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Review Article

SALT TOLERANCE BY CYANOBACTERIA AND RECLAMATION OF USAR SOIL

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ABSTRACT
Usar soils are hard impervious and nonproductive in nature containing high concentration of salt on the surface. Approximately 10% of the total cropped land surface is covered with various types of salt affected soil. It has been an important factor which has affected crop productivity. In the Asian continent maximum area affected by salt affected usar land. Cyanobacteria are capable to survive and thrive different conditions as extreme pH and high salinity and it can be used to reclaim alkaline soil and improved fertility of the soil for cultivation of crops.

Keywords: *Cyanobacteria, Reclamation, Salinity, Tolerance, Usar Soil*

INTRODUCTION
Usar soils are grouped into two categories- the saline and sodic soil. Sodic soils are characterized by high exchangeable Na^+ (more than 15%), low quantities of Ca^{2+}, and high pH values that usually range between 8.5 and 10.5 (Dhar and Mukherjee, 1936; Singh, 1950; Singh, 1961). Saline soils are those having elevated concentration of any kind of salt, whereas 'Sodic' soils have a high proportion of sodium ions relative to other cations in the soil**.** Sodic soils contain high level of free carbonate and bicarbonate and excess of sodium on the exchangeable site of clay particles. These soils are deficient in nitrogen, phosphorus and zinc. Saline soil becomes sodic through the leaching of salt (eg. NaCl). As salt is washed down through the soil it leaves some sodium behind and it bound to clay particles displacing more useful substances such as calcium. This sodium builds up in the soil and interferes with soil structure (Rengasamy and Walter, 1994). The amount of sodium and salt left determines whether the soil is non-sodic (very little sodium), sodic (a lot of sodium), or saline and Sodic (a lot of salt and sodium)

Table 1: Different horizons of usar soil, its depth and morphology-

Horizons	Depth	Morphology
A	0-11 in	Dark grey in colour; clayey loam in texture; cloddy structure; alkaline in reaction; very slightly calcareous; hard and compact.
B	11-24 in 24-38 in	Ash grey in colour; clayey in texture; cloddy structure; alkaline in reaction; calcareous; 'Kankar' nodules present; harder than above.
C	38-72 in	Ash grey in colour with yellow tinge; clayey in texture; cloddy in structure; alkaline in reaction; strongly calcareous; hard pan of 'Kankar' present.

Source: (Singh, 1961)

Distribution of Cyanobacteria in 'Usar' Soil
Cyanobacteria evolved about 3,000 million year ago and found everywhere because of their versatile occurrence ((Brock, 1973). Occurrence of Cyanobacteria in saline/alkaline soil has been described by (Singh, 1950; Singh, 1961). Soil pH is an important factor in Cyanobacterial distribution in soil (Sardeshpande and Goyal, 1981). Different cyanobacterial strains have potential to scavenge toxic sodium ion from the soil and subsequent improve soil properties in the form of carbon and nitrogen nutrition.

Cyanobacteria: A Potential Agent for Reclamation of Sodic Soil
Sodic soil has a high pH and high exchangeable Na and is often barren. Cyanobacteria, however, tolerate excess Na and grow extensively on the soil surface in wet season. Cyanobacteria tolerant to sodicity by

accumulating inorganic ions and organic compounds (sugar, polyols, quaternary amines) and osmoregulators (Rao and Burns, 1991) observed that enrichment of such soils with native cyanobacteria , over a period of time improved the soil quality and making it arable by bringing about a decrease in pH , exchangeable sodium , Na/Ca and overall increase in N,P, organic matter and water holding capacity of soil. This ultimately lowers the sodium adsorption ratio, which is an index of alkalinity and improve the hydraulic conductivity of sodic soils.

