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Impact of Organic Wastes on Physical and Chemical Properties of Sandy and Loamy Soils in Egypt

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Authors' contributions

This work was carried out in collaboration between both authors. Authors AAAS and OEN designed the research work and performed the experiment, analyzed the data and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The aim of this study was to evaluate the effect of two organic wastes used as soil amendments i.e. filter mud cake (FMC) and vinasse (V) on some physical and chemical properties of sandy and loamy sandy soils. Applications of organic were incubated with the soils for a three periods of 15, 30 and 60 days at four application rates (0, 0.5, 1 and 2%). This study was carried out in a two way randomized completely block design with three replications. After incubation periods, bulk density, porosity, water retention, soil pH, electrical conductivity (EC) and organic matter were determined.
Results showed that the values of soil bulk density and soil pH were decreased with increasing the application rates of filter cake or vinasse compared with the control in two soils. In addition, application of different filter mud cake and vinasse rates to the study soils increased soil porosity, field capacity (FC), wilting point (WP), available water (AW), electrical conductivity (EC) and organic matter contents (OM) as compared to control at different period incubation time. The data of this study concluded that, organic wastes or byproducts of sugar industries could be applied to improve some soil properties.

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Keywords: Soil properties; filter cake; vinasse and incubation time.

1. INTRODUCTION

Sugarcane industry is one of the oldest industries in Egypt. Cane plantations are concentrated in the area of Upper Egypt specifically in Menia, Sohag, Qena, Luxor and Aswan. There are eight sugarcane producing factories in Egypt, most of them located in Upper Egypt close to the cultivations. Processes sugar produce from sugarcane generate large amounts of waste and need sustainable approach to their reuse, through proposals and implementations to reduce pollution considering economic, health and environmental factors [1]. Filter cake, a residue from the treatment of sugar cane juice by filtration, is a rich source of nutrients and organic matter and has large moisture content [2,3]. The filter cake, which is a dark spongy solid, is continuously collected and sold to contractors to be used as soil amendment or fertilizer due to its richness in nutrients. El-Tayeh, et al. [4] showed that the soil pH decreased by increasing application rates of Filter cake (FC) compared with control. Since pH values were 6.8 at control, 6.77 at 10% FC, 6.5 at 30% FC and 6.33 at 50% FC. The manufacturing processes to produce alcohol generates a large residues from sugarcane cultivation, such as vinasse which have a great potential for use in agriculture as soil improvers and fertilizers [5]. Vinasse as a sugar industrial waste represents the residues from molasses fermentation. Vinasse contains many elements and can be profitably recycled to improve soil properties [6].

In this sense, the concern with environmental protection linked to the high cost of fertilizers led to research on the recycling of organic waste, such as the by-products of the sugar-energy sector [7]. The use of filter mud cake and vinasse as an organic amendment in plant production has become an increasingly common practice because, in addition to increasing nutrients, it also benefits the physical and chemical characteristics of the soil, such as the improvement of porosity (Santana, et al. 2012).

Concerning the influence of vinasse applications on soil chemical and physical properties, several studies reported that, the application of vinasse to the soil, especially at high doses (5 ton ha^{-1}), negatively affect soil physical properties as structure and available water [8]. Tejada, et al. [9] found that, the application of vinasse had a detrimental impact on the soil's physical (structural stability, bulk density), chemical (EC soil) properties. Other researchers reported that the application of vinasse to soil decreased bulk density as a result of dilution of the deep soil mineral fraction [10,11]. All vinasse have high content of monovalent cations, which can cause dispersion of organic matter and clay particles, breaking of aggregates and soil structure. The dispersed clay particles can block pores, cause hardening of the soil upon drying, decrease water infiltration and permeability, and as consequence reduce plant growth [12].

The objective of this research was to evaluate use of some organic wastes (by product from sugarcane) as soil amendments namely filter mud cake (FMC) and vinasse (V) for develop some physical and chemical properties of sandy and loamy sandy soils of Egypt.

2. MATERIALS AND METHODS

2.1 Soil Sampling and Soil Amendments

Surface soil samples (0 – 20 cm soil depth) were taken from two different soils, the first soil (No. 1) represents sandy soil was taken from Wady Kherat eastern Nile River basin (far about 30 km) and another soil (No. 2) represent loamy sand (sedimentary soil) was taken from El-Sabel area eastern Nile River basin (far about 5 km) at Kom-Ombo City Aswan. Separately, each soil sample was air-dried, ground, soil mixed, sieved through a 2 mm sieve and was analyzed for some physical and chemical properties, according to procedure Klute, [13] and Cottenie, et al. [14] and the obtained data were recorded in Table 1.

