International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 2163-2168

Received: 12-05-2018
Accepted: 15-06-2018

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Study on long term effect of organic and inorganic farming on different soil properties under middle Gujarat condition

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Abstract
An investigation was carried out to study the long term effect of organic *vs* inorganic management on physico-chemical and biological properties of soils of middle Gujarat condition. The survey work was carried out by collecting bulk soil samples at 0-20 cm and 20-50 cm soil depths particularly from 8-10 years old organically and adjoining inorganically managed ten fields of Ahmedabad, Kheda, Anand and Vadodara districts of middle Gujarat region. The results obtained from analyzing these soil samples revealed that organically managed soils have low bulk density (BD) and particle density (PD) than inorganic managed soils and both values were increase with depth of soil. While maximum water holding capacity (MWHC) was found to be maximum (16.88%) under organically managed soils as compared to inorganic soils. Soil texture of Anand, Kheda, Ahmedabad and Vadodara district of middle Gujarat was found to be loamy sand, loamy sand to clayey, sandy loam to silt loam and clayey, respectively. These soils are neutral (7.00) to alkaline (8.33) in reaction and have low salinity (EC <0.8 dS m^{-1}). Significantly higher values of Soil organic carbon (SOC), available P_2O_5, K_2O and S were found in organically managed soil whereas significantly higher values of available Fe were found in inorganically managed soils. Overall increase in total microbial count was 15.89% in organically over inorganically managed soils.

Keywords: Organically *vs* inorganically managed soils, soil properties

1. Introduction

Organic agriculture is aimed at producing high quality food that is not only rich in nutrients but also contributes to health care and well-being of mankind. Since organic farming eliminates the use of most 'conventional' fertilizers, pesticides, animal drugs and food additives, it can improve soil, water and environmental quality and thus improve the overall quality of life. Agricultural sustainability depends on productive soil. During the last several decades, much research has focused on increasing productivity and protecting environmental quality under different farming systems. Conventional farming systems are reported to be associated with a decline in soil structure and soil aggregation, decrease in water infiltration and increase in soil bulk density, soil salinity, nitrogen leaching and ground water contamination (Prasad and Sinha, 1980) [16].

Soil organic matter (SOM) improves a soil's chemical and physical properties by promoting biological activity and maintaining environmental quality, and this is why organic fertilisers, such as manure, promote the activities of soil microbial communities (Morugán-Coronado *et al.*, 2011). The study was carried out to evaluate the differences in soil quality as due to use of organic manure in soils collected from the areas where organic farming is being practiced for more than 8-10 years and nearby conventionally managed soils of middle Gujarat.

2. Materials and Methods

The survey work was carried out during the month of February-March, 2017 and soils were collected particularly from 8-10 years old organically and adjoining conventionally managed fields of Ahmedabad, Kheda, Anand and Vadodara districts of middle Gujarat region. The ten locations (organically and conventionally managed field) were selected for soil sample collection and sampling was done at 0-20 cm and 20-50 cm soil depths. The total 40 samples were collected for the present investigations. The details are given in Table 1.

Soil samples from surface layer (0-20 cm) and sub-surface layer (20-50 cm) were collected from each sampling location for organically and inorganically managed soils. In each of the field, samples were collected, air-dried under shade, grinded in a wooden mortar and pestle and sieved through 2 mm sieve.

Table 1: District-wise information of soil sampling locations

S. No	Districts			
	Anand (D1)	**Kheda (D2)**	**Ahmedabad (D3)**	**Vadodara (D4)**
1.	Sekhadi (L1)	Matar (L4)	Kakaj (L6)	Samiyala (L9)
2.	Boriyavi (L2)	Vadala (L5)	Kathvada (L7)	Kothiya (L10)
3.	AAU campus (L3)	-	Nandej (L8)	-

The important soil properties like physical, chemical and biological were analyzed using standard methods as given below. Different physical soil properties such as bulk density, particle density of soil were determined by using methods given by Richards (1954) [17], water holding capacity of soil by Kanwar and Chopra (1976) [8] and particle size analysis by Piper (1966) [15]. Soil chemical properties like pH and EC (1:2.5, Soil: Water ratio) of soil were determined by methods suggested by Jackson (1973) [7], organic carbon by Walkley and Black (1935) [23], available nutrients like N by Subbiah and Asija (1956) [19], P_2O_5 by Olsen and Watanabe (1954) [14], K_2O by Jackson (1973) [17] and S and available micronutrients (Fe, Mn, Zn and Cu) in soil by Lindsay and Norvell (1978) [10]. A serial dilution method described by Bunt and Rovira (1955) [2] for total microbial count. Statistical analysis *i.e.*, T-test aasuming equal variance was carried out as described by Steel and Torrie (1980) [18].

