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Modeling the influence of floriculture effluent on soil quality and dry matter yield of wheat on Fluvisols at Ziway

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Abstract

Greenhouse experiments were conducted at DZARC on soil sampled from farmers' field to examine the influence of floriculture effluent on soil quality and crop performance, and to see the most likely trends. The sample was splitted into two; the first remained to be as it is while the second was subjected to sterilization and call it non-sterilized (NS) and sterilized (S) soil, respectively. Seven rates of effluent was used as a treatment and laid out in CRD with four replications. The effluent was found to have high pH, EC, N, P, S, exchangeable bases, low in micronutrients and very low in heavy metals. The shoot dry weight was reduced by 36.9 and 58.8 % for NS and S soils respectively in the first harvest. The second round experiment further confirmed that it keeps decreasing due to effluent additions. However, at lower volumes, the non-sterilized soil showed benefit from the effluent and hence the value started to increase but later it followed the same trends with application of higher volumes. Chemical properties were highly influenced by effluent additions. The pH and EC continuously increased whereas OC and TN increased to some extent but decreased as the volume of effluent increased. Exchangeable bases and micro-nutrients were continuously increased. The trends indicated that dry weight on Fluvisols will decline corresponding to the decrease in soil organic matter while pH, CEC and ESP continuously increases ending in the shift of slight alkaline soil to sodic soil. Generally, the effluent was found to disturb the performance of the crop and soil quality parameters. Disturbance in terms of shoot dry weight and soil quality parameters revealed that it was much less for the NS owing to the presence of organism.

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

Introduction

Environmental problems have been increased over the last few decades through increasing usage of chemicals with poor treatments largely responsible for the gross pollution. Lado et al., (2005) from Israel, 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 and Floriculture effluents Malefia (2009) and Mulugeta (2009) from Ethiopia similarly reported its impact on the environment.

The majority of industries are water based and a considerable volume of wastewater is discharged to the environment either treated or inadequately treated leading to the problem of surface and ground water pollution. An example of this can be found in tannery, pharmaceutical, pulp and paper mill effluents which have been reported by Babyshakilla (2009); Osaigbovo et al. (2006) and Kannan and Oblisami (1990). Recently, one of the issues that attract 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 Nigeria, industries are determined by various criteria, some of which are environmentally unacceptable; thereby posing serious threat to the environment (Adebisi and Fayemiwo, 2010). Similar trends were and still are observed in developing countries like Ethiopia; textile and steel industry around Addis Ababa, and tannery and flower industries at Ziway are some of the example to be mentioned.

Despite the economic and employment importance of floriculture industry in Ethiopia, it has been blamed for using too much chemicals, which damage the environment (http://news.bbc.co.uk/2/hi/africa/5016834.stml). According to the MoARD, Crop Protection Department's Quarantine Office; as cited by Sisay (2007) it uses more than 300 chemicals as pesticides and growth regulators. Thus, its discharge found to kill useful organisms and disturb biodiversity (http://ucanr.org/freepubs/docs/8221.pdf, and http://www.nrcs.usda.gov). It is also known for using large volume of water resulted in shrinking of surface and underground water. For instance, Greenwood Flower Plc in Hawassa uses 80,000 liters per day; indicating utilization of 2.4 million liters water in month (Tatek, 2010, personal communication and discussion). Companies such as Rose Ethiopia and Garad Flowers are some examples causing shrinkage of water (Negusu, 2006; Trade and Industry Minister, 2006).

Wastewaters are used by farmers for irrigation in many regions around the globe where freshwater is scarce and agricultural land is located near cities (Buechler and Devi, 2005). There is an association between its quality and the soil after and during irrigation. The quality of effluent varies depending on the type of industry and their mode of treatment before expelling to water bodies. For any agricultural purposes, therefore, the influence should be seen from the point of soil texture, soil structure, current nutrient status, cation exchange capacity-nutrient storage, and exchangeable sodium percentage (ESP). Accordingly, if the effluent having a pH of different or far from 7 and EC > 1 dS m-1 (1000 uS cm-1) should be investigated further (Patterson, 1999).The absence of detailed studies o floriculture effluent on soil quality and crop performance initiated this study with the objectives of addressing its impact on soil quality and tries to indicate the most likely trends in changes.