Two organic amendments varied in their properties were used in this study which resourced from sugar manufacturing wastes. The first organic waste was filter mud cake (FMC) supplied from a Kom-Ombo Sugar Factory in Kom-Ombo City Aswan Governorate, Egypt. The another organic amendment was vinasse supplied from Egyptian Sugar & Integrated Industries Factors (Hawamdyia City, Giza Governorate, Egypt). Some chemical and physical properties of filter cake and vinasse were determined according methods of A.O. A. C. [15] and the found data were recorded in Table 2.

2.2 Experimental Design

A pots incubation experiment was carried out to study the effect of two organic wastes on some

chemical and physical soil properties of two different soils of Egypt. This study was carried out in a two way randomized completely block design with three replications and conducted under laboratory conditions at Soil and Water Department laboratory - Faculty of Agriculture and Natural Resources - Aswan University-Egypt. And sharing in samples analysis with Department of Soils and Water laboratory – Faculty of Agriculture – Sohag University. A 48 plastic pots with 15 cm of diameter and 15 cm depth were used in this study. These pots were divided into two main groups (24 pot/ main group) representing the used two soil. Each pot was filled with 3 kg fine soil of soil No. 1 or No. 2. The pots of each main group were divided into two subgroups representing the used organic wastes (filter cake and vinasse). Also, the pots of each subgroup were arranged in four sub subgroups (3 pot / sub subgroup) representing application rates of the used organic wastes (0, 0.5, 1.0 and 2%). The added organic wastes good mixed with the potted soil and incubated at room temperature (25±2ºC). During the incubation period, the soil moisture content in the pots was maintained at field capacity of each treatment. The moisture content was checked every five days and moisture loss was adjusted by weight difference by irrigation water. After various incubation periods (15, 30 and 60 days) soil of one replicate was taken separately and air dried, ground to pass through a 2 mm sieve, divided into three equal portions and analyzed as three replications according to Klute, [13] and Cottenie, et al. [14]. The studied soil properties were soil pH, electrical conductivity (EC), bulk density, porosity, organic matter and water retention. The moisture retention content of the studied soil at 1/3rd and 15 bars were determined as per procedure using pressure plate apparatus described by Richards [16].

2.3 Statistical Analysis

The results were statistically analyzed and was based on two-way analysis of variance (ANOVA) for the comparison of statistical significances among different treatments using Microsoft Excel 2010. The least significant differences (LSD) at the 5% level of probability were computed to detect the difference among the treatments and their interactions.

3. RESULTS AND DISCUSSION

3.1 Soil Physical Properties

3.1.1 Soil bulk density

Soil bulk density is considered as a good parameter of all soils. It is well known also that total soil porosity is related to soil bulk density. Data in Table 3 show that values of soil bulk density significantly decreased with increasing the application rates of filter cake or vinasse compared with the control in the two soils analyzed. These results are similar to those obtained by Puget, et al. [17], who found that a good soil bulk density depended on the content and nature of the organic matter added. This decrease in soil bulk density may be because of increases soil organic matter lead to the dilution of the denser soil mineral fraction and soil aeration increases. This decrease was especially evident for the high rate of filter cake

Table 1. Some chemical and physical properties of the studied soils

Soil properties and units	Soil number	
	No. 1	No. 2
Particle size distribution (%)		
Sand	97.8	86
Silt	1.4	4.6
Clay	0.8	9.4
Texture class	Sandy	Loamy sand
Field capacity %	14	22
Wilting point %	6.74	11.23
Available water content %	7.26	10.77
*OM %	0.30	0.73
Bulk density (gm/cm^3)	1.58	1.48
Real density (gm/cm^3)	2.78	2.67
Porosity %	43.16	44.56
pH (1:2.5) soil:water susp.	8.46	8.50
*EC. in extract (1:5) dSm^{-1}	0.45	0.15

**EC. is electrical conductivity, *OM is organic matter*

Table 2. Selected properties of the organic wastes used

Parameters	Unit	Filter cake	Vinasse
pH (1:2.5 organic waste: water)		6.7	4.7*
EC	dS/m	1.9	20.8
OM	%	32.3	4.09
Total C	%	18.7	2.37
Total N	%	2.1	1.55
C/N ratio		8.9	1.53

