3+}) relative to hydroxyl (OH^-) ions is called as acid soil. Acid Soil is a base unsaturated soil which gives the soil to a pH lower than 7.0

Kinds of acidity – a)Active acidity (Potential acidity),

b) Exchangeable acidity,

C) Residual (Reserved) acidity**.**

Characteristics of acid soils

1. Low pH and high proportion of exchangeable Aluminium and Hydrogen.
2. Dominant in Kaolinitic and Illitic types of clay minerals.
3. Low base saturation and CEC.
4. Low in available P.

5. Microbial imbalance and effect on BNF.

Formation (sources) of acid soils

1. Carbon dioxide.
2. Acid forming fertilizers.
3. Acid parent material and sulphur.
4. Plant roots and Humus.
5. Leaching due to heavy rainfall.
6. Acid rains.
7. Removal of bases by crops.
8. Hydroxides.

Management of acid Soils

Lime Requirement – is defined as the amount of liming material that must be added to raise the soil pH to some prescribed value.

Influence of liming material on soil properties in relation to plant nutrition

Direct Effect : 1.Toxicity of Al and Mnand reduced uptake and Mg.

2. Removal of hydrogen ion.

Indirect Effect

1. Phosphorous availability.
2. Micronutrient availability.
3. Nitrification.
4. Nitrogen fixation.
5. Soil physical condition.
6. Diseases.
7. Efficiency of fertilizers.

Acid Sulphate Soils – Soil with sufficient sulphides (FeS2 and others) to become strongly acidic ($pH < 3$) when drained and aerated enough for cultivation are termed acid sulphate soils, also called as cat clays.

Types of acid sulphate soils

Potential acid sulphate soils

ASSwhich have not been oxidized by exposure to air are known as potential acid sulphate soils (PASS). They are neutral in pH (6.5-7.5),contain unoxidised iron sulfides,are usually soft,sticky and saturated with water and are usually gel like muds but can include wet sands and gravels have the potential to produce acid if exposed to oxygen.

Actual acid sulphate soils

When PASS are exposed to oxygen,the iron sulfides are oxidized to produce sulfuric acid and the soil becomes strongly acidic (usually below pH4.0).These soils are then called actual acid sulphate soils (ASSS).They have a pH of less than 4.0,contain oxidized iron sulfides, vary in texture and often contain jarosite (a yellow mottle produced as a by-product of the oxidation process).

Occurance in India

Soil with sufficient sulphides (FeS_2 and others) to become strongly acidic when drained are termed acid sulphate sols 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 Phand 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,Orissa,Andhra Pradesh,Tamil Nadu and West Bengal.

Formation of Acid sulphate soils :

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 is oxidized to sulphate by a combination of chemical and bacterial action,forming sulphuric acids.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 is present,the oxidized iron accentuates the acidity but not as much as aluminium in normal acid soils because the the ion oxides are less soluble than aluminium oxides and so hydrolyze less.

Characteristics of Acid sulphate soils : Acid sulphate soils contain sulphuric horizon which has a Ph of the 1: 1 soil: water ratio of less than 3.5,plus some other evidences of sulphidecontent (yellow colour).Sulphaquepts,Sulphihemists,Sulphohemists andSulphaquents greatgroups are included in acid sulphate soils.Such strong acidity in acid sulphate soils results toxicities of aluminium and iron,soluble salts,manganese and hydrogen sulphide gas.Hydrogen sulphide often formed in low land rice soils causing akiochi diseae that prevents rice roots from absorbing roots.

Management of Acid sulphate soils

1. Keeping the area flooded.
2. Controlling water table.
3. Liming and leaching.

Lesson 7 and 8

Topic: Calcareous Soil: definition, formation, characteristics, effect on plant growth, reclamation and management.

Definition :

Soil containing sufficient free $CaCO_3$ and/or $MgCO_3$ to effervesce visibility treated with cold 0.1 N HCl. Scale to know calcareousness (NBSS LUP).

Class	% $CaCO_3$
Non calcareous	Nil
Slight	< 5
Moderate	5-15
Strong	> 15

Formation

1.Insufficient precipitation.

2.Precipitation of Calcium and Magnesium as Calcium Sulphate or Carbonate and Magnesium Sulphate or Carbonate.

3. This precipitation gradually increases and accumulates in the soil at varying depth, depending upon the penetration of rainwater.

Characteristics ofCalcareous Soils

1.The clay complex is base saturated and calcium forms the predominant exchangeable base.

2.The soils are highly buffered in presence of water.

3.The soil reaction is slightly to moderately alkaline(pH 7.5 to 8.5)

Effects on plant growth

1.Accumulation of $CaCO_3$ forms hardpan by cementing the soil particles. The hardpan is usually impermeable and is very often cause of water logging.

2.Responsible for physiological disorders - Iron chlorosis can be a problem with some crops on high-pH, calcareous soils. Sorghum and soybeans are more affected by iron chlorosis than corn, wheat, or alfalfa. Marked differences in tolerance of calcareous soils also exist among horticultural crops.

