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Modeling the Influence of Floriculture Effluent on Soil Quality and Dry Matter Yield of Wheat on Vertisols at Debre Zeit, Ethiopia

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Abstract

Floriculture is one of the booming sectors in Ethiopia. With its expansion, there is a growing concern as to its adverse effect on the environment. The objectives of this study were therefore, to provide concrete information on the influence of floriculture effluents on soil quality and crop productivity. Two permanent greenhouse experiments were conducted at Debre Zeit Agricultural Research Center on soils samples collected from farmer's field using wheat as a test crop. The soil samples were divided into two equal parts as sterilized and non-sterilized. Seven rates of floriculture effluents (0, 15.0, 30.0, 45.0, 60.0, 75.0 and 90.0 ml pot^{-1}) were used as treatment in CRD with four replications. The effluent was characterized by high pH, EC, N, P, S and basic cations (K, Ca, Mg and Na), low in micronutrients (Cu, Fe, Mn and Zn) and very low in heavy metals (Mo, Ni, Cd and Cr). Accordingly, its application did not significantly influence the texture and water holding capacity (WHC) of the soil, though decreasing values of FC, PWP and WHC were obtained both from sterilized and non-sterilized soils. Chemical properties were highly influenced by effluent additions. The pH, EC, exchangeable bases and micronutrients of the soil were significantly raised after first and second harvest. Organic carbon and Total Nitrogen increased with increasing volume of effluent, but decreased at high levels. Shoot dry weight of the wheat was also significantly affected by increasing volume of effluent. In non-sterilized soils, addition of low volume effluent increased shoot dry weight which later followed the same trends as sterilized soils. The decreasing trend in shoot dry weight was in line with that of soil organic matter, whereas continuous increments in pH, CEC and ESP resulted in changing the neutral soil to saline. Hence, floriculture effluent was found to affect the performance of wheat and soil quality parameters, where the effect was pronounced for sterilized soil. Future research should focus on long-term effects of floriculture effluents on physical, chemical and biological properties of soil and crop productivity.

Keywords: Effluents, floriculture, non-sterilized, sterilized, soil quality

Introduction

Industrialization is imperative to a nation's socio-economic development as well as its political stature in this globalized world, as the global economy is led by free market. Industry varies according to process technology, size and nature of product, characteristics and complexly of waste discharges (Amuda, 2006). Recently, one of the issues that attracted the attention of researchers is wastewater chemicals that can penetrate into the soil, plant and finally enter into the food chain (Ashworth and Alloway, 2003).

In Ethiopia, floriculture as an industry counts only a decade but expands from two (2000) to 85 (2011) in number (Hortiflora Magazine, 2011). Even though different types of flowers are grown and exported to Europe and US market, the climate provide nearly ideal conditions for roses. Hence, the level of production has made Ethiopia the second-largest producer of roses in Africa next to Kenya and sixth in the world after Holland, Colombia, Ecuador, Kenya and Israel (Getu, 2009). The sector's contribution to employment and export revenue has been progressively increased over the last few years. According to the report from Ethiopian Flower Producer Association (EFPA, 2007) 35,000-50,000 workers are employed of which 60 percent are women. It contributes major share of the national economy by setting its export earning to 100 million USD (www.ethiopianflowerexport.com/profile.html),(www.africanagricultureblog.com/2007/09/ethiopia-now-africas-secondbiggest) in 2007, increase of five-fold from 2005. In 2008, Ethiopia has earned 186 million USD from horticulture exports out of which 80 percent was generated by flower (Getu, 2009). According to the report of Ethiopian Horticulture Producer and Exporters Association (EHPEA) in 2010 the revenue of the sector has grown by 25 percent from 2008, following the global economic and financial crisis (Hortiflora Magazine, 2011). However, there are a number of challenges that must be resolved to continue the development of the sector with present rapid speed. Among the challenges include environmental impacts of the sector which can create pressure on the sustainability and market acceptability of flower industries.