**pH was determined in solution*

Table 3. Effect of organic wastes rates and incubation periods on the bulk density of soil (g/cm^3)

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		1.58	1.542	1.582	1.57	1.44	1.43	1.44	1.44
Filter cake rate	0.50%	1.542	1.522	1.543	1.54	1.38	1.392	1.416	1.40
	1%	1.535	1.52	1.54	1.53	1.34	1.349	1.379	1.36
	2%	1.512	1.504	1.529	1.52	1.286	1.289	1.35	1.31
Vinasse rate	0.50%	1.565	1.515	1.566	1.55	1.27	1.319	1.391	1.33
	1%	1.557	1.537	1.57	1.55	1.228	1.32	1.332	1.29
	2%	1.533	1.475	1.541	1.52	1.3	1.313	1.325	1.31
Means		1.55	1.52	1.55		1.32	1.34	1.38	
LSD at 5%	*A	0.019				0.044			
	*B	0.012				0.029			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

Table 4. Effect of organic wastes rates and incubation periods on the porosity of soil (%)

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		43.15	44.55	43.08	43.59	52.23	50.18	49.28	50.56
Filter cake rate	0.50%	44.55	45.24	44.49	44.76	48.3	47.86	46.96	47.71
	1%	44.77	45.33	44.6	44.90	49.82	49.48	48.37	49.22
	2%	45.61	45.92	45	45.51	51.82	51.74	49.43	51.00
Vinasse rate	0.50%	43.72	45.49	43.66	44.29	52.42	50.61	47.89	50.31
	1%	43.98	44.71	43.53	44.07	54.02	50.57	50.12	51.57
	2%	44.85	46.94	44.57	45.45	51.32	50.82	50.37	50.84
Means		44.38	45.45	44.13		51.42	50.18	48.92	
LSD at 5%	*A	0.680				1.488			
	*B	0.445				0.974			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

and vinasse (2%). In this respect similar were obtained results by Tejada and Gonzalez, [8]. Data as shown in Table 3 appeared that, the effectiveness of filter cake on reduce soil bulk density was more influence than the effects of vinasse at same application rates. Also, in Table 3 were all applications of organic wastes in the two soils analyzed. Soil bulk density was significantly decreased with increasing incubation intervals (15 and 30 days) except at 60 days was increasing.

3.1.2 Soil porosity

Soil porosity is the gap between solid particles, which contains water and air. So, that adding any

materials to soil are cause increase areas of water and air in the soil will be responsible for increasing total soil porosity. Soil porosity is related to soil bulk density and particle density. Data in Table 4 showed that adding each filter cake or vinasse resulted in a decrease of soil porosity. These results may be due to the low density of organic materials (filter cake and vinasse) and their decrease effect on soil bulk density.

3.1.3 Soil moisture relations

Data presented in Tables 5, 6 and 7 revealed that application of filter mud cake and vinasse at different rates to the sandy and loamy sand soils increased field capacity (FC), wilting point (WP) and available water (AW) as compared to control at different period incubation time. Also results indicated that the values of soil moisture content (FC, WP and AW) increased gradually by increasing the rate added organic wastes in all incubation times. The high rate of filter cake (2%) was more effective on increasing the values of the FC, WP and AW, as compared to some the addition rate of vinasse.

The available water ranged between 6.67 and 19.99% in the sandy soil and between 10.72 and 25.92% in the loamy sand. The maximum available water was recorded in the loamy sand soil treatment by filer cake at 2% after 60 days incubation time compared to control treatment, while the lowest values was found in the control treatment of sandy soil after 15 days incubation time. This is finding may be due to the high moisture capacity of added organic materials compare with that for soil mineral particles sand and also, may be attributed to the role of organic matter forming stable aggregates which improve soil moisture retention [18,11,19,20]. In addition, the effect of organic acids, which formed either during decomposition of organic amendments, may be helpful development of soil physical properties [21,22].

3.2 Soil Chemical Properties

3.2.1 Soil pH

Concerning pH values in Table 8 the data indicated that soil pH was significantly decreased with filter cake and vinasse applications. In this case, the rate of this decrease was increased with the increase rate of organic wastes, compared with soil without organic materials treatment. Hamed, et al. [23] found that pH values of soil treated with filter cake decreased with increasing the level of filter cake addition. Also, data in Table 9 showed that effectiveness of filter cake addition on decrease soil pH values was greater than vinasse addition with control treatment at all incubation periods in two soils under study. These findings may be due to that high organic matter content in filter cake compared with that in vinasse.