3. Result and Discussion

3.1 Physical properties of soils

After analysis of soil samples at two different depths (0-20 and 20-50 cm) of organically and inorganically managed soils, it was revealed that the bulk density (BD) of soil was ranged from 1.20 to 1.31 Mg m^{-3} and 1.28 to 1.43 Mg m^{-3}, respectively with the mean values of 1.25 and 1.37 Mg m^{-3}. Increase of bulk density with soil depth might be due to over-burden pressure causing compaction in the subsurface horizons, while the surface soils were less compacted probably due to high amount of organic matter and plant root concentration. The values of particle density of these soils were varied from 2.36 to 2.53 Mg m^{-3} and 2.41 to 2.62 Mg m^{-3} with mean values of 2.43 to 2.48 Mg m^{-3}, respectively (Table 2). This data indicated that significantly lower BD and PD of soil were found under organically managed soils in both depths as compared to inorganically managed soils. While, maximum water holding capacity (MWHC) was found to be varied from 38.48 to 54.00% and 33.57 to 46.10% with mean values of 45.27 and 38.73%, respectively in organically and inorganically managed soils. Overall increase in MWHC of soil under organically managed soils was around 16.88% irrespective of depth and the locations. MWHC of soil was found significantly maximum in organically managed soils as compared to inorganically managed soils. Increase of bulk density with soil depth might be due to over-burden pressure causing compaction in the subsurface horizons, while the surface soils were less compacted probably due to high amount of organic matter and plant root concentration. Similar findings of long term effect on soil physical properties were reported by several scientists (Velmourougane, 2016) [22]. The results of organically managed soils reveal that the texture of Anand district soils was loamy sand in all three locations, while in Kheda district it varied from loamy sand to clayey. In Ahmadabad soils texture was sandy loam (two locations) and silty loam in one location, while soils of Vadodara district showed clayey texture. Interestingly in inorganically managed soils of Anand, Kheda and Ahmedabad districts, the soil textures were loamy sand, sandy loam to clayey, silty loam to loam as well as sandy loam to loamy sand, respectively. In Vadodara districts soils texture was not affected due to management practices.

3.2 Chemical properties of soils

The soil pH under both the depths of organically and inorganically managed soils was varied widely from 7.55 to 8.33 (alkaline) and 7.00 to 8.11 (neutral to alkaline) with mean values of 8.07 and 7.83, respectively (Table 5). Soil pH values were found to be higher under organically managed soils than inorganic. The lower pH values in the inorganically managed soil probably resulted from the application of acid forming fertilizers and from a lower buffering capacity because of less organic matter content in soil (Bolton *et al*., 1985) [1]. These soils having low salinity as it varied from 0.15 to 0.56 dS m^{-1} and 0.15 to 0.50 dS m^{-1} with average values of 0.28 and 0.23 dS m^{-1}, respectively. No any significant difference was observed in EC of soils in either of the depths or locations due to soil management practices. Organically managed soils showed higher content of salts (EC) probably due to higher water holding capacity of soil due to improved organic matter content of soils, which might have retained more salts as the waters of the regions are saline. The organic carbon in organically and inorganically managed soils was ranged from 4.3 to 6.1 g kg^{-1} (low to medium) and 3.7 to 4.3 g kg^{-1} (low) with mean values of 5.2 and 4.1 g kg^{-1}, respectively. Significantly higher organic carbon was noticed under organically managed soils as compared to inorganically managed soils. The magnitude of organic carbon was found to be higher on surface soil and declined with depth could possibly due to the fact that cultivation enhances and promotes the decomposition of plant organic residues at surface level (Vasanthi and Kumarswamy, 2000) [21].

