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Soil Salinity: Causes, Impacts and Management

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Soil salinity is a major concern in arid and semi arid regions across the world, making it a global challenge. It may be caused naturally or by human activities. Over the time soil salinity has increased and resulted in land degradation and desertification. It is necessary to carry out some management practices to reclaim the salt affected soils and improve the fertility and productivity of soils.

Introduction

Salinity is a major factor which affects the crop growth and productivity at a global level. Salt stress in plants is developed due to excess salts in the soil, which reduces the water potential of the soil and making the nutrients in soil solution unavailable to the plants. The process by which the saline soil formed is called salinization. It is caused due to high accumulation of Ca, Mg as well as sodium and then anions such as SO_4^{2-} , NO_3^-, CO_3^{2-} and HCO_3^-, Cl^-, etc. The Electrical Conductivity (EC) of saline soil is more than 4 dS m^{-1} (deci Siemens/meter), Exchangeable Sodium Percentage (ESP) is less than 15 % and pH is less than 8.5. On an approximation it has been found that an area of 7 million hectares has been covered by saline soils in India (Patel *et al.*, 2011). Most of the saline area occurs in Indogangetic plane which covers Punjab, Haryana, Uttar Pradesh, Bihar and some parts of Rajasthan. Arid tracts of Gujarat and Rajasthan and semi-arid tracts of Gujarat, Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh are also largely affected by salinity. Salinity impacts the growth of plants directly through the effects on water uptake, nutrient availability and by imposing plant toxicity (Litalien and Zeeb, 2020) and indirectly through the deterioration of physical conditions of soil.

Causes of soil salinity

Soil salinity is caused by natural processes and human/anthropogenic activities. The accumulation of salts in the soil occurs through natural processes like physical or chemical weathering and transport from parent material, geological deposits or groundwater. It can also occur due to parent rock constituents, such as carbonate minerals and/or feldspars or as a result of the one-time submergence of soils under seawater. Some of the parent materials of the saline soils include intermediate igneous rocks such as phenolytes, basic igneous rocks such as basalt, undifferentiated volcanic rocks, sandstones, alluvium and lagoonal deposits. Saline soils occur mostly in arid or semi arid regions. Because of low rainfall in arid regions it becomes difficult to leach out the soluble salts present. High evaporation rates also increase the concentration of salts in the soils (Yadav *et al.*, 2011). Human activities such as using salt rich irrigation water, poor irrigation practices or excess water from water logging or irrigation without proper drainage conditions can lead to salinity. The untreated industrial effluents and waste water having high dissolved salts also cause salinity (Muhamuduzzaman *et al.*, 2014).

Impact of soil salinity

The alteration in osmotic potential can be seen in the soil solution due to the presence of salts. The osmotic potential increases due to the presence of water-soluble salts in the soil which reduces the water potential of the soil. Therefore, the uptake of water reduces thereby causing the water stress for the plant (Stavi *et al.*, 2021). Specific ion effects on plants are also seen due to toxicity of ions like chlorides and sulphates. The appropriate ion ratios provide a tool to the physiological response of a plant in relation to its growth and development (Wang *et al.*, 2003). However, increased salt uptake induces specific ion toxicities like that of high Na^+, Cl^-, or SO_4^{2-} that decrease the uptake of essential nutrients like phosphorus, potassium and nitrogen (Zhu, 2001). Phosphorus gets fixed as calcium phosphate (Ca-P) under saline condition and increases the Ca ion activity (Bruland and DeMent, 2009). The nitrogen fixing bacterial growth and spread is limited under saline conditions. The increase of electrical conductivity affects the soil physical properties such as soil structure, bulk density, and permeability (Xie *et al*., 2022).

Management of soil salinity

Leaching- It is a reclamation process which involves the removal of salts from the salt affected soils with water and drainage. For leaching there must be availability of good quality water having low salt concentration. It involves dissolution of salts and deep percolation through the soil profile which prevents the excessive buildup of salts in the root zone. The volume of water required to reclaim a soil is determined by the texture of soil, salts present in it, volume of soil to be reclaimed, and desired salt level in the rhizosphere as well as plants to be grown after reclamation (Qadir *et al.*, 2000; Biswas and Biswas, 2014).

Sub-surface drainage- It is an effective method for removal of excess salts present in the soils and prevents the salinization caused by some specific ions like chlorides and sulphates. This method brings down the water table and has the potential to reduce the salinity by 50% (Raju *et al*., 2016).

Scrapping- It is practiced to remove the salt accumulated on the surface layer and reduces the salinity at the root zone thereby minimizing the toxic effect of salts on a temporary basis.

Mulching- Mulching with crop residues will reduce the evaporation of moisture from the soil surface when compared to the barren soil (Al-Rawahy *et al*., 2011). It will curtail the upward movement of salts from the ground water table.

Irrigation management- Mixing of good quality irrigation water with the saline water in a definite proportion will effectively reduce the detrimental effect of salinity. Among the different irrigation systems adopted, the improved methods like drip, sprinkler and pitcher irrigation have been found to be efficient than the conventional flood irrigation method which uses relatively lesser amount of water.

Soil / cultural management- The sowing or planting practices can be modified to obtain a more favourable salt distribution in relation to seed location and growing roots. Planting the seed in the centre of the raised bed / ridge may affect the germination as it is the spot of greatest salt accumulation. A better salinity control can be achieved by using sloping beds with seeds planted on the sloping side just above the water line. Planting at the furrow is found to be effective in ridge furrow method and reduce the injury to the germinating seeds. Different planting techniques like planting in pits, saucer pits, continuous or intermittent trenches, ditch-ridge, mound, niche seedling technique can be employed (Biswas and Biswas, 2014).

Fertilizer management- Low availability of nitrogen in salt affected soils can be compensated by the application of extra 25% of recommended nitrogen dose. Addition of organic manures like, FYM, vermicompost and compost will help in reducing the detrimental effect of salinity. The organic acids produced during the decomposition of these organic

manures will help in reducing the soil salinity. Green manuring or green leaf manuring is also effective. After decomposition, green manuring crops bring about a reduction in soil pH, thereby enhancing nutrient uptake and improve soil health in order to obtain a better crop production. The use of leguminous green manuring crops for salinity reclamation is environmental friendly and economical to improve soil fertility and crop production in salt-affected areas (Irin *et al.*, 2022).

Conclusion

Soil salinity is a major problem in arid and semi arid areas worldwide. It reduces the soil fertility and productivity of cultivable lands. Reclamation measures like leaching, sub surface drainage, scrapping, mulching, irrigation, soil and fertilizer management can be carried out to restore the affected areas. A proper monitoring and management of soil salinity is necessary to reach a step closer towards global food security.

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