Problematic Soil and Soil Testing

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Problematic Soil

- The ‘problematic soil’ is define as the soil that has agricultural problems due to the soil’s unsuitable physical and chemical properties, or less suitable for cultivation, resulting in that crops are not able to grow and produce yields as normal.
- These soils always occur naturally, including saline soil, acid sulfate soil, sandy soil, organic soil, skeletal soil and shallow soil.
- Furthermore, it may also include areas with steep slope. If these lands are used for agricultural purpose, then it may cause some severe effects on the ecology and environment.

Classification of Problematic Soil

Problematic Soil

- Acidic Soil
- Alkali Soil
- Saline Soil
- Non-saline Soil
- Calcareous Soil

Acid Soil

- The soil with low pH contain relatively high amounts of exchangeable H^+ and Al^{3+} considered as the acid soil.
- Ultra acidic- 3.3
- Extremely acidic – 3.3.to 4.5
- Very strong acidic- 4.5 to 5.0
- Moderately acidic- 5.6-to 6.0
- Slightly acidic- 6.1 to 6.5

Different Sources for Formation of Acid Soil

- Rain fall
- Parent materials
- Fertilizer application
- Plant root activity
- Decomposition of organic matter
- Climate
- Vegetation cover
- Topography
- Human interface

Rain Fall

- Soils developed in high rain fall regions are mostly acidic.
- Alkali and alkaline earth bases that are liberated during weathering are leached out leaving the soil deficient in bases.
- Additionally rain water has slightly acidic pH is 5.
- Creates base unsaturation.
- Increase the percentage of H^+ and Al^{3+} ion in soil.

Parent Materials

- The development of acid soil on acidic rocks like Granite, Gneiss, quartz, silica.
- When these rocks lacks bases, produce acidity in soil after decomposition by weathering.
- Silicic acid-orthosilicic acid and trisilicic acid.
- Reason for development of acid soil from parent material
- Parental rock with simple composition.
- Less adsorbed cation.
- Poor buffering capacity.
- Quick percolation of water through them.

Fertilizer Application

- Repeated application of ammoniacal fertilizer leads to the formation of acid soil.
- Ammonium sulphate and ammonium nitrate fertilizer reacts in the soil process is called nitrification to form nitrate.
- This process release the hydrogen ions.

Plant root activity

- Plant uptake nutrients in the forms of both anion and cation.
- Plant must maintain a neutral charge in their roots.
- In order to compensate the extra positive charge they release the H^+ ions.
- Some plants roots produce the organic acid-acid soil.

Decomposition of Organic Matter

- Acid soils can also be produced through the accumulation of organic residues.
- The decomposition of organic matter in absence of oxygen gives rise to product called Peat which is acidic reaction and it is due to the accumulation of the humic acids.

- The soil acidity is also increased by the use of materials like sulphur, molasses which liberate acids during their course of their decomposition. The increase in acidity decreases the soil production.

- Slightly acidic soils are quite suitable for growing crops without any treatment, but those that are strongly our even moderately acidic do not allow the normal growth of plants. So acidity has been neutralized before the crops are grown. The lack of exchangeable bases is the main cause of unproductiveness, which can be restored by adding, lime dolomite etc.
- $CaO + H_2O \longrightarrow Ca(OH)_2$
- $Ca(OH)_2 + 2CO_2 \longrightarrow Ca(HCO_3)_2$
- As the concentration of carbon dioxide in soil is quite high, all these compounds are converted into soluble bicarbonates which day in react with the soil colloids.
- H_2-clay +$Ca(HCO_3)_2$ Ca-clay + $2H_2CO_3$
- The carbonic acid further reacts with lime and sweet shop changes repeats itself and turns colloidal clay into calcium -clay which increases the pH of the soil. As this reaction is reversible in nature, therefore additional quantities of lime added from time to time to maintain the pH of soil.
- Gypsum and calcium chloride cannot be used for improving acid soils because they are neutral salt with no alkaline effect. Their addition makes the soil more acidic.

Reclamation of acidic soil

- The quantity of lime required to be added to soil is known as its lime requirement.
- It depends on the initial PH, base unsaturation, and buffer capacity. Lime requirement varies inversely as PH and buffer capacity. Lime requirement also depends on the type of crop to be grown.
- For determining lime requirement known weight of soil is mixed with varying quantities of standard calcium hydroxide are barium hydroxide solution in a number of flasks and allowed to settle down. The pH of each flask solution is determined electrometrically. Titration curves are drawn from the data so obtained and the quantity of lime needed to produce any particular PH is calculated from the curve. Usually pH 6.5 or 7 is taken to represent the desired pH for most crops the figure so obtained is multiplied by the limiting factor gives the actual lime requirement.