In case of macronutrients in organically and inorganically managed soils at 0-20 and 20-50 cm depths, available N was varied widely from 156.8 to 250.9 kg ha^{-1} (low to medium) and 156.8 to 235.2 kg ha^{-1} (low) with mean values of 201.5 and 198.4 kg ha^{-1}, respectively, available P_2O_5 from 25.22 to 64.70 kg ha^{-1} (low to high) and 9.56 to 40.88 kg ha^{-1} (low to medium) with mean values of 46.19 and 22.79 kg ha^{-1}, respectively and available K_2O from 233.6 to 534.9 kg ha^{-1} (medium to high) and 215.0 to 446.2 kg ha^{-1} (medium to high) with mean values of 363.9 and 306.1 kg ha^{-1}, respectively. Here, available N did not differ significantly but available P_2O_5 and K_2O were increased significantly under organic system of management than inorganically managed soils. The values of available N were categorized as low (<250 kg ha^{-1}) except organically managed soil from Matar (250.9 kg ha^{-1}), as long term application of organic manures do not help in built up of available nitrogen. The non-significant results could be due to less built of organic matter under tropical conditions and applied nitrogen is being used by the plants. Similar results were reported by Meng *et al*. (2005) [12]. The built up of available P_2O_5 under surface soil could be due to very little movement of applied P and its chemical fixation as Calcium phosphate. The beneficial effect of FYM on mineralization of P to a greater extent in soil and accumulation of P was higher at surface as compared to the lower depth (Garg and Milkha, 2010) [4]. The soils of middle Gujarat are rich in potassium due to predominance of illitic clay mineral, which is rich in potassium. The beneficial effect of FYM on available K is because, besides acting as a source of K, it also release organic collides with greater cation exchange sites that attract K from the non-exchangeable pool and applied K, which ultimately favour the available K (Majumdar *et al.,* 2005) [11]. Available S in these soils was found to be varied from 14.0 to 28.6 mg kg^{-1} (medium to high) and 4.4 to 15.0 mg kg^{-1} (low to medium) with average values of 21.5 and 10.0 mg kg^{-1}, respectively. Organically managed soils have found to be significantly higher available S as compared to inorganically managed soils. The adequate values under organically managed soils could be due to enrichment of soils with organic matter and main pool of sulphur is organic matter (organically bound sulphur) (Ullah *et al*., 2008) [20].

So far micronutrients were concerned, available Fe was ranged from 3.06 to 18.94 ppm (low to medium) and 4.04 to 24.26 ppm (low to high) with mean values of 7.87 and 11.44 ppm, respectively, available Mn from 11.34 to 20.88 ppm (low to high) and 7.62 to 26.92 ppm (low to high) with mean values of 15.29 to 14.95 ppm, respectively, available Zn from 0.48 to 1.98 (low to high) and 0.28 to 3.96 ppm (low to high) with mean values of 1.03 and 0.96 ppm, respectively and available Cu from 0.08 to 2.34 ppm (low to medium) and 0.58 to 3.30 ppm (low to medium) with mean values of 2.50 and 1.33 ppm, respectively under organically and inorganically managed soils at 0-20 and 20-50 cm depths (Table 6). Among these micronutrients, available Fe was found to be significantly higher under inorganically managed soils as compared to organically managed soils but not any significant difference was observed in available Mn, Zn and Cu in both the situations *i.e.,* depth of soil and locations. The high amount of organic matter in compost, its oxidation and degradation and neutral pH are the factors that increase micronutrients availability such as Fe, Mn, Zn and Cu in soil (Gallardo-Lara and Nogales, 1987) [3]. The absence of pronounced effect on micronutrients by addition of FYM may be due to the formation of organo-metallic complexes (Gupta *et al.,* 1988) [5].

