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**RECLAMATION OFALKALINE SOILS**

**Factors Which Make the Soils Alkaline:**

**These are:**

1. Poor drainage in arid region,

2. Rapid evaporation of alkaline soil solution, and

3. Excess uptake of alkaline salts and little percolation.

In arid and semi-arid regions, the rainfall is too low to leach or remove the saline matter from the top soils. Besides this, water along with dissolved alkali salts moves upward by capillary action which on reaching to the soil surface evaporates and the salts accumulate in the form of a hard layer or pan in the subsoil. This hard layer is responsible for impermeability of such soils. Miller is of the opinion that many plants absorb excess acidic ions, e.g., NO–3, than the basic ions. This excessive removal of acidic ions results in the accumulation of basic ions which make the soil alkaline.

**According to a chemical hypothesis, alkali soils may result in the following steps:**

(a) Reaction between NaCl or KCl and soil (S):

NaCl + S (Soil) → Na (S) + CI– ion

(b) Then the soluble products are leached away from the soil surface by drainage water, and

(c) Finally, reaction between insoluble Na (S) complex and carbonates.

2 Na (S) + CaCO3 → Ca (S) (alkaline) + Na2CO3 (alkaline)

In these soils, the Exchangeable Sodium Percentage (ESP) is greater than 15, pH is more than 8.2 and Electric Conductivity (EC) is below 4 ds/m. Recommended interventions for reclamation of alkali soils are:

a) Field bunding, land shaping, construction of irrigation channels & field drains/link drains etc.;

b) Application of soil amendments (Gypsum/Pyrite) at the average rate of 5 tonnes per ha. and it’s mixing with soil when temperature is around 40 degree centigrade;

c) Green manuring & its mulching in the soil for increasing organic carbon in the soil and high degree use of Farm Yard Manure (FYM);

d) Application of soil test based chemical fertilizers and micro-nutrients to ensure judicious and balance use of fertilizers;

e) Growing of suitable crops/horticultural/agroforestry species including food, fuel & fodder plantations depending upon soil and slope conditions for one year;

f) Casualty replacement and post planting care in case of horticulture and agroforestry plantation for about three years; and

g) Organization of skill development and awareness programmes for adoption of recommended package of practices on continuous basis to prevent reoccurrence of such problem soils.

**Reclamation of Alkali Soils:**

**Alkali soils are best reclaimed by the following methods:**

**(A) Chemical method:**

(1) By cationic exchange (replacement of alkali from soil colloids by calcium ions). Application of calcium sulphate (gypsum) in the soil reduces alkalinity to a great extent and makes the soil fertile.

**The reaction proceeds in the following way:**

2Na-clay + CaSO4 → Na2SO4 + Calcium-clay

Na2CO3 + CaSO4 + CaCO3, + Na2SO4

Good drainage leaches away Na2SO4.

(2) Alkali salt percentage can also be reduced in the soil by the use of acid forming chemical amendments such as sulphur, ferrous sulphate and limestone. Sulphur, when applied to the soil, oxidises and forms sulphuric acid which converts carbonates of sodium and potassium to Na2SO4 and K2SO4 respectively that may be removed from top soil by drainage water. The amount of gypsum and sulphur required to reclaim the alkali soils will be different depending upon the degree of alkalinity, drainage and buffering capacity of soils.

