RESEARCH ARTICLE

Comparative analysis of farm yard manure and compost on physico-chemical and microbiological parameters of problem soils

Alok Bharadwaj*

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Soil is the fertile and uppermost layer of the earth crust. To meet the requirements of increasing population, farmers used chemical fertilizers and insecticides to increase the crop yield. As a result of which the soil become saline or usar. So, here in this paper an effort has been made to treat such problem soil with certain amendments such as farmyard manure (FYM) and prepared compost and make a comparative analysis by improving the physicochemical and microbiological status of the problem soil. Quantitative analysis of soil microfungi was performed under various combinations of amendments (5%, 10%, 15%, 20% and 25%) with both farm yard manure and prepared compost was recorded in terms of IVI (individual value index).

In the present study both these (fym and prepared compost) were taken in the ratio of 5%, 10%, 15%, 20% and 25% (w/w) separately and mixed with the powered soil samples. Physicochemical and microbiological status of the control soil and various amendments was performed. The results clearly indicates that the values of water holding capacity, organic matter, total nitrogen, organic carbon, cation exchange capacity and exchangeable potassium amplified in both the farmyard manure and prepared compost. On the basis of results obtained of this comparative analysis it can be confirmed that various doses of prepared compost demonstrated improved reclamation of saline-alkali soil over the farm yard manure (FYM). The results of microbial population dynamics clearly depicted that prepared compost indicated improvement in all the three types of microflora i.e bacterial, fungal and actinomycetes population over the control in comparison to farm yard manure (FYM). The improvement in the population of bacterial, fungal and actinomycetes is an indicative of improvement in soil reclamation and management of problem soil.

Key Words: *Farm yard manure; Compost; Physicochemical parameters and microbial population*

INTRODUCTION

India is a land of agriculture having 159.7 million hectare of agriculture land. Out of which 9.38 million hectare area is salt affected, 5.5 million hectare area are saline soil and 3.88 million hectare area have alkali soils [1]. This problem is not associated only with India but it's a global issue.

There are several factors associated with the soil degradation. Some major issues are increasing human population, uncontrolled irrigation and mono cropping practices. To fulfill the requirements of increasing population, farmers excessively using chemical fertilizers and plant protection pesticides for maximizing the crop yield. Their regular use of this practice makes the soil unproductive or unfertile. Uncontrolled irrigation through saline water makes the land alkaline in nature. This is the key factor in the accumulation of salts on the upper surface of soil [2]. In the past, there was also reported an increase in the saline soil area e.g. India has 6.1 million hectare saline land in 1965 [3], that increased to 7 million hectare in 1971 [4] and reached upto 23.8 million hectare in 1974 [5]. If such trend will be continuing, it has been estimated that approximately 20 million hectare land become saline by 2050 [6]. In India, Uttar Pradesh also has 50,000 acres of saline soil in 1939 [7] that increased upto 1.37 million hectare till now [6].

To overcome the problem of soil salinity, amendments practices plays an important role. Several organic and inorganic supplements are being available for improving the texture as well as nutritive status of the degraded soil. Several researches have been available in which soil physicochemical characteristics have been improved by using such amendment practices [8-11]. In the present study an effort has been made for the reclamation and management of saline-alkali soils by using different doses of organic compost and farm yard manure. In addition to it, a comparison has been made to find out the best option (either organic compost or farm yard manure) for reclamation of saline soil.

MATERIALS AND METHODS

In the present study the soil samples (saline soil) were collected from five chosen sites of village Chomuha in the Chhata tehsil of Mathura District and finally make a composite sample. The soil samples were collected aseptically up to 0-6 cm depth from the surface, with the help of sterilized iron borer and collected in the pre-sterilized containers [13]. These saline soil samples were analyzed in the laboratory for its physico-chemical and microbiological analysis as per the method given by Jackson [14] and Piper [15]. For reducing the soil salinity, both the farm yard manure and prepared compost materials has been used in different proportions i.e. 5%, 10%, 15%, 20% and 25% with saline soil for improving its physico-chemical and microbiological characteristics.