Effect of lime on acid soils

- Lime improves chemical and biological properties of acid soil without affecting its physical conditions.
- It encourages the decomposition of organic matter producing excess of organic colloids.
- The calcium humus produced during the reaction acts consenting agent in binding the soil particles.
- It increases the availability of almost all the plant nutrients like nitrogen, phosphorus, potassium, calcium, magnesium, boron, zinc, copper, and molybdenum and reduces the toxicity caused by soluble iron, aluminium, and managense.
- It encourages the microbial activity of the soil by raising the pH.
- Lime stimulates activity of both symbiotic and about rapid decomposition of both native and added organic matter, resulting in increased microbial activity which increases the availability of nitrogen, phosphorus, and sulphur.

Effect of over liming of soil

- Over liming of soil is toxic for crops, especially in case of sandy and organic matter deficient soils. It reduces the availability of major and minor essential nutrients like iron, Mn, boron, copper, zinc, phosphorus, potassium, etc. It also interferes with the absorption of certain elements like potassium, phosphorus, boron etc by plants does hinder their utilization.
- Over liming affects the very rapid decomposition of organic matter in the soils of arid and semi arid regions. Therefore, in order to make the acid soil fertile, a moderate quantity of lime should be added from time to time rather than to make a heavy application at a time.

Alkaline soil

- The soils have pH greater than 7. Calcareous soils give alkaline reaction mainly due to presence of calcium carbonate and magnesium carbonate while alkaline soils are one whose alkalinity varies with the predominance of sodium salts in soil solution or the presence of sodium clay or both. They are formed in the low rainfall and high evaporation regions. Due to low rainfall they have downward and upward movement of rainwater which helps in the accumulation of salts in the surface layer soils of arid and semi arid regions.
- These soils are also available in see me humid and temperate regions especially when drainage is defective or where the underground water table is high or close to the surface. Under humid conditions the soluble salts formed by the weathering of rocks and minerals are carried down and removed with the drainage water into the stream and finally to the ocean. In case of defective drainage water they accumulate at lower layers and makes the soil alkaline. High water table also makes the soil alkaline. Alkaline soil are also found on sea coast where tidal water flood the land periodically and deposit their salts.
- Artificial alkaline soil is produced where canal water is used for irrigation due to movement of salts between the layers seepage irrigation water gets water logged in low-lying tract of or valley and produce alkaline soil.
- In some cases alkaline soils result from irrigation water itself having an excess of soluble salts as in the case of soil water wells or due to the canal water passing through saline regions.

Reclamation of alkali soil

- Reclamation of saline soil is done by removing excess of salts either by scrapping the salt from the surface or by washing them down into the lower layers beyond the root zone or by growing salt tolerant plants or by a combination of two or more of these methods. Reclamation is never complete in the soil in which the colloidal complexes are sodiumised. The best method of leaching with water having low sodium salt content.
- Alkali soil cannot be e reclaimed by mere flooding the land. These soils contain free calcium carbonate. The addition of substances which produce acidity reclaims the soil like FYM, green manure, sulphur, molasses, iron and aluminium sulphate and even sulfuric acid.
- The acidity developer during the course of their decomposition In the soil neutralizes alkalinity and at the same time brings calcium carbonate into solution which then reacts with the sodium clay and converts it into calcium clay.
- The carbon dioxide liberated by the decaying organic matter and by the plant roots increases the solubility of calcium carbonate due to which the concentration of Ca^{2+} ions in the soil solution is increased. The sulphuric acid also increases the concentration of Ca^{2+} ions by dissolving calcium carbonate. The growing of salt tolerant crops which can also withstand water logging such as rice, berseem, etc. After the concentration of soluble salts has been sufficiently reduced to allow their growth further helps reclamation process.
- Use of acidifying fertilizers Superphosphate and ammonium sulphate, which increases acidity in soil and maintains fertility of soil, is impoverished by leaching and cropping. Suitable crop rotation including salt tolerant crops helps the reclamation process. The crop root helps to increase the permeability of the subsoil by exerting carbon dioxide pressure and developing cracks in it which allows easy percolation of water.