Material and Methods

Ziway is located 160 km south east of Addis Ababa at geographical coordinates between 07056'20''N and 38042'58'' E. It has an altitude of 1636 m.a.s.l. The mean annual rainfall is estimated to be 600 mm and characterized by semi-arid climate (NMA, 2007). The dominant landform is flat lacustrine terrace with Andi-Eutric Fluvisols and gently undulating terrace with Mollic and Eutric Fluvisols (Malefia, 2009).

Fifty four geo-referenced surface samples were collected from the nearby farmer's field, where there was unlikely influence of effluent and a composite sample was made. Part of it was grounded and passed through 2mm sieve and used for determination of physico-chemical properties prior to sowing. The remaining 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 1900C for 4 hours to kill the soil organisms. Then, fifty six polyethylene pots having a height of 30 and a diameter of 19.10 cm were filled with 3 kg of the sample.

Hundred liters was sampled from the temporary storage 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 characterization before application, while the rest was used as treatment (0, 30.0, 60.0, 90.0, 120.0, 150.0 and 180.0 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 650C 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. 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 by using a Model 4310 Conductivity meter (1:5). Organic carbon was determined using Walkley-Black oxidation method (Allison, 1965), total nitrogen by the micro-Kjeldahl digestion, distillation and titration method, and available P using the standard Olsen extraction method (Olsen et al., 1954). Total exchangeable bases were determined after leaching the soils with NH4OAC (Reeuwijk, 2002). Amounts of K+, Na+, Ca2+ and Mg2+ in the leachate were analyzed by AAS. Cation exchange capacity was determined at soil pH level of 7 after displacement by using 1N NH4OAC, 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 indicated that the reaction and EC were increased by 13.04, and 109.87 % as compared to the water sample. Besides, N, P and S values falls in the range of mid to high classes (FAO, 2008). It was found to contain high concentration of Na (48.5), and then followed by K (47.6), Mg (19.1) and Ca (7.38 mg L-1). The highest concentration of Na can interfere with soil properties and hence on crop performance (Lado et.al., 2005). On the contrary the concentrations of all micronutrients were found to be very low (Table 1). This entails that the industry has been using intensive chemicals (Mulugeta, 2009; Osibaizo and Adie, 2007). It would cause nutrient imbalances and thereby affecting physico-chemical properties of the soil (Adebisi and Fayemiwo, 2010; Babyshakilla 2009; Lado et al., 2005).

The SAR indicates moderately safe category of Sodicity (FAO, 2008) but the concentration of Na is high enough to cause sodicity if the application continues for some time (Lado et al., 2005).

Table 1 Chemical composition of floriculture effluents at Ziway

Sample Source	pH	EC (μscm^{-1})	N	S ($mg\ L^{-1}$)	P	Basic Cations ($mg\ L^{-1}$)				Micro-Nutrients ($mg\ L^{-1}$)			
						K	Ca	Mg	Na	Fe	Zn	Cu	Mn
Ziway	8.58	1148	30	12.25	14.8	47.6	7.38	19.1	48.5	0.21	0.06	0.38	1.09
S'$_1$*	8.15	712	32	12.2	14.2	19.3	3.27	15.2	45.4	0.09	0.37	0.99	1.50
S'$_2$*	8.14	716	31	11.9	13.9	20.4	3.33	15.3	47.7	0.12	0.41	0.02	1.05
Z (H_2O)	7.59	547	7	1.02	1.9	5.95	1.28	11.4	28.4	0.03	0.02	0.38	1.12

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

1ds m^{-1}=1000 μscm^{-1}

** The concentrations of Mo and B were about 0.003, whereas Pb, Ni, Cd and Cr were found to be less than 0.0002 mgl^{-1}.*

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 8.00 to 8.50 for non-sterilized whereas a relatively higher value of 8.68 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 0.29 and 0.30 units for non-sterilized and sterilized soils, respectively at the highest application rate of effluents. Similarly, the EC increased from 222.35 to 238.26 and from 261.70 to 276.61 for the respective soils (Table 2). This is in agreement with the findings of Osibaizo and Adie (2007) who independently reported similar changes in the chemical properties of the soil after being supplied with effluents.