The industry is blamed for using too much chemicals which damage the environment through its discharge (http://news.bbc.co.uk/2/hi/africa/5016834.stm; Sisay, 2007). The production uses more than 300 chemicals as pesticides and growth regulators, which kills useful organisms in the soil and disturbs the biodiversity (Sisay, 2007; http://ucanr.org/freepubs/docs/8221.pdf and http://www.nrcs.usda.gov). Getu (2009) confirmed that intensive chemical fertilizers and pesticides that are frequently applied to produce a quality rose resulted in the negative impact on the environment.

Even though detailed research on floriculture effluent is scant, several studies prove the impact of other industrial effluents and municipal wastes on soil quality. For instance, Mohammad *et al.*, 2010 showed that the concentration of N, P and K in the soil changed as the treated municipal waste water was applied as irrigation in Iran. They also found out that a significant accumulation of soluble salts and heavy metals pollutes the water quality being used for irrigation. Municipal sewage by Voegbolo and Abdulkabir (2006) from Ghana and Libya, Abattoir by Osibaizo and Adie, (2007), Pharmaceutical effluent by Osaigbovo *et al.* (2006) both from Nigeria similarly reported its impact on the environment. Similar efforts were done on tannery, pulp and paper mill effluents which support the findings of others by Babyshakilla (2009) and Kannan and Oblisami (1990). Authors like Mohammed *et al.*, 2010; Babyshakilla 2009 and Osaigbovo *et al.*, 2006 confirms that these effluents can be used for effective plant growth at a lower volume where as it declines with prolonged application due to the accumulation of soluble salts creating osmotic stress. Pimentel *et al.* (1995) and UNEPA report (1997) from an experience in Colombian flower farm where the savanna of Bogota changed into sterile land. Prolonged use of these effluents for irrigation could increase ESP and OM content of irrigated soil and changes in these two parameters could affect the soil structure and its stability (Lado *et al.* 2005). Therefore, the objectives of this study were to determine the influence of floriculture effluents on soil quality and dry weight production of wheat and to see the most likely trends in soil quality parameters

Material and Methods

Debre Zeit is located at 45 km South East of Addis Ababa and lies in a geographic coordinates of $8^0$45'52''N to $8^0$48'45''N and $38^0$58'53''E to $39^0$01'00''E with an average altitude of 1950 masl. It is characterized by humid tropical climate and heavy precipitation from June to August having an annual mean rainfall of 800.0 mm. The mean annual maximum and minimum temperature are 25.5^0C and 10.5^0C, respectively (NMA, 2007). Vertisols are the dominant soil types (WRB, 2006). Geologically, these soils are from alkaline basalt and trachyte belonging to the Bishoftu Formation of the Cenozoic volcanic eruptions (Tefera *et al.*, 1996).

Fifty four geo-referenced sub-samples were collected from the nearby farmer's field, where there was unlikely influence of the effluent from floriculture farms and a composite sample was made. Part of the composite sample was grounded and passed through 2mm sieve and used for determination of physico-chemical properties prior to sowing. The remaining sample was split into two parts of pot experiment; the first part being air dried while the second was subjected to sterilization at a temperature of 190^0C for 4 hours to kill the soil organisms. Then, 56 polyethylene pots having a height of 30 and a diameter of 19.10 cm were filled with 3 kg of the sample.