3.3 Biological properties of soils

The total microbial count under organically vs inorganically managed soils was varied widely from 6000 to 543000 cfu and 3500 to 170000 cfu with overall mean of 1052000 and 62280 cfu, respectively (Table 7). Overall increase in total microbial count was 15.89% in organically managed soils over inorganic soils and was found to be decrease with increase in depth of soil. The increased microbial activity and diversity in the surface soils are attributed to the greater availability of organic carbon, nutrients, moisture, and aeration status compared to subsurface soil. Depth of root penetration and nutrient exhaustive characteristics of crops also may be another reason for the decline of microbial population in deeper layers (Hansel *et al*., 2008) [6]. Organic practices were found to rapidly improve soil microbial characteristics and slowly increase soil organic C. Organic manuring with plant residues was reported to have a stronger impact on soil microbial activity as compared to other fertilization methods (Kautz *et al*., 2004) [9].

Table 2: Bulk density, particle density and water holding capacity of organically and inorganically managed soils of different districts of middle Gujarat

Sr. No	Location	Depth (cm)	Bulk density (Mg m^{-3})		Particle density (Mg m^{-3})		Water holding capacity (%)	
			Org	In-org	Org	In-org	Org	In-org
1	D1L1	0-20	1.28	1.38	2.44	2.50	47.54	44.80
		20-50	1.31	1.41	2.39	2.41	45.18	41.49
	D1L2	0-20	1.26	1.39	2.45	2.47	48.57	43.72
		20-50	1.29	1.43	2.37	2.43	45.56	41.52
	D1L3	0-20	1.26	1.39	2.42	2.48	47.93	43.95
		20-50	1.28	1.41	2.36	2.42	45.76	41.73
2	D2L1	0-20	1.25	1.39	2.46	2.49	49.18	44.17
		20-50	1.29	1.44	2.35	2.44	45.10	40.98
	D2L2	0-20	1.26	1.37	2.45	2.51	48.57	45.41
		20-50	1.28	1.40	2.37	2.42	45.99	42.18
3	D3L1	0-20	1.23	1.33	2.49	2.55	50.60	47.84
		20-50	1.27	1.38	2.42	2.44	47.52	43.44
	D3L2	0-20	1.22	1.34	2.48	2.54	50.80	47.24
		20-50	1.27	1.37	2.40	2.45	47.08	44.08
	D3L3	0-20	1.22	1.33	2.46	2.57	50.40	48.24
		20-50	1.25	1.37	2.44	2.44	48.77	43.85
4	D4L1	0-20	1.20	1.28	2.53	2.62	52.56	51.14
		20-50	1.24	1.34	2.48	2.47	50.00	44.39
	D4L2	0-20	1.20	1.30	2.50	2.59	52.00	49.80
		20-50	1.23	1.35	2.46	2.46	50.00	45.12
Overall mean			1.25	1.37	2.43	2.48	48.45	44.75
t statistic			10.03**		2.78ns		4.58**	

Table 3: Texture of organically and inorganically managed soils of different districts of middle Gujarat (0-20 cm depth)

Sr. no	Location/district	Mechanical analysis									
		Organic					Inorganic				
		% Coarse sand	% Fine sand	% Silt	% Clay	Texture class	% Coarse sand	% Fine sand	% Silt	% Clay	Texture
1	D1L1	2.0	77.0	9.0	4.0	Loamy sand	1.50	78.0	12.0	4.0	Loamy sand
	D1L2	1.0	78.0	10.0	2.0	Loamy sand	1.0	81.0	10.0	1.0	Loamy sand
	D1L3	1.0	75.0	8.0	7.0	Loamy sand	1.0	77.0	10.0	8.0	Loamy sand
2	D2L1	2.0	70.0	6.0	15.0	Loamy sand	1.0	72.0	6.0	17.0	Sandy loam
	D2L2	3.0	8.0	15.0	66.0	Clayey	2.0	10.0	15.0	68.0	Clayey
3	D3L1	3.0	31.0	45.0	13.0	Silty loam	3.0	33.0	47.0	13.0	Loam
	D3L2	3.0	70.0	5.0	12.0	Sandy loam	4.0	71.0	5.0	14.0	Loamy sand
	D3L3	1.0	74.0	5.0	12.0	Sandy loam	2.0	76.0	5.0	13.0	Loamy sand
4	D4L1	5.0	13.0	25.0	47.0	Clayey	5.0	15.0	25.0	50.0	Clayey
	D4L2	5.0	17.0	10.0	57.0	Clayey	7.0	19.0	12.0	58.0	Clayey

