Yield and Nutritional Value of *Abelmoschus esculentus* L. (Okra) and *Telfairia occidentalis* Hook, F. (Fluted pumpkin) as Influenced by Beauty Salon Wastewater

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The effect of beauty salon wastewater on yield and nutritional quality of *Abelmoschus esculentus* L. and *Telfairia occidentalis* F. was investigated. Plants were grown in perforated polythene bags filled with 3 kg of top soil and irrigated with 0 (control), 25, 50, 75 and 100% of the wastewater. Plants were laid out in a completely randomized design (CRD) consisting of 5 treatments with 6 replicates per treatment. Results showed that the yield parameters of *Abelmoschus esculentus* including number of fruits/plant, fruit fresh weight and dry weight increased at 25-75% concentrations but decreased at highest concentration of 100% wastewater in comparison with the control. Similarly, the total biomass of *Telfairia occidentalis* and *Abelmoschus esculentus* increased at 25-75% concentrations of wastewater. The N, K, Ca and Na composition of the leaf of *T. occidentalis* and fruits of *A. esculentus* increased at all wastewater treatment levels. The percentage ash and protein increased in both plants treated with the wastewater. Lipid content increased while the fibre content decreased in *T. occidentalis* whereas in *A. esculentus* fibre content increased while the lipid content decreased in comparison to the control. Percentage carbohydrate increased in both plants treated with the wastewater.
wastewater. The use of beauty salon wastewater in irrigation of vegetables would not only reduce environmental pollution but also serve as an alternative source of fertilizer for vegetable production.

Keywords: Beauty salon wastewater; Telfairia occidentalis; Abelmoschus esculentus; pollution; fertilizer.

1. INTRODUCTION

The use of wastewater for irrigation is widely seen in many cities of developing countries where urban wastewater becomes the irrigation source for farmers in urban and semi-urban areas [1]. Wastewater use for agriculture is an important management strategy in areas with limited freshwater resources, yielding potential economic and environmental benefits. The practice has manifold benefits in the form of water conservation, nutrient recycling and prevention of surface and ground water pollution [2]. The reuse of wastewaters for purposes such as agricultural irrigation can reduce the amount of water that needs to be extracted from environmental water sources [3]. The reuse of wastewater for irrigation purposes gives it a different fate as agricultural crops can make use of the extra water and nutrients.

Wastewater has a potential to supply carbon nutrients (NPK) and micro nutrients to support crop/plant growth [4]. It serves as a valuable source of plant nutrients and organic matter needed for maintaining fertility and productivity levels of the soil [5]. Wastewater can have a positive effect on soil and eventually plant growth, due to its being rich in organic matter and nutrients [6,7]. Kiziloglu et al. reported that application of wastewater to cropland and forested lands is an attractive option for disposal because it can improve physical properties and nutrient contents of soils [8]. Wastewater irrigation not only provides water, N, and P but also organic matter (OM) to the soils [9]. The results of Aghtape et al. and Tavassoli et al. experiments showed that irrigation with wastewater significantly increased the fresh and dry forage yield of corn than that of irrigation with well water [10,11]. Abu Nada undertook study to assess the long term impacts of wastewater irrigation on different parameters of soil and crop. He observed that Long term wastewater irrigation increased salt, organic matter and plant nutrients in both soil layers [12]. Khurana and Singh summarized the available data on chemical composition of different wastewaters and their effects on soil fertility, soil heavy-metal content, crop yield and quality. Field application of all types of wastewaters significantly increased soil OC percentage and cation exchange capacity (CEC) [13]. Nadav et al. indicated that the physico-chemical properties of soils were altered by wastewater irrigation, as a result of long-term accumulation of organic matter in the soil profiles. High level of organic matter in wastewater acts as cement for the building up of soil aggregates [14].