3.Depressing effect on absorption of nutrients

Management of calcareous soils

Improvement of calcareous in $CaCO_3$ is present in problematic amount may be done by improving the drainage, sub soiling for breaking the hardpan formed due to $CaCO_3$ accumulation at lower depths and leaching. Also acid forming substance like S, Fe, SO_4, Al_2 (SO_4) may be used followed by leaching.

1. Calcareous soils are those that contain enough free calcium carbonate (CaCO3) and give effervescence visibly releasing CO_2 gas when treated with dilute 0.1 N hydrochloric acid. The pH of calcareous soil is > 7.0 and also regarded as an alkaline (basic) soil.
2. Fertilizer management in calcareous soils is different from that of non calcareous soils because of the effect of soil pH on soil nutrient availability and chemical reactions that affect the loss or fixation of some nutrients. The presence of $CaCO_3$ directly or indirectly affects the chemistry and availability of nitrogen (N) Phosphorus (P), Magnesium (Mg), Potassium (K), Manganese

(Mn), Zinc (Zn) and iron (Fe). The availability of copper (Cu) also is affected.

3. Application of acid forming fertilizers such as ammonium sulphate and urea fertilizers, sulphur compounds, organic manures and green manures is considered as effective measures to reduce the pH of soil to neutral pH value.
4. Elemental sulfur is one amendment that can be used to lower the pH of a calcareous soil. Even sulfur will take some time to be effective. Elemental sulfur is microbially converted in the soil to sulfate, and soil acidification is a by -product of this process. This acidity reacts with the excess lime to neutralize the soil. Unfortunately, it takes quite a bit of elemental sulfur to neutralize the excess lime in a calcareous soil. A soil with one percent excess lime would have 20,000 pounds of excess lime per acre in the top 6-7 inches of soil. This would mean 6,600 pounds of elemental sulfur per acre would be needed. At $0.30 to $0.40 per pound, this is not economical in most agronomic situations. Many of the calcareous soils causing severe chlorosis on grain sorghum and soybeans have more than one percent excess lime.

Lesson Plan 9

Topic: Eroded and Compacted Soils; definition, formation, characteristics, effect on plant growth, reclamation and management.

Soil Erosion – The detachment and transportation of soil mass from one place to another through the action of wind, water in motion or by the beating action of rain and biotic factors.

Factors causing Soil Erosion

1. Soil
2. Water
3. Wind
4. Biotic

Effect of Soil erosion

1. Loss of soil to support the growth of plant.
2. Deposition sediments, loads causing reverse to change course.
3. Variable seasonal flow of rivers and flooding.
4. Water pollution.
5. Air pollution.

Soil Erodibility Factors and Definition

Control measures of soil erosion

A) Biological Methods

1. Good crop management.
2. Crop rotation.
3. Cover crops to stabilize slope.
4. Strip planting.
5. Mulching.
6. Correct stalking rate of pastures.
7. Use of trees and hedges as a wind breaks.

B) Cultivation Practices

1. Contour ploughing.
2. Use of graded furrows.
3. Minimum tillage.

C) Mechanical Protection

1. Graded channel.
2. Absorption terrace.
3. Bench terrace.
4. Irrigation terrace.

Soil Compaction

Soil compaction is the process in which soil particles are packed together in a closer state of contact indicated by a change in bulk density, porosity etc.

Changes occurred due to soil compaction

1. Compression of soil solids.
2. Compression of liquid and gases.
3. Changes in liquid and gas contents in the pore space(both macro and micro pore spaces).
4. Re-arrangement of soil solids.

Soil Cracking- It has high relationship with the phenomenon of the shrinkage which arises due to expansion and contraction of soil mass.

Soil Crusting – It is phenomenon associated with deterioration of soil structure, where the natural soil aggregates break and disperse.

Influence of soil crusting on soil productivity

1. Serious barrier for seedling emergence
2. Crust clogs the surface macro pores and inhibits the rate of infiltration of water in the soil causing runoff.
3. Loss of water storage in soil profile and less availability of water to plants
4. Causes interill soil erosion
5. Lack of soil aeration

Control of soil crusting

1. Surface mulch
2. Addition of organic matter
3. Application of soil conditioners i.epolyionic conditioners like HPAN (Hydrolyzed poly acrylonitrile), VAMA (Vinyl acetate maleic acid copolymer)and non soil conditioner like polyvinyl alcohol (PVA).
4. Application of gypsum, pyrite in sodic soil, lowering of exchangeable sodium percentage minimizes crust formation.
5. A light tillage while the soil is still moist break up the crust before it hardens.

Lesson Plan10

Topic: Submerged and Floodedsoils: definition, formation, characteristics, effect on plant growth, reclamation and management.

Upland Soil –The soil which is in oxidized condition for the greater part of the growing season.

Submerged soil – These soils are referred to soils that are saturated with water for sufficiently long time annually to give the soil the distinctive gley horizons resulting from oxidation – reduction process having high water table.

