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The Effects of Hair Dressing Effluent Irrigation on Soil Chemical Properties, Germination and Growth in Maize (*Zea mays* L.) and Cowpea (*Vigna unguiculata* [L.] Walp)

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Abstract

The effects of hair dressing effluent on soil chemical properties, germination and growth of maize and cowpea were investigated in pot experiment. The experiment was laid out in a completely randomized design of 3 effluent treatments (100 ml, 200 ml and 400 ml) and control with 5 replications at University of Port Harcourt Centre for Ecological Studies. Results showed that pH ranged between 6.8±0.2 – 7.5±0.4 for both control and treatments, total organic carbon (TOC) increased from 1.56±0.4% in control to 1.95±0.09 - 2.55±0.05% in treatments. Oil and grease increased from 24.20±2.64 ppm in control to 48.70±4.10 - 129.80±3.00 ppm in treatments. Germination percentage were 98% and 48% in control for maize and cowpea respectively and ranged between 84 – 88% and 12 – 32% in treatments for maize and cowpea respectively. Shoot lengths were 27.6±5.8 cm and 20.4±1.4 cm in control for maize and cowpea respectively and ranged between 29.1±4.1 – 32.2±1.0 cm and 18.5±1.7 – 19.8±7.8 cm in treatments for maize and cowpea respectively. Fresh weights were 100.4±7.5 g and 52.3±8.7 g in control for maize and cowpea respectively while it ranged between 97.8±2.9 g – 111.0±6.4 g and 42.0±5.1 – 58.2±4.0 g in treatments for maize and cowpea respectively. In conclusion, hair dressing effluent had no effect on soil pH but increased soil TOC and O & G. It had no effect on germination percentage of maize but reduced it in cowpea and no significant effects on shoot length and biomass accumulation of the test crops.

Key Words: Effluent; Soil; Maize; Cowpea; Growth, irrigation

Introduction

Effluent is liquid waste produced from human activities. Domestic, commercial and industrial activities are some major human activities that generate effluents. The fashion industry (i.e. female beauty fashion) in Nigeria and most parts of African has come with its waste, and effluent which are mostly discharged into the environment. Female beautification is a social change introduced to Africans as European body and hair are used to enhance beauty. Contemporary female body fashion or body care is undertaken through regular and intensive use of some chemical substances e.g. oils, lotions, sprays, dyes, shampoos and creams collectively called cosmetics. The mass adoption of beauty fashion treatments has led to widespread establishment of hair/body care shops popularly known as Beauty salon for fashion services in urban and rural settlements in Nigeria.

In Nigeria, fashion shop effluents are released directly into the environment without any treatment. This could be harmful to the environment as the effluent contains chemicals which could alter soil and water physical and chemical properties (Bowers *et al*., 2002). Ajuzie and Osaghae (2011) has reported increased chemical and biological oxygen demands in hair dressing salon effluent contaminated soil**.** Furthermore, toxicological evaluation of surfactants and detergents which are major ingredients of cosmetics by USEPA (1997) and Environmental Canada (1999) hinted that surfactants and detergents cause endocrine disorders in fish and wildlife. Chude and Ekpo (2010) also reported that hair dressing salon effluent had acute toxic effect on fingerlings of both *Oreochromis niloticus* and *Clarias garienpinus*.

However, not much has been done in the study of the effects of fashion effluents on the environment especially as it relates to plant and soil. This situation has led to paucity of research reports and understanding of likely harmful effects of hair dressing effluent on soil and plants. This paper was therefore set out to study the effects of hairdressing effluent on soil chemical properties and some selected growth parameters of two indigenous tropical crops. This will add to existing information on the effects of effluents on agricultural crops. This is necessary because the effluent is normally discharged into nearby terrestrial environment which are suitable land for home gardening.

Materials and Methods

Place of the Study and Sources of Materials

This experiment was carried out at Centre for Ecological Studies of the Department of Plant Science and Biotechnology, University of Port Harcourt, Nigeria. University of Port Harcourt is located between latitudes 4°52' - 4° 55' N and longitudes 6° 54′ E - 6° 55′. Certified and viable seeds of maize (*Zea mays* 'Swan1-yellow') and cowpea (*Vigna unguiculata* 'T98KK-533-1-1') were obtained from the same centre. Top soil was collected from fallow land within the Uuniversity premises while hair dressing effluent was obtained from Unik Beauty Salon, Aluu. The effluent collected was generated from hairdressing service on the day of collection and taken to Plant Physiology Laboratory of Department of Plant Science and Biotechnology where it was preserved in a refrigerator. The chemical properties of sample hair dressing effluent collected were determined in the laboratory and values obtained were shown in Table 1.