For this freshly collected powdered soil samples were taken in separate fresh polythene bags. In order to maintain the biological activity, moisture level of the amendment soil samples was kept upto 60%-70% water. The samples were stored at room temperature and analyzed after 10 days. Un-amended soil samples serve as control were also similarly maintained and studied.

RESULTS AND DISCUSSION

The results of physicochemical properties of have been given in the Table 1. The results clearly depicted that various parameters i.e. electrical conductivity (7.34 ± 0.1665), chlorides (28.1 ± 0.5257), pH (8.3 ± 0.0446), exchangeable sodium (88.4 ± 0.1560), bicarbonate (30.5 ± 0.3529) and sulpahte (12.04 ± 0.3925) showed that the soil sample is of saline in nature and is unhealthy for cultivation.

Department of Biotechnology, GLA University, Mathura (U.P.), India

Correspondence: *Alok Bharadwaj, Department of Biotechnology, GLA University, Mathura (U.P.), India, E-mail: alok.bhardwaj@gla.ac.in*

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TABLE 1

Physio-chemical analysis of saline-alkali soils amended with different doses of Farm Yard Manure (FYM) and prepared compost after 10 days of amendment.

			Doses of fym amendment (w/w)						Doses of prepared compost(w/w)					
S. No	Characteristics	Ctrl soil	5%	10%	15%	20%	25%	Avg.	5%	10%	15%	20%	25%	Avg.
1	Temperature (0C)	28.4 ± 0.1682	22.2 ± 0.060	21.1 ± 0.535	23.7 ± 0.376	23.6 ± 0.415	23.8 ± 0.523	22.88 ± 0.252	20.2 ± 0.246	22.0 ± 0.340	24.0 ± 0.705	23.0 ± 0.213	23.0 ± 0.677	22.4 ± 0.202
2	Moisture (%)	2.47 ± 0.2021	2.14 ± 0.268	4.24 ± 0.192	4.39 ± 0.176	4.36 ± 0.392	3.84 ± 0.307	3.79 ± 0.105	3.66 ± 0.366	4.52 ± 0.240	4.73 ± 0.366	4.78 ± 0.184	4.42 ± 0.207	4.42 ± 0.196
3	Water holding capacity (%)	21.6 ± 0.1824	21.8 ± 0.460	22.9 ± 0.366	24.4 ± 0.258	22.8 ± 0.502	25.3 ± 0.483	23.44 ± 0.256	23.9 ± 0.464	23.8 ± 0.330	24.5 ± 0.607	22.8 ± 0.966	25.3 ± 0.372	24.0 ± 0.462
4	pH	8.3 ± 0.0446	8.2 ± 0.081	8.0 ± 0.073	8.2 ± 0.096	8.2 ± 0.092	8.1 ± 0.070	8.14 ± 0.056	8.0 ± 0.0107	8.3 ± 0.083	8.2 ± 0.096	8.0 ± 0.091	7.9 ± 0.102	8.08 ± 0.082
5	Organic carbon (%)	0.22 ± 0.0092	0.9 ± 0.016	1.39 ± 0.168	2.02 ± 0.042	2.14 ± 0.067	2.17 ± 0.053	1.724 ± 0.052	1.32 ± 0.166	1.72 ± 0.189	2.39 ± 0.170	2.93 ± 0.143	3.14 ± 0.221	2.3 ± 0.162
