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INFLUENCE OF VARIOUS AMENDMENTS AND NPK FERTILIZATION ON SOIL PROPERTIES AND AVAILABLE NUTRIENT CONTENTS IN AN INDUSTRIALLY POLLUTED SOIL

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Abstract

An experiment was conducted in the Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalainagar during July 2017 to October 2017 to evaluate the effect of organic and inorganic soil amendments in an industrially polluted soil to assess the changes in physico-chemical properties and nutrient availability with sunflower as a test crop. The results revealed that higher pH and Ec values were observed in RDF+ lime applied treatments and the lower values in RDF+EDTA amended treatment. Whereas higher CEC and soil organic carbon content were noted in RDF +FYM treatment and lower values under RDF+ lime applied. Higher soil available N,P and K,S were recorded under RDF+FYM amended treatment and lower status were observed under RDF+lime applied treatment. Higher availability of Fe,Mn,Zn and Cu were registered in RDF+ press mud amended pots and lower availability were observed in RDF+ lime amended pots. Based on the experimental results, it can be concluded that amending with RDF + FYM or Press mud to maintain the fluctuating soil physico-chemical properties in an industrially polluted soil along with enhancing the availability of soil available NPKS and Fe, Mn, Zn, Cu significantly.

Keywords : CEC, EDTA, FYM, pH, Nutrient availability, Press mud, Polluted soil

Introduction

The issues of contamination of agricultural soils and chemical residues in agricultural produce have become increasingly important in recent years due to increased public awareness and concern for food and land quality (Rizwan *et al.*, 2016b; Shaheen and Rinklebe, 2015). In agriculture, various amendments both organic and inorganic are frequently used to improve the soil properties such as physico-chemical, microbial and enzyme activities or properties of soil organic matter and many of them significantly modify the mobility of pollutants in soil environment. Soil organic matter consists mainly of humic substances that plays a key role in governing complexation / immobilization / retention of trace metal ions (metal mobility) and hence their bioavailability (Piccolo, 1989; Almas *et al.,* 1995). Certain organic and inorganic amendments (FYM, pressmud, zeolite, K-humate, lime, gypsum) can serve as immobilizing and mobilizing agents for some nutrient and metal ions.

In recent past, industrialization in Tamil Nadu, the southernmost state of India, stepping up in various sectors are proved innumerable growth in economy as well as in pollution. Major industries in these areas include pharmaceuticals, fertilizers, agrochemicals, beverages, hardware, automobiles etc. Present study area, Cuddalore district have numerous industrial units most of them set at SIPCOT and it disposes their effluents in eastern (sea coast) and northern parts (agricultural lands) are likely to cause excess accumulation of metals and thereby resulting in deterioration of soil health. This area mostly covered by sandy and sandy loam soils and due to poor soil health they become unproductive. So, there is an immediate need for cleanup these polluted soils to maintain it to be productive and avoid the spread of this contamination to chronic levels. If it is not done then this area become abandon agriculture very soon.

Hence, keeping all these above aspects in view, to provide a suitable cleanup strategy and enhancing soil and crop productivity in an industrially polluted soil, the present investigation was, therefore been undertaken to study the effect of organic and inorganic soil amendments (FYM, press mud, lime, gypsum, K-humate, zeolite and EDTA) along with application of NPK fertilizers on assessment of fluctuating soil physico-chemical properties and soil available macro and micro nutrients cropped with sunflower.

Materials and Methods

Experiment was conducted in the Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalainagar during July 2017 to October 2017 to evaluate the effect of organic and inorganic soil amendments in an industrially polluted soil to assess the changes in physico-chemical properties and nutrient availability with sunflower as a test crop with following treatments detailed below.