Soil pH were significantly deceased at incubation periods increased up to 30 days but it was increased often that at 60 days. These findings may be due to organic acids produced by hydrolysis or decomposition of organic matter added in short incubation times (15 and 30 days) cause to decreasing soil pH. But at latter incubation times (60 day) may be by product of analysis organic materials (organic acids) insert in internal reaction in soil responsible on increasing of soil pH. Similar results were obtained by El-Etr and Hassan, [24].

Table 5. Effect of organic wastes rates and incubation periods on the field capacity of soil

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		14.44	14.81	15.7	14.98	23.12	23.91	23.41	23.48
Filter cake rate	0.50%	15.38	18.23	23.04	18.88	26.81	34.29	42.15	34.42
	1%	18.32	23.43	27.91	23.22	30.47	38.44	45.07	37.99
	2%	18.88	26.92	34.12	26.64	32.8	39.69	47.84	40.11
Vinasse rate	0.50%	14	16.2	20.04	16.75	23.58	28.74	38.24	30.19
	1%	18.02	23.5	27.54	23.02	24.54	33.13	42.24	33.30
	2%	18.96	24	27.94	23.63	26.28	36.55	43.07	35.30
Means		16.86	21.01	25.18		26.80	33.54	40.29	
LSD at 5%	*A	3.819				5.436			
	*B	2.500				3.559			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

Table 6. Effect of organic wastes rates and incubation periods on the wilting point of soil

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		7.73	7.64	7.05	7.47	11.02	11.65	12.69	11.79
Filter cake rate	0.50%	8.36	9.68	11.45	9.83	13.96	16.23	20.14	16.78
	1%	8.75	9.65	11.47	9.96	16.02	18.6	21.55	18.72
	2%	8.75	12.96	14.13	11.95	17.23	19.49	21.92	19.55
Vinasse rate	0.50%	7.33	7.62	9.84	8.26	11.4	14.84	17.18	14.47
	1%	7.12	8.54	10.41	8.69	12	16.13	18.84	15.66
	2%	7.32	9.86	10.61	9.26	12.83	17.68	18.93	16.48
Means		7.91	9.42	10.71		13.49	16.37	18.75	
LSD at 5%	*A	1.823				1.757			
	*B	1.193				1.150			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

Table 7. Effect of organic wastes rates and incubation periods on the available water content of soil

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		6.71	7.17	8.65	7.51	12.1	12.26	10.72	11.69
Filter cake rate	0.50%	7.02	8.55	11.59	9.05	12.85	18.06	22.01	17.64
	1%	9.57	13.78	16.44	13.26	14.45	19.84	23.52	19.27
	2%	10.13	13.96	19.99	14.69	15.57	20.2	25.92	20.56
Vinasse rate	0.50%	6.67	8.58	10.2	8.48	12.18	13.9	21.06	15.71
	1%	10.9	14.96	17.13	14.33	12.54	17	23.4	17.65
	2%	11.64	14.14	17.33	14.37	13.45	18.87	24.14	18.82
Means		8.95	11.59	14.48		13.31	17.16	21.54	
LSD at 5%	*A	2.399				4.063			
	*B	1.570				2.660			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

Table 8. Effect of organic wastes rates and incubation periods on soil reaction (pH)

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		8.4	8.55	8.62	8.52	8.49	8.53	8.55	8.52
Filter cake rate	0.50%	8.35	8.37	8.73	8.48	8.45	8.53	8.5	8.49
	1%	8.28	8.21	8.65	8.38	8.41	8.45	8.47	8.44
	2%	8.25	8.24	8.57	8.35	8.39	8.39	8.46	8.41
Vinasse rate	0.50%	8.41	8.59	8.75	8.58	8.35	8.39	8.45	8.40
	1%	8.32	8.54	8.74	8.53	8.29	8.33	8.33	8.32
	2%	8.29	8.46	8.67	8.47	8.2	8.23	8.31	8.25
Means		8.33	8.42	8.68		8.37	8.41	8.44	
LSD at 5%	*A	0.132				0.039			
	*B	0.087				0.025			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

Table 9. Effect of organic wastes rates and incubation periods on soil EC (dS/m)