6	Organic matter (%)	0.38 ± 0.0160	1.54 ± 0.027	2.39 ± 0.243	3.48 ± 0.073	3.69 ± 0.116	3.73 ± 0.092	2.97 ± 0.324	2.36 ± 0.286	2.82 ± 0.327	4.12 ± 0.293	5.05 ± 0.247	5.36 ± 0.381	3.94 ± 0.254
7	Total nitrogen (%)	0.018 ± 0.0007	0.07 ± 0.001	0.11 ± 0.017	0.17 ± 0.003	0.18 ± 0.005	0.18 ± 0.004	0.142 ± 0.004	0.11 ± 0.014	0.14 ± 0.016	0.20 ± 0.014	0.25 ± 0.012	0.26 ± 0.019	0.19 ± 0.012
8	Calcium carbonate (%)	1.52 ± 0.0230	0.06 ± 0.008	1.84 ± 0.020	1.67 ± 0.155	1.56 ± 0.109	0.94 ± 0.048	1.214 ± 0.015	1.48 ± 0.254	1.80 ± 0.154	1.68 ± 0.213	1.71 ± 0.240	0.89 ± 0.249	1.51 ± 0.162
9	Ex. Potassium (ppm)	2.40 ± 0.169	10.9 ± 0.337	11.5 ± 0.371	14.9 ± 0.292	17.7 ± 0.595	21.0 ± 0.460	15.2 ± 0.250	9.9 ± 0.248	11.5 ± 0.228	15.0 ± 0.298	17.0 ± 0.547	21.0 ± 0.361	14.8 ± 0.246
10	CEC (me/100gm)	5.33 ± 0.2177	5.52 ± 0.193	5.32 ± 0.182	6.19 ± 0.252	6.30 ± 0.246	6.14 ± 0.267	5.89 ± 0.156	5.78 ± 0.217	5.64 ± 0.164	6.34 ± 0.190	6.44 ± 0.162	5.72 ± 0243	5.98 ± 0.198
11	ESP	88.4 ± 0.1560	83.7 ± 0.534	76.3 ± 0.194	65.0 ± 0.334	60.8 ± 0.598	56.4 ± 0.631	68.44 ± 0.242	87.8 ± 0.203	76.0 ± 0.644	64.8 ± 1.342	60.3 ± 1.100	62.0 ± 0.269	70.1 ± 0.212
12	Ece (dsm^{-1})	7.34 ± 0.1665	5.20 ± 0.309	5.23 ± 0.145	4.86 ± 0.236	5.73 ± 0.271	5.03 ± 0.253	5.21 ± 0.125	6.28 ± 0.025	5.49 ± 0.644	5.33 ± 0.002	5.25 ± 0.002	4.58 ± 0.199	5.38 ± 0.022
13	Ca^{2+} + Mg^{2+} (meL^{-1})	22.6 ± 0.5375	18.3 ± 0.338	19.6 ± 0.377	20.3 ± 0.325	19.1 ± 0.352	19.4 ± 0.428	19.34 ± 0.214	21.4 ± 0.181	16.8 ± 1.027	15.2 ± 0.436	14.0 ± 0.177	17.4 ± 0.538	16.9 ± 0.682
14	Na+ (meL^{-1})	45.6 ± 0.5408	30.4 ± 0.532	29.5 ± 0.237	23.0 ± 0.448	21.4 ± 0.544	28.0 ± 0.259	26.46 ± 0.236	40.5 ± 0.270	39.4 ± 0.462	35.0 ± 0.932	32.7 ± 0.333	28.9 ± 0.579	35.3 ± 0.328
15	CO_3^{-2} + HCO_3^{2-} (meL^{-1})	30.5 ± 0.3529	20.3 ± 0.222	24.8 ± 0.262	21.9 ± 0.398	20.6 ± 0.450	17.7 ± 0.245	21.06 ± 0.204	22.1 ± 0.385	20.5 ± 0.630	18.5 ± 0.003	15.3 ± 0.428	16.2 ± 0.513	18.5 ± 0.356
16	Cl- (meL^{-1})	28.1 ± 0.5257	22.8 ± 0.243	20.2 ± 0.340	18.6 ± 0.442	19.3 ± 0.360	21.6 ± 0.253	20.5 ± 0.352	25.1 ± 0.373	23.5 ± 0.999	20.3 ± 0.400	19.0 ± 0.428	18.7 ± 0.942	21.3 ± 0.258
17	SO_4^{2-} (meL^{-1})	12.04 ± 0.392	14.0 ± 0.366	11.9 ± 2.576	14.9 ± 0.490	14.3 ± 0.277	7.98 ± 0.139	12.61 ± 0.202	15.0 ± 0.216	12.3 ± 0.407	12.6 ± 0.470	11.8 ± 0.455	7.08 ± 0.540	11.7 ± 0.358