Changes occurring in submerged soil

a) Depletion of Oxygen.
b) Accumulation of CO_2.
c) Electrochemical changes i) pH ii) Redox potential iii) Specific conductance.
d) Nitrogen transformation: Mineralization accumulation of NH_3. Losses of N_1
   (i) Denitrification 2 NO_3, 12 H^2 + 10e = N_2 + 6 H_2O_4 (ii) NH_2 Volatilization and
   (iii) leaching losses.
e) Phosphorus transformation :
f) Iron, Sulphur and Manganese reduction.

(Oxidation) (Reduction)

$MnO_2 + 4H + 2e = Mn^{2+} + 2H_2O$

$Fe(OH)_3 + e_+ = Fe(OH)_2 + OH^{-2}$

$SO_4^{2+} + 2H_2O + 2e^+ = SO_3^{2+} + 2OH^{-2}$

$SO_4^{2+} + 3H_2O + 6e^+ = S^{2+} + 6OH^{-2}$

Formation of sulphide (S^{2+}) occurs in a strongly reduced environment.

Management of submerged soil

1. Levelling of land.
2. Mechanical drainage.
3. Controlled irrigation.
4. Flood control measures.
5. Plantation of trees having high transpiration rate.
6. Check the seepage in the canals and irrigation channels.
7. Selection of crops and their proper varieties.
8. Sowing on bunds or ridges.
9. Nutrient management.

Flooded soils

Flooded soils, now known as Hydric soils, are characteristic of wetlands and irrigated fields cropped to rice (paddy soils). In them, water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year.

Impact of Food on soil

Flooded soils create significant challenges for agricultural lands. The floods have many direct impacts, the most prominent being:

1. Deposition of sand and debris on productive lands;
2. Erosion of agricultural soils; and
3. Flooded soil syndrome—loss of beneficial fungi which mobilize soil-based plant nutrients. As a result of these effects after floods, farmers are challenged by yield losses and devastation of arable land. Subsequently, producers need to plan for the slow recovery of their arable soils.

Effect of Flooding on plant growth

1. Corn growing on flooded soils showed purple leaves that were disappeared in a week.
2. Flooded fields with weeds or without tillage showed less purpling than those tilled

to control weeds.

3. Fields with high manure application history (i.e., feedlots) showed no adverse effect for flooded soils on crop.

4. Crops planted after a fallow/flood period grew poorly.

5. P deficiency symptoms in crops — for corn it is slow early growth and purple coloration.

6. Flooded soils may have normal P test level and low AM population.

7. To alleviate P deficiency, high banded P rates needed — twice or more than the normal recommended rate.

Post-Flooding Soil Management

Land Leveling and Sand Cleaning – Sand cleaning depends on the depth of accumulation.

1. Few inches (i.e. 2-4 inches) can be incorporated in soil using normal field operations. Otherwise, minimum soil disturbance is advisable to promote even weed growth till next spring.

2. If sand is up to 6 inches deep, then moldboard plow to a depth twice the sand depth to incorporate.

3. Sand 8-24 inches, it is advisable to consider spreading to areas with less sand and incorporate with special deep tillage equipment. However, it is advisable not to move sand to fill lower or severally eroded areas in the field without proper top soil to cover the sand.

4. Sand above 24 inches deep, evaluate cost of removing sand or stockpile to decide whether to remove the sand.

5. In case of severe erosionand deep cuts, top soil from surrounding fields should be used to fill such areas.

Soil Testing

1. Soil testing should be conducted after any land leveling is done.

2. Soil samples should not be collected immediately after soils dry, and may need to be collected in the spring.

3. Need to allow time for P reactions after soils aerate.

4. Potassium (K) deficiency can occur due to soil compaction.

5. Soil tests could increase from sediment deposition.

Cover Crop

1. Use a cover crop immediately after soil dries to promote growth of microorganisms that are essential for nutrient cycling.
2. Planting conditions should provide good soil seed contact for cover crop success.
3. Consider overwintering cover crops to provide additional benefits of continuous growth in the spring prior to planting.
4. When planting soybean, as a precaution seed should be inoculated with *Bradyrhizobiumjaponicum* to ensure nodulation and N fixation.
5. AM fungi inoculation of soil is not feasible.
6. Once soils become aerobic, soil microflora will recover naturally.

Lesson Plan11

Topic: Polluted Soil: definition, sources and their remediation

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Soil pollution:soil pollution as part of land degradation is caused by the presence ofXenobiotic(human- made) chemicals or other alteration in the natural soil environment. It istypically caused by industrial activity, agriculturalchemicals or improper disposal of waste.

Sources of Pollution

A) Soil –

(a) Through the air gases and quantaminants emitted from exhausts
(b) Through drainage system.
(c) Through dumped solid materials like refuses from mines, animal slurries or sewage sludge etc.

B) Water- Water has unique property of dissolving industrial by-products, pesticides, chemical fertilizers etc. Such waste water pollute the soil.

Kinds of Soil Pollution

1. Pesticides.
2. Inorganic quantaminants mostly heavy metals.
3. Organic wastes – municipal and industrial wastes.
4. Fertilizers and other salts
5. Radionuclides.

