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# Effect of Gypsum on the Chemistry of Saline – Sodic Soils of Sangamner Area, Ahmednagar District, Maharashtra, India

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## Abstract

India is concerned to food security to meet the demands of growing millions of human population. The millions of hectares of land are lying barren due to saline – sodic problem. It is important to maintain soil health for sustainable productivity, food security and increasing agricultural production for multiple demands against fast mounting pressure on limited soil resource. Several chemical amendments including gypsum have been tried to reclaim salt affected soils. In view of this, attempts have been made to study the effect of gypsum on the chemistry of saline – sodic soils and thereby improve the current status of such soils. Eighteen soil samples were analyzed for their pH, EC, exchangable cations, organic carbon, available N, P, K and gypsum requirement by standard methods. pH is reflecting alkaline nature of soils. Higher EC have been obtained for downstream area which is associated with shallow water table. Out of four exchangable cations, the exchangable $Na^+$ was found to be higher in the downstream part. The available N varies from 88 to 199kg/ha, P varies from 0.87 to 28.4 kg/ha whereas K from 75 to 1176 kg/ha in the area. The saline sodic soils have low to very low content of nitrogen and phosphorus and high to very high content of available K. The gypsum requirement (GR) varies from 7.76 to 30.50 t/ha in the area. The GR of the soils in the area is found to be very high. This is possibly due to high order of K and Mg present in the soils. The application FYM, compost and vermi compost including green manures along with gypsum should be encouraged to reclaim saline – sodic soils. Farmer's participation and training has been looked as the best means of solving the problem of soils management in the area.

**Keywords:** Saline – sodic soils, gypsum requirement, reclamation of soils, soil quality and soil productivity.

## Introduction

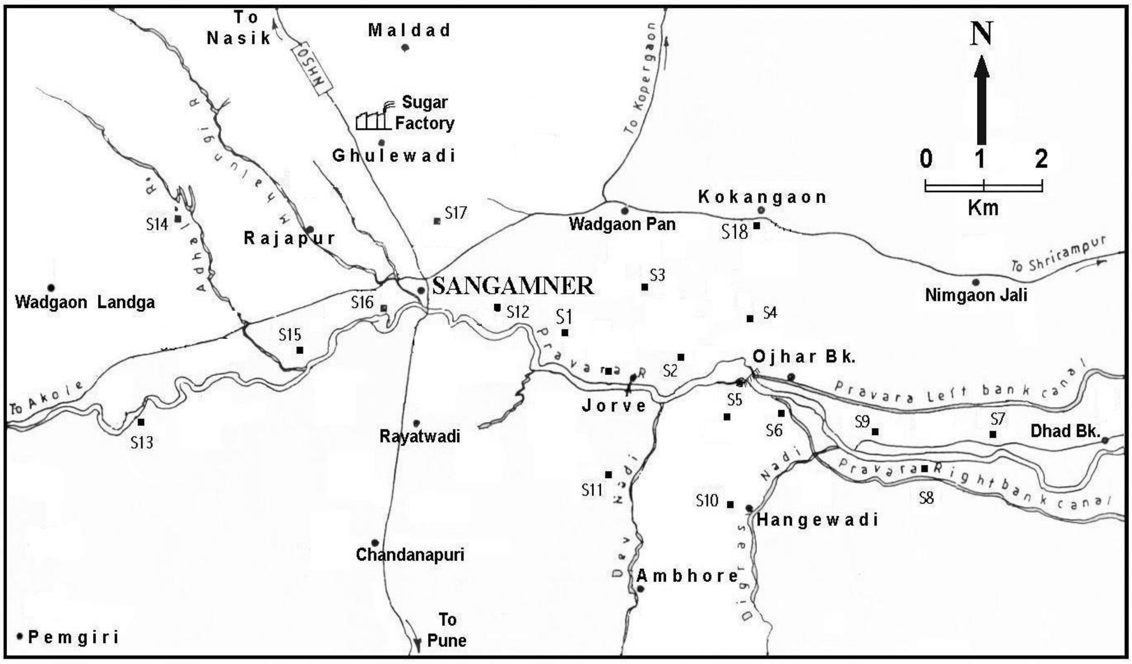
Soil and water are the important resources for all life forms. However, there is need to manage these resources judiciously to ensure sustainability on the long term basis. This is because with increase in population, there is large scale degradation of these resources. As a result, a greater threat is being posed to the social, economic and political stability of many developing countries including India. Land degradation is the major problem being faced by man today. Soil degradation causes by salinization and sodificaiton is of universal concern. Food and agriculture organization (FAO) of the United States reported that nearly one billion hectares of soil around the world were having some degree of salinization and sodificaiton problem (FAO, 1992). Most of the land shows evidence of degradation thereby affecting productive resource base. Out of total geographical area of 329 mha, 175 mha is considered salt affected in which alkali soils and saline soils including coastal areas account for 3.6 mha and 5.5 mha respectively (Somani, 2013). The major threats to Indian soils emerge from loss of organic matter, erosion, nutrient imbalance, compaction, salinization, water logging, decline in biodiversity, urbanization and contamination with heavy metals and pesticides (Patra et al., 2011). Anthropogenic activities such as the introduction of large-scale irrigation, excess use of chemical fertilizers and pesticides, deforestation and overgrazing leads to accelerated soil degradation.