Other parameters such as water holding capacity, moisture content and temperature also found to be 21.6 ± 0.1824, 2.47 ± 0.2021 and 28.4 ± 0.1682 respectively, intimating that the soil health was very poor. The nutritive status of the soil sample such as organic carbon, organic matter and total nitrogen was found to be 0.22 ± 0.0092, 0.38 ± 0.0160 and 0.018 ± 0.0007 respectively. All such findings were the witness that the soil was of very poor health structure (Table 1).

As we have discussed in the introduction section that for improving the physicochemical parameters of such problem soil, amendments practices play an important role. Here we have used farm yard manure (FYM) and prepared compost as an enrichment component and compared their efficacy also. From Table 1, it has been concluded that the values of pH, exchangeable sodium percentage and electrical conductivity, Ca^{2+} + Mg^{2+}, Na^{+}, CO_3^{2-} + HCO_3^{2-} and SO_4^{2-} have reduced significantly, however compost have shown better impact in comparison to farm yard manure. Other parameters of soil those were important for nutritive value like organic carbon, organic matter, total nitrogen and cation exchange capacity found to be increased significantly with better result of compost over farm yard manure (Table 1). Moisture content and water holding capacity were also found to be increased significantly however better results were obtained in case of compost amendment soil. Other workers were also found similar findings and also improved the soil health and texture [13,16,17].

Important Value Index (IVI) of fungal species in Farm Yard Manure (FYM) and prepared compost were expressed in Tables 2 and 3 respectively. It was evident from Table 2 that maximum IVI were noticed for Aspergillus *fumigatus1* (IVI=28.31) followed by *A. nidulans2* (IVI=27.25) and A. *fumigatus2* (IVI=22.89). From the previous research it has been evident that Aspergillus was the most dominant fungi in soil [18]. From Table 2, it has been concluded that there were total 9 fungal species that were found in the entire amendments i.e.5%, 10%, 15%, 20% and 25%. Out of these 9 fungal species, 8 belong to genus *Aspergillus*. Thus, it can be concluded that out of 36 fungal species isolated from farm yard manure (FYM), genus *Aspergillus* have maximum 10 species.

Table 3 depicted the IVI of fungal species isolated from prepared compost. In control soil the maximum IVI was reported for A. fumigatus1 (28.31) followed by *A. nidulans2* (27.25) and *A. fumigatus2* (22.89). Out of 36 fungal species isolated from prepared compost, maximum 10 species belongs to genus *Aspergillus*. *Aspergillus* was the most dominant species that found in all doses of amendments. These findings were similar to the views of Alexender [19]. According to him soil serves as a nutritive media in which microorganisms can grow, multiply and interact with each other.

Similar results were obtained from the earlier researchers [16,20,21]. Data represented in Table 4 explain the population dynamics of bacteria, fungi and actinomycetes in the problem soil that was treated with different combinations of farm yard manure (FYM) and prepared compost.

It was depicted from the data attained from Table 4 that in control soil of both the supplements (FYM and compost) the pattern of population of microorganisms was found to be bacteria>actinomycetes>fungi. From the results it has become evident that as we increase the dose of amendments (FYM and compost) the number of bacteria, fungi and actinomycetes were also increased. From this quantitative analysis it has become clear that

TABLE 2

IVI of Fungal species obtained in varying doses of treated with Farm Yard Manure (FYM).