Table 1. Properties of sample hair dressing effluent used in the trial

Parameter	**Value**
pH	6.8±0.3
Conductivity (µS/cm)	246.0±4.3
Phosphate (ppm)	0.1±0.04
Nitrate (ppm)	1.4±0.03
Total Organic Carbon (%)	1.1±0.05
Oil & Grease (ppm)	0.01±0.00

Note: Value = Mean ±Std

Experimental Methods

Four kilogram (4 kg) of the soil weighed with digital balance (model: EK5350) was placed in each of 40 nursery bags which had bottom and side perforations for aeration and to drain out water. The soil filled bags were randomly separated into sets A and B of 20/set. Into each bag of set A were sown five seeds of the maize while into each bag of set B were sown five seeds of the cowpea. Each set was by random selection further separated into 4 batches of 5 bags/batch and labelled batches 1, 2, 3 and 4. Batch

1 (the control) was irrigated with 100 ml of distilled water twice daily while batches 2, 3 and 4 were irrigated with 100 ml, 200 ml and 400 ml respectively of hair dressing effluent at the same irrigation regime as the control. One week after planting germinated seeds were thinned to one seedling per bag. The experiment was allowed to run for six weeks.

Sampling and Data Collection

Soil samples were collected at the end of the experiment from three replicates of each treatment and analyzed to determine its chemical properties. Germination percentage and period were monitored and determined at 7 days after planting. Shoot length, leaf production and leaf area were monitored weekly for four weeks from 2 weeks after planting to 5 weeks after planting while fresh and dry weights were determined at the end of the experiment.

Study Parameters and Their Determinations

Soil pH and conductivity were determined by meter method from 1:1 (w/v) slurry of sample soil and distilled water using pH meter (Hanna HI 8314) and conductivity meter (HACH Ectestr microprocessor series). Soil nitrogen and phosphorus were determined by spectrophotometry with HACH DR/890 colorimeter, total organic carbon was determined by titrimetric method while oil and grease (O & G) was determined by gravimetric method after soxhlet extraction (ASTM D 9071B - 7) with n-hexane as extraction solvent.

Germination percentage was obtained by calculation using the formula given in Naseri *et al*. (2012) stated as -

$$\text{Germination percentage} = \frac{\text{No. of seeds germinated in a treatment}}{\text{Total No. of seeds planted in the treatment}} \times \frac{100}{1}$$

Germination period was obtained by counting the number of days between initial and final seedling emergence (i.e. germination) while shoot length was determined by measuring with a metre rule the length of shoot axis of the plant from the point of the stem at soil surface as it emerged from the soil to the shoot apex. Leaf production (LP) was obtained by count of the number of leaves on each plant. Maize leaf area was estimated by calculation with a standard formula as the product of leaf length (L) and leaf width (W) at the widest portion corrected to 0.85 as given by Steward & Dwyer (1995) using the formula:

$LA_M = L \times W \times a$

Where: LAM = leaf Area (cm^2) for maize

L = leaf length (cm)

W = leaf width at widest margin (cm)

a = constant called co-efficient of correction = 0.73.

Cowpea leaf area was estimated by calculation with a standard formula as the product of the coefficient of correction (0.67) and the sum of the area of each leaf lobe as given by Pekesen *et al*. (2005) using the formula:

$LA_C = 0.67 \times [(L_1 x\ W_1) + (L_1 x\ W_2) + (L_3 x\ W_3)]$

Where: LA_C= leaf Area (cm^2) for cowpea

L_1 =length of first leaf lobe (cm)

L_1 = length of second leaf lobe (cm)

L_3 = length of third leaf lobe (cm)

W_1 = width of first leaf lobe (cm)

W_2 = width of second leaf lobe (cm)

W_3 = width of third leaf lobe (cm)

0.67 = constant called co-efficient of correction.

Fresh weight was obtained by destructive (harvest) method and weighing each harvested crop in digital weighing balance (EK5350). Dry weights were obtained after drying the harvested fresh crops in hot air oven at 50 ^{0}C for 5 days to constant weight and their weights taken.