India is the home of more than 1.26 billion and shares only 2.4% of the world's geographical area (329 mha) but supports about 16.7% of the world's population and over 17.20% of the world's livestock. Out of the total land area in the country, 162 Mha (49.2%) is arable, 141 Mha (42.9%) is net sown, 69Mha (20.8%) is under forest / woodland and 11 Mha (3.3%) is under permanent pastures. The availability of land per capita has decreased sharply from 0.48 ha in 1951 to 0.20 ha in 1981 and 0.15 ha in 2000 and to be further decreased 0.12 by 2025(FAO, 2001). The declining availability per capita land resources are further exacerbated by degradation and desertification of land. Therefore one of the greatest challenges today is to develop and implement soil management technologies that enhance the plant productivity and the quality of soil. If we do not improve the productive capacity of our fragile soils, we cannot continue to support the food and fiber demands of our growing population. Gypsum is most commonly used amendments for sodic soil reclamation and for reducing the harmful effects of high sodium irrigation water because of its solubility, low cost, availability and cause of handling. Several authors (Agarwal and Gupta, 1968, Ilyas et al 1997, Porta 1998, Qadir et al 2001, Walwarth 2006, Zanen et al 2008, Muya et al 2009, Rai et al 2010, Zade 2010, Ogel 2010, Deshmukh 2013 and Somani, 2013) studied the various aspects of irrigation-induced problems such as salinization and/or alkalization and role of amendment particularly gypsum for reclaiming saline - sodic soils in various parts of the world. Thus, a fairly good amount of literature is available on effect of gypsum on the chemistry of saline – sodic soils. However, little or no attention has been paid on such studies in the Sangamner area. Therefore, the present investigation will be useful in finding the remedial measures of the problems created by man-made activities in the area. Moreover, Sangamner area is also experiencing salinization and/or alkalization problems with its unique landform configuration displaying prohibitive slopes, though it has low rainfall condition in the area developed typical condition. However, irrigation not only caused the overall change in the economy as well as general development of the area but also affected agricultural ecosystem. Lack of proper management of water and land resources have started deteriorating the system, particularly in the downstream part of Pravara River. In view of this, it was decided to study effect of amendments particularly gypsum on the chemistry of saline – sodic soils and thereby improve the current status of such soils in the study area.

*The Study Area*

Sangamner area is located in the northern part of the Ahmednagar district of Maharashtra State, India. The tahsil lies between 18°36' N to 19°1' N latitude and 74° ‘ W to 74° 56’ W longitude. The Sangamner city is located on the confluence of the Mahalungi and Pravara River. It is a Taluka head quarter which is at a distance of 150 km from Pune, on Pune-Nasik National Highway No. NH-50 (Figure 1).

