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Micro-biochemical Properties under Saline-sodic conditions

Santosh Patil[1*], Deepak Patil[1], Sunil Joshi[1] and Sunil Jawale[2]
[1]BAIF Development Research Foundation, Uruli Kanchan, Pune 412 202, Maharashtra, India
[2]Department of Soil Science and Agriculture Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India
santosh86patil@gmail.com

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Abstract

An investigation was conducted on farmer's field with an objective to study the "Residual effect of post-biomethanated spent wash on properties of soil solum and yield of Pearl millet" in the jurisdiction of Padmashri Vitthalrao Vikhe Patil Sahakari Sakhar Karkhana, Pravaranagar, Rahata Tahsil, Dist. Ahmednagar with determine the effect of saline-sodicity on the soil micros and their correlations with chemical properties of soil. For this randomly 75 soil samples of depth 0-15 cm were collected from salt-affected soils of Mula command area of Rahuri Tahsil, Dist. Ahmednagar (M.S.) by using GPS technique. The randomly collected soil samples were analyzed for saline-sodicity appraisal parameters viz., pHe, ECe and ESP. On basis of these parameters, soil samples were grouped into low, medium and high saline-sodic soil. Adjacent soil samples from normal cultivated areas of a depth of 0-15 cm were also taken as a normal soil group. The total 28 soil samples from the four soil groups as treatments and seven soil samples from each group as replications were analyzed for microbial population. The results showed that the microbial population viz., bacteria, fungi, actinomycetes, PSB and Azotobacter and soil respiration (CO_2 evolution) were found to be decreased with an increasing saline-sodicity. The significant positive correlations were observed in between microbial properties and organic carbon content in soils, whereas, negative correlations with cations like Ca^{++}, Na^{+}, Mg^{++} and anions like HCO_3^{-}, Cl^{-} suggested that any decrease in the microbial activities.

Keywords: Saline-Sodicity, Microbial Activity, Correlations.

Introduction

Soil degradation can be defined as the rate of adverse changes in soil quality resulting in productive capacity of land due to processes induced either by natural or human intervention[1]. Soil degradation is a major environmental constraint with severe negative impacts on agricultural productivity and sustainability[2]. Research has been done on the soil chemical, physical properties and plant growth; however, microbial activities relatively less studied. Considerable research undertaken to study the effects on the chemical and physical properties of sodic and saline-sodic soils[3]. Some of the research has been also carried out in naturally saline soils[4] but little is known on micro-biochemical properties of soil.

By considering the above situation the research was carried out to determine how saline-sodic soils under semi-arid conditions affected population of micro-organisms, enzyme activities and also to ascertain the existence of microbes specifically beneficial microbes like PSB and N-fixers under extreme stress environment and to study the pattern of activity of enzymes involved in biochemical reactions in saline-sodic soils. The use of GPS technique for soil sampling will be useful for locating sites for future sampling in proposed work. The outcome of this research will help to undertake future research for identification and isolation of efficient strains of PSB and N-fixer from extreme saline-sodic soils and there *in vivo* and *in vitro* study performance as a biofertilizer with and without various cheap organic amendments locally easy available on farmers field for saline-sodic soils, thereafter to monitor their effects on improvement of productivity of degraded soils.

Materials and Methods

Soil with varying levels of secondary saline-sodicity was collected with the help of GPS from different sites of salt affected soils of Mula Command area of Ahmednagar district during *Kharif* 2009. The study sites were situated on both sides of Pune-Manmad state highway, about 33 km North of Ahmednagar city, MS, India. Initially a survey of salt affected soils on basis of morphological and physical properties of soils from Mula Command area was made for locating graded levels of saline-sodicity areas. The randomly 75 soil samples (0-15 cm) using GPS were collected and analyzed for saline-sodicity appraisal parameters, *viz.,* pHe, ECe and ESP. On basis of saline-sodicity appraisal parameter soils were categorized into three saline-sodic groups' *viz.,* low, medium and high saline-sodic soils (Table-1). The area were identified and located as low, medium and high saline-sodic soils in Mula command area. After locating areas, seven fresh field moist samples (0-15 cm solid depth) from three groups were collected during June-July, 2009. Adjacent soil samples (0-15cm) from normal cultivated

area were also taken as a normal soil group. Thus, altogether 28 samples were sieved (<2 mm) and collected, processed soil samples were stored at 4^0C until their determination of microbial and biochemical properties[5].

Table-1
Categorization of saline-sodic soils

Groups of saline- sodic soils	ESP	pHe	ECe (dSm^{-1})
Normal	< 5	7.5-8.0	< 0.25
Low	5-10	8.0-8.25	1-2
Medium	10-15	8.25-8.5	2-4
High	> 15	>8.5	>4

Analytical procedure: Saturation paste extracts of soil samples were prepared; pHe and electrical conductivity (ECe) were measured by the method described by Jackson[6]. The microbial population was measured by serial dilution plating technique[7]. Soil respiration *viz.,* CO_2 evolution from field moist soil with a vial containing standard NaOH in a 500 ml conical flask and making it air tight with a stopper. Incubating the samples for 24 hrs in the dark at 25^0C. After 24 hrs of incubation the vial containing the NaOH (1M) solution was removed and the trapped CO_2 was estimated by titrating NaOH with HCl (1M)[8] and evolved CO_2 from soil was expressed as mg CO_2-C 100g-1 soil $24hr^{-1}$.