Data Analyses and Presentations

The parameters studied were subjected to standard One-way Analysis of Variance procedure and Tukey's Honest Significant Difference (HSD) statistical analyses at P = 0.05 after treatments descriptive statistics were calculated.

Results and Discussion

Soil Chemical Properties

Acidity or alkalinity of water or soil is known as pH. The pH of the effluent used in this study was 6.8±0.3 (Table 1) which was almost at the neutral pH point. Soil pH was neutral in control and treatments (Table 2). This observation meant that the effluent had no effect on soil pH and this disagreed with the finding of Orhue *et al.* (2010) from the study of changes in chemical properties of an ultisol amended with brewery effluent which reported no change in soil pH. The result could have been because of the marginal difference between pH of the effluent and the control. Soil conductivity was reduced in the effluent treated batches compared with control. This observation was speculated to have resulted because of the organic chemical nature of the effluent. Therefore, addition of the effluent may have responsible for the reduction in conductivity of treated soil. The observed reduction in conductivity is contrary to Khai *et al*. (2008) which reported high conductivity values in their field study of the effects of wastewater used as nutrient source on soil chemical properties.

Phosphorus is one of the essential macronutrients. Its amount serves as soil fertility indicator and it is present in soil as compounds of phosphorus. Phosphate and nitrate contents were reduced in treatments compared with control. Their amounts increased with increase in volume of effluent treatments (Table 2) which showed that the effluent has the capacity to increas nutrient contents of soil. This agrees with Khai *et al*. (2008). Total organic carbon (TOC) was low in control but high and increased with volume of effluent treatments. However, Orhue *et al.* (2010) reported decrease of TOC in brewery effluent treated soil. The higher TOC contents of the treatments could have resulted from the effluent application since the hairdressing effluent contain high TOC.

Table 2: Chemical properties of control and hair dressing effluent treated soil

Parameter	Treatments			
	Control	100 ml	200 ml	400 ml
pH	7.5±0.4	7.4±0.9	6.8±0.2	7.2±1.1
Conductivity (µS/cm)	163.0±6.8	55.0±5.5	58.0±3.0	161.0±4.0
Phosphate (ppm)	1.93±0.06	0.98±0.08	1.08±0.02	1.86±0.15
Nitrate (ppm)	0.50±0.01	0.1±0.01	0.2±0.06	0.3±0.09
Total Organic Carbon (%)	1.56±0.04	1.95±0.09	2.3±0.08	2.55±0.05
Oil & Grease (ppm)	24.2±2.64	48.7±4.10	64.9±3.28	129.8±3.00

Results = Mean±Std

Germination Percentage and Germination Period

Germination is a physiological process that is negatively affected by the presence of some substance(s) in its environment. The effect of hair dressing effluent was checked with germination performances of the seeds of the test crops. Germination percentage in maize was 98% in control and ranged between 84 – 88% in effluent treated soil while for cowpea, the highest germination percentage was recorded in the control and the least recorded in 400 ml effluent treatment (Table 3). This showed that hair dressing effluent had no negative effect on germination of maize seeds which may be attributed to the pH of the effluent which was within the favourable range for germination of the test crop (Tindall, 1983). Swaminanthan and Vaidhecswarn, (1991) reported improved germination of groundnut seeds exposed to dye factory effluents.

Reduction in germination percentage of cowpea agreed with Mohammad and Khan (1985) who reported similar observation in kidney bean and lady finger seeds planted in industrial effluent irrigated soil. The result suggested that the effluent may have played a role in inhibiting germination. This could also be attributed to the soil pH of the effluent irrigated soil which was above the tolerable range (5.6 – 6.0) for germination of cowpea (Directorate of Plant Production-ARC, 2011).

Germination period for maize was reduced to 2 days in 100 ml effluent treatment and increased to 3 days in the other treatments including the control. This suggested that 100 ml effluent treatment was more favourable and stimulated germination of the test crop. This could have been responsible for the recorded short germination period. However, the longest germination period (i.e. 4 days) was recorded in 200 ml and 400 ml effluent treatments in cowpea (Table 3). It therefore has demonstrated that hair dressing effluent stimulated germination in maize but prolonged germination period in cowpea.

Table 3: Germination percentage and period of maize and cowpea in hair dressing wastewater treated soil

Parameter		**Treatments**			
		control	100 ml	200 ml	400 ml
Germination Percentage (%)	Maize	98	88	84	88
	cowpea	48	32	16	12
Germination Period (days)	Maize	3	2	3	3
	cowpea	2	3	4	4

Results = Mean±Std.

Shoot Length

Growth is a phenomenon that proceed under favourable condition. The effect of irrigation with the effluent on shoot length, leaf production, leaf area, fresh and dry weight were monitored on the test crops. Increase in shoot length was progressive with time in the two test crops (Figs. 1a and b). There were increase in shoot length in both test crops with no significant difference between treatments and control. However, Oregani *et al*. (2014) recorded a significant effect on shoot length from their investigation of the impact of wastewater irrigation on seedling growth of canola (*Brassica napus*).

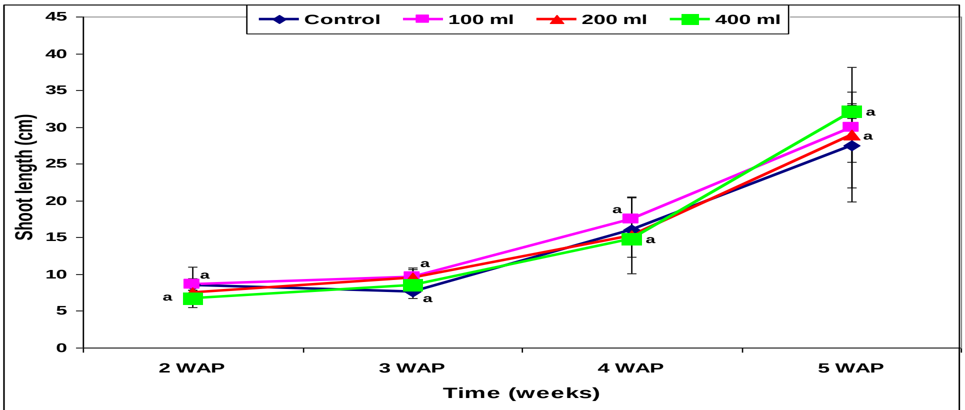

Fig. 1a: Shoot lengths of maize grown in hair dressing effluent irrigated soil

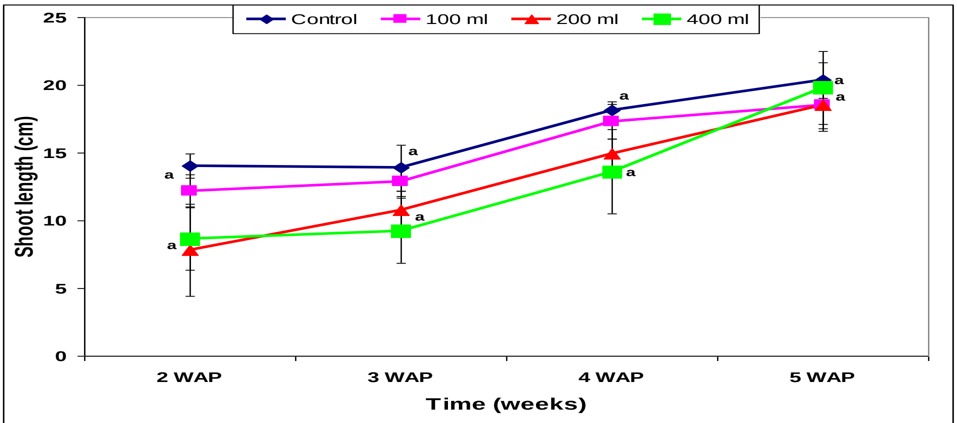

Fig. 1b: Shoot lengths of cowpea grown in hair dressing effluent irrigated soil

Leaf Production

There was a general increase in leaf production (i.e. number of leaves) in the control and effluent treated setups (Fig. 2a and b). Leaf production in maize was constant between 2 and 3 WAP in 100 ml and 400 ml effluent treatments but was reduced in the 200 ml treatment (Fig. 2a). From 3 WAP leaf production increased production increased in all treatments in maize. Leaf production in cowpea also increased in all treatments from 2 - 5 WAP. Increase in leaf production was in line with Orhue *et al*. (2005). Therefore, there was significant difference in leaf production between treatments in both crops.

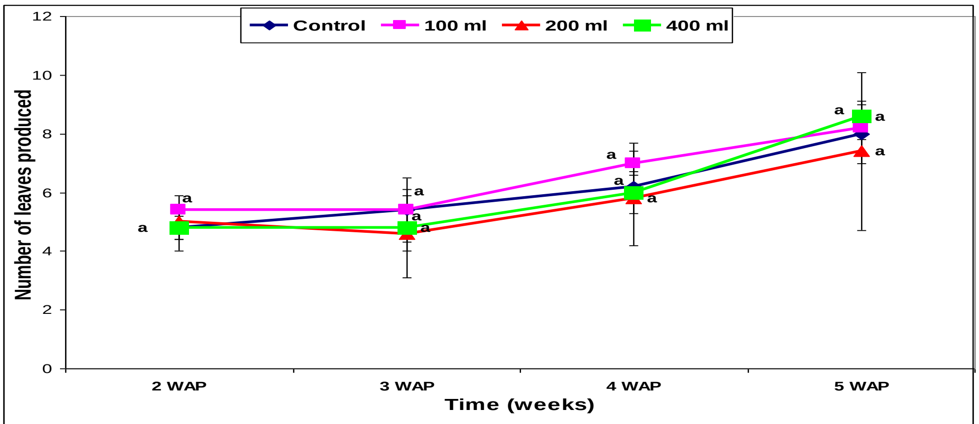

Fig. 2a: Leaf production of maize grown in hair dressing effluent irrigated soil

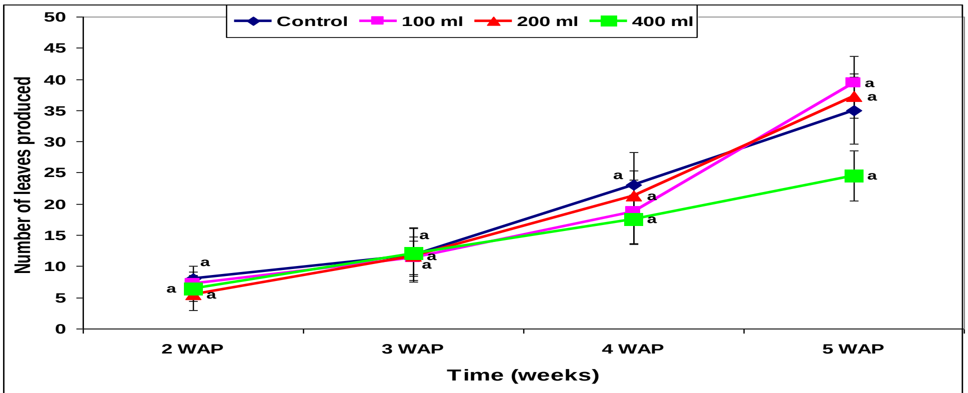

Fig. 2b: Leaf production of cowpea grown in hair dressing effluent irrigated soil

Leaf Area

Leaf area increased with time in both treatments and control in the two test crops (Figs 3a and b). Increase in leaf area in maize was stimulated in all treatments at 4 WAP but 2 WAP in cowpea. Leaf area at 5 WAP ranged between 200.1±8.4 – 304.8±8.3 cm^2 and 44.4±9.5 – 50.7±12.1 cm^2 in maize and cowpea grown in both control and treatments respectively. Hence, there were no significant difference between leaf areas treatments and control. Increase in leaf area corresponded with Abegunrin *et al*. (2013) as was determined from the study of the effect of kitchen wastewater irrigation on growth of cucumber. However, this result contrasts with the finding of Oregani *et al*. (2014).

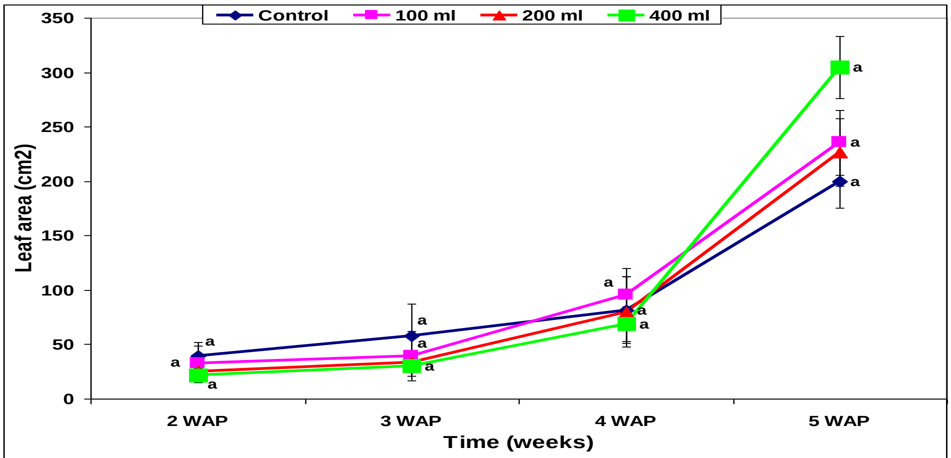

Fig. 3a: Leaf area of maize grown in hair dressing effluent irrigated soil

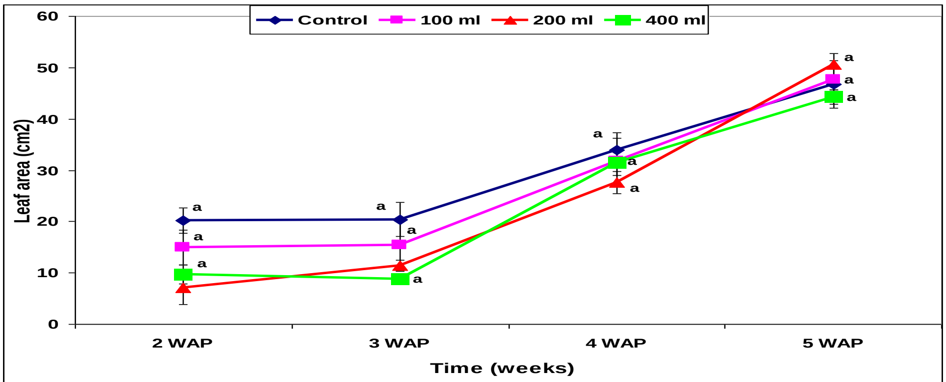

Fig. 3b: Leaf area of cowpea grown in hair dressing effluent irrigated soil

Fresh Weight and Dry Weight

Fresh weight result for the test crops were presented in Table 4. In maize, fresh weight was slightly reduced in 100 ml effluent treatment but increased in 200 ml and 400 ml treatments compared with control while in cowpea it was higher in 100 ml and 200 ml treatments but lower in the 400 ml treatment. Decrease in fresh weight of cowpea at 400 ml effluent treatment agreed with the finding of Zereen *et al.* (2013) from their study of the effect of tannery wastewater on the growth and yield of sunflower. It was speculated that the observation made on maize could have been that the crop utilized nutrients contained in the effluent especially with the favourable pH in the soil for biomass production while according to the worker, the effluent at higher concentration may have acted as pollutant hence imposed stress on cowpea. Perhaps, this may have resulted in the reduction in fresh weight of the affected crop at the 400 ml treatment.

Dry weights of maize grown in the treatments were low compared with control. This may be because the effluent had negative influence on biosynthesis and biomass accumulation. In cowpea, the highest dry weight was recorded on 200 ml treatment and the least on 100 ml effluent treatment (Table 4). Low dry weights in maize grown in effluent irrigated treatments compared with control disagreed with Orhue *et al.* (2005). However, the result agreed with the finding of Zereen *et al.* (2013). The results obtained showed no definite trend of impact of hair dressing effluent on biomass accumulation (fresh and dry weights) in maize and cowpea.

Table 4: Effects of hair dressing effluent irrigation on fresh and dry weights

Parameter		**Treatments**			
		control	100 ml	200 ml	400 ml
Fresh Weight (g)	Maize	100.4±7.5	97.8±2.9	111.0±6.4	110.2±17.0
	cowpea	52.3±8.7	58.2±4.0	57.0±16.0	42.0±5.1
Dry Weight (g)	Maize	25.6±17.7	22.4±3.6	24.8±14.6	21.4±5.9
	cowpea	7.8±2.2	6.2±3.0	8.0±1.7	7.5±5.0

Results = Mean±Std.