**Figure 1.** *Location Map Showing the Sampling Stations of the Area*




The area is drained by the Pravara River which is a tributary of Godavari and has its origin in the hilly region of Western Ghats. Geologically, basalt underlay the Pravara basin, which is characterized by thick alluvium (up to 35 m.). Several dams and weirs have been constructed across Pravara River. Because of construction of Bhandardara dam in the source region of Pravara

River, the valley has been brought under intensive agriculture with sugarcane as a single dominant crop. Subsequent to the establishment of co-operative sugar mill at Sangamner in 1967, the agriculture in the area has witnessed rapid changes in the cropping pattern. In addition to the sugar industry, several allied industrial units have also come up in the area. The effluents from the sugar industry, with little or no treatment have been stored in lagoons and then discharged into the natural stream flowing through the agricultural area for a distance of about 8 to 9 km. This effluent stream finally meets the Pravara River at Sangamner. While flowing through the natural stream, the effluent infiltrates through the soil zone into the nearby dug/bore wells, thereby adversely affecting natural soil and groundwater quality.

## Methodology

Selected 18 surface soil samples (0-20 cm) were collected in cloth bags as per the standard procedure (U.S. Salinity Laboratory Staff, 1954). Quartering technique was used for preparation of the soil samples. The samples were dried in air, crushed and passed through 2 mm sieve. The processed soil samples were analyzed for their chemical characteristics as per the standard procedures. The soil pH and EC were determined from the saturation extract (1:5 soil water ratio) of soils (Richards, 1968). The exchangeable cations such as $Ca^{2+}$, $Mg^{2+}$, $Na^{+}$ and $K^{+}$ were determined from neutral ammonium acetate extract of the soils as per the standard procedures (Jackson, 1973). Exchangable sodium percentage (ESP) was estimated by using the standard procedures. Organic carbon was determined by Walkley and Black's rapid titration method (Jackson, 1973). The available N (alkaline permanganate method), available P (Olsen's method) and available K (Flame photometer method) were estimated by standard procedures. Gypsum requirement (t/ha) was determined by Schoonoover's method as described by Richards (1968). The results obtained were presented in Tables 1.

**Table 1.** *Chemical Analysis of Soils from Study Area*

| Sr. No. | pH | EC (dS/m) | Exchangeable Cations (meq/100g) | | | | ESP | OC % | Available NPK (kg/ha) | | | GR t/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | | | N | P | K | |
| S1 | 8.6 | 2.84 | 9.71 | 0.38 | 31.75 | 18.28 | 17.47 | 0.64 | 144 | 11.77 | 710 | 13.78 |
| S2 | 8.9 | 22.1 | 11 | 1.08 | 31.5 | 8.01 | 30.12 | 0.31 | 88 | 5.94 | 709 | 26.80 |
| S3 | 8.8 | 11.8 | 10.35 | 0.56 | 32.5 | 4.5 | 22.46 | 0.48 | 107 | 28.4 | 694 | 18.90 |
| S4 | 9.5 | 8 | 9.2 | 0.3 | 18.5 | 1.25 | 25.19 | 0.16 | 94 | 4.31 | 302 | 30.50 |
| S5 | 9.1 | 1.6 | 5.5 | 0.24 | 23.75 | 20.78 | 17.10 | 0.46 | 135 | 3.14 | 396 | 19.12 |
| S6 | 9.7 | 6.3 | 8.5 | 0.38 | 12.5 | 3.0 | 20.37 | 0.40 | 88 | 4.74 | 613 | 24.02 |
| S7 | 9.1 | 2.16 | 5.5 | 0.42 | 21.5 | 18.53 | 15.43 | 0.52 | 125 | 7.11 | 627 | 12.19 |
| S8 | 8.6 | 1.1 | 6.46 | 0.51 | 24 | 22.29 | 19.55 | 0.70 | 144 | 2.58 | 709 | 8.89 |
| S9 | 8.7 | 4.7 | 8.27 | 0.35 | 23 | 28.3 | 15.85 | 0.85 | 147 | 6.67 | 75 | 10.67 |
| S10 | 8.6 | 5.5 | 3.87 | 0.37 | 23 | 22.29 | 8.56 | 0.42 | 141 | 2.7 | 880 | 23.35 |
| S11 | 8.9 | 1.42 | 4.34 | 0.28 | 27.5 | 19.78 | 9.27 | 0.63 | 138 | 4.88 | 448 | 14.05 |
| S12 | 8.6 | 1.11 | 3.72 | 0.21 | 27.75 | 26.54 | 6.58 | 1.05 | 125 | 3.4 | 358 | 7.60 |
| S13 | 8.8 | 0.66 | 6.4 | 0.28 | 22.22 | 28.05 | 15.10 | 0.45 | 199 | 2.47 | 463 | 14.23 |
| S14 | 8.6 | 0.45 | 1.55 | 0.35 | 25.25 | 18.53 | 2.18 | 0.57 | 153 | 2.17 | 629 | 11.80 |
| S15 | 8.9 | 1.7 | 5.37 | 0.34 | 27.5 | 17.78 | 9.50 | 0.43 | 122 | 0.87 | 463 | 23.00 |
| S16 | 8.6 | 1.84 | 4.75 | 0.18 | 22.5 | 22.54 | 8.28 | 0.51 | 119 | 7.36 | 275 | 12.25 |
| S17 | 8.8 | 0.94 | 6.61 | 0.18 | 30.75 | 44.58 | 10.86 | 0.96 | 135 | 1.99 | 261 | 7.95 |
| S18 | 8.7 | 0.41 | 1.86 | 1.36 | 25 | 12.52 | 3.33 | 0.61 | 156 | 1.39 | 1176 | 14.10 |