**The types of reaction which occur when an amendment is applied to an alkali soil are given below:**

**(1) With Sulphur:**

(i) 2S + 3O2 = 2SO3

(ii) SO3 + H2O = H2SO4

In the next step, if soil is calcareous—

(iii) H2SO4 + CaCO3 = CaSO4 + CO2 + H2O

(iv) 2Na-Clay + CaSO4= Ca-Clay + Na2SO4

But if the soil is non-calcareous—

(v) 2Na-Clay + H2S04= 2H-clay + Na2S04

**(2) With lime-sulphur:**

(i) CaS5 + o2 + 4H2O = CaSO4 + 4H2SO4

Now if the soil is calcareous—

(ii) H2SO4 + CaCO3 = CaSO4 + CO2 + H2O

(iii) 2Na-Clay + CaSO4 = Ca-Clay + Na2SO4

But if the soil is non-calcareous—

(ii) 10Na-Clay + 4H2SO4 + CaSO4 = 8H-Clay + Ca-Clay + 5 Na2SO4

**(3) With ferrous sulphate:**

(i) FeSO4 + H2O = H2SO4 + FeO

Now if the soil is calcareous—

(ii) H2SO4 + CaCO3 = CaSO4 + CO2 + H2O

(iii) 2Na-Clay + CaSO4 = Ca-Clay + Na2SO4

But if the soil is non-calcareous—

(ii) 2Na-Clay + H2SO4 = 2H-Clay + Na2SO4

**(4) With limestone on non-calcareous soils:**

(i) Na-Clay + H2O = H-Clay + NaOH

(ii) 2H-Clay + 2NaOH + CaCO3 = Ca-Clay + Na2CO3 + 2H2O

**(5) With any H-Clay:**

(i) 2H-Clay + CaCO3 = Ca-Clay + CO2 + H2O

The use of pyrite (FeS2) as an amendment is a recent development in the chemical amelioration and reclamation of alkali soils. In presence of moisture and air, pyrite is converted into sulphuric acid which then replaces exchangeable sodium by hydrogen or calcium released from insoluble calcium present in the soil. In addition it is said to correct iron deficiency and lime induced iron chlorosis in alkali soils. It is important to mention that the formation of H2SO4 in the soil by the application of pyrite may take place through chemical and microbiological actions. Pyrite is oxidised according to the following equation suggested by Bloomfield (1973).

FeS2 + 2Fe+3 = 3Fe+2 + 2s (Chemical)

Sulphur thus formed could be the substrate for thioxidants which convert it into H2SO4.

S + 3(0) + H2O = H2SO4

**Temple and Kochler (1954) explained the action of ferroxidans on the formation of H2SO4 as follows:**

FeS2 + H2O + 7O = FeSO4 + H2SO4

2FeSO4 + O + H2SO4 = Fe2(SO4)3 + H2O

FeSO4 formed in the above reaction may be converted into H2SO4 by hydrolysis.

FeSO4 + H2O → H2SO4 + FeO

**In brief, the pyrite is oxidized in soils to ferrous sulphate and sulphuric acid as depicted in the following equation:**

2FeS2 + 2H2O + 702 = 2FeSO4 + 2H2SO4

Both sulphuric acid and ferrous sulphate help in reclamation of calcareous as well as non- calcareous salt affected soils by lowering the pH and solubilising free calcium from calcium carbonate present.

**The reactions are given below:**

**In salt affected calcareous soils:**

la. CaCO3 + H2SO4 = CaSO4 + CO2 + H2O

lb. 2Na-Clay + CaSO4 = Ca-Clay + Na2SO4

II. FeSO4 + H2O → FeO + H2SO4

H2SO4 formed in reaction II reacts as per equations la and lb

III. H2SO4 also neutralizes NaHCO3 and Na2CO3 present in these soils.

2NaHCO3 + H2SO4 → Na2SO4 + 2H2O + 2CO2

Na2CO3 + H2SO4 → Na2SO4 + H2O + CO2

**But if the soil is non-calcareous:**

(I) 2Na-Clay + H2SO4 = 2H-Clay + Na2SO4

(II) FeSO4 + H2O = FeO + H2SO4

H2SO4 formed in reaction II acts in similar manner as in reaction I.

(3) Dhar’s method. In India, Dr. Neel Ratan Dhar (1935) succeeded in reducing the alkalinity and salinity of the soil by the use of molasses and press-mud.

**For one acre land he recommended the mixture of the following substances:**

(i) 2 tons of molasses, (ii) 1-2 tons of press-mud (a waste product of sugar industry) and (iii) 50-100 pounds of P2O5 in the form of basic slag.

The molasses is fermented by soil microbes and as a result of fermentation organic acids are produced which lower the alkalinity and increase the availability of phosphates. The press- mud contains Ca which forms calcium salts that reduce the content of exchangeable sodium. Phosphate helps in the microbial fixation of nitrogen into nitrogenous compounds in the soil.

**(B) Mechanical methods:**

**The alkali salts are removed by:**

(1) Scraper or by rapidly moving streams of water,

(2) Deep ploughing of the land which reduces the alkalinity and makes the soil more permeable.

(3) Application of green manures of Dhaincha, guar, jantar (Sesbania aculeata) has been found most successful in reclamation of alkali and saline soils.

(4) Spreading of straw and dried grasses and leaves on the alkaline soil.

**(C) Agricultural method:**

Growing of alkali tolerant crops and plants, such as sugar-beet, rice, patsann (Hibiscus cannabinus), wild indigo and babul in such soils successfully reduces alkalinity. Rice is commonly the first crop grown on salty lands to be reclaimed. In Punjab the usual practice of reclamation of salty lands involves growing of paddy after first initial leaching followed by berseem or senji which has higher water requirement than Dhaincha as green manure which IS followed by sugarcane and then wheat or cotton.

Introduction of leguminous crops helps in building up of nitrogen supply and opens the soils. Dhaincha-paddy-berseem rotation has been found to be the best cropping pattern on mild type of alkali soils in Punjab region. In U.P. also, paddy or dhaincha-paddy are the usual crops taken during first stage of reclamation of salty soils. This is followed by berseem or barley in winter. Pulse crops like gram or peas show poor performance.