Treatments	-	Fertilizers/Amendments
T_1	-	Control (100 % RDF)
T_2	-	RDF + Farm yard manure
T_3	-	RDF + Pressmud
T_4	-	RDF +EDTA
T_5	-	RDF + Lime
T_6	-	RDF + Gypsum
T_7	-	RDF + Potassium humate
T_8	-	RDF + Zeolite

Statistical Design	: CRD
Treatment combinations	: 8
Replications	: 3
Number of pots	: 24
Weight of soil pot^{-1}	: 24 kg
Duration of experiment	: 95days

RDF: 60:90:60 kg NPK ha^{-1}
Crop :Sunflower

Table 1 : Physico-chemical properties of experimental soil

Particulars	
Physical properties (Mechanical analysis)	
Bulk density (Mg m^{-3})	1.51
Particle density (Mg m^{-3})	2.30
Pore space (%)	34.35
Water holding capacity (%)	31.5 (42 ml/100 g of soil)
Chemical properties	
pH	7.81
EC (dSm^{-1})	0.72
Cation exchange capacity (cmol (P^+) kg $^{-1}$)	13.52
Organic carbon (g kg^{-1})	0.41
Available nitrogen (kg ha^{-1})	178.2
Available phosphorus (kg ha^{-1})	11.3
Available potassium (kg ha^{-1})	146.8
Exchangeable calcium (cmol (P^+) kg $^{-1}$)	10.02
Exchangeable magnesium (cmol (P^+) kg $^{-1}$)	5.21
Available sulphur (mg kg^{-1})	4.54
DTPA – Fe (mg kg^{-1})	7.56
DTPA – Mn (mg kg^{-1})	8.03
DTPA – Zn (mg kg^{-1})	1.02
DTPA – Cu (mg kg^{-1})	0.26
Heavy Metals	
Total – Pb (mg kg^{-1})	68.9
Total – Cd (mg kg^{-1})	1.32
DTPA – Pb (mg kg^{-1})	1.27
DTPA – Cd (mg kg^{-1})	0.81

24 kilograms of soil was taken in cement pot of 30 cm height and diameter. Calculated quantity of NPK fertilizers viz., 60: 90: 60 kg ha^{-1} were applied in all the treatments on dry weight basis. Amendments (organic and inorganic) selected for the study were applied as per the treatment schedule with three replications for each treatment. Sunflower seeds were sown and maintained up to 95 days. Water was added to keep at 60 % water holding capacity of the soil during plant growth. The soil and plant samples were drawn at 45^{th} day and at harvest and processed for further analysis. Pre - experimental composite soil sample was analyzed for physical, and chemical properties (Table 1). Soil samples were collected from each pot at 0 -15 cm depth, shade dried, powdered, sieved through 2.0 mm sieve and analyzed for physical, chemical properties as per the standard procedures. The data on various parameters studied during the investigation were statistically analyzed as suggested by Gomez and Gomez (1984).Whenever the treatment differences were found significant (F test), the critical differences were worked out at 5% probability level and the values were compared. Treatment differences which were not significant are denoted as 'NS'.

Results and Discussion

Effect of soil amendments on soil properties

Soil pH: Soil pH values were recorded at 45 DAS and at harvest ranging from 7.25 to 8.37 and 7.13 to 8.35 at 45 DAS and at harvest respectively. The treatment effects were statistically significant with each other. However, the highest pH values of 8.37 and 8.35 were recorded in RDF + lime applied treatment (T_5) respectively at 45 DAS and at harvest and it was followed by the treatments T_3 (RDF + pressmud), T_8 (RDF + zeolite), T_7 (RDF + K – Humate) and T_1 control (RDF alone). T_1 followed by T_2 and T_6 being on par with lowest pH values of 7.25 and 7.13 which were recorded in RDF + EDTA (T_4) respectively at both stages.

Electrical conductivity (EC): The data pertinent to electrical conductivity (EC) are offered in table 2. The organic and inorganic amendments significantly influenced the electrical conductivity of contaminated soil. The EC values were recorded at 45 DAS and at harvest ranging from 0.35 dSm^{-1} to 0.95 dSm^{-1} and 0.27 dSm^{-1} to 0.87 dSm^{-1}, respectively. The highest EC value of 0.95 dSm^{-1} at 45 DAS and 0.87 dSm^{-1}at harvest were recorded in RDF + lime (T_5) followed by T_8 (RDF + zeolite) and T_7 (RDF + K – Humate) were on par with each other. T_7 followed by T_3, T_1, T_2 and T_6. Further, the lowest of EC (0.35 at 45 DAS and 0.27 dSm^{-1} at harvest) were recorded by the treatment RDF + EDTA (T_4).