Mechanisms for Salt Tolerance by Cyanobacteria

Cyanobacteria adapted and tolerated stresses in salt affected soils such as nutrient deficiency, salinity and high pH. Cyanobacteria adapted to salt stress by accumulating organic solutes (Blumbald *et al.*, 1983; Mackay *et al.*, 1983; Reed *et al.*, 1984) by maintaining inorganic ion level (Miller *et al.*, 1976) contribution of ion transport processes (Apte and Thomas, 1983; Apte and Thomas, 1984; Reed and Stewart, 1985; Apte and Thomas, 1986; Apte *et al.*, 1987) and different metabolic adjustment (Blumwald and Tel-Or, 1984; Thomas and Apte, 1984).

Studies of stress responsive proteins have been done by different workers (Apte and Bhagwat, 1989; Fulda *et al.*, 2000; Acea *et al.*, 2003) Restricted entry of Na^+ studied to understand salt tolerance mechanism in cyanobacteria (Acea *et al.*, 2003; Pandey *et al.*, 2005; Malam *et al.*, 2007). Different work has been done to understand Na^+ efflux (Waditee *et al.*, 2001; Waditee *et al.*, 2002). Mechanism of Na^+-dependent K^+ Uptake (Suzuki *et al.*, 2000; Mikami *et al.*, 2002; Ferjani *et al.*, 2003) and formation of compatible solutes and lipids in Cyanobacteria under salt stress (Allakhverdiev *et al.*, 2000; Allakhverdiev *et al.*, 2000; Allakhverdiev *et al.*, 2001; Singh *et al.*, 2002). Enhancement of cyanobacterial salt tolerance by combined nitrogen (Apte *et al.*, 1987; Reddy *et al.*, 1989). Study of all these mechanisms helps us for better understanding salt tolerance in cyanobacteria.

Cyanobacteria Improving Property of Saline Soil

Definitely cyanobacterial application results to the enrichment of soil with fixed nitrogen, soil structure improvement, decrease of pH, electrical conductivity and Na^+. These changes improved the crop productivity and yield in salt – affected soil (Kaushik and Subhashini, 1985). Alkaline soil having high pH and Na^+ favour growth of Cyanobacteria with a consequent decrease in pH (Elayarajan, 2002; Prabu and Udayasoorian, 2007). Cyanobacteria application to saline soil reduces the electrical conductivity (Kannaiyan *et al.*, 1992; Prabu and Udayasoorian, 2007). A cyanobacterium reduces sodium ion content of the soil by making more calcium ion availability to the soil (Bhatnagar and Roychoudhury, 1992). Excreted extracellular polysaccharide by Cyanobacteria can improve soil structure by increasing soil binding property (Rogers and Burns, 1994). Soil property improves with enhanced hydraulic conductivity (Malam *et al.*, 2001). Nutrient content of saline soil was enhanced by the application of Cyanobacteria in the form of organic matter (Apte and Thomas, 1997). Available phosphorous and sulphur increased in soil in response to cyanobacterial application (Hashem, 2001). Cyanobacteria not only grown in saline ecosystems but it also improve the Physico-chemical properties of soil by enriching them with carbon, nitrogen, and available phosphorous (Antarikanonda and Amarit, 1991).

CONCLUSION

Cyanobacterial reclamation of usar soil has been reported as early as 1950 (Singh, 1950). Different physical and chemical methods such as addition of gypsum or sulphur and excessive irrigation used for usar soil reclamation do not completely remove the soluble salts and exchangeable sodium. Cyanobacteria because of their dual capacity for photosynthesis and N_2 fixation are capable of contributing to productivity in different situations (Fogg *et al.*, 1973). Understanding the salt response in Cyanobacteria will make an impact on understanding the detrimental effect of salinity on crop plants (Pandhal *et al.*, 2008). Cyanobacteria can be used to reclaim alkaline soil because they form a thick layer on the surface of soil during rainy and winter months. Algal material incorporated organic C and N and organic P and moisture to the soil and converts Na^+ to Ca^{2+}. Improvement of soil aggregation by lowering the pH and electrical conductivity and by increasing hydraulic conductivity of usar soils by cyanobacteria (Kaushik and Subhashini, 1985).

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