About 100 L of the effluent was sampled from the septic tank of flower farm after mixing thoroughly to make sure that the sample is representative. Then, a liter was passed through Whatman No.42 for characterizing the effluent before application, while the rest was used as treatments (0, 15.0, 30.0, 45.0, 60.0, 75.0 and 90.0 ml pot^{-1}) based on the volume of discharge. They were laid out in CRD with four replications and *Assassa* wheat variety was used as a test crop. The above ground biomass was harvested from each pot, dried at 65^0C for 72 hours to a constant weight and shoot dry weights were recorded for each pot and every harvest. Accordingly, the soil from each pot were sampled and subjected for its physico-chemical analysis after first and second harvesting. Texture was determined by hydrometer method (Bouyoucos, 1962). The moisture content at field capacity (FC) and permanent wilting point (PWP) of the soil samples were measured by a pressure membrane (suction methods) via subjecting the saturated soil sample to 0.33 and 15 bars, respectively. The soil pH was potentio-metrically measured in the supernatant suspension of a 1:2.5 soil to water ratio using the glass electrode in VWR Scientific Model 2000 pH meter (Rayment and Higginson, 1992) while the electrical conductivity was measured in 1:5 using a Model 4310 Conductivity meter. Organic carbon was determined using Walkley-Black oxidation method (Allison, 1965). Total nitrogen was determined by the micro-Kjeldahl digestion, distillation and titration method, and available P was determined using the standard Olsen extraction method (Olsen *et al*., 1954). Total exchangeable bases were determined after leaching the soils with ammonium acetate (Reeuwijk, 2002). Amounts of K^+, Na^+, Ca^{2+} and Mg^{2+} in the leachate were analyzed by AAS. Cation exchange capacity was determined at soil pH level of 7 after displacement by using 1N ammonium acetate method in which it was, thereafter, estimated titrimetrically by distillation of ammonium that was displaced by sodium (Chapman, 1965). Micronutrient and heavy metals (Fe, Cu, Mn, Mo, B, Cl and Pb, Ni, Cr, and Cd) were extracted by Diethylenetriamine pentaacetic acid (DTPA) and concentrations were determined by AAS. The pH, EC and Na of the effluents were directly measured with the respective pH, EC and flame photometer, respectively while nitrogen by Kjeldhal method, Sulfur by Turbidity, Boron by Mohr's titration methods, all micronutrients and bases were extracted with EDTA and each element is directly read by AAS (FAO, 2008).

Results and Discussion

Effluent Characteristics

The analytical results revealed that the pH and EC were higher by 17.2 and 107.2 % as compared to the water sample. According to FAO (2008) classification of nutrient levels, the N, P and S content of the effluent fall in the range of mid to high classes. It had 81.1, 47.3, 21.8, and 8.92 mg L^{-1}, respectively, which was also considered to be high. On the contrary, the concentrations of micronutrients and heavy metals were found to be very low; 0.47, 0.27, 0.12 and 0.08 mg L^{-1} for Fe, Mn, Zn and Cu, respectively (Table 1). Patterson (1999) indicated that any effluents having pH and EC higher than 7.0 and 1dS m^{-1} (1000 µS cm^{-1}), respectively could affect the physico-chemical properties of the soil. The chemical compositions of the effluents showed that intensive use of chemicals (Getu, 2009), which might cause nutrient imbalances and thereby affecting physico-chemical properties of the soil. Similar findings have been reported by and Babyshakilla (2009) using effluents from different industries. The sodium adsorption ratio (SAR) of the effluent indicated moderately safe category of sodicity (FAO, 1985; 2008). However, the concentration of Na is high enough to cause sodicity, if the application continues for some time (Mohammed *et al*., 2010; Lado *et al*., 2005).

Soil Characteristics

Soil texture was not influenced by the application of increasing volumes of effluent (Table 2), which might be due to the fact that it can only be affected through long term application (Babyshakilla, 2009; Osibaizo and Adie, 2007). Increasing volume of effluents generally resulted in decreasing the FC, PWP and WHC of both sterilized and non-sterilized soils in the first application, relatively noticeable decline of WHC started after the application of 45.0 mL (disposal) and 30.0 mL for non-sterilized and sterilized soils, respectively. The declining points were lowered to 30.0 and 15.0 mL during the second harvest. The WHC of the non-sterilized soil was higher than that of sterilized soil for every treatment and the differences increased with time (Table 2). This shows the presence of native soil organisms, which could be involved in absorbing the shocks but with declining capacity with time. These finding is in agreement with the previous studies made by Babyshakilla (2009) who reported that the role of organisms in buffering the pressure exerted from the intake of effluents were reduced over years. A research reports by Lado *et al*. (2005) also showed that long term application of effluent produced a deleterious effect on soil structure, infiltration and seal formation. This is supported by the reports of Pimentel *et al*. (1995) and UNEPA report (1997) from Colombian flower farm where the savanna of Bogota changed into sterile land.

The soil chemical properties were found to be significantly ($P \leq 0.05$) influenced by the effluent. The pH increased with increasing volume of effluent from 7.07 to 7.32 for non-sterilized whereas a relatively higher value of 7.54 was found for sterilized soil at application of the highest volume of effluent for the first harvest. During the second harvest, there were further increments of pH by 0.28 and 0.32 units for non-sterilized and sterilized soils, respectively at the highest application rate of effluents. Similarly, the EC increased from 152.63 to 167.54 and from 182.40 to 197.43 for the respective soils (Table 3). This is in agreement with the findings of Mohammed *et al*. (2010); Sisay (2007); Osibaizo and Adie (2007) who independently reported similar changes in the chemical properties of the soil after being supplied with effluents.