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		0.41	0.35	0.26	0.34	0.14	0.17	0.15	0.15
Filter cake rate	0.50%	0.38	0.35	0.21	0.31	0.14	0.17	0.16	0.16
	1%	0.57	0.5	0.31	0.46	0.14	0.17	0.17	0.16
	2%	0.57	0.5	0.31	0.46	0.14	0.17	0.19	0.17
Vinasse rate	0.50%	0.48	0.54	0.28	0.43	0.21	0.23	0.19	0.21
	1%	0.52	0.57	0.28	0.46	0.3	0.26	0.26	0.27
	2%	0.7	0.74	0.39	0.61	0.42	0.36	0.33	0.37
Means		0.52	0.51	0.29		0.21	0.22	0.21	
LSD at 5%	*A	0.088				0.047			
	*B	0.058				0.031			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

Table 10. Effect of organic wastes rates and incubation periods on the organic matter content in soil (%)

Treatments		Soil type							
		Sand soil				Loamy sand soil			
		Incubation period (day)			Means	Incubation period (day)			Means
		15	30	60		15	30	60	
Control		0.28	0.26	0.24	0.26	0.7	0.68	0.67	0.68
Filter cake rate	0.50%	0.58	0.46	0.41	0.48	0.99	0.96	0.9	0.95
	1%	0.62	0.55	0.49	0.55	1.09	1.06	0.97	1.04
	2%	0.72	0.67	0.61	0.67	1.6	1.51	1.39	1.50
Vinasse rate	0.50%	0.45	0.41	0.4	0.42	1.09	1.06	1.03	1.06
	1%	0.57	0.51	0.5	0.53	1.38	1.32	1.22	1.31
	2%	0.66	0.55	0.53	0.58	1.39	1.35	1.26	1.33
Means		0.55	0.49	0.45		1.18	1.13	1.06	
LSD at 5%	*A	0.047				0.056			
	*B	0.031				0.036			

**A = Organic waste (filter cake or vinasse)*
**B = Incubation period (15, 30 and 60 day)*

3.2.2 Soil EC

Soil EC values, as shown in Table 9 were significantly increased by increasing rates of OM applications as compared to control treatments particularly with the highest application rates (2%) from filter cake or vinasse. This is may be due to the soluble products produced from OM decomposition such as organic acids and its reactions with soil components in the two ways the first that the organic acids itself are cause increasing EC soil and the secondary action is that the organic acids are working dissolve some insoluble salts in soil. Also, data in Table 9 indicated that vinasse applications were more effect on increasing soil EC compare with filter cake and control treatments at all incubation periods in two soils. This is may be due to that high vinasse EC. These results may be supports by the results of Table 2 [8].

Results in Table 9 showed that soil EC was significantly decreased with increasing incubation periods where, those lowest values of soil EC were at latter incubation period (60 days) and with the two soils under study. These findings may be due to fixation apart from soluble salts in inter lattice or with OM specialty with increase incubation intervals. Before that similar results were obtained by Chang, et al. [25] and Usman and Gameh [26].

3.2.3 OM content

OM content in soil is a good indicator for soil fertility. One of the clearest effects of filter cake

and vinasse applications was the increase in the soil organic matter content. Data in Table 10 showed that the content of OM (%), of the two soils under study, were increased as a result of different of applications of filter cake and vinasse especially at high application rates in the two soils compared to the control. Also, data in Table 10 appeared that effectiveness of filter cake on the increase of OM content in soil was greater than that resulted from vinasse applications at the same incubation periods used in this study. The highest value of soil OM (1.60%) was obtained for the incubation period of 15 day with treatment 2% of filter cake for loamy sand soil but it was 1.39% for the incubation period of 15 day with treatment 2% of filter cake and vinasse for sandy soil. Madejón, et al. [27] found that, the application of vinasse and filter cake to the soil increased the OM content by 1.7 times greater than the mean value in the control.

4. CONCLUSION

It can be concluded that, soil bulk density and soil pH were decreased with increasing the application of filter cake or vinasse rates compared with the control (without organic wastes) in the two soils analyzed. In addition, application of different filter cake and vinasse rates to the study soils increased soil porosity, field capacity (FC), wilting point (WP), available water (AW), electrical conductivity (EC) and organic matter contents (OM %) as compared to control at different period incubation time. It could be recommended from the research that the filter cake and vinasse are from the best organic wastes in improvement many from properties of soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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