## Results and Discussion

*Soil Salinity*

Increase in the concentration of dissolved salts in the water attributable to both natural and human induced factors, leads to the process of salinization (Salama et al, 1999). However, salinization is usually caused by mismanagement of irrigation. It badly affects physical properties of soils and plant growth and also leads to reduction in crop yields. Salinization causes corrosion of plumbing, industrial boilers and household appliances and thereby increases the water treatment costs, which affect industrial and municipal users. There is deterioration in drinking water quality due to salinization (E1 – Ashry et al, 1985).

High pH of soil in the area is reflecting alkaline nature of soils. Increased soil pH has also lead to excessive phosphorus fixation, thereby causing high P – retention capacity and low soil productivity (Muya et al 2009). The high pH of sodic soils are also due to sodium on clay and carbonate ions which are elevated in such soils reacts with water to produce hydroxide ions (Somani, 2013).

$$Na - clay + H_2O \longrightarrow H - clay + Na^+ + OH^-$$

$$CO_3^{2-} + H_2O \longrightarrow HCO_3^- + OH^-$$

Decrease in pH of sodic soil was more remarkable in combined application of gypsum and FYM treatments. Gypsum provides $Ca^{2+}$ to replace the absorbed $Na^+$ and manure further boosts the process of producing organic acid and $CO_2$ to dissolve $CaCO_3$ to liberate more $Ca^{2+}$ for replacement of $Na^+$. The decrease in pH may be due to removal of exchangable sodium from the soil column. Moreover gypsum solubility is also enhanced because of the increased activity coefficient of calcium and sulphate as a result of increased ionic strength of solution and formation of sodium sulphate ion pair. Besides, large quantities of $CO_2$ are evolved during leaching process. Some of which would become solution in soil soluble giving carbonic acids.

Soil salinity is estimated by the ability of water extract of soil to conduct an electric current i.e. electrical conductivity of the soil extract. Several workers (USSL, 1954, Muhr 1963, Gupta and Gupta 1997 and Hopkins and Richardson, 1999) have proposed various criteria on the basis of EC to assess the degree of salinity of soils. However, Gupta and Gupta, (1997) have suggested the salinity appraisal on the basis of EC particularly in relation to plant growth. By using this criterion following salinity classification is proposed for the soils from study area (Table 2).