Classification of alkali soil

- The soils are mainly divided into three groups
- Saline soil
- Saline alkali soil
- Non saline alkali soil

Saline soil

- The soil which contain excess of sodium salt but the clay complex contain excess of exchangeable calcium known as saline soils' or solonchak. The process of accumulation of salts leading to the formation of saline soil is known as **Salinization**.
- The composition of soil depends on the composition of rock and nature of weathering process. These soil generally contain chlorides, sulphates, nitrates soil of sodium calcium and magnesium.
- Some soils also contain potassium salts. Soluble carbonates are generally absent in such soils. This soil is also known as White soil due to the presence of sodium chloride and sodium sulphate which impart white colour to it. Sometimes the colour is brown due to the presence of calcium chloride and magnesium chloride.
- The pH of soil is between 7.5 and 8.5. ESP is very low. The clay particles of this soil are well granulated but do not have well-developed structure. It has high salt concentration. It is permeable to water and air. High salt content is harmful to the crop.

Saline alkali soil

- On accumulation of soluble salt in a soil over a prolonged period sodium is the predominant cation in soil solution while plants absorb calcium, magnesium and potassium. Sodium doesn't serve as an essential nutrient except for a few crop plants. Due to evaporation of moisture of soil or absorption from plants, calcium carbonate and magnesium carbonate or calcium sulphate gets precipitated, thus increasing the sodium concentration considerably. When the concentration is above 50% of the total cations Na+ ions replace the exchangeable Ca^{2+} and Mg^{2+} ions of the K complex due to high concentration. Calcium clay + Na- salt convert sodium clay + calcium salt.
- Though the reaction is reversible, calcium salts are removed in drainage water as soon as they are formed. Thus making the reaction uni-directional. The process of converting normal soil into alkali soil is called alkalization. The soil may contain sodium clay and excess of salt or only sodium clay with no soluble salt.
- If the soluble salts are not reached out due to insufficient rains then the soil contains sodium clay and excess of soluble salt in solution and it is known as alkali soil.
- This soil remains friable and possesses aggregate crumb structure because of the presence of sodium salt that do not allow the sodium clay to get dispersed. Its pH is less than 8.5 and ESP is more than 15%.

Non-saline alkali soil

- When soluble salts are removed by leaching as a result of the increase in rainfall or due to the fall of the water table or by irrigation water washing them down or for any other reason, it gives rise to non -saline alkali soils. It contains colloidal complex saturated with exchangeable sodium and insoluble salt. The soil changes depend on the presence or absence of free calcium carbonate in it.
- Na-clay + $CaCO_3$ $\longrightarrow$ Ca-clay +Na_2CO_3
- Free sodium carbonate reconverts the exchange complex into sodium clay due to low concentration of soluble calcium carbonate. Due to presence of sodium carbonate, soil organic matter makes black solution which on drawing forms black patches on the ground surface with black deposits on soil particles. This soil is known as black alkali. The clay gets deposited in the lower layers making them impervious having prismatic or columnar structure. These soils are called solonetz. The process of development of these soils from saline soils is known as solonization.
- The soil reaction is strongly alkaline. The pH range from 8.5 to 10. ESP is greater than 15. But electrical conductivity is less than 4mmhos/cm. Drainage and aeration are poor because of deflocculating of collide material which swells the clay and chokes the soil pore. As a result the soil loses crumble structure. The presence of free sodium carbonate has a caustic effect on plant roots. The high pH, the impaired physical condition of the soil and the toxic effect of free calcium carbonate and the exchangeable sodium adversely affect plant growth these soils are therefore almost barren.

Degraded alkali soil

- The mature of changes during soil development is slightly different when it does not contain free calcium carbonate which results in the prolonged leaching. The sodium clay hydrolyzes and liberates free sodium hydroxide which combines with the carbon dioxide of the soil air and forms sodium carbonate.
- Na-clay + H_2O → H-clay + NaOH
- $2NaOH + CO_2$ → Na_2CO_3 + H_2O

The humus gets dissolved in sodium carbonate and the solution passes down to lower layers which acquire black colour due to its deposition. A part of exchangeable Na+ is also replaced by H+ which breaks into silicic acid and sesquioxides which are also leached down along with humus. This process is known as Solonization and the soil so formed is called solod or soloth or degraded alkali soil.