OC and TN contents decreased at higher volume of effluents and with successive harvests (Table 3). 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 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 4). Similar findings have been reported earlier by Adebisi and Fayemiwo (2010); Babyshakilla (2009); Osibaizo and Adie (2007); Voegbolo and Abdulkabir (2006). However, high nutrient content in the effluent did not influence growth of wheat (Table 6 and 7). Previous findings by Osaigbovo et al. (2006) proved that pharmaceutical effluent enhanced soil chemical properties but not reflected in maize yields. Increased in Na may lead to Na toxicity in plants (Mohammed et. al., 2010). According to a research findings by Babyshakilla (2009) and Orhue et al. (2005) high concentration of Na, K, N, Ca and metals like Cr, Fe, Zn, Cu were found high in contaminated soil than the control.

Table 2 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	8.02^{e}	8.05^{e}	122.08^{g}	121.91^{g}	8.14^{e}	8.20^{e}	125.15^{g}	127.98^{g}
30.0	8.12^{d}	8.28^{d}	133.175^{f}	137.8^{f}	8.21^{d}	8.34^{d}	144.65^{f}	149.27^{f}
60.0	8.25^{c}	8.42^{dc}	152.9^{e}	158.8^{e}	8.35^{c}	8.49^{d}	165.70^{e}	171.60^{e}
90.0	8.38^{b}	8.58^{c}	174.73^{d}	180.79^{d}	8.49^{b}	8.67^{c}	187.75^{d}	193.86^{d}
120.0	8.42^{ba}	8.73^{ba}	190.08^{c}	199.07^{c}	8.56^{a}	8.83^{b}	203.31^{c}	212.30^{c}
150.0	8.47^{a}	8.77^{ba}	214.35^{b}	224.35^{b}	8.62^{a}	8.92^{a}	229.8^{b}	239.85^{b}
180.0	8.50^{a}	8.79^{a}	222.35^{a}	238.26^{a}	8.68^{a}	8.98^{a}	261.7^{a}	276.61^{a}
LSD (5%)	0.04	0.09	8.14	4.18	0.08	0.095	3.37	4.37
CV (%)	0.72	0.72	1.17	1.17	0.40	0.40	1.16	1.16

Table 3 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	0.773^{d}	0.731^{d}	0.045^{d}	0.037^{bc}	0.751^{e}	0.611^{abc}	0.040^{a}	0.025^{a}
30.0	0.907^{c}	0.769^{ba}	0.049^{bc}	0.039^{a}	0.899^{b}	0.699^{a}	0.039^{ab}	0.026^{a}
60.0	1.099^{a}	0.793^{a}	0.057^{a}	0.041^{a}	1.004^{a}	0.688^{a}	0.041^{a}	0.027^{a}
90.0	1.025^{b}	0.750^{b}	0.056^{a}	0.039^{a}	0.97^{a}	0.615^{ab}	0.042^{a}	0.023^{a}
120.0	0.97^{ab}	0.710^{abc}	0.052^{b}	0.038^{b}	0.939^{b}	0.593^{abc}	0.041^{a}	0.022^{ab}
150.0	0.89^{bc}	0.650^{bc}	0.048^{c}	0.033^{bc}	0.901^{c}	0.379^{bc}	0.035^{b}	0.012^{b}
180.0	0.73^{d}	0.610^{dc}	0.040^{e}	0.031^{c}	0.866^{d}	0.297^{c}	0.030^{c}	0.010^{c}
LSD (5%)	0.055	0.22	0.001	0.006	0.031	0.18	0.0014	0.005
CV (%)	9.40	9.40	11.38	11.38	12.77	12.77	11.42	11.42