However, apart from plant nutrients contained in wastewater, it may contain various potentially toxic elements and organic matters with highly harmful effects on human and animal health. Municipal wastewater contains relatively high amounts of sodium, which can be accumulated in the soil during irrigation with this wastewater and display toxic effects on the plants. If this wastewater is not disinfected or treated in stabilization ponds, it is highly contaminated with microorganisms. Therefore, the utilization of municipal wastewater for the irrigation of crops is associated with a number of risks. Very serious risks are those of crop yields reduction, crops contamination with pathogens and intestinal helminthes [15].

Vegetables play important role in meeting the food requirements of people world-wide, because they are important source of various essential components i.e. minerals, dietary fibers and [16]. They are also potential sources of essential nutrients, constitutes functional food components by providing protein, iron and calcium which have noticeable health effects [17]. The continuous demand for vegetables has increased the need to cultivate these crops all year round. This in effect leads to the dependence on wastewater during the dry seasons or during periods of drought. Also, due to the light water requirement of some crops, the use of wastewater to supplement the freshwater, if any, becomes inevitable.

Okra and fluted pumpkin constitute a major part of the commonly consumed vegetables which are widely grown on the field and in home gardens where there is high tendency of contact
with beauty salon wastewater. The study is therefore aimed at investigating the impact of beauty salon wastewater on okra and fluted pumpkin growth.

2. MATERIALS AND METHODS

2.1 Experimental Location

The experiment was conducted in the screen house of the Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria with latitude 7°28‘N and longitude 5°44‘E.

2.2 Planting Materials

Matured seeds of Abelmoschus esculentus were obtained from the Premier Seed Company Ibadan, Oyo State, Nigeria, while that of Telfairia occidentalis were obtained from a local market at Oka-Akoko, Ondo State, Nigeria.

2.3 Experimental Set Up

Top soil used for the experiment was collected from the experimental farm of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko. The soil was air-dried and sieved through to remove stones. The beauty salon wastewater was collected from a septic wastewater tank from a beauty salon in Akungba Akoko, Ondo State. Concentrations of 25, 50, 75, and 100% of the wastewater were prepared in a plastic keg just before each treatment by dilution with tap water to make the desired concentrations. Four viable seeds of Abelmoschus esculentus and three viable seeds of Telfairia occidentalis were sown in perforated polythene bags containing 3kg of top soil. Seedlings were allowed to establish for three weeks and thinned to one seedling per pot. Plants were irrigated with the wastewater at 0 (control), 25%, 50%,75% and 100% concentrations. Each pot was treated with 250mL (volume enough to keep the soil moist) 2 times in a week; thus each pot received 500mL of wastewater treatment per week. The treatment lasted for 8 weeks. The experiment was carried out from July to October, 2016. Pots were laid in a completely randomized design, with 6 replicates per treatments. The experiment ended in October 2016 by harvesting the fruits of Abelmoschus esculentus with the seeds and leaves of Telfairia occidentalis. Their fresh weight was determined after which they were oven-dried at 80°C for the dry weight measurement.

2.4 Measurement of Yield

Measurement of yield of Abelmoschus esculentus and of Telfairia occidentalis irrigated with different concentrations of beauty salon wastewater was done. The parameters studied include: Number of fruits/plant, total fresh weight of fruits/plant, total dry weight of fruits/plant.

2.5 Chlorophyll Content Analysis

The total chlorophyll content of leaves of Abelmoschus esculentus and Telfairia occidentalis was determined using the Arnon method 18. One gram of fresh leaves was ground with acid leached sand, (sand washed with concentrated sulphuric acid (H₂SO₄) and thoroughly rinsed with distilled water to remove all nutrients). The chlorophyll content was extracted using 10ml of 80% acetone and centrifuged at 2000rpm for 15minutes. The clear supernatant liquid was decanted and the absorbance read with photo spectrophotometer at 663nm and 645nm respectively. The 80% acetone served as reference blank. The total chlorophyll content was calculated using the formula:

\[ \text{Total chlorophyll content} = \{20.2 \times D_{645} + 8.02 \times D_{663}\} \times \left(\frac{50}{100} \times \frac{100}{5} \times \frac{1}{2}\right) \]