Acid Rain –

Chemical reactions involved in acid rain.

Soil Pollutants: i. Agricultural pesticides ii. Organic waste iii. Heavy metals
iv. Fertilizers v. Redionuclotidesvi. Acid rains

Preventive control measures: Reducing chemical fertilizer and pesticide use, Applying bio-fertilizers and manures can reduce chemical fertilizer and pesticide use.Biological methods of pest control can also reduce the use of pesticides and therebyminimize soil pollution.

Lesson Plan 12

Topic: Water pollution: definition, sources and their remediation

Water is universal dissolver and cleaner, must periodically be cleaned itself before it becomes reusable. A good quality water become waste water through the dissolution of different detergents chemicals like pesticides etc and other industrial effluents and when this waste water is used for the irrigation purpose and others than it becomes a serious problem resulting in water pollution.

Water pollution: Impairment of water quality from its normal water quality is evaluated by its aesthetic, physical, chemical and biological properties which get influenced by Agricultural, industrial and anthropogenic use.

Sources of Water Pollution

Some of the importantsources of water pollution are: (i) Domestic effluents and sewage, (ii) Industrialeffluents, (iii) Agricultural effluents, (iv) Radioactive wastes, (v) Thermal pollution, and(vi) Oil pollution.

Causes of Water Pollution

1. Industrial waste:
2. Sewage and waste water:
3. Mining activities:
4. Marine dumping:
5. Accidental Oil leakage
6. Burning of fossil fuels:
7. Chemical fertilizers and pesticides:

Remedial measures to control water pollution

1. Municipal waste water treatment. 2. On site sanitation and safely managed sanitation. 3. Industrial waste water treatment. 4. Agricultural waste management treatment.5 Erosion and sediment control from construction site.6. Control of urban runoff.

Lesson Plan 13

Topic : Quality of Irrigation water and its suitability for irrigation.

Characteristics that determine quality of Irrigation water

1) Total concentration of soluble salts (EC).
2) Relative proportion of sodium to other cations (SAR).
3) Concentration of boron or other elements that may be toxic.
4) Bicarbonates concentration as related to the concentration of calcium + magnesium.

Criteria and Standards for Assessing Suitability of Saline Water for Irrigation

The suitability of water for irrigation should be evaluated on the basis of criteria indicative of its potential to create soil conditions hazardous to crop growth (or to animals or humans consuming those crops). Relevant criteria for judging irrigation water quality in terms of potential hazards to crop growth are primarily:

Permeability and tilth - The interactive, harmful effects of excessive exchangeable sodium and high pH in the soil and low electrolyte concentration in the infiltrating water on soil structure, permeability and til:h. These effects are evidenced by disaggregation, crusting, and poortilth (coarse, cloddy and compacted topsoil aggregates) and by a reduced rate of water infiltration.

Salinity - The general effect of salts on crop transpiration and growth which are thought to be largely osmotic in nature and, hence, related to total salt concentration rather than to the individual concentrations of specific salt constituents. These effects are generally evidenced by reduced transpiration and proportionally retarded growth, producing smaller plants with fewer and smaller leaves.

Toxicity and nutritional imbalance- The effects of specific solutes, or their proportions, on plant growth, especially those of chloride, sodium and boron. These effects are generally evidenced by leaf burn and defoliation.

Classification of Irrigation water

1) **Based on salinity hazard: Four salinity classes.**

Water class	Electrical conductivity (d S m^{-1})	Salt concentration g/l	Suitability
C_1 : Low Salinity	01 – 0.250	Less than 0.16	Safe with likelihood of any salinity problem
C_2 : Medium salinity	0.25 – 0.75	0.16 – 0.5	Will need moderate leaching
C_3 : High salinity	0.75 – 2.25	0.5 – 1.5	Cannot be used on soils with restricted drainage

C_4 : Very high salinity	2.25 – 5.00	1.5 – 3.00	Unsuitable under ordinary conditions.

2) **Based on Sodium (Alkali) hazard : SAR (Sodium adsorption ratio)**

SAR = $Na^+ / (Ca^{++} + Mg) / 2$

Where Na^+, Ca^{2+} and Mg^{2+} represent the concentrations in mill equivalents per litre.

Water class	**SAR**	**Suitability**
S_1 : Low sodium	0 – 10	Can be used on all soils with little danger of exchangeable sodium.
S_2 : Medium sodium	10 – 18	Produce appreciable hazard in fine textured soils, can be used in coarse textured soils.
S_3 : High sodium	18 – 26	Produce harmful levels of exchangeable sodium
S_4 : Very high sodium	more than 26	Unsuitable for irrigation.