Cation exchange capacity (CEC): The data related to cation exchange capacity (CEC) of experimental soil are presented in table 2. The application of organic and inorganic amendments along with recommended dose of fertilizers significantly machinates the CEC. CEC obtained at 45 DAS and at harvest ranging from 8.24 to 15.53 and 7.75 to 16.13 C mol (p^+) kg^{-1}, respectively. The highest CEC of 15.53 at 45 DAS and 16.13 C mol (p^+) kg^{-1} at harvest were recorded by the treatment received RDF + FYM(T_2), which was on par with treatment RDF + pressmud (T_3) and followed by T_1, and it was on par with T_4 and T_6. Further, T_6 was followed by treatments T_7 and T_8 and the lowest CEC values of 8.24 and 7.75 C mol (p^+) kg^{-1} were recorded in RDF + lime (T_5) at both stages respectively.

Soil organic carbon (SOC): The data associated to soil organic content analyzed from the experiment are furnished in table 2. SOC content was significantly influenced by various soil amendments and the values ranging from 0.08 to 0.65 and 0.072 to 0.73 g kg $^{-1}$ at 45 DAS and at harvest, respectively. Application of RDF + FYM (T_2) registered higher SOC values of 0.65 and 0.68 g kg $^{-1}$ at both stages of analysis *viz*., 45 DAS and at harvest and it was followed by the treatment RDF + press mud (T_3), T_1, T_4, T_7 and T_6. T_6 followed by T_8 and T_8 were on par with T_5 (RDF + lime) which registered the lowest organic carbon content of 0.08 and 0.07 g kg $^{-1}$, respectively at 45 DAS and at harvest stages.

The higher pH, EC and CEC, SOC were observed in RDF + lime (T_5) and RDF+FYM (T_2) amended treatments, respectively (Table 2). This might be attributed due to the effect of lime on heavy metal contaminated soils duly increased soil pH which depends on pH of liming material and Ca^+ concentration in soil solution (Rehman *et al*., 2015b) and also addition of lime have positive momentum of increasing soil pH and EC (Argo and Biernbaum, 1996).Whereas, higher values of CEC and SOC were attributed duly by the addition of FYM which increased adsorption sites by increasing negative charges on the soil surface and reducing competing metal cations (Alamgir *et al*., 2011). Further, addition of soil organic carbon might be due to accumulation plant residual lignin in FYM directly flows to the structural and metabolic soil carbon pool and increased biologically active soil organic carbon such as microbial biomass carbon and mineralizable carbon (Kanchikerimath and Singh, 2001; Chang,2007). Lower values of pH, EC were observed in RDF + EDTA (T_4) amended treatments at both stages. This could be ascribed due to the EDTA's chelating effect (induces variable charge) on growth medium and thus reduces both pH and EC. While, the lower values of CEC and SOC were recorded by RDF +lime amended treatments. The reduction in CEC and SOC content in lime applied treatments might be caused by effect of lime on reducing pH, EC and increasing soluble salts contents.

Table 2 : Effect of amendments on pH, EC (dS m^{-1}), CEC (cmol (p^+) Kg^{-1}) and SOC (g kg^{-1})

Crop stage	45 DAS				Harvest			
Treatments /Parameters	**pH**	**EC**	**CEC**	**SOC**	**pH**	**EC**	**CEC**	**SOC**
T_1- Control (100% RDF)	7.79	0.64	13.9	0.48	7.70	0.60	14.5	0.57
T_2- RDF + Farm yard manure	7.60	0.58	15.5	0.65	7.53	0.51	16.1	0.73
T_3- RDF + Pressmud	7.80	0.72	15.2	0.57	7.78	0.65	15.8	0.68
T_4- RDF +EDTA	7.25	0.35	13.4	0.40	7.13	0.27	14.0	0.49
T_5- RDF + Lime	8.37	0.95	8.24	0.08	8.35	0.87	7.75	0.08
T_6- RDF + Gypsum	7.61	0.50	12.7	0.24	7.51	0.41	13.3	0.37
T_7- RDF + Potassium humate	7.75	0.80	11.4	0.29	7.71	0.76	12.0	0.29
T_8- RDF + Zeolite	8.33	0.85	9.40	0.10	8.30	0.80	8.25	0.10
SEd±	0.29	0.02	0.38	0.01	0.32	0.03	0.38	0.01
CD (p=0.05)	0.62	0.06	0.80	0.03	0.68	0.05	0.81	0.03