2.6 Fresh and Dry Weight Determination

Plants were carefully uprooted at the end of experiment by soaking the soil with water for easy uprooting without any damage to the root. The roots were washed and each plant was separated into stems, roots and leaves. The parts were taken to the laboratory for weighing to determine the fresh weight. Dry weight was also determined after drying in an oven at 80°C to constant weight. The weight was measured using sensitive weighing balance. Also, fruits of plant were harvested and weighed in the laboratory to determine the fresh weight. The fruits dry weight was determined after drying in an oven at 80°C.

2.7 Plant Analysis

Dried seeds of Abelmoschus esculentus and dried leaves and stems of Telfairia occidentalis were ashed and dissolved with 10 ml of 20% sulphuric acid. The Solution was placed on a hot plate preset at 30°C to facilitate its dissolution. It was removed from hot plate, filtered into 10 ml capacity volumetric flask and marked to volume with distilled water. This filtrate was used for
Ca²⁺, Mg²⁺, Na⁺, K⁺. Na⁺ and K⁺ analysis by flame photometer, and Mg² and Ca²⁺ analysis by EDTA. Seeds and leaves were also assayed for proximate compositions: crude protein, fat and carbohydrate, crude fiber and total ash following the method of AOAC.

2.7.1 Sodium and potassium determination

A 2.54 g and 1.9067 g of pure oven dried NaCl and KCl respectively were dissolved in water to make 1 litre. 10ml each of the reagent was then pipette to make 100 ml with ammonia acetate to have 100 ppm solution from the 100 ppm, 0.2, 4, 6, 8, and 10 ml were pipette into 100 ml flask and made each to mark, to have 0, 2, 4, 6, 8, 10 ppm working standard for two stocks. The ammonium acetate extract was employed for the determination. The flame photometer was adjusted according its instruction manual. The standards were aspirated to obtain reliable curves before aspirating the samples. The blank (ppm) is the ammonium acetate.

2.7.2 Calcium and magnesium determination

A 10 ml aliquot of the plant samples was carefully transferred in duplicate into 150 ml conical flask capacity. A drop of potassium cyanide and hydrochloride were introduced to both beakers. To one set of the beaker, 5 ml of ammonium buffer, three drops of erichrome black, and indicator were added and titrated against 0.05 M EDTA solution. The titre value obtained gave a combine result for calcium and magnesium while to the second set of beaker; 5 ml of 8M of NaOH and a pinch of cal-red indicator were added and titrated against 0.05 M EDTA solution. The titre value obtained gave directly the result of calcium concentration. The difference between the first and the second value obtained gave the amount of magnesium.

2.7.3 Determination of crude protein

The estimation of crude protein involves the determination of total nitrogen usually by kjedahl procedure. The amount of crude protein is obtained by multiplying the nitrogen content by 6.25. This factor is based on the assumption that all the nitrogen in the tissue is present as protein.

2.7.4 Crude fibre determination

About 0.50-2.0 g of the milled sample was measured into 1 litre conical flask (W₀). 200 ml of boiling 1.25% H₂SO₄ was added and boiled gently for 30 minutes using cooling fingers to maintain a constant volume, this was filtered through muslin cloth or poplin material stretched over 9cm Buchner funnel. It was rinse well with hot distilled water added and the material was scraped back into flask with spatula. About 20 ml of boiling 1.25% NaOH was added and boiled gently for 30 minutes using cooling fingers to maintain a constant volume. This was filtered through poplin cloth and residues washes with 10% HCl and twice with industrial methylated spirit, acetone or ethanol. This was allowed to drain, dry and the residue scraped into a crucible or silica dish. This was dried overnight at 105°C in the oven and then cooled in a desiccator. The sample was weighed (W), ashed at 550°C for 90 minutes in a muffle furnace, cooled in a desiccators and weighed again (W₂).