Table 4: Soil $pH_{(1:2.5)}$, $EC_{(1:2.5)}$ and Organic carbon content of soil of organically and inorganically managed soils of different districts of middle Gujarat

Sr. No	Location	Depth (cm)	Soil $pH_{(1:2.5)}$		$EC_{(1:2.5)}$ (dS m^{-1})		Organic carbon (g kg^{-1})	
			Org	In-org	Org	In-org	Org	In-org
1	D1L1	0-20	8.07	8.00	0.24	0.23	5.2	4.2
		20-50	8.05	7.91	0.29	0.30	4.5	4.0
	D1L2	0-20	7.98	7.00	0.23	0.22	6.0	4.3
		20-50	7.60	7.90	0.33	0.25	4.8	4.1
	D1L3	0-20	7.89	7.34	0.24	0.16	4.5	3.9
		20-50	7.80	7.20	0.28	0.18	4.3	3.7
2	D2L1	0-20	8.15	8.00	0.24	0.22	5.8	4.3
		20-50	8.10	7.96	0.42	0.23	4.7	4.1
	D2L2	0-20	8.10	8.00	0.27	0.35	6.0	4.1
		20-50	8.05	7.96	0.44	0.29	4.5	3.9
3	D3L1	0-20	8.25	8.11	0.28	0.15	6.2	4.3
		20-50	8.20	8.09	0.56	0.50	4.9	4.2
	D3L2	0-20	8.30	8.10	0.18	0.17	5.8	4.2
		20-50	8.17	8.01	0.15	0.15	4.7	3.9
	D3L3	0-20	8.33	8.06	0.26	0.23	5.9	4.3
		20-50	8.30	8.01	0.36	0.30	4.6	4.1
4	D4L1	0-20	7.98	7.51	0.33	0.20	6.0	4.1
		20-50	7.55	7.43	0.29	0.25	4.8	3.9
	D4L2	0-20	8.09	8.07	0.23	0.17	6.1	4.3
		20-50	8.02	7.96	0.17	0.21	4.9	4.1
Overall mean			8.05	7.83	0.28	0.23	5.2	4.1
t statistic			2.46^{*}		1.80^{ns}		7.15^{**}	

Table 5: Available N, P_2O_5, K_2O and S status of organically and inorganically managed soils of different districts of middle Gujarat

Sr. No	Location	Depth (cm)	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})		Available S (mg kg^{-1})	
			Org	In-org	Org	In-org	Org	In-org	Org	In-org
1	D1L1	0-20	219.5	203.8	64.70	26.20	273.6	271.5	24.4	14.3
		20-50	203.8	172.5	42.52	12.39	274.2	264.2	21.2	11.3
	D1L2	0-20	203.8	219.5	58.72	30.77	336.8	293.0	20.4	8.4
		20-50	172.5	203.8	44.58	16.31	295.7	272.8	15.4	5.1
	D1L3	0-20	235.2	188.2	59.81	26.75	309.1	220.4	18.9	12.4
		20-50	188.2	156.8	34.25	09.56	241.9	215.0	15.5	9.7
2	D2L1	0-20	250.9	203.8	57.20	35.34	413.9	287.1	28.6	13.0
		20-50	219.5	172.5	42.52	23.70	392.4	255.1	22.4	11.0
	D2L2	0-20	203.8	235.2	50.24	30.77	397.8	325.3	24.3	9.1
		20-50	172.5	219.5	42.95	14.35	368.3	319.9	20.6	13.4
3	D3L1	0-20	188.2	235.2	55.56	31.75	233.6	374.7	27.1	15.0
		20-50	172.5	203.8	48.17	18.26	282.0	416.4	20.0	13.4
	D3L2	0-20	219.5	219.5	50.24	40.88	534.9	426.1	26.8	11.0
		20-50	188.2	188.2	39.36	29.25	483.8	384.4	23.1	7.1
	D3L3	0-20	250.9	203.8	47.19	32.73	354.8	263.4	28.0	8.8
		20-50	203.8	203.8	30.23	10.98	323.9	223.1	24.1	4.4
4	D4L1	0-20	203.8	188.2	53.93	18.81	410.7	223.1	18.0	8.0
		20-50	188.2	172.8	25.22	10.54	360.2	209.7	14.0	4.7
	D4L2	0-20	188.2	219.5	47.08	22.02	532.2	446.2	22.0	13.5
		20-50	156.8	156.8	29.25	14.35	456.1	430.1	16.3	8.2
Overall mean			201.5	198.4	46.19	22.79	363.9	306.1	21.5	10.0
t statistic			0.40^{ns}		7.34^{**}		2.15^{*}		9.68^{**}	