S. No	Name of species	Control soil	5%	10%	15%	20%	25%
1.	*A. fumigatus 1*	28.31	26.06	14.28	15.34	8.39	19.46
2.	*A. nidulans 2*	27.25	20.67	9.84	15.06	12.38	8.42
3.	*A. fumigatus 2*	22.89	19.05	14.28	18.93	16.37	16.54
4.	*Aspergillus flavus*	20.65	26.06	18.93	17.35	22.83	14.49
5.	*A. niger 2*	20.65	31.46	22.52	29.14	22.83	18.55
6.	*Alternaria alternata*	19.05	-	-	-	-	-
7.	*Mycellia sterilia 2*	16.69	6.63	-	-	14.72	24.78
8.	*Mucor hiemalis*	15.31	15.28	16.54	13.05	16.37	16.56
9.	*A. nidulans 1*	15.31	22.83	16.62	18.93	8.39	26.47
10.	*A. niger 1*	15.20	26.06	32.66	30.64	29.30	26.47
11.	*A. terreus*	13.03	20.67	16.62	15.06	21.23	16.56
12.	*R. stolonifer*	10.96	13.68	-	7.4	13.11	13.24
13.	*A. glocus*	10.96	-	-	-	-	-
14.	*Phoma herbarum*	10.96	-	-	-	-	-
15.	*Unidentified 1*	8.90	-	18.93	18.93	-	-
16.	*F. solani*	8.79	-	-	-	-	8.42
17.	*Mycellia sterilia 3*	8.79	11.44	18.93	-	-	-
18.	*A. ustus*	6.58	5.69	-	-	-	10.48
19.	*Curvularia lunata*	5.56	-	-	-	-	-
20.	*F. oxysporum*	5.56	-	-	-	-	-
21.	*P. funiculosum*	5.56	13.66	-	13.05	-	10.48
22.	*Mycellia sterilia 1*	5.56	-	24.93	20.06	30.94	18.20
23.	*Absidia butleri*	-	8.85	16.54	17.4	16.37	-
24.	*A. lichtheimii*	-	8.85	-	-	-	-
25.	*Rhizopus nigricans*	-	8.23	11.96	-	-	-
26.	*Syncephalstrum racemosum*	-	5.69	-	-	-	10.48
27.	*Botryotricum piluliferum*	-	-	-	-	15.51	-
28.	*Botrytis cinerea*	-	-	11.96	-	-	-
29.	*Fusarium chlamydosporium*	-	8.85	-	-	-	-
30.	*Humicola fuscoatra*	-	-	-	-	8.39	-
31.	*Myrothecium roridum*	-	-	9.49	12.18	-	11.60
32.	*Paecilomyces inflatus*	-	-	-	-	5.30	-
33.	*Paecilomyces variotii*	-	-	9.84	17.4	-	-
34.	*Penicillium chrysogenum*	-	-	14.7	5.63	16.38	11.56
35.	*Stemphylum sp.*	-	-	-	-	5.30	-
36.	*Unidentified 2*	-	-	-	-	19.58	16.56

TABLE 3
IVI of Fungal species obtained in varying doses of treated with compost.