$H(R_2O_3,SiO_2.H_2O)$ $H(SiO_2.H_2O)$ + R_2O_3

H-clay. Silicic acid. Sesquioxides

It is acidic in nature. The soil pH 6 ESP is greater than 15. It is very compact and has low permeability.

Tolerance by plants

- Both saline and alkaline soil are harmful to plants on account of the excessive concentration of soluble salts in soil solution in one case and of exchangeable sodium or both in the other. The large amount of salt in solution increases the osmotic pressure and reduces the uptake of water which causes plasmolysis. Plasmolysis increases with the concentration of solution until the all the functions of plant collapses completely and plant finally dies.
- In addition to the total salt concentration, the harmful effects of the salt depends on the nature of salt present, the plant species, the nature of the soil especially its texture and the distribution of salts in the profile. Sodium carbonate is the most harmful as compared to NaCl and sodium sulphate.
- In the case of alkali soils, the preponderance of exchangeable sodium in the colloidal complex reduces the availability of calcium and thus prevents, its intake by plants. Plants growing under such conditions wilt and die for want of sufficient water.
- Salt tolerance varies also with age of plants. Plants that have deep root systems are able to tolerate salinity better than others. Plants growing in sandy soils are able to tolerate greater concentration of soluble salt than those in clayey or other fine textured soils. The climate also influences salt tolerance by crops. Climate also influenced salt tolerance by crops. Plants growing in arid and semi arid regions are able to tolerate greater salt concentration than those in semi humid and tropical regions.

Calcareous soil

- Calcareous soils are formed in warm temperate and semi acid region where rainfall is low and evaporation is high. Soil profile of those soils which contain calcium carbonate and magnesium carbonate in varying proportions and precipitations is not sufficient to leach out all the basic products of weathering. Hence, soil has high concentration of soluble salt of calcium and magnesium. Due to evaporation of water or absorption of water by plants calcium is precipitated as calcium sulphate or calcium carbonate and magnesium as magnesium carbonate. Due to gradual precipitation, calcium and magnesium salts gets accumulated in soil. If the soil body is highly permeable these salt accumulate in parent material from which soil has formed. Sodium and potassium salts are either deposited in the lower depths or removed from the solum completely.
- Calcareous soils are highly buffered. Carbonate present in them get hydrolyzed due to presence of water.

$$CaCO_3 + H_2O \longrightarrow Ca^{2+} + OH^-$$

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2 \longrightarrow Ca^{2+} + H^+ + HCO_3^{2-} + CO_3^{-2}$$

- The pH of such soil depends on the concentration of carbon dioxide in soil air and its value lies between 7.5 to 8.5. The high pH and presence of calcium and magnesium carbonates in these soil reduce the availability of the plant nutrients. Diseases like lime induced chlorosis are caused in crops due to this type of soil. The presence of excess amount of calcium in balances the uptake of certain nutrients like potassium and magnesium properly managed. Calcareous soils are very productive and suitable for a wide variety of crops.

Introduction to soil testing

- Soil testing is used for determining the soil fertility level. Soil fertility plays an important role in increasing the crop production in almost all the soils of the world. It provides the plant with proper nutrients in a proper proportion at proper time. It is difficult for the farmers or cultivators to know the amount and type of fertilizers to be used buy them for their land and to get the optimum results. The problem of fertilizer use needs a quantitative assessment of the fertility status of the soils that is it can measure the-
- Level of NPK in soil
- pH of soil
- Salt content
- Salinity and bicarbonate content
- Texture
- On the basis of this information, an agronomist can recommend the type of fertilizer and its proportion to be used to the farmer.

Different methods of soil fertility evaluation

- Soil testing has been done by soil scientist as an aid in determining the soil fertility level. It is a rapid chemical analysis to access the available nutrient status of soil and includes interpretation, evaluation and fertilizer recommendations. Soil scientist can guide the farmer in fertilizer used for different crops after knowing the chemical the analysis results soil type crop history. Different methods applied for fertility evaluation are
- Pot culture experiments
- Field experiments
- Biological tests
- Deficiency symptoms
- Plant tissue analysis
- Soil testing

Objectives of soil testing

- Assessing nutrient status and grouping soils into classes relative to the nutrient levels.
- Predicting the probability of getting profitable response.
- Helping to evaluate soil productivity.
- Determining specific soil condition like alkalinity, salinity and acidity.