**Table 2.** *Soil Salinity Classification on the Basis of EC of Soil Extract*

| **Nature of Soil** | **EC (dS/m)** | **Plant Growth** | **No. of samples and their locations** |
|---|---|---|---|
| Normal | < 1.5 | Normal for all crops | S8, S11, S12, S13, S14, S17 and S18 = **07 (38.88 %)** |
| Low Salinity | 1.5 – 3 | Yields of very sensitive crops restricted | S1, S5, S7, S15 and S16 = **05 (27.77%)** |
| Medium Salinity | 3 to 5 | Yields of many crops restricted | S9 = **1 (5.56 %)** |
| High Salinity | 5 – 10 | Only tolerant crops yield satisfactory | S4, S6 and S10 = **3 (16.66%)** |
| Very high salinity | > 10 | Only a few very tolerant crops yield satisfactorily | S2 and S3 = **2 (11.11 %)** |

It is observed from the table that out of 18 soil samples, 7 (38.88%) samples belong to normal salinity class, which is normal for all crops. The remaining 11 (61.11%) samples have some of kind of salinity problem developed in the area. 5 (27.77%) and 1 (5.55%) samples have low to moderate salinity categories respectively. Further 3 (16.66%) and 2 (11.11%) samples have high salinity to very high salinity classes respectively. It is observed that the soils from the downstream part of Pravara River and in the backwaters area of Ojhar weir have high to very salinity classes (Fig 1). The observation shows that the normal soils with EC less than 1.5 lie in the upper part of the basin, which is predominantly non-irrigated. On the contrary, it is interesting to note that samples having EC greater than 20 (S. No. S2) was observed in the down-stream part of the area where intensive irrigation is practiced. Also it is observed from the table that considerable irrigated area is under the threat of soil and groundwater salinization.

*Origin of Soil Salinity in the Area*

The locations of soil and groundwater salinization identified in the area demonstrate the existence of salinity problem. Salinization is a cumulative effect of various parameters such as climate, topography, geology, over-irrigation, irrigation practices, quality of irrigation water, restricted drainage, use of chemical fertilizers and landuse have played an important role in the development of saline soils in the area.

*Climate*

The Sangamner area is characterized by semi-arid climatic conditions with average rainfall not exceeding 500 mm. The area is semi-arid with maximum temperature as high as $42^0$C. Since it falls under the rain shadow zone having scanty rainfall thereby leaching of soils does not take place effectively. These salts accumulated within the area are probably added to groundwater during wet period. In addition, reduction in the flow of river is due to impoundment of water at Bhandardara reservoir has further reduced the flowing rates of the salts. Furthermore, the impoundment of water at Ojhar weir along with the siltation has restricted the movement of salts from the area. Thus, high temperature favoring higher rate of evaporation, lack of surface flow condition, congestion of drainage conditions and siltation in the Ojhar weir seems to hasten the process of salinization of ground water and soils in the area.

*Geology*

The soils from the area are derived from basaltic rocks, which are rich in bases. Therefore they are potentially able to supply very large amount of calcium, magnesium and sodium salts. Due to introduction of irrigation, the dissolution of these bases has been accelerated. As result of this, the ground water was heavily charged with salts. In addition, the salts leached from the upper parts of the area are further accumulated in the downland leading to salinization of both, soil and groundwater resources. Due to flat topography of alluvial aquifers in the downstream part of the area, free natural drainage is absent. This leads to increase the residence time and sluggish ground water movement producing salinization. In some parts, salts are highly concentrated to the extent that no salt tolerant crops could endure the soil conditions because of this many acres of land has remained uncultivated.

*Use of Chemical Fertilizers and Nitrate Pollution*

Heavy application of fertilizers along with irrigation facilities has also contributed to salinity problem. Commercial fertilizers yield chloride, sulphate, nitrate, phosphate, calcium, potassium, magnesium, ammonium and sodium ions in various amounts increasing their concentration in groundwater. Excessive use of fertilizers particularly in soils under intensive monoculture tends to lose organic matter and their ability to retain moisture. Thus, becoming more susceptible to erosion and ultimately losing their fertility and productivity.