Conclusion

This investigation has demonstrated that hair dressing effluent soil irrigation soil had no effect on soil pH but reduced soil conductivity and increased soil phosphate, nitrate, total organic carbon and oil & grease contents. It was found to stimulate germination in maize but prolonged germination period in cowpea. Result also showed no effect on shoot length and definite impact on biomass accumulation (fresh and dry weights) in maize and cowpea. Based on the results obtained reuse of hair dressing effluent for irrigation of maize is safe but detrimental on cowpea. Therefore, proper management of hairdressing effluent is recommended in order to harness its potential benefits crop cultivation.

References

Abegunrin, T. P., Awe, G. O., Idowu, D. O., Onigbogi, O. O. & Onofua, O. E. (2013). Effect of kitchen wastewater irrigation on soil properties and growth of cucumber (*Cucumissativus*). *Journal of Soil Science and Environmental Management*, 4(7): 39-145.

Ajuzie, C. U. & Osaghae, B. A. (2011). The bacterial and physico-chemical properties of hair salon wastewater and contaminated soil in Benin metropolis. *African Journal of Biotechnology*, 10(11): 2066-2069.

Bowers F, Cole K, Hoffman, J. (2002). *Characterizing Beauty Salon wastewater for the purpose of Regulating Onsite Disposal Systems*. New Jersey: Department of Environmental Protection, p. 5.

Chude, L. A. & Ekpo, I. E. (2010). Laboratory comparison of effect of hair dressing salon effluent on fingerlings of *Oreochromi sniloticus* and *Clarias gariepinus*. *Nigerian Journal of Agriculture*, *Food and Environment*, 6 (1&2):104 - 109.

Directorate Plant Production-ARC (2011). *Production guidelines for cowpeas*. Directorate Agricultural Information Services Department of Agriculture, Forestry and Fisheries, Pretoria, South Africa.

Environmental Canada (1999). Endocrine Disrupting Substances in the Environment: Accessed at http://www.ec.gc.ca/eds/fact/index.htm on 15th April, 2016.

Khai, M., Tuan, P. T., Vinh, N. C. & Oborn, I. (2008). Effects of using wastewater as nutrient sources on soil chemical properties in peri-urban agricultural systems. *VNU Journal of Science, Earth Sciences*, 24 87-95.

Mohammad A, Khan AU (1985). Effect of a textile factory effluent on soil and crop plants. *Environ. Pollut*. 37: 131–148 Serial A.

Naseri, R., Emami, T., Mirzaei, A. & Soleymanifard, A. (2012). Effect of salinity sodium chloride) on germination and seedling growth of barley (*Hordeum vulg*are L.) cultivars. *International Journal of Agriculture and Crop Sciences*, 4 (13): 911-917.

Oregani, K. E., Esfeh, Z. K.., Gholami, A., Yazdi, H. L. (2014). Impact of wastewater irrigation on germination, growthseedling and concentration of heavy metals in soil and Canola (*Brassica napus* L.). *International Journal of Biosciences*, 4(10):89-98.

Orhue, E. R., Osaigbovo, A. U. & Vwioko, D. E. (2005). Growth of maize (*Zea mays* L.) and changes in some chemical properties of an ultisol amended with brewery effluent. *African Journal of Biotechnology*, 4 (9):973-978.

Pekesen, E. Aruk, C., Patabryrk, B. (2005). Determination of genotypical difference for leaf characteristics in cowpea (*Vignaunguiculata*L. Walp) genotypes. *Asian J. Plant Sci*. 4(2): 95-97.

Stewart, D. W. & Dwyer, L. M. (1999). Mathematical characterization of leaf shape and area of maize hybrids. *Crop Science*, 39:422-427.

Swaminathan K, Vaidhecswarn P (1991). Effect of dying factory effluents on seed germination and seedling development of groundnut (*Arachis hypogea*). *Journal of Environmental Health*. 19(3): 165–175.

Tindall, H. D. (1983). *Vegetables in the tropics*. Hampshire, Britain: Macmillan Education Ltd.

U.S. Environmental Protection Agency (1997). EPA Special Report on Endocrine Disrupters: Screening and Testing Advisory Committee (EDSTAC) Final Report. Publication EPA/630/R-96/102 USEPA, Washington D. C. [Accessed at HTTP://www.epa.gov/ORD/webPubs/endocrine on 15th April, 2016].

Zereen, A., Wahid, A., Khan, Z. & Sardar, A. A. (2013). Effect of tannery wastewater on the growth and yield of sunflower (*Helianthus Annuus*L.). *Bangladesh J. Bot.*,42(2): 279-285.