3) **Based on Residual sodium carbonate (RSC)**

RSC = $\{ C0_3^{2-} + HCO_3^- \} + \{ Ca^{2+} + Mg^{2+} \}$

Expressed as milli equivalents per litre (me/1)

Water class	**RSC (Meq/1)**	**Suitability**
Low RSC	Less than 1.25	Safe for irrigation
Medium RSC	1.25 – 2.50	Marginally safe
High RSC	More than 2.5	Unsuitable for irrigation

4) **Concentration of Boron :**

Permissible limits of boron in ppm for irrigation water :

Boron class	**Sensitive crop**	**Semi crops**	**Tolerant crops**
1	Less than 0.33	Less than 0.67	Less than 1.00
2	0.33 – 0.67	0 – 1.33	1.00 – 2.00
3	0.67 – 1.00	1 – 2.00	2.00 – 3.00
4	1.00 – 1.25	2 – 2.50	3.00 – 3.75
5	More than 1.25	More than 2.50	More than 3.75

Tolerance of plants to Boron :

Tolerant - Sugarbeet, onion, Turnip, Cabbage, lettice,

Semitolerant - Sunflower, potato, Tomato, Radish, wheat,

Sensitive - Apple, grape, fig, cherry, Apricot, Orange,

Lesson 14
Topic :Utilization of Saline and Sewage Water in Agriculture

Management for Crop Production

Management practices for the safe use of saline water for irrigation primarily consist of:

1. Selection of crops or crop varieties that will produce satisfactory yields under the existing or predicted conditions of salinity or sodicity;
2. Special planting procedures that minimize or compensate for salt accumulation in the vicinity of the seed;
3. Irrigation to maintain a relatively high level of soil moisture and to achieve periodic leaching of the soil;
4. Use of land preparation to increase the uniformity of water distribution and infiltration, leaching and removal of salinity;
5. Special treatments (such as tillage and additions of chemical amendments, organic matter and growing green manure crops) to maintain soil permeability and tilth. The crop grown, the quality of water used for irrigation, the rainfall pattern and climate, and the soil properties determine to a large degree the kind and extent of management practices needed.`