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

Table 4 Exchangeable bases as affected by increasing volume of effluents

Effluents	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	2.55^{b}	2.72^{b}	21.18^{e}	23.98e	2.21	2.95	1.07^{d}	0.98^{c}	2.70^{b}	2.74^{b}	22.06^{c}	22.17^{d}	2.32^{b}	3.15^{b}	1.29^{c}	1.02^{f}
30.0	2.65^{b}	2.79^{b}	21.57^{d}	21.47^{d}	2.32	3.25	1.16^{c}	1.33^{c}	2.85^{b}	2.88^{b}	22.69^{b}	22.76^{d}	2.46^{b}	3.58^{b}	1.33^{bc}	1.78^{e}
60.0	2.73^{a}	2.87^{b}	21.89^{d}	23.13^{d}	2.42	3.34	1.27^{b}	1.52^{c}	2.96^{ba}	3.06^{ba}	23.34^{ab}	25.02^{c}	2.57^{ab}	3.75^{b}	1.38^{bc}	2.01^{d}
90.0	2.73^{a}	3.09^{a}	23.59^{c}	24.69^{c}	2.55	3.45	1.31^{ab}	1.71^{c}	2.97^{ba}	3.34^{ba}	25.21^{a}	27.45^{c}	2.72^{ab}	3.95^{b}	1.42^{ba}	2.77^{c}
120.0	2.76^{a}	3.12^{a}	24.22^{bc}	24.94^{bc}	2.58	3.68	1.33^{a}	2.11b	3.08^{a}	3.42^{a}	26.94^{ab}	27.77^{c}	2.75^{ab}	4.21^{b}	1.48^{ba}	3.97^{b}
150.0	2.79^{a}	3.49^{a}	24.35^{b}	25.22^{b}	2.67	3.83	1.35^{a}	2.31^{a}	3.13^{a}	3.88^{a}	27.21^{ab}	29.34^{b}	2.85^{b}	4.31^{b}	1.51^{ba}	4.28^{b}
180.0	2.90^{a}	3.59^{a}	25.48^{a}	26.26^{a}	2.95	3.92	1.34^{a}	2.51^{a}	3.31^{a}	3.99^{a}	28.52^{a}	34.05^{a}	3.15^{a}	4.87^{a}	1.56^{a}	5.03^{a}
LSD(5%)	0.34	0.34	1.03	1.31	NS	NS	0.02	1.22	0.18	0.53	0.630	2.92	0.25	0.33	0.06	0.61
CV (%)	6.37	6.37	1.99	1.99	7.12	7.12	10.9	10.9	5.68	5.68	4.44	4.44	4.34	4.34	11.75	11.75

Table 5 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	0.22^{g}	4.51^{g}	0.32^{f}	0.29^{f}	3.21^{g}	0.35g	0.86^{e}	0.93^{f}	0.27^{d}	4.69^{e}	0.37^{d}	0.30^{f}	3.25^{e}	0.42^{e}	0.92^{e}	2.24e
30.0	0.24^{f}	5.71^{f}	0.36^{e}	0.31^{e}	3.30^{f}	0.37^{f}	1.78^{d}	2.85^{e}	0.32^{d}	6.97^{e}	0.44c^{d}	0.35^{e}	3.37^{de}	0.47^{de}	2.84^{d}	3.56^{d}
60.0	0.29^{e}	6.02^{e}	0.40^{d}	0.33^{d}	3.39^{e}	0.42^{e}	2.39^{c}	3.46^{d}	0.38^{c}	7.31^{d}	0.49^{c}	0.42^{d}	3.45^{cd}	0.53^{cd}	3.45^{c}	4.29^{c}
90.0	0.30^{d}	6.77^{d}	0.42^{d}	0.35^{dc}	3.42^{d}	0.43^{d}	2.70^{c}	3.77^{d}	0.44^{b}	9.85^{c}	0.56^{c}	0.48^{c}	3.57^{c}	0.59^{c}	3.76^{c}	4.64^{c}
120.0	0.34^{c}	8.01^{c}	0.45^{c}	0.40^{c}	3.50^{c}	0.44^{c}	3.49^{b}	4.56^{c}	0.48^{b}	13.47^{b}	0.59^{bc}	0.53^{b}	3.75^{bc}	0.64^{bc}	4.55^{b}	5.82^{b}
150.0	0.38^{b}	8.28^{b}	0.49^{b}	0.41^{b}	3.55^{b}	0.46^{b}	3.57^{b}	4.64^{b}	0.44^{b}	14.21^{a}	0.65^{b}	0.58^{b}	3.84^{b}	0.69^{b}	4.63^{b}	6.52^{b}
180.0	0.40^{a}	8.69^{a}	0.52^{a}	0.44^{a}	3.73^{a}	0.49^{a}	4.57^{a}	6.54^{a}	0.60^{a}	15.26^{a}	0.72^{a}	0.65^{a}	4.02^{a}	0.78^{a}	6.53^{a}	8.52^{a}
LSD (5%)	0.011	0.011	0.02	0.015	0.03	0.06	0.53	0.53	0.05	0.02	0.08	0.03	0.11	0.108	0.39	0.39
CV (%)	2.14	2.14	1.79	1.79	1.11	1.11	2.71	2.71	4.45	4.45	3.94	3.94	2.03	2.03	2.58	2.58