Effect of soil amendments on soil available nutrients (NPKS (g pot^{-1}) and Fe, Mn, Zn, Cu (mg pot^{-1}):

Enduring effect of soil amendments along with application of NPK fertilizers were showed a significance in improving available macro(NPKS) and micro (Fe, Mn, Zn, Cu) nutrient status in polluted soil at 45 DAS and at harvest stages of sunflower and are presented in table 2 and 3. In both stages of crop growth, higher availability of N, P were observed in the RDF +FYM amended treatment (T_2) (4.07, 0.21 and 3.14, 0.19 mg pot^{-1}) respectively at 45 DAS and at harvest and it was on par with T_3 (RDF + press mud).T_3 was followed in order of $T_4 > T_1$, $T_6 > T_7$, T_8. Whereas higher available K, S was recorded by RDF + K - humate amended treatment (T_7) of 2.14, 9.02 and 1.42, 8.89 mg pot^{-1} at both stages respectively. T_7 was followed as T_2, $T_3 > T_4 > T_6 > T_1$,T_8 with respect to available K and $T_6 > T_2$,$T_3 > T_4 > T_1 > T_8$ in the order with respect to available S. Treatment received RDF + lime (T_5) registered the lower available N, P, K, S (2.9, 0.08, 1.38, 3.05 and 1.89, 0.07, 0.65, 3.01 mg pot^{-1}) respectively at both stages of soil analysis. With respect to micronutrients availability in both stages of crop growth, significantly higher of Fe, Mn, Zn, Cu (10.19, 10.88, 1.38, 0.49 mg pot^{-1} and 9.93, 10.39, 1.29, 0.42 mg pot^{-1} respectively at 45 DAS and at harvest) were observed in the RDF + press mud amended treatment (T_3) and it was on par with T_2 (RDF+FYM). T_2 was followed by T_4, $T_6 > T_1$, $T_8 > T_7 > T_5$, respectively. Treatment received RDF+ lime (T_5) registered the lower available Fe, Mn, Zn, Cu (6.21, 6.43, 0.71, 0.07 and 6.16, 6.02, 0.62, 0.04 mg pot^{-1}) respectively at both stages of soil analyzed.

Table 3 : Effect of amendments on available NPK and S (g pot^{-1})

Crop stage	45 DAS				Harvest			
Treatments /Parameters	**N**	**P**	**K**	**S**	**N**	**P**	**K**	**S**
T_1- Control (100% RDF)	3.41	0.15	1.54	4.46	2.29	0.11	0.80	4.40
T_2-RDF + Farm yard manure	4.07	0.21	1.84	6.53	3.14	0.19	1.13	6.43
T_3- RDF + Pressmud	3.81	0.20	1.93	6.61	2.54	0.17	1.20	6.51
T_4- RDF +EDTA	3.71	0.17	1.75	5.92	2.42	0.15	1.03	5.89
T_5-RDF + Lime	2.90	0.08	1.38	3.05	1.89	0.07	0.65	3.01
T_6-RDF + Gypsum	3.63	0.16	1.65	7.18	2.52	0.12	0.92	7.01
T_7-RDF + Potassium humate	3.33	0.12	2.14	9.02	2.04	0.10	1.42	8.89
T_8-RDF + Zeolite	2.74	0.10	1.44	3.32	2.0	0.09	0.72	3.47
SEd±	0.16	0.008	0.06	0.22	0.08	0.007	0.05	0.22
CD (p=0.05)	0.35	0.018	0.14	0.47	0.18	0.016	0.11	0.47

Table 4 : Effect of amendments on soil available Fe, Mn, Zn and Cu (mg kg^{-1})

Crop stage	45 DAS				Harvest			
Treatments /Parameters	**Fe**	**Mn**	**Zn**	**Cu**	**Fe**	**Mn**	**Zn**	**Cu**
T_1-Control (100% RDF)	7.48	8.12	1.01	0.17	7.22	7.78	0.89	0.13
T_2-RDF + Farm yard manure	9.13	9.92	1.31	0.37	8.93	9.32	1.20	0.31
T_3- RDF + Pressmud	10.2	10.9	1.38	0.49	9.93	10.39	1.29	0.42
T_4- RDF +EDTA	8.52	9.21	1.19	0.23	8.21	8.92	1.07	0.18
T_5-RDF + Lime	6.21	6.43	0.71	0.07	6.16	6.02	0.62	0.04
T_6-RDF + Gypsum	8.02	8.40	1.06	0.20	7.88	8.19	0.93	0.15
T_7-RDF + Potassium humate	11.2	11.9	1.25	0.29	10.8	11.4	0.98	0.24
T_8-RDF + Zeolite	7.43	7.17	0.88	0.11	6.86	8.01	0.73	0.08
SEd±	0.41	0.36	0.04	0.01	0.33	0.44	0.03	0.01
CD (p=0.05)	0.86	0.77	0.09	0.03	0.71	0.93	0.08	0.02

Availability of plant nutrients in the soil is the capacity of soils to be productive depends on more than just plant nutrients. The physical, biological and chemical attributes of soil decides quantity of the nutrient available to plants to produce more. In the present study, organic and inorganic amendments applied were entirely differed significantly from each other especially in soil chemical environment. Applied amendments showed significant difference in availability of N and P in RDF + FYM (T_2), K in RDF+K–humate (T_7) and S in RDF+ gypsum (T_6) amended treatments at 45 DAS and at harvest stages respectively (Table 3).This might be attributed due to addition of organics stimulated the growth and activities of microorganisms, which increased N and P release and the effect was further enhanced by the addition of inorganic fertilizers in FYM treatments. These results are in corroboration with those of Pandey *et al*. (2010) who opined that microbes harboring crop rhizosphere provide better nutrient availability or solubilizing insoluble forms of nutrients and play a key role in organic matter decomposition, nutrient cycling and other chemical transformations in soil (Murphy *et al*., 2007). Further, humic substances and K-humuate applications significantly enhanced the K availability in the experimental soil (Khan and Mir, 2002). Furthermore, in the present study, regarding to sulphur availability might be attributed due to application of RDF plus gypsum which increased the availability of S in soil solution and it increases with increase in inorganic sulphur in soil solution simultaneously reducing the soil pH in the experimental soil (Sudhakara babu and Hedge, 2003).

DTPA extractable Fe, Mn, Zn and Cu content were noticed in optimum levels with application of RDF + pressmud amended treatments (T_3) at 45 DAS and at harvest stages (Table 4) might be due to decomposition of organic manures produce several biochemical substances *viz*., organic acids, poly phenols, amino acids and polysaccharides and enhanced synergetic nutrient interactions,which stimulated the solubility, transport and availability of these micronutrients. This is in conformity with those of several workers Banik and Sharma (2008) and Ramalakshmi *et al*. (2013). The lowest N, P, K, S, Fe, Mn, Zn, and Cu nutrient availability were noticed in RDF + lime amended pots both at 45 DAS and at harvest. This might be attributed due to reduced availability of macro and micronutrients (Rehman *et al*., 2015b) and lime addition increases the pH of the soil solution and thus availability of these elements were reduced were common cause for the reduction in both macro and micronutrient availability. This present results were well supported by Mishra *et al*.(2014) who reported that soil organic matter largely controlled by environment and it in turn affects the availability of plant nutrients, which was very low in lime amended treatments.

Conclusion

Based on the experimental results, it can be concluded that amending with RDF + FYM or Press mud to maintain the fluctuating soil properties in an industrially polluted soil along with enhancing the availability of soil available NPKS and Fe, Mn, Zn, Cu significantly.

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