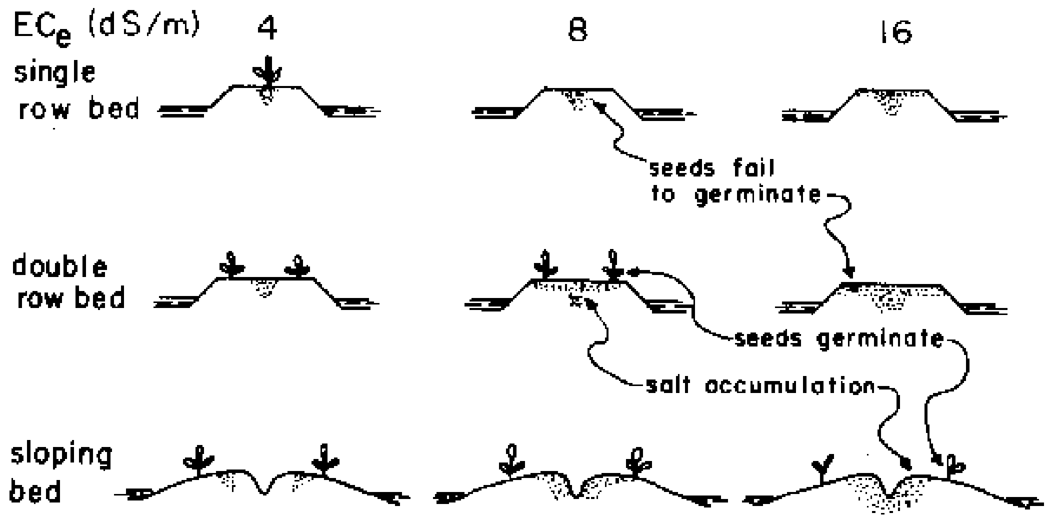


Fig.1Pattern of salt build-up as a function of seed placement, bed shape and

level of soil salinity

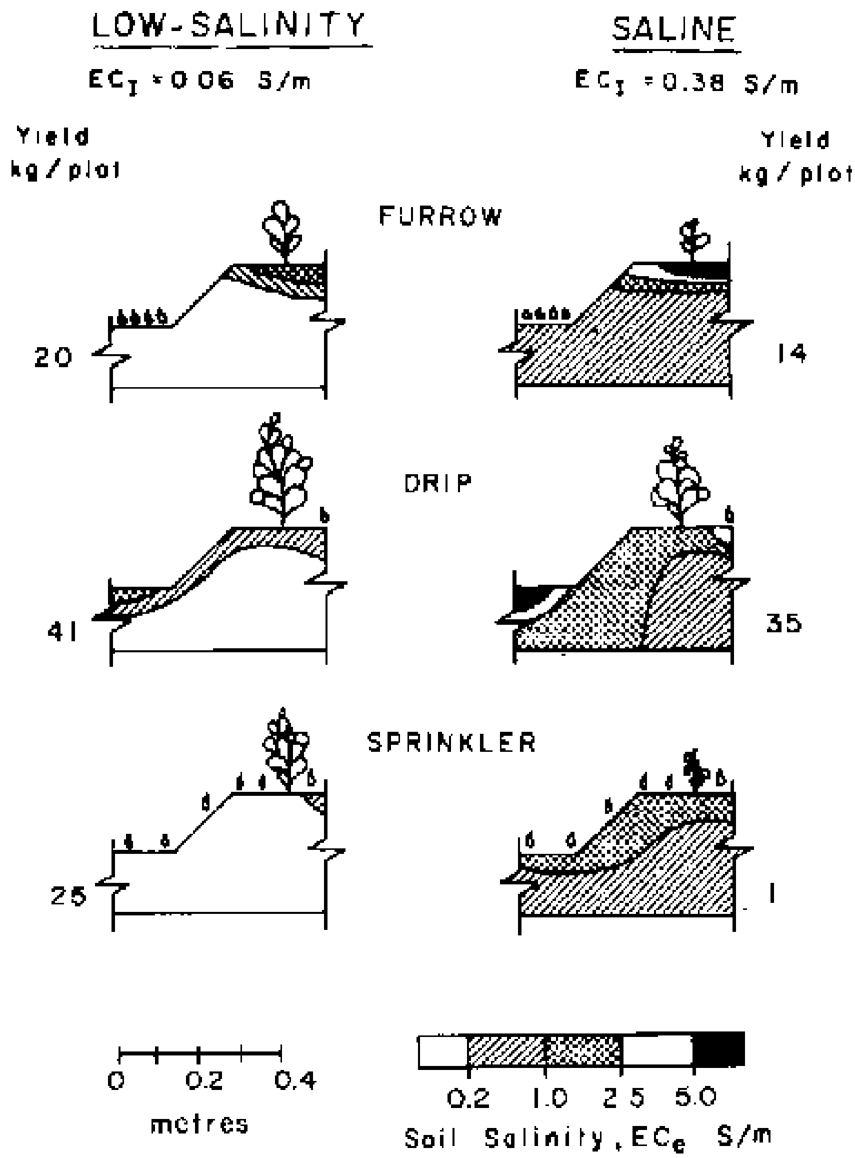


Fig.2 Influence of the irrigation system on the soil salinity pattern and yield of bell pepper at two levels of irrigation water quality

Managing soils under saline water irrigation

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. Sodic soils are especially subject to puddling and crusting; they should be tilled carefully and wet soil conditions avoided. Heavy machinery traffic should also be avoided. More frequent irrigation, especially during the germination and seedling stages, tends to soften surface crusts on sodic soils and encourages better stands.

Deep ploughing - refers to depths of ploughing from about 40 to 150 cm. It is most beneficial on stratified soils having impermeable layers lying between permeable layers. 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. The selection of the right plough types (shape and spacings between shanks), sequence, ploughing depth and moisture content at the time of ploughing should provide good soil tilth and improve soil structure .

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 - **Gypsum** is by far the most common amendment for sodic soil reclamation, particularly when using saline water with a high SAR value for irrigation. Calcium chloride is highly soluble and would be a satisfactory amendment especially when added to irrigation water. **Lime** - is not an effective amendment for improving sodic conditions when used alone but when combined with a large amount of organic manure it has a beneficial effect.

Sulphur- too can be effective; it is inert until it is oxidized to sulphuric acid by soil micro-organisms. Other sulphur-containing amendments (sulphuric acid, iron sulphate, aluminium sulphate) are similarly effective because of the sulphuric acid originally present or formed upon microbial oxidation or hydrolysis.

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.

Growing legumes and using green manure will improve soil structure. Green manure has a similar effect to organic manure.

Mulching to reduce evaporation losses will also decrease the opportunity for soil salinization. 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.

Effect of Saline water on

1. Soil properties:a. Salinity b.SAR c. Physical properties d. Nutrient availability.
2. Plant growth .

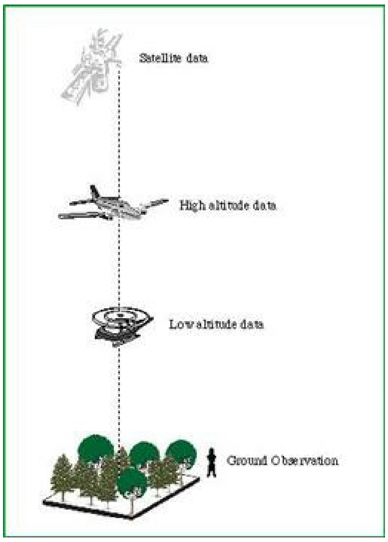
Lesson Plan 15

Topic:Remote sensing and GIS in diagnosis and Management of

Problem soils

Remote Sensing

`Remote Sensing can be defined as obtaining information about an object by observing it from a distance and without coming into actual contact with it. Example: Eye sight, Photos taken from a camera. In general, the word remote sensing is used for data collection from artificial satellites orbiting the earth and processing such data to make useful decisions. Hence, remote sensing can also be defined as the science and art of collecting information about an object, area or phenomenon from a far-off place without coming in contact with it.