Calculation

\[ \% \text{ crude fibre} = \frac{W₁ - W₂}{W₀} \times 100 \]

2.7.5 Determination of soluble carbohydrate (Nitrogen free extract)

The nitrogen-free extractive (NFE) referred to as soluble carbohydrate is not determined directly but obtained as a difference between crude protein and the sum of ash, protein, crude fat and crude fibre.

\[ \text{NFE} = 100 - (\% \text{ash} + \% \text{ crude fibre} + \% \text{ crude fat} + \% \text{ crude protein}) \]

2.8 Statistical Analysis

The data obtained were subjected to one-way analysis of variance (ANOVA) and means were separated with Tukey HSD Multiple Range tests at 5% level of probability using SPSS 21.0.

3. RESULTS

Table 1 shows the effect of beauty salon wastewater on the yield of *Abelmoschus esculentus*. Beauty salon wastewater at 25-75% concentrations increased the yield of *Abelmoschus esculentus*. But the yield reduced at 100% concentration in comparison with the control. Plants irrigated with 75% of the wastewater yielded an average of 4.00 fruits per plant compared to average of 3.85 fruits per plant in control and average of 3.67 fruits per plant in higher concentration of 100% of the wastewater. Similarly, the fruits fresh and dry weight increased at 75% concentration and reduced at 100% concentration of the wastewater in comparison with the control.
This present experiment shows significant effects of beauty salon wastewater on fresh and dry weight of plants parts. Tables 2 and 3 illustrate the impact of beauty salon wastewater on the fresh and dry weights of roots, stems and leaves of *Abelmoschus esculentus* and *Telfairia occidentalis*.

### Table 1. Yield of *Abelmoschus esculentus* (Okra) grown in soil irrigated with water containing different proportions of beauty salon wastewater under screen house condition

| Yield parameters | Quantity of beauty salon wastewater applied (%) |
|------------------|-----------------------------------------------|
|                  | 0  | 25 | 50 | 75 | 100 |
| Number of fruits/plant | 3.85±  | 4.00±  | 3.87± | 4.00± | 3.67± |
| Fruit fresh weight/plant (g) | 31.64± | 36.41± | 34.04± | 41.48± | 31.56± |
| Fruit dry weight/plant (g) | 4.31± | 4.76± | 4.66± | 6.36± | 3.81± |

Each value is a mean± S.E of 6 replicates. For each value, means with the same letter(s) in superscript on the same row are not significantly different at P>0.05 (Tukey HSD test).

### Table 2. Effect of beauty salon wastewater on the fresh and dry weight (g) of plant parts in *Abelmoschus esculentus*

| Parameter          | Plant part       | Concentration of beauty salon wastewater applied (%) |
|--------------------|------------------|-----------------------------------------------|
|                    |                  | 0  | 25 | 50 | 75 | 100 |
| Fresh weight (g)   | Root fresh weight | 12.53± | 15.10± | 13.63± | 13.85± | 11.41± |
|                    | Leaf fresh weight | 5.62± | 5.56± | 9.08± | 5.82± | 3.56± |
|                    | Stem fresh weight | 11.67± | 14.90± | 13.23± | 15.85± | 8.72± |
| Dry weight (g)     | Root dry weight  | 2.49± | 3.29± | 2.70± | 2.88± | 2.03± |
|                    | Leaf dry weight  | 1.38± | 1.41± | 2.49± | 1.44± | 0.98± |
|                    | Stem dry weight  | 2.26± | 2.60± | 2.58± | 2.99± | 1.59± |

Each value is a mean± S.E of 6 replicates. For each value, means with the same letter(s) in superscript on the same row are not significantly different at P>0.05 (Tukey HSD test).