However, the solubility of phosphate fertilizers is low and it is adsorbed on the soil. Potassium ions from the potash fertilizers are also very well adsorbed on the soil. On the contrary, neither physical nor chemical sorption of nitrate ions occurs with nitrogen fertilizers. Their absorption is predominantly biological. However, the plants through the roots absorb part of nitrogen fertilizer and some part is transformed into cell walls of microorganism. However, this mechanism of nitrate removal is insignificant in soil environment. Overall, the nitrate from fertilizer percolates into the groundwater thereby increasing the nitrate pollution. Majority of the irrigated area under study has been occupied by sugarcane. It encourages using excess of irrigation water, over dose of chemical fertilizers irrespective of crop requirement and soil properties. This has disturbed the quality of soil resulting into emergence of saline tract within the irrigated part of the region.

*Landuse*

In any irrigated area, assessment of current land-use is important because it has direct bearing on the water resource utilization pattern (Rao, 1975). However, in the area, land use pattern, unique geological and topographic system have considerable impact on the soil and groundwater quality. The industrial and urban development in the area is not much significant. However, agricultural development along the Pravara River is noticeable. The high value crops like sugarcane followed by vegetables like tomato, bhendi, cauliflower, cabbage, bringles etc have been cropped in the irrigated land use. Such land-use encourages the application of fertilizers and pesticides combined with the changes in the soil and groundwater chemistry. However in the hilly area, it is observed that part of the traditional agriculture have been responsible for degradation of the land. The degradation includes deforestation coupled with loss of structure, soil erosion and depletion in soil fertility. The barren, rocky and typical stony wasteland is observed in this area. The large patches of scrubs are seen near the villages like Jorve, Kolhewadi, Rahimpur and Ojhar (Fig 1). These scrubs are *Prosopis juliflora*, reeds etc. all along the major drainage/stream courses in the region. Many a times, this vegetation is closely associated with salt affected lands.

## Soil Sodicity

The soils in which the exchange complex contain appreciable quantities of exchangeable $Na^+$ but may or may not contain excess salts, are called alkali or sodic soils. The process is known as sodiumization/alkalization (Daji, 1996). In this process, the salts such as sodium bicarbonate and/or carbonate predominate. It is characterized by ESP > 15, pH usually between 8.5 and 10, EC < 4 and they exhibit poor physical conditions (Tripathi, 1998). The dissolved organic matter present in the soils is alkaline which gets deposited on the soil surface by evaporation to give rise ‘black alkali’. Further dispersed clay transported downward through the soil profile accumulates at lower levels. As a result, a few inches of surface soil is relatively coarse in texture and friable, below which clay develops layer of low permeability, with columnar prismatic structure. This further leads to change in soil and water chemistry. Organic amendments decreased soil sodicity and increased $Ca^{2+}$ and $Mg^{2+}$ (Anand, 1992). The chemical analysis of groundwater from the study area reflected predominance of $Na^+$ followed by $Ca^{2+}$ and $Mg^{2+}$. The anions were found in the order of abundance $Cl^->HCO_3^->SO_4^{2-}>NO_3^-$. This suggests that carbonates / bicarbonates saturated water causing precipitation of calcium and magnesium have left behind sodium rich solution that is forming sodicity in the area. The absorption of sodium increases with high Mg/Ca ratio of waters resulting in enhanced sodicity (Paliwal and Gandhi, 1976). Velayutham (1999) has made suggestions to estimate the degree of soil sodicity on the basis of ESP. According to him when ESP < 15, then degree of sodicity of soil slight, if it is 15-40 then moderate and when greater than 40 then soil shows strong sodicity. Based on this, soils from the area can be classified. It is observed from the table that out of 18 samples, 8 (44.44%) samples show slight sodicity, 10 (55.55%) samples show moderate sodicity. This indicates that there is considerable degree of sodiumization of soil that is restricted in irrigated area. This problem is more serious in the downstream part of Pravara River where backwater of Ojhar weir has caused waterlogging condition. It is observed that the samples with ESP greater than 15 (S. No. S1, S2, S3, S4, S5, S6, S7, S8, S9 and S13) also lie all along the river bank areas where intensive agriculture is practiced. The samples showing ESP values below 5 (S. No. S32, S41, S42, S43, S45, S46, S47, S48, S50, S51, S52, S59, S60 and S62) have been collected from local high ground water divide areas (Fig 1) that are necessarily under non-irrigated agriculture land use. Sodiumization in the downstream part may be attributed to waterlogging in the area. It is further observed that (Table 1) the exchangeable $Na^+$ is higher in the downstream part compared to $Ca^{2+}$ and $Mg^{2+}$. The occurrence of exchangeable $Na^+$ seems to be associated with clay content of the soils. The soils in the study area are mostly clay to clayey loam (Deshmukh, 2012). Montmorillonite is the dominant clay mineral found in these soils. As a result, sodiumization of soils in the area has taken place. The evidences of sodiumization are manifested in the poor physical condition of the soil which have high ESP (Table 1) and development of white incrustation on the surface.