Mapping salt-affected soils of India

Remotely sensed data from satellites are being operationally used to derive information on degraded lands and monitor them periodically in time and space domain using multi temporal data in India. At NRSA, the maps of salt-affected soils were prepared at 1:250,000 scale for entire country using satellite data from Landsat MSS/TM/IRS sensors in association with other central and state government organizations. According to this study, the area under salt affected soils in India is 6.727 million hectares. These maps are being utilized for planning reclamation of salt-affected soils at regional level. NRSA has also prepared maps of salt-affected soils at 1:50,000 scale in parts of UP, Gujarat, South coastal districts of AP and various irrigated commands of India.

Applications of Remote sensing in agriculture

Agriculture applications of remote sensing are characterized by number of phonological, land management and economic features which combine ensure that remote sensing has significant role in monitoring agricultural tract.

Brief account of Remote sensing applications in agriculture

a) Scientific applications of relevance in agriculture.
b) Management applications of remote sensing in agriculture.

Geographical Information System (GIS)

A geographic information system or (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographical data.

In general, the term describes any information system that integrates, stores, edits, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.

GIS can be effectively used to study soil survey, soil classification, land use planning, crop forecasting, weather forecasting, water resource study, integrated nutrient and paste management etc.

Components of GIS

1. Computer systems and software.
2. Spatial data.
3. Management and data analysis.

Lesson Plan 16
Topic: Multipurpose tree species, Bioremediation of Soils

Multipurpose trees are trees that are deliberately grown and managed for more than one output. They may supply food in the form of fruit, nuts, or leaves that can be used as a vegetable; while at the same time supplying firewood, add nitrogen to the soil, or supply some other combination of multiple outputs. "Multipurpose tree" is a term common to agro forestry, particularly when speaking of tropicalagro forestry where the tree owner is a subsistence farmer.
When a multipurpose tree is planted, a number of needs and functions can be fulfilled at once. They may be used as a windbreak, while also supplying a staple food for the owner. They may be used as fencepost in a living fence, while also being the main source of firewood for the owner. They may be intercropped into existing fields, to supply nitrogen to the soil, and at the same time serve as a source of both food and firewood.

Common multipurpose trees of the tropics include:

- *Gliricidia sepium* – the most common tree used for living fences in Central America, firewood, fodder, fixing nitrogen into the soil.
- Moringa *(Moringa oleifera)* – edible leaves, pods and beans, commonly used for animal forage and shade (it does not fix nitrogen as is commonly believed[1])
- Coconut palm – used for food, purified water (juice from inside the coconut), roof thatching, firewood, shade.
- Neem - limited use as insect repellent, antibiotic, adding nitrogen to the soil, windbreaks, biomass production for use as mulch, firewood.

Ideally most trees found on tropical farms should be multipurpose, and provide more to the farmer than simply shade and firewood. In most cases they should be nitrogen fixing legumes, or trees that greatly increase the farmer's food security.

Advantages of Phytoremediation:

1. It requires no outlay for purchase of chemical amendments.

2.Build up soil structure and stabilizes aggregates through solubilization of Ca from calcite which has flocculating effect on soil particles.
3.Poor soil fertility is associated with low productivity of alkali soils.Phytoremediation improves the availability of plant nutrients by solubilizing nutrients adsorbed/fixed with calcite besides enhanced N_2 fixation.
4. Amelioration with routine chemical amendment is largely confined to surface horizon with limited improvement in deeper layers.Phytoremediation facilitates greater zone of amelioration in terms of soil depth.
5.The crop based approach of phytoremidiation has shown promise as an effective low cost amelioration intervention.
6. Phytoremediation is much cheaper than chemical amelioration.

Selection of plant species

1.Crop tolerance to salinity.
2. Crop tolerance to exchangeable sodium.

Lesson Plan 17

Topic :Land Capability& Land suitability Classification

On the basis of the soil survey maps and reports, a land capability classification has been developed in which every acre of land is classified according to its capabilities and limitations. There are eight capability classes, which are numbered from I to VIII. Those lands, which have the maximum capabilities and the least limitations, are placed in class 1, whereas those lands, which have the maximum limitations and the least capabilities, are placed in class VIII. The Capability classification consists of three categories.

Capability classes– Class I to Class IV encompasses land suitable for cultivation, unit class V to Class VIII includes land unsuitable for cultivation but suitable for permanent vegetation .

Capability subclasses: These are based on kinds of dominant limitation such as wetness or excess water (w), climate (c), soil (s) and erosion (e).

Capability units:- These are further subdivisions of capability subclasses. A capability includes soils which are sufficiently uniform in their characteristics, potential and limitations and required fairly uniform conservation treatment and management practices.

Land Suitability Classification

c) Land suitability for irrigation

Suitability Criteria- The criteria used are usually the available WHC, Effective rooting depth and intake characteristics of the soil. The FAO workers developed a system of soil suitability for irrigation. The system is based on limitations of different land characteristics such as texture, depth, permeability, salinity and topography. The soil units are grouped into the following sis suitability classes as under:

Class 1 to 3: Arable suitable for agriculture.

Class 4 :- Restricted arable with severe limitations of soil.

Class 5 :- Undetermined arable.