The OC and TN contents decreased at higher volume of effluents and with successive harvests (Table 4). The extent of OC and TN losses were found to be relatively higher for non-sterilized than sterilized soils owing to the decline in biological activities in non-sterilized soil due to the side effect of effluents. The reduction in OC is an indicative for the deterioration of soil quality. The concentration of all exchangeable bases increased with increasing volumes of applied effluents, but with varying extent and proportion. The increases in their concentrations at the end of the second harvest were because of high concentrations of the cations in the effluent (Table 5 and 6). However, high nutrient content in the effluent did not influence growth of wheat (Table 7 and 8). Previous findings by Osaigbovo *et al*. (2006) proved that pharmaceutical and cassava mill effluent enhanced soil chemical properties but not reflected in maize yields.

Shoot Dry Weight

Generally, the shoot dry weight of wheat showed a declining trend with increasing volume of the effluents, though significant increments were recorded until application of 45.0 and 15.0 mL effluents during the first and second harvests, respectively in non sterilized soils as compared to control (Table 7 and 8). This might be due to the presence of soil organisms in non-sterilized soil that have a positive effect at lower volume of effluents. The results is in a agreement with the findings of Mohammed et al. *(2010) and Babyshakilla (2009) who reported that the effluent can be used for effective plant growth at a lower volume. Accordingly, the effluent disposed from this industry could produce an increasing shoot dry weight over the control at lower volumes, till the 45.0 mL and 15.0 mL during the first and second harvest, respectively. The highest dry weight (6.85 g pot*$^{-1}$*) obtained from application of 30.0 mL effluent in non-sterilized soil was reduced to 4.37 g pot*$^{-1}$ *for the same treatments during the second harvest due to the accumulation of soluble salts and thereby increased osmotic stress (Table 7 and 8).*

Modeling the Trends

The relationship among the volume of effluent over years with shoot dry weight of wheat and selected soil quality parameters have been made using SAS and a stepwise multiple regression models were developed accordingly. Fifty six observations were used to develop a multiple regression models out of which forty five were used for calibration and the rest for validating the models.

Shoot dry weight

The shoot dry weight production potential of wheat was highly influenced by the application of effluent. At application of lower volume, the test crop benefits from effluent application but the dry weight decreases at high volumes. These trends are summarized by the following multiple regression models indicating the decrease in shoot dry weight of wheat with increasing volume of effluents and years.

$SDW\ (NS) = -0.028X-1.71Y+7.67$ *Equation 1*

$SDW\ (S) = -0.046X-1.92Y+10.40$ *Equation 2*

Where SDW= shoot dry weight
NS= non-sterilized soil
S= sterilized soil

The models show that it will be exhausted at year five with the applications of 75.0 ml pot^{-1} effluent in non-sterilized soil while similar trends, but with sharp decline is expected at year four for sterilized ones. This indicates that sterilization kills organisms that would play a vital role in the bio-chemical reaction with the effluents, whereas reduction will be somewhat offset each other with the presence of organisms.

Soil characteristics

Since the texture of the soil was not changed significantly and the changes in micro-nutrients concentrations were also low to medium, the soil pH, OM, CEC and ESP were used for developing regression models. These parameters would also help to predict other properties, such as nutrient status, base saturation and acid saturation.

$pH\ (NS) = 0.0034X+0.24Y+6.78$ *Equation 3*

$pH\ (S) = 0.003X+0.27Y+6.96$ *Equation 4*

Generally, the prediction shows that for the first three years, the soil reaction of the non-sterilized soil was less than that of the sterilized ones but then after the values approach that of the sterilized soils. The prediction further indicates that the non-sterilized soils will have approximately the same reaction as that of sterile soils at year seven and on wards with the application of 90.0 ml. This might have been due to the loss of organic matter and organisms in the non-sterilized soils that can have role in producing the associated carbonic acids to reduce the soil pH and creating suitable environment for optimum crop production. This was also inline with the report of the USEPA (1997) from the experience of Colombian flower farm.