## Reclamation of Saline – Sodic Soils from Study Area

*Chemistry of Gypsum in Reclamation of Saline Sodic Soils*

The amount of gypsum that should be applied is best determined by soil analysis. The kind and quantity of chemical amendment to be used for replacement of sodium in the soil depend on the soil characteristics including the extent of soil deterioration, desired level of soil improvement including crop intended to be grown and economic consideration (Haq et al, 2007). Reclamation of saline –sodic soils requires removal of $Na^+$ from the colloid's cation exchange sites, usually by gypsum and leaching of the replaced $Na^+$ out of the root zone in percolating water. The exchange reaction between gypsum and the soils' exchangable $Na^+$ depends on the contact of gypsum with soil particles and the rate of removal of $Na^+$ from the soil solution.

$$CaSO_4 + 2Na\text{-clay} \longrightarrow Ca\text{-clay} + Na_2SO_4 \downarrow$$

Gypsum applications increases permeability and leaching, improve flocculation and macro porosity, decrease bulk density and reduce surface crusting (Frenkel H, 1985). The addition of organic matter in conjunction with gypsum has been successful in reducing adverse soil properties associated with sodic soils. Addition of organic matter and gypsum to the surface will decreases spontaneous dispersion and EC down to the sub soil compared to the addition of gypsum alone (Chauhan et al, 1986, Patel and Sutar, 1993 and Vance et al, 1998). In view of this, the GR of sodic soils in the study area was estimated and results are presented in Table 1. The present study gypsum requirement varies from 7.76 to 30.50 t/ha in the area. The gypsum requirement (GR) of the soils is found to be high for the soils having less organic matter content (Table 1). In general, GR of the soils in the area is found to be high. This is possibly due to high order of K and Mg present in the soils (Somwanshi, 1999). This is because GR does not distinguish between exchangeable Na, K and Mg. Gypsum requirement of soil is also influenced by soil texture and exchangeable sodium percentage of the soils from the area (Deshmukh, 2012).

*Role of Organic Matter in Reclamation of Saline Sodic Soils*

Soil organic matter encourages granulation, increases cation exchange capacity (CEC) and is responsible upto 90% adsorbing power of the soils. Cations such as $Ca^{2+}$, $Mg^{2+}$ and $K^{+}$ are produced during decomposition (Brandy and Weil, 2005). In the present study, organic carbon content ranges from 0.16 to 1.05% in the soils from the area. However, low status of organic carbon was noticed in all the samples except for three samples (S. No. S9, S12 and S17). This is possibly due to strong alkaline condition (pH>8.5) which might have dissolved the humic substances of soil and further they are lost from the soils. Along with gypsum, equivalent quality of press mud locally available as the byproduct of sugar factory is used to enhance the efficiency of gypsum in the area. Such an approach can reduce the cost of reclamation by using locally available organic amendments.