Class 6: Non arable unsuitable for irrigation.

Lesson Plan 18

Topic: Problematic soils under different Agro-ecosystems

Agro climatic region is the land unit in terms of major climate, superimposed on length of growing period (moisture availability period) and an agro-ecological zone is the land unit carved out of the agro climatic region, superimposed on the land form, which acts as a modifier to climate and length of growing period.

The area estimates of the degraded and wastelands in different AERs revealed that region 4 is highly degraded with area coverage of 14,960 thousand hectare. The other AERs having appreciably high area coverage are AER-2, AER-5, AER-10, AER-12 and AER-17. Though the AERs are affected but the least affected are AER-1 and AER-20.

Water erosion (classes1,2) has affected almost all AERs and AERs with large affected areas are; AER-4, AER-66, AER-5, AER-12, AER-14, AER-7 and AER-8. Least affected AERs are AER-20, AER1 and AER-17.Soil acidity has been observed in a AERs except AER-1. AER-2 AER-3 and AER-20. Highly affected AERs are AER-17, AER-15, AER-12 and AER-11.

Salinity affected (classes 7, 8, 9, 10, 11, 12) agro-ecological regions are located in the semi-arid and sub-humid climatic zones of the country. Highest area coverage with salinity is in AER-2 followed by AER-18 an AER-4.

Sodicity and salinity are observed in combination in some of the AERs. Notable among them are AER-2, AER-4, AER-6 and AER-18.Agroclimatic conditions coupled with management practices are the main reasons for the development of soil sodicity. Highest sodicity (classes 13,14,15,16,17) is observed I AER-4 followed by AER-9, AER-6, AER-2 and it is not problem in AER-1, AER-11, AER-12, AER-15, AER-16, AER-17, AER-19 and aer-20.

Wind erosion (class-6) is predominant in AER-2 and has a little affected area in AER-4.

AERs	Degraded and wastelands classes* ('000 ha)																			Total degraded area ('000 ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
2	638	123	0	0	0	11,419	1,106	6	0	110	60	0	405	1	30	0	0	8	7	13,913
3	2,341	76	0	0	0	0	1	0	0	0	0	0	75	47	0	0	0	20	0	2,560
4	12,109	1,024	0	1	0	6	367	7	0	0	0	0	929	423	0	1	11	14	68	14,960
5	6,455	983	3	22	0	0	184	2	0	0	0	0	25	15	0	0	5	6	0	7,700
6	10,374	257	0	0	0	0	171	6	0	0	0	0	269	175	0	0	1	17	0	11,270
7	4,376	465	12	7	0	0	0	0	0	0	0	0	79	15	0	0	1	31	0	4,986
8	4,412	391	272	151	60	0	3	1	0	0	0	0	287	36	0	17	2	48	5	5,685
9	3,122	378	3	3	0	0	2	3	0	0	0	0	368	293	0	2	0	9	89	4,272
10	6,934	822	119	308	28	0	0	0	0	0	0	0	35	20	0	1	0	21	0	8,288
11	3,843	514	653	726	159	0	0	0	0	0	0	0	11	3	0	0	0	16	0	5,925
12	4,917	1,512	469	1,089	142	0	2	0	0	0	0	0	0	0	0	0	0	38	24	8,193
13	3,803	48	41	41	0	0	40	9	0	0	0	5	2	24	0	0	0	1	163	4,177
14	4,009	1,025	75	289	222	0	0	0	0	0	0	0	10	0	0	0	0	4	61	5,695

Table: Area under degraded and wastelands of India under different AERs

15	2,011	213	647	1,229	328	0	64	0	0	0	0	0	0	0	0	0	0	1	242	4,735
16	576	229	275	651	782	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2,523
17	210	992	439	516	5,330	0	0	0	0	0	0	0	0	0	0	0	0	1	31	7,519
18	928	48	43	12	3	0	574	4	0	0	0	25	115	6	0	0	0	10	83	1,851
19	2,944	187	2,029	674	76	0	40	1	20	0	0	0	0	0	0	0	0	15	76	6,062
20	0	0	0	0	0	0	77	0	0	0	0	0	0	0	0	0	0	0	0	77
Total	74,021	9,287	5,080	5,719	7,130	11,425	2,631	39	20	110	60	30	2,610	1,058	30	21	20	260	859	120,410

Note: Classes*: 1. Exclusively water erosion (>10 tonnes /ha/yr); Water erosion under open forest, 2. Forest; 3. Exclusively acid soils (pH <5.5); 4. Acid soils under water erosion; 5. Acid soils under open forest; 6. Exclusively wind erosion; 7. Exclusively saline soils; 8. Eroded saline soils; 9. Acid saline soils; 10.Saline soils under wind erosion; 11. Saline soils under open forest; 12.Water logged saline soils; 13. Exclusively sodic soils; 14.Eroded sodic soils; 15. Sodic soils under wind erosion; 16. Sodic soils under open forest; 17. Eroded sodic soils under open forest; 18.Mining / Industrial waste; 19. Waterlogged area (Permanent)