Table 6: Available micronutrients (Fe, Mn, Zn and Cu) status of organically and inorganically managed soils of different districts of middle Gujarat

Sr. No	Location	Depth (cm)	Available Fe (ppm)		Available Mn (ppm)		Available Zn (ppm)		Available Cu (ppm)	
			Org	In-org	Org	In-org	Org	In-org	Org	In-org
1	D1L1	0-20	4.74	5.10	11.48	13.20	1.04	0.72	1.44	1.06
		20-50	5.82	5.20	13.54	12.96	0.62	0.50	1.24	1.10
	D1L2	0-20	6.10	5.74	15.30	15.06	1.92	1.58	1.36	1.66
		20-50	4.74	5.50	12.16	11.46	0.84	0.40	1.48	1.08
	D1L3	0-20	5.10	5.62	14.68	14.54	1.32	0.42	2.08	0.94
		20-50	6.50	6.44	11.34	12.12	1.02	0.54	2.34	0.90
2	D2L1	0-20	3.54	15.64	20.88	16.82	1.30	1.76	1.18	3.30
		20-50	3.06	12.04	16.46	13.66	0.50	0.50	1.34	1.40
	D2L2	0-20	6.38	16.46	14.46	10.46	1.04	3.96	0.08	1.46
		20-50	14.24	18.34	12.40	17.68	0.82	0.56	1.34	1.24
3	D3L1	0-20	13.26	13.34	19.56	14.38	1.20	1.14	0.96	0.72
		20-50	9.00	10.66	19.64	8.26	0.68	0.36	1.70	1.10
	D3L2	0-20	18.94	4.04	17.72	13.28	1.36	0.74	1.10	0.70
		20-50	9.36	4.18	14.94	13.30	0.70	0.28	1.94	0.58
	D3L3	0-20	4.68	19.82	13.70	7.62	1.40	1.68	1.02	1.28
		20-50	4.62	19.42	14.94	16.94	0.86	0.58	2.06	1.10
4	D4L1	0-20	6.28	9.56	16.28	21.74	0.64	0.76	1.80	1.32
		20-50	7.36	8.14	15.96	16.22	0.48	0.30	2.10	1.80
	D4L2	0-20	10.16	24.26	15.04	26.92	1.98	1.42	1.56	2.40
		20-50	13.42	19.12	15.36	22.30	0.80	0.98	1.92	1.50
Overall mean			7.87	11.44	15.29	14.95	1.03	0.96	1.50	1.33
t statistic			2.08*		0.29^{ns}		0.31^{ns}		0.94^{ns}	

Table 7: Total microbial count of organically and inorganically managed soils of different districts of middle Gujarat

Sr. No	Location	Depth (cm)	Microbial count (cfu)	
			Org	In-org
1	D1L1	0-20	266000	93100
		20-50	101000	79000
	D1L2	0-20	2750000	150000
		20-50	1530000	128000
	D1L3	0-20	2100000	170000
		20-50	170000	55000
2	D2L1	0-20	1990000	54000
		20-50	54000	23000
	D2L2	0-20	371000	66000
		20-50	66000	11000
3	D3L1	0-20	2750000	80000
		20-50	80000	25000
	D3L2	0-20	5420000	6000
		20-50	6000	3500
	D3L3	0-20	117000	10000
		20-50	10000	71000
4	D4L1	0-20	1450000	98000
		20-50	98000	80000
	D4L2	0-20	1700000	11000
		20-50	11000	32000
Overall mean			1052000	62280
t statistic			3.11^{**}	

4. Conclusion
From the present findings it can be concluded that there was substantial improvement in physical, chemical and biological properties of Anand, Kheda, Ahmedabad and Vadodara district of middle Gujarat due to long term use of organic management practices over inorganic farming.

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