The OM content of these soils, however, will decline continuously and finally be exhausted at year five and four for non-sterilized and sterilized soils, respectively. This was also reflected in reducing the dry matter production of wheat (*Equation 1 and 2*). The non-sterilized soils contains organism that could contribute to OM content, but their effect will not be sustained as they are continuously challenged by effluent and the soil reaction rises hindering their roles.

$SOM\ (NS) = -0.0015X-0.46Y+2.55$ *Equation 5*

$SOM\ (S) = -0.002X-0.42Y+2.24$ *Equation 6*

The CEC of the soil was found to be increasing across the year and volume of effluents.

$CEC (NS) = 0.015X+1.35Y+17.41$ Equation 7

$CEC (S) = 0.075X+2.70Y+16.62$ Equation 8

Floriculture industry is blamed for its negative impact on environment, especially changing the soil environment whereby the discharge without being treated was largely responsible for it. The contribution of exchangeable sodium was taken as an additional parameter to verify this. Hence, the prediction shows that it will not reach 15.0 but the accumulation of soluble salts continues to be increasing and changes the neutral soils to saline soils within five years.

$ESP (NS) = 0.08X+0.29Y+1.95$ Equation 9

$ESP (ZS) = 0.07X+0.54Y+2.53$ Equation 10

Table 1 Chemical composition of floriculture effluents at Debre Zeit

Sample	pH	EC	N	S	P	Basic cations				Micro-nutrients			
Source		(μscm^{-1}))	($mg L^{-1}$)			($mg L^{-1}$)				($mg L^{-1}$)			
						K	**Ca**	**Mg**	**Na**	Fe	Zn	Cu	Mn
Debre Zeit	8.06	1036	33	12.28	14.5	81.1	8.92	21.8	47.3	0.47	0.12	0.08	0.27
S'_1*	8.15	712	32	12.20	14.2	19.3	3.27	15.2	45.4	0.09	0.37	0.99	1.50
S'_2*	8.14	716	31	11.90	13.9	20.4	3.33	15.3	47.7	0.12	0.41	0.02	1.05
Water (H_2O)	6.88	500	5	0.84	1.6	6.9	1.44	12.6	25.5	0.05	0.04	0.02	0.47

** S'_1 and S'_2 are effluents passing through for the first and second time with the red ash.*

$1 ds\ m^{-1} = 1000\ \mu S\ cm^{-1}$

The concentration of Mo, Ni, Cd and Cr were found to be lower than $0.002 mg\ L^{-1}$

Table 2 Soil physical properties as affected by increasing volume of effluent on Vertisols at Debre Zeit

	Non-sterilized soil						Sterilized Soil					
Treatment (ml Pot^{-1})	Texture (%)			WHC (%w/w)			Texture (%)			WHC (% w/w)		
	Sand	Silt	Clay	FC	PWP	WHC	Sand	Silt	Clay	FC	PWP	WHC
Before 1st	10	40	50	24.93	13.62	11.30	11	40	49	24.71	13.66	11.04
After the first harvest												
0.0	10	39	51	24.90	13.55	11.35	11	40	49	24.70	13.65	11.04
15.0	10	40	50	24.87	13.54	11.33	11	40	49	24.68	13.64	11.04
30.0	10	40	50	24.85	13.53	11.33	12	41	48	24.55	13.62	10.93
45.0	10	40	50	24.79	13.50	11.29	12	41	48	24.50	13.53	10.97
60.0	11	40	49	24.60	13.50	11.10	12	41	47	24.20	13.51	10.70
75.0	11	40	49	24.50	13.48	11.02	12	41	47	24.10	13.49	10.60
90.0	11	41	48	24.41	13.46	10.95	13	41	46	24.00	13.46	10.54
Before 2nd	10	40	50	24.64	13.56	11.07	11	40	49	24.64	13.65	10.99
After the second harvest												
0.0	10	39	51	24.64	13.54	11.10	12	38	50	24.63	13.63	11.00
15.0	11	39	50	24.61	13.53	11.08	12	38	50	24.60	13.62	10.98
30.0	12	34	54	24.56	13.52	11.05	12	38	50	24.50	13.59	10.91
45.0	12	36	52	24.53	13.49	11.04	12	38	50	24.20	13.52	10.69
60.0	13	38	49	24.41	13.46	10.95	14	34	52	24.10	13.49	10.60
75.0	14	38	48	24.35	13.46	10.89	14	36	50	24.00	13.48	10.52
90.0	14	38	48	24.30	13.44	10.85	16	32	52	23.90	13.44	10.46