Phases of soil testing

- Soil testing is done in three phases
  - Collection of soil sample from the field
  - Analysis of the sample in the laboratory
  - Interpretation of results and fertilizer recommendations.

Collection of soil sample from the field

- Collection of soil sample is the most important step in the soil testing. Its chemical analysis reveals the nutrient status of the soil and guides the scientist two profitable use of fertilizer. Soil sample cannot be collected at any time throughout the year.
- Summer is the most appropriate time for collection of sample. The sample may be collected after the harvest of crop as the soil is dry at that time. Wet sample have to be dried before begin testing.
- The method of sampling depends largely on the purpose for which it is to be collected. When general fertility is to be found out the number of samples to be collected where is recording to the size of the plot.

Soil sampling tools and sampling depths

- To obtain a representative sample, a composite sample should be collected consisting of small portions of soil from approximate 12 locations with the help of the tools like auger, spade, khurpi or travel. Before collecting the sample, organic debris, rocks and trash from surface of sampling area are removed. The field is divided according to the slope, colour, depth, texture, management and cropping pattern. Each unit is divided into two parts and the zigzag line is drawn so that it covers whole area.
- A V- shaped cut is made in the soil to the depth of sampling. Next 2 - 3 cm thick vertical slice of the same depth is removed from the smoothest side off the cut. The collected samples are mixed thoroughly from the bucket is poured on a piece of clear paper or cloth and mixed thoroughly. It is divided into four equal parts and opposite potions are discarded. Remaining two portions are mixed thoroughly and the procedure is repeated to get desired quantity of soil sample.

Sampling Tools

- Proper sampling tools are essential for collection of good soil samples. Screw type and post- hole augurs are generally used for this purpose. Screw-type auger is used for harder soils. For soft moist soil, soil tube or prove is used which allows a uniform portion of the soil to be collected rapidly and accurately by pushing the tube into the ground to the desired depth and removing a soil core. The other tools used for this purpose shovel, spade, khurpi etc.
- Sample generally, soil from all the fields, should be tested at least once in every three to four years. More soil testing is required for the soils on which vegetables and other cash crops are grown. The frequency may vary depending upon the cropping intensity, soil type, fertilization rate, tillage methods, weather conditions and new research findings. The test for phosphorus and potassium is needed only once in 3-4 years while the test for available nitrogen is done annually and organic matter levels are tested once in every 5 years.

A complete soil sample information sheet is required with each soil sample submitted for soil testing information required includes-

- Name of the farmer with complete address
- Last crop grown on the soil
- Date of sampling
- Whether crop is to be irrigated
- Amount of nutrients applied last year
- Soil characteristics such as low-lying, upland, stonyness and topography
- Crop and variety to be grown and yield goals desired.
- Cropping pattern to be followed
- Depth of sampling
- Drainage slope

Use of proper tools for soil sampling

- Sampling should not be done from
- Farm lanes and field boarders.
- Fertilizer bands in row crops.
- Any areas which are distinct from the dominant soil type in the field such as eroded spots, small saline areas, sandy ridges, unless these areas are sampled separately.
- Dead furrows and headlands.
- Old manure piles for old straw stack bottoms.
- Locations where brush piles you were burnt.

Analysis in the Laboratory

- The soil sample is sieved through a 2 mm sieve and then analyzed for texture, carbonate content, PH, electrical conductivity and the level of available nutrients that is the chemical forms of an essential plant nutrient in the soil whose variation in amount is reflected in the differential growth of plant and yield.
- The basic principle of soil testing is that simple rapid chemical analytical procedure should be designed for accurate measurement of the level of available nutrients in the soil.

Classification chart for soil test data

- From the soil testing results, the soil may be classified into different categories that is to medium or high, acidic, alkaline or neutral.

Interpretation of results and fertilizer recommendations

- On the basis of soil testing results fertilizer doses are recommended for better yield of crops. If the level of nutrient in soil is very low, the fertilizer dose for the crop is increased by 50% ; if low by 25% and for moderate to moderately high, the dose is reduced by 25% and for very high, by 50%.
- Target yields can be made for the recommended fertilizers. The fertilizer's requirement for any crop is the total amount of nutrient needed by the crop minus the amount that the soil can supply. Thus, farmer can give balanced fertilizer to the crop and achieve his target of the season.