Shoot Dry Weight

Shoot dry weight of wheat showed a declining trend with increasing volume of the effluents, though significant increments were recorded until application of 60.0 and 30.0 mL effluents during the first and second harvests, respectively in non sterilized soils as compared to control (Table 6 and 7). This might be due to the presence of soil organisms in non-sterilized soil that have a positive effect at lower volume of effluents. Accordingly, the effluent disposed from this industry could produce an increasing shoot dry weight over the control at lower volumes, till the 60.0 mL and 30.0 mL during the first and second harvest, respectively. The highest dry weight (6.03 g pot-1) obtained from application of 60.0 mL effluent in non-sterilized soil was reduced to 5.68 g pot-1 with 30.0 mL during the second harvest due to the accumulation of soluble salts and thereby increased osmotic stress (Table 6 and 7). This is in a harmony with the study made by Mohammed et al., 2010; Babyshakilla 2009; Osaigbovo et al., 2006; that the effluent can be used for effective plant growth at a lower volume. Thus, the effluent could be tolerated and produce an increasing shoot dry weight over the control till the 60.0 and 30.0 mL get into the soils system. Then, the shoot dry weight started to decline gradually as the salt accumulation increases osmotic stress, simulating the negative climatic water balance.

Table 6 Mean comparison of shoot dry weight at Ziway for 1st harvest (August-November, 2010)

Effluents ($ml\ pot^{-1}$)	Dry Weight ($g\ pot^{-1}$)		Advantage Or Loss ($g\ pot^{-1}$)			
	Non-sterilized Soil	Sterilized Soil	Non-sterilized Soil		Sterilized Soil	
			Gain	Loss	Gain	Loss
0	5.53b	7.35a				
30.0	6.12a	6.96a	0.59			-0.39
60.0	6.03a	6.48a	0.50			-0.87
90.0	5.47c	4.43b		-0.06		-2.92
120.0	3.84d	3.45bc		-1.69		-3.90
150.0	3.58d			-1.95		-4.10
		3.25c				
180.0	3.49d	3.03c		-2.04		-4.32
LSD	0.39	0.89				
CV (%)	3.59	7.78				

* Means within a column followed by different letters are significantly different at P ≤ 0.05.

Table 7 Mean comparison of shoot dry weight at Ziway for 2nd harvest (November 2010- February 2011)

Effluents ($ml\ pot^{-1}$)	Dry Weight ($g\ pot^{-1}$)		Advantage Or Loss ($g\ pot^{-1}$)			
	Non-sterilized Soil	Sterilized Soil	Non-sterilized Soil		Sterilized Soil	
			Gain	Loss	Gain	Loss
0	5.34b	5.88a				
30.0	5.68a	5.16b	0.34			-0.72
60.0	5.37b	4.69c	0.03			-1.19
90.0	4.27c	3.28d		-1.07		-2.6
120.0	3.28d	3.16d		-2.06		-2.72
150.0	2.73e	2.73e		-2.61		-3.15
180.0	2.33f	2.28f		-3.01		-3.6
LSD	0.28	0.29				
CV (%)	2.93	3.23				

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

Modelling 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 productions

The shoot dry weight production potential of wheat was influenced by the application of floriculture effluents. These trends are summarized in the following multiple regression models indicating decreasing shoot dry weight of wheat with increasing volume of effluents and years.

SDM (NS) = -0.018X-1.0594Y+6.96 *Equation 1*

SDM (S) = -0.024X-1.095Y+7.28 *Equation 2*

Where SDW= shoot dry weight

NS= non-sterilized soil

S= sterilized soil

It will be exhausted after five years at application of 150.0 mL pot-1 for the non-sterilized soils while the same would happen before year four but shifted to 120.0 mL for the sterilized soils (Equation 1 and 2). This shows that sterilization kills organisms that would play a vital role in the bio-chemical reaction with the effluents, whereas reduction will be somewhat stabilized with the presence of organisms.