Table 3 Soil PH and EC as affected by increasing volume of effluents

Effluents (ml pot^{-1})	Non-sterilized soils				Sterilized Soil			
	PH		EC		PH		EC	
	1*	2	1	2	1	2	1	2
0	7.07^{e}	7.10^{e}	72.16^{g}	79.99g	7.20^{f}	7.24^{e}	88.88^{g}	91.71^{g}
15.0	7.11^{d}	7.20^{d}	94.98^{f}	99.7f	7.29^{e}	7.37^{d}	114.83^{f}	119.45^{f}
30.0	7.12^{dc}	7.28^{dc}	111.93^{e}	117.83^{e}	7.34d^{e}	7.48^{d}	131.81^{e}	137.71^{e}
45.0	7.15^{c}	7.33^{c}	129.32^{d}	135.43^{d}	7.38d^{c}	7.55^{c}	151.62^{d}	157.73^{d}
60.0	7.19^{b}	7.39^{b}	138.78^{c}	147.77^{c}	7.42b^{c}	7.64^{b}	164.57^{c}	173.56^{c}
75.0	7.25^{b}	7.48^{ba}	146.20^{b}	156.25^{b}	7.49^{b}	7.79^{a}	175.82^{b}	185.87^{b}
90.0	7.32^{a}	7.60^{a}	152.63^{a}	167.54^{a}	7.54^{a}	7.86^{a}	182.40^{a}	197.31^{a}
LSD (5%)	0.01	0.10	6.40	3.14	0.04	0.05	6.58	3.37
CV (%)	0.46	0.72	0.44	1.17	0.37	0.40	0.49	1.16

Table 4 Soil OC and TN as affected by increasing volume of effluents

Effluents (ml pot^{-1})	Non-sterilized soils				Sterilized Soil			
	OC		TN		OC		TN	
	1*	2	1	2	1	2	1	2
0	0.89^{d}	0.670^{d}	0.0563^{c}	0.037^{bc}	0.98^{b}	0.66^{d}	0.0510^{ab}	0.032^{a}
15.0	1.01^{c}	0.739^{b}	0.060^{b}	0.038^{b}	1.11^{b}	0.70^{b}	0.0520^{ab}	0.032^{a}
30.0	1.15^{b}	0.802^{a}	0.065^{ab}	0.040^{a}	1.17^{a}	0.767^{a}	0.0530^{a}	0.034^{a}
45.0	1.28^{a}	0.812^{a}	0.070^{a}	0.041^{a}	1.13^{b}	0.683^{b}	0.0520^{ab}	0.032^{a}
60.0	1.25^{a}	0.753^{b}	0.0725^{a}	0.040^{a}	1.10^{b}	0.599^{c}	0.0450^{b}	0.030^{ab}
75.0	1.16^{b}	0.691^{c}	0.068^{ab}	0.036^{bc}	0.93^{b}	0.480^{e}	0.0420^{c}	0.028^{b}
90.0	1.06^{c}	0.610^{e}	0.065^{ab}	0.033^{c}	0.82^{c}	0.461^{f}	0.0400^{d}	0.027^{c}
LSD (5%)	0.080	0.012	0.004	0.005	0.035	0.014	0.001	0.0044
CV (%)	5.35	9.40	10.7	11.38	9.33	12.77	7.43	11.42

* 1 and 2 shows the 1st and 2nd harvest

Table 5 Exchangeable bases as affected by increasing volume of effluents

Effluents (ml pot^{-1})	Non-sterilized soils								Sterilized soils							
	K		Ca		Mg		Na		K		Ca		Mg		Na	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0	1.36^{d}	1.31^{d}	20.076^{d}	19.98^{e}	4.69^{e}	5.69	0.66^{e}	0.71^{e}	1.40^{f}	1.33^{f}	22.63^{f}	22.54^{d}	4.80^{e}	5.80^{d}	0.85^{e}	0.90^{e}
15.0	1.41^{c}	1.64^{d}	20.96^{c}	22.29^{d}	4.82^{de}	5.93	0.70^{d}	1.11^{e}	1.46^{e}	1.69^{d}	30.54^{e}	31.98^{cd}	5.03^{e}	6.18^{b}	1.13^{d}	1.88^{de}
30.0	1.46^{c}	1.72^{b}	22.28^{c}	22.61^{d}	4.92^{d}	6.03	0.78^{bc}	1.25^{de}	1.53^{d}	1.79^{de}	30.03^{d}	32.47^{cd}	5.19^{cde}	6.34^{b}	1.18^{c}	2.33^{de}
45.0	1.51^{bc}	1.94^{a}	22.30^{bc}	29.63^{c}	5.01^{cd}	6.12	0.81^{bc}	1.46^{cd}	1.59^{c}	2.02^{c}	31.66^{c}	33.10^{c}	5.51^{b}	6.66^{a}	1.25^{bc}	2.96^{c}
60.0	1.52^{b}	1.97^{a}	23.86^{abc}	30.19^{bc}	5.19^{c}	6.30	0.83^{bc}	1.68^{c}	1.63^{c}	2.08^{c}	32.29^{c}	33.73^{c}	5.75^{ab}	6.90^{a}	1.28^{abc}	3.43^{bc}
75.0	1.56^{a}	2.34^{a}	24.67^{ab}	32.00^{b}	5.25^{c}	6.36	0.86^{bc}	1.98^{c}	1.70^{b}	2.48^{a}	34.43^{b}	35.87^{a}	5.84^{ab}	6.99^{a}	1.50^{ab}	3.96^{bc}
90.0	1.57^{a}	2.44^{a}	24.75^{a}	32.08^{a}	5.46^{a}	6.57	0.91^{a}	2.26^{a}	1.75^{a}	2.62^{a}	35.49^{a}	36.93^{a}	6.09^{a}	7.24^{a}	1.69^{a}	4.34^{a}
LSD (5%)	0.039	0.34	0.81	1.23	0.10	NS	0.04	1.09	0.04	0.31	0.51	2.92	0.09	0.24	0.03	0.61
CV (%)	10.0	6.37	4.8	1.99	3.44	7.12	3.0	10.9	10.5	5.68	1.09	4.44	4.13	4.34	2.80	11.75

Table 6 Micronutrients as affected by increasing volume of effluents

Effluents (ml pot^{-1})	Non-sterilized soils								Sterilized soils							
	Cu		Fe		Mn		Zn		Cu		Fe		Mn		Zn	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0	0.51^{b}	0.54^{g}	4.39^{e}	4.62^{f}	2.07^{e}	3.22^{g}	0.52^{g}	0.59^{f}	0.54^{e}	0.67^{e}	4.79^{d}	5.03^{f}	3.69^{d}	3.80^{e}	0.78^{d}	1.09^{e}
15.0	0.52^{a}	0.58^{f}	4.59^{d}	4.74^{e}	3.37^{d}	3.35^{f}	0.59^{f}	0.89^{e}	0.56^{d}	0.85^{e}	4.86^{d}	5.35^{e}	3.89^{c}	5.40^{de}	1.34^{bc}	1.19^{d}
30.0	0.53^{a}	0.65^{e}	4.64^{cd}	4.82^{d}	3.43^{cd}	3.90^{e}	0.79^{e}	1.37^{d}	0.58^{cd}	0.92^{d}	5.05^{c}	5.42^{d}	3.94^{c}	5.52^{cd}	1.39^{bc}	2.19^{c}
45.0	0.56^{a}	0.68^{d}	5.11^{bc}	5.17^{bc}	3.54^{cd}	4.13^{d}	1.12^{d}	1.88^{d}	0.59^{ab}	0.98^{c}	5.13^{bc}	5.51^{c}	4.21^{b}	5.65^{c}	1.42^{c}	2.35^{c}
60.0	0.58^{a}	0.75^{c}	5.14^{b}	5.21^{c}	3.92^{bc}	4.26^{c}	1.60^{c}	2.29^{c}	0.60^{a}	1.03^{b}	5.34^{a}	5.59^{b}	4.41^{a}	6.07^{bc}	1.89^{b}	2.44^{b}
75.0	0.58^{a}	0.85^{b}	5.09^{b}	5.30^{b}	4.31^{b}	4.34^{b}	1.99^{b}	2.58^{b}	0.59^{a}	1.06^{a}	5.36^{a}	5.63^{b}	4.44^{a}	6.48^{b}	1.90^{a}	2.60^{b}
90.0	0.59^{a}	0.92^{a}	5.16^{a}	5.35^{a}	4.39^{a}	4.48^{a}	2.13^{a}	2.97^{a}	0.61^{a}	1.10^{a}	5.49^{a}	5.85^{a}	4.46^{a}	7.08^{a}	1.92^{a}	2.71^{a}
LSD (5%)	0.01	0.01	0.05	0.02	0.11	0.06	0.07	0.53	0.01	0.02	0.17	0.03	0.173	0.108	0.96	0.39
CV (%)	10.0	2.14	5.34	1.79	5.77	1.11	4.24	2.71	10.6	4.45	5.53	3.94	1.60	2.03	2.90	2.58

Table 7 Mean comparison of shoot dry weight at Debre Zeit for 1st harvest

Effluents (ml pot^{-1})	Dry Weight (g pot^{-1})		Gain Or Loss (g pot^{-1})			
	Non-sterilized Soil	Sterilized Soil	Non-sterilized Soil		Sterilized Soil	
			Gain	Loss	Gain	Loss
0.0	6.45^{b}	8.56^{a}				
15.0	6.83^{a}	8.34^{a}	0.38			-0.22
30.0	6.85^{a}	7.73^{b}	0.40			-0.83
45.0	6.78^{a}	6.58^{c}	0.33			-1.98
60.0	4.32^{c}	5.73^{d}		-0.33		-2.83
75.0	4.20^{d}	5.34^{e}		-1.83		-3.22
90.0	4.09^{e}	4.36^{f}		-2.32		-4.20
LSD	0.118	0.24				
CV (%)	1.35	1.64				

**Means within a column followed by different letters are significantly different at $P \leq 0.05$.*

Table 8 Mean comparison of shoot dry weight at Debre Zeit for 2nd harvest

Effluents (ml pot^{-1})	Dry Weight (g pot^{-1})		Gain Or Loss (g pot^{-1})			
	Non-sterilized Soil	Sterilized Soil	Non-sterilized Soil		Sterilized Soil	
			Gain	Loss	Gain	Loss
0.00	4.89^{b}	6.75^{a}				
15.0	4.99^{a}	5.12^{b}	0.10			-1.63
30.0	4.37^{bc}	4.68^{c}		-0.52		-2.07
45.0	3.84^{c}	4.34^{c}		-1.05		-2.41
60.0	3.51^{d}	3.78^{d}		-1.38		-2.97
75.0	3.26^{de}	3.67^{de}		-1.63		-3.08
90.0	3.02^{e}	3.34^{e}		-1.87		-3.41
LSD	0.53	0.027				
CV (%)	5.75	3.63				

**Means within a column followed by different letters are significantly different at $P \leq 0.05$.*

Summary and Conclusions

The results obtained from this study showed that most of the soil chemical properties were significantly influenced by floriculture effluent application. The soil pH was markedly increased for the first and second harvests both in non sterilized and sterilized soils. The OC and TN contents increased with increasing application of effluents, but declined at higher doses. The soil pH, EC, exchangeable bases and micronutrients concentrations also increased with increasing volume of effluent applications. Consequently, the neutral soil of Debre Zeit was changed to saline soil. Generally, it was found out that the presence of organisms in the non-sterilized soil buffer the impact of the incoming effluent and sustained the conditions of non-sterilized soils better than that of sterilized soils. Furthermore, the findings study also proved that the effluents discharged from the floriculture industry at Debre Zeit have potential to degrade soil quality parameters and reduce the performance of wheat. Therefore, waste water management and treatment is recommended to reduce the impact of effluents on soil quality.

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