Ten gm of soil along with 0.1g of $CaCO_3$ mixed thoroughly and from this mixture 3 gm of mixture was placed in test tubes in triplicate which were incubated at 37^0C for 24 hrs with 0.5 ml TTC (3%) during incubation as a substrate. Triphenyl formazan (TPF) produced during enzymatic reaction as a TTC to TPF and which was extracted with methanol and the red color intensity of TPF formed during reaction time was measured on spectrophotometer at 485 nm. The activity of dehydrogenase was expressed as µg TPF g^{-1} $hr^{-1.}$

The urease activity was determined by adopting the standard method proposed by Tabatabai and Bremmner 1972[9]. The activity of urease was expressed as mg NH_4-N 100 g^{-1} soil hr^{-1}. The acid and alkaline phosphatase was assessed by using 5 gm moistened soil in assay medium, 20 ml modified universal buffer (pH 6.5 and pH 11), 1 ml pure toluene, and substrate 5 ml Na-β-glycerol phosphate (0.2M)[10]. The activity of both phosphatases was determined after incubation for one hour at 37 ^{0}C by measuring absorbance at 400 nm on spectrophotometer of the p-nitrophenol (PNP) released and expressed as µg PNP g^{-1} hr^{-1}.

Statistical analysis: For statistical analysis BASICA (dry soft) was used. The three groups i.e. (high, medium and low) saline-sodic soils and the fourth normal soil were considered as four treatments in this study. Statistical difference of enzyme activities and microbial population were determined using a randomized block design (RBD). With the help of Microsoft excel software correlation was determined on the basis of Pearson's correlation coefficient.

Results and Discussion

Soil Microbial Properties: The treatments i.e. various groups of saline-sodic soils significantly influenced the microbial population *viz.,* bacteria, fungi and actinomycetes, PSB and *Azotobacter*. This microbial population decreased as there was increase in saline-sodic levels. In general, the microbial population was very less in high saline-sodic soils as compared with normal soils. Among the treatments, the higher microbial population was observed in normal soil followed by low saline-sodic soils. In this study, measures of density were equally or more closely negatively correlated to ECe, pHe and other cations and anions and positively correlated with the organic carbon content. The negative relationship between microbial population and ECe, pHe and other cations and anions (Table-1) showed the extremely harmful effects that increasing saline-sodicity has on soil microbes. Our results match with the Ragab, 1993[11]; Rietz and Haynes, 2003[12], Sardinha *et.al.*[13] and Zahran *et.al.*[14]. The microbial population and soil organic carbon are in most situations[15,16].

Due to increased salinity, microorganisms tend to dehydrate. Mg alkalinity conditions, toxicities of Mg^{2+} and other accompanying ions e.g. CO_3^{2-} and HCO_3^- along with the very high pH may also inhibit microbial growth[4]. The highest reduction was observed in fungi in high saline-sodic soils followed by bacteria and actinomycetes. The population of PSB and *Azotobacter* showed significant decrease as the saline-sodicity levels increased. The PSB population was as ranged between 1.57 to 8.85 x 10^4 cfu g^{-1} soil and the *Azotobacter* population observed in the range of 5 to 15.71x10^4 cfu g^{-1} soil in high, medium and low saline-sodic soils as compared with normal soil. PSB population showed 82 % reduction and *Azotobacter* as 68 % reduction in high saline-sodic soils as compared with the normal soil.

Statistical analysis showed significant correlations between soil organic carbon, however negative correlations between the cations like Mg^{++}, Ca^{++}, Na^+ and anions like HCO_3^- and Cl^-. The impact of Mg^{++} ion was more pronounced on enzyme activities as compared to other ions. Soil respiration expressed as mg CO_2-C 100g-1 soil $24hr^{-1}$ determined from various groups of saline-sodic soils showed that 43.51mg CO_2-C $100g^{-1}$ soil $24hr^{-1}$ from normal soil and 37.02, 27.01 and 18.65 mg CO_2-C $100g^{-1}$ soil $24hr^{-1}$ was respired from low, medium and high saline-sodic soil groups. Soil respiration in high saline-sodic soil was significantly lower than that of normal soil (control).

Table-2
Soil Microbial Properties as influenced by varying levels of saline-sodicity

Tr. No.	Treatments	Bacteria (_x 10^5 cfu g^{-1} soil)	Fungi (_x10^4 cfu g^{-1} soil)	Actinomycetes (_x10^4 cfug^{-1} soil)	PSB (_x10^4 cfu g^{-1} soil)	*Azotobacter* (_x10^4 cfu g^{-1} soil)
T_1	Normal soil	39.42	17.714	26.42	8.85	15.71
T_2	Low saline-sodic soil	31.85 (-19.20)	12.57 (-29)	23.57 (-11)	5.71 (-35)	10.78 (-31)
T_3	Medium saline-sodic soil	24.42 (-38.05)	8.57 (-51)	18.42 (-30)	3.14 (-82)	8.21 (-48)
T_4	High saline-sodic soil	13.28 (-66.31)	3.0 (-83)	12.00 (-54)	1.57 (-82)	5.00 (-68)
	S.E. ±	0.760	0.442	0.401	0.327	0.742
	CD at 5%	2.256	1.313	1.190	0.972	2.205

Thus, our data indicate that soil respiration was consistently lowered in low, medium, and high saline-sodic soils. About 15, 38 and 57% reduction in soil respiration could be explained by the variation in various groups of saline-sodic soils; respectively as compared with the normal soil.

Conclusion

This study revealed that the soil microbial population and biochemical properties were adversely affected by saline-sodicity soil environment and the situation was extreme in high saline-sodic soils. Our data show that high saline-sodicity tend to result in a small fungal population followed by bacteria and actinomycetes. Also the population of PSB and *Azotobacter* reduced as the saline-sodicity increased. The enzyme activities *viz.*, dehydrogenase, urease, acid and alkaline phosphatase and nitrate reductase activity decreased significantly with increase in saline-sodicity. This study also indicates the existence of few PSB and *Azotobacter* strains under extreme soil conditions.

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