S. No	Name of species	Control soil	5%	10%	15%	20%	25%
11	*A. fumigatus 1*	28.31	11.9	23.77	17.69	18.85	-
15	*A. nidulans 2*	27.25	8.79	19.1	11.12	13.41	-
12	*A. fumigatus 2*	22.89	12.01	8.21	17.69	-	18.08
10	*Aspergillus flavus*	20.65	13.51	17.6	22.27	22.82	23.76
17	*A. niger 2*	20.65	27.28	22.37	30.06	24.14	23.57
7.	*Syncephalstrum racemosum*	19.05	-	12.10	-	-	19.52
34	*Mycellia sterilia 2*	16.69	-	-	26.86	16.94	15.49
4.	*Mucor hiemalis*	15.31	14.44	10.33	16.31	19.91	13.18
14	*A. nidulans 1*	15.31	15.21	20.97	20.9	18.40	16.68
16	*A. niger 1*	15.20	25.51	27.04	19.59	13.44	26.57
18	*A. terreus*	13.03	22.13	27.04	-	19.91	20.47
6.	*R. stolonifer*	10.96	13.51	11.19	-	-	-
32	*Phoma herbarum*	10.96	-	12.17	-	13.44	-
13	*A. glocus*	10.76	8.68	-	17.69	16.94	18.08
36	*Unidentified 1*	8.90	22.13	-	-	19.91	-
26	*F. solani*	8.79	-	-	-	5.00	-
35	*Mycellia sterilia 3*	8.79	-	17.6	-	-	-
19	*A. ustus*	6.58	8.56	-	-	15.48	-
21	*Curvularia lunata*	5.56	-	-	-	-	-
25	*F. oxysporum*	5.56	-	-	-	-	-
30	*P. funiculosum*	5.56	14.94	14.0	19.06	13.44	10.32
33	*Mycellia sterilia 1*	5.56	22.13	-	22.27	-	15.49
1	*Absidia butleri*	-	18.48	-	16.31	-	15.28
2	*Cunninghamella echinulata*	-	18.48	13.03	-	-	-
3	*A. lichtheimii*	-	-	-	-	13.44	-
5.	*Rhizopus nigricans*	-	-	11.19	11.12	-	12.44
8.	*Alternaria alternata*	-	-	-	-	15.66	-
9	*A. humicola*	-	-	-	-	-	11.45
20	*Curvularia geniculata*	-	-	-	10.51	-	-
22	*Fusarium chlamydosporium*	-	-	-	-	-	13.18
23	*F. arvenaceum*	-	15.21	17.4	-	-	-
24	*F. poae*			10.03	-	-	-
27	*Myrothecium verrucaria*	-	8.68	-	-	-	-
28	*Myrothecium roridum*	-	5.45	-	-	-	-
29	*Penicillium chrysogenum*	-	-	-	8.18	18.40	15.28
31	*Trichothecium roseum*	-	-	-	8.18	-	-

the number of microorganisms increased slowly in 5% and 10% dose of amendments because of the accumulation of salt on the upper surface of soil. As the soil salinity decreased due to the incorporation of farm yard manure and compost, the microbial population also increased rapidly upto 25% dose of amendment [16,22,23].

In control soil the population of bacteria, fungi and actinomycetes was found to be 3.2×10^3, 2.7×10^3 and 3.0×10^3 respectively. The pattern of microbial population has shown the dose dependant increase and highest population was found to be noted in at 25% dose. At 25% dose of Farm Yard Manure (FYM) the microbial population was 4.7×10^3, 4.0×10^3 and 4.2×10^3 for bacteria, fungi and actinomycetes respectively. In case of 25% amendment of compost the population of bacteria, fungi and actinomycetes was found to be 6.5×10^3, 3.5×10^3 and 5.2×10^3 respectively.

From this analysis it can be concluded from Table 4 that prepared compost has showed greater increase in the population of bacteria, fungi and actinomycetes in comparison to control. Henceforth, compost has proved better improvement in the soil physicochemical and microbiological characteristics.

TABLE 4

Distribution of Microbial population in Saline- alkali soils amended with various doses of prepared compost and Farm Yard Manure (FYM).

S. No	Doses of amendment (w/w)	Soil amended with farmyard manure material			Soil amended with prepared compost material		
		Microbial Population x 10^3/gm soil			Microbial Population x 10^3/gm soil		
		Fungi	Bacteria	Actinomycetes	Fungi	Bacteria	Actinomycetes
1	Natural Undisturbed soil (Control)	2.7	3.2	3.0	2.7	3.2	3.2
2	5%	3.0	3.9	3.5	2.8	4.5	4.3
3	10%	3.5	4.0	3.9	3.3	5.8	4.8
4	15%	3.5	4.0	4.0	3.3	6.0	5.0
5	20%	3.8	4.4	4.1	3.3	6.1	5.1
6	25%	4.0	4.7	4.2	3.5	6.5	5.2

CONCLUSION

From this study it has become clear that microbial activity (bacteria, fungi and actinomycetes) is mainly responsible for the fertility of any organic enricher. As in this paper compost has showed more microbial population in contrast to farm yard manure. Henceforth, compost has better physicochemical characteristics in comparison to farm yard manure. So, the use of compost is recommended in agricultural practices.