Soil characteristics

Since the changes in micro-nutrients concentrations were low to medium, the soil pH, OM, CEC and ESP were used for developing a regression model. These parameters would also help to predict other properties, such as nutrient status, base saturation, AS and ESP.

pH (NS) = 0.0021X+0.27Y+7.96 *Equation 3*

pH (S) = 0.0023X+0.25Y+8.02 *Equation 4*

Generally, the finding has shown that for the first two years; the soil reaction of the non-sterilized soil was less than that of the sterilized soil. Then after, the values approach that of the sterilized soils. This might have been due to the loss of organic matter and organisms in the non-sterilized soils that can have a role in producing the associated carbonic acids to reduce the soil pH and creating suitable environment for optimum crop production. This was also witnessed by the report of the US-EPA (1999) from the experience of Colombian flower farm.

SOM (NS) = -0.0009X-0.56Y+2.36 *Equation 5*

SOM (S) = -0.001X-0.64Y+2.35 *Equation 6*

Similar to SDW, the OM content of the soils was reduced within and across the year as the volume of effluents was changed at Ziway. The OM contents of the soils will decline and finally exhaust at year four and three for Ziway, in non-sterilized and sterilized soils, respectively (Equation 5 and 6). This was also reflected in reducing the dry matter production of the test crop (Equation 1 and 2) and total nitrogen (Table 3). The non-sterilized soils contained organism that could contribute to OM content, but these values could not help them to sustain it as they are continuously being challenged with effluent and the soil reaction goes up to hinder their roles.

Like to soil reaction, the CEC of the soil was found to be increasing across the year and volume of effluents. This would entail an advantage for non-saline as well as non-sodic soils. The highest CEC values within the range of crop performance were attained by 160.0 (28.78) and 120.0 (28.87) ml of effluent application in four years for the non-sterilized and sterilized soils (Equation 7 and 8).

CEC (NS) = 0.05X+1.90Y+13.51 *Equation 7*

CEC (S) = 0.033X+6.29Y+11.66 *Equation 8*

Increasing CEC of the soil is of an advantage for the non-saline and non-soidic soils (FAO, 2008). Floriculture industry was blamed for environmental problems, especially changing the soil environment whereby the discharges without being treated were largely responsible for the change. The contribution of exchangeable sodium was taken as additional parameter to verify its impact. Similar to the rest of soil parameters, stepwise multiple regression models were developed for ESP using the soil data. The predicted values of ESP will reach 15 at application of 190.0 mL effluent at year five for both NS and S soils of Ziway (Table 19).

ESP (NS) = 0.06+0.04X+3.53 *Equation 9*

ESP (S) = 0.04+0.03X+7.48 *Equation 10*

Summary and Conclusions

Potential benefits and harm of effluent on biological, chemical and physical properties of soils and crop performance have been tested in many parts of the world, whereas knowledge pertaining to their benefits and harmful effects is very scant in Ethiopia. Therefore, this study was initiated to investigate the influence of floriculture effluents on the soil quality and crop performance. It was carried out on effluents and soil samples collected from Ziway. In order to see the existence of organisms, two separate set of experiments were run on non-sterilized soils harboring the organisms and sterilized soils devoid of it

The effluent found to have a high pH (8.58) and EC (1.148 dS m-1) and enriched with N, P, S and exchangeable bases, whereas micronutrients and heavy metals were low. The results obtained from this study showed that most of the soil chemical properties were significantly influenced by effluent application. The soil pH was markedly increased for the first (8.50) and second harvest (8.79) from its initial values of 8.00 for non-sterilized soils. These figures were raised for sterilized soil to 8.68 and 8.97 for the second harvest. Similar trends were observed for EC, exchangeable bases and micronutrient. The OC and TN contents increased with increasing application of effluents, but started to decline at higher doses and thereby reducing the performance of wheat. It also contained relatively high concentration of sodium as compared to other basic cations. The presence of Na in the effluent has an influence on soil SAR and ESP affecting soil quality. The concentration of exchangeable bases revealed that the effluents have a potential to convert the slight alkaline soils at Ziway to sodic.

This study showed that the effluent discharged from the floriculture industry at Ziway has a potential to degrade soil quality parameters and reduce the performance of test crops. Disturbance in soil quality parameters and crop performance is low for non-sterilized soil as compared to sterilized ones, as was reflected in the reduction of shoot dry matter of the test crops in both years.

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