*Role of Nutrient Management in Reclamation of Saline Sodic Soils*

Excessive sodicity, high pH and poor physical condition are chief factors responsible for nutrient imbalance and reduced availability of many plant nutrients to sodic soils (Somani, 2013). Sodic soils are generally poor in organic matter. The availability of nutrients particularly nitrogen, phosphorus sulphur and zinc is poor in sodic soils. Thus such soils require the addition of manure and fertilizers (Singh et al, 1998). Nitrogen level in these soils is not only low due to impeded mineralization processes but also low due to increased leaching in the reclamation process (Sidhu and Cornfiled, 2006).

In the present study, the available N, P and K from sodic soils were estimated and results obtained are presented in Table 1. The available nitrogen in the soils ranges from 88 to 199 kg/ha. It shows soils from the area have low to very low content of available nitrogen. Urea is not preferred due to high pH of sodic soils. The high pH and presence of carbonate in sodic soils are responsible for the decreased urease activity and slow rate of hydrolysis (Somani, 2013). The low carbon and nitrogen level in saline – sodic soils is associated with impeded biological and mineralization processes due to low soil quality resulting from chemical degradation. The slower rate of urea hydrolysis, N mineralization and greater volatilization lead to reduced nitrogen availability in sodic soils in the area.

The available P ranges from 0.87 to 28.4 kg/ha (Table 1). The low status of available P was found in the soils from study area. Only one sample (S. No. S3) showed high available P. This is possibly attributable to strongly alkaline condition of the soil (pH>8.5). The sodic soils do not respond to P application. This is possibly due to the reaction between insoluble calcium phosphate and sodium carbonate to give soluble sodium phosphate (Chhabra and Abrol, 1981). The reaction can be represented as

$$Ca_3(PO_4)_2 + Na_2CO_3 \longrightarrow Na_3PO_4 + 3CaCO_3$$

Therefore, when sodic soil is leached without gypsum, considerable loss of P occurs. However, reclamation of such soils by gypsum decreases the leaching of soluble P. This is due to immobilization of soluble P by $CaSO_4$ through the formation of less soluble Ca - P compounds, common ion effect to decrease solubility of Ca-P compounds and lowering of soil pH decreases the solubility of Ca - P compounds in the pH range 8.3 to 10 (Somani, 2013). Therefore gypsum can be used successfully to reclaim sodic soils and P application can be practiced in such soils.

The available K in the soil ranges from 75 to 1176 kg/ha (Table 1). All the samples except one (S. No. S9) have high to very high content of available K. This is possibly due to the release of K from clays under high pH conditions. It was also observed that the rate of release of $K^+$ and its uptake are not ordinarily influenced in salt affected soils. This is due to water soluble and ammonium acetate soluble $K^+$ is at a high to very high level in these soils. No responses of $K^+$ application have been observed in the area. Therefore, application of potash fertilsers as such are not required for the reclamation of sodic soils in the area. Sodic soils by and large are dominated by illitic clay minerals and are rich in K. very high amount of potassium is a characteristic feature of sodic soils.

## Conclusions

The Sangamner area is characterized by semi-arid climatic conditions with high temperature and scanty rainfall. Due to this leaching of salts does not take place effectively in the area. The soils from the area have poor structure, high pH, low organic matter and high electrical conductivity. This leads to increased salinity, high ESP showing saline – sodic conditions. Majority of the population from the area is dependent upon agriculture. Therefore, there is need to improve the quality of existing soil and thereby to increase agricultural productivity. This requires use of appropriate amendments techniques. Amongst variety of chemical amendments, gypsum is preferred due to its unique properties. It improves soil properties and hence the yield of the crops.

In the study area, sodic soils have low to very low content of available nitrogen, phosphorus and organic matter. The application of ammonium sulphate instead of urea should be facilitated in such soils depending upon the crop requirement. The use of gypsum in such soils does not hamper the availability of phosphorus to the plants. High to very high content of available K was found in the sodic soils. The application of FYM, compost and vermi compost including dung should be encouraged to reclaim such soils. Selected species of salt tolerant crops and grasses can be planted in saline – sodic soils.

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