REFERENCES

1. IAB. Indian Agriculture in Brief. (27th edition). Agriculture Statistics Division, Ministry of Agriculture, New Delhi. 2000.
2. Bhargava GP. Salt affected soils of India: A source book. Oxford IBH Publication, New Delhi. 1989.
3. Chaudhary R. Classification and management of saline and alkali soils of India. Proc. Symp Soidic Soil Budapest Talaj Es Agrok Iu. 1965;83-90.
4. Abrol IP, Bhumbia DR. Saline and alkali soils in India-Their occurrence and management. FAO World Soil Resources Rep. 1971;41:42-51.
5. Massouds FI. Salinity and alkalinity as soil degradation hazards. FAO UNESCO Publication, Rome. 1974;74:10.
6. Sharma DK, Singh A, Sharma PC, et al. CSSRI Vision 2050. Central Soil Salinity Research Institute, Karnal. 2014.
7. Bains SS. Reclamation and use of saline wasteland In: Reclamation and use of saline wasteland in India. Proceedings of the symposium published by Indian National Science Academy, New Delhi. 1972;195-200.
8. Dixit MK. Studies in physio-chemical aspects of soil fertility on the addition of ammonium chloride, sodium phosphate, potassium sulphate and cellulosic substances. Ph.D. Thesis, University of Sagar, Sagar, India. 1960.
9. Bandopadhya AK, Sahoo R, Bandrachalam A, et al. Effect of continuous application of compost, ammonium sulphate and line on some physical and chemical properties of rich soil. J Indian Soc Soil Sci. 1969;17:369-74.
10. Vishwanath DP. Effect of repeated application of heavy doses of fertilizers on physical and chemical properties of soils and uptake of nutrient by hybrid maize (Zea mays). Ph.D. Thesis, University of Agricultural Sciences, Hebbal, Banglore, India. 1975.
11. Gautam M. Studies on the role of organic amendments in reclamation and management of saline alkali soils of Mathura. Ph.D. Thesis, Dr. Bhim Rao Ambedkar University, Agra, India. 2002.
12. Johnson LE, Curl EA. Methods of research on the ecology of soil-borne plant pathogens. Burges Publishing Co, Minneapolis, Minnesota. 1972.
13. Bharadwaj A, Khandelwal V, Choudhary P, et al. Comparative studies of organic enrichers in the improvement of physico-chemical and microbiological characteristics of saline/usar soils. J Chem Pharm Res. 2011;3(6):997-003.
14. Jackson ML. Soil chemical analysis. Prentice-Hall of India Pvt Ltd, New Delhi. 1973.
15. Piper CS. Chemical analysis of saline soil. Soil and plants analysis. Hans Publication, Bombay. 1966.
16. Mrinal M, Bharadwaj A, Goyal S. Enrichment of physicochemical parameters of sludge using earthworm perionyx ceylanesis. Test Eng Manag. 2020;83:2909-916.
17. Birajdar GM, Gavali MT, Mane SR, et al. Physico-chemical parameters oforganic compost andits impact on pigeon pea and jowar crop plants productivity. IOSR J Pharm Biol Sci. 2018;13(2):74-79, 2018.
18. Saksena RK, Krishnanand FNI, Sarbhoy AK. Ecology of the soil fungi of Uttar Pradesh IV. Bundelkhand and gangetic tract soils. Reprinted from the proceeding of the National Institute of Science of India. 1966; 33B(5,6).
19. Alexander M. Microbial ecology. J Willeyand Sons. New York. 1971.
20. Zhen Z, Liu H, Wang N, et al. Effects of manure compost application on soil microbial community diversity and soil microenvironments in a temperate cropland in china. PLoS One. 2014;9(10):e108555.
21. Bharadwaj A. Vermiremediation: A revolution for sustaining soil fertility. Int J Psycho Rehab. 2020;24(8):7086-096.
22. Michovsky M. Ann Fac Agric Skopje.1961:2:220-45.
23. Bharadwaj A. Processing of different types of organic wastes through vermicomposting. J Env Sci Eng. 2011;53(3):371-74.