### Table 3. Effect of beauty salon wastewater on the fresh and dry weight (g) of plant parts in *Telfairia occidentalis*

| Parameter          | Plant part       | Concentration of beauty salon wastewater applied (%) |
|--------------------|------------------|-----------------------------------------------|
|                    |                  | 0  | 25 | 50 | 75 | 100 |
| Fresh weight (g)   | Root fresh weight | 18.80± | 18.96± | 19.91± | 26.55± | 14.83± |
|                    | Leaf fresh weight | 13.75± | 13.85± | 13.97± | 13.32± | 12.73± |
|                    | Stem fresh weight | 14.20± | 16.93± | 15.27± | 19.68± | 13.53± |
| Dry weight (g)     | Root dry weight  | 2.92± | 4.17± | 3.52± | 5.68± | 2.69± |
|                    | Leaf dry weight  | 2.20± | 2.45± | 2.46± | 2.42± | 1.88± |
|                    | Stem dry weight  | 2.41± | 3.23± | 2.73± | 3.75± | 2.22± |

Each value is a mean± S.E of 6 replicates. For each value, means with the same letter(s) in superscript on the same row are not significantly different at P>0.05 (Tukey HSD test).

### Table 4. Dry mass, Root: Shoot ratio of *Abelmoschus esculentus* and *Telfairia occidentalis* grown in soil irrigated with beauty salon wastewater

| Vegetable species | Concentration of beauty salon wastewater applied (%) |
|-------------------|-----------------------------------------------|
|                   | 0  | 25 | 50 | 75 | 100 |
| Root dry mass (g) | *Telfairia occidentalis* | 2.92± | 4.17± | 3.52± | 5.68± | 2.69± |
|                   | *Abelmoschus esculentus* | 2.49± | 3.29± | 2.70± | 2.88± | 2.03± |
| Shoot dry mass (g) | *Telfairia occidentalis* | 4.3± | 5.06± | 5.75± | 6.17± | 6.63± |
|                   | *Abelmoschus esculentus* | 3.3± | 4.13± | 5.86± | 7.86± | 7.73± |
| Total biomass (g) | *Telfairia occidentalis* | 6.43± | 7.29± | 8.08± | 8.53± | 9.19± |
|                   | *Abelmoschus esculentus* | 5.8± | 7.03± | 8.89± | 10.99± | 9.59± |

Each value is a mean± S.E of 6 replicates. For each value, means with the same letter(s) in superscript on the same row are not significantly different at P>0.05 (Tukey HSD test).
occidentalis irrigated with beauty salon wastewater. Fresh and dry weights parts of Abelmoschus esculentus increased with a significant different (p>0.05) at 25-75% concentrations of the beauty salon wastewater but decreased at highest concentrations of 100% when compared with the control (Table 2). Similarly, the fresh weights of the different parts of Telfairia occidentalis increased at 25-75% concentrations of beauty salon wastewater compared with the control (Table 3).

Table 4. shows the effect of beauty salon wastewater on the total biomass of the two vegetables. The total biomass is the total sum of the root and shoot dry mass. The total biomass increased upon irrigation with beauty salon waste water in comparison with the control. (Also see Figs. 1 and 2).

Beauty salon wastewater at all treatment levels (25-100%) caused an increase in the nutrient composition of the fruits of Abelmoschus esculentus and leaves of Telfairia occidentalis when compared with the control. N, K, Ca and Na composition of the two vegetables increased in comparison with the control. The result also shows increase in the percentage ash and protein content of the plants. Lipid content increased while the fibre content decreased in T. occidentalis whereas in A. esculentus fibre content increased while the lipid content decreased in comparison to the control.

4. DISCUSSION

The effect of wastewater on yield and nutritional value of crops has been demonstrated and discussed extensively by many authors. Day et al. reported that using municipal wastewater...
Fig. 3. Effect of beauty salon wastewater on the chlorophyll content of *Telfairia occidentalis*.

Fig. 4. Effect of beauty salon wastewater on the chlorophyll content of *Abelmoschus esculentus*.

Fig. 5. Nutritional and proximate composition of leaves produced by *Telfairia occidentalis* (Fluted pumpkin) grown in soil irrigated with water containing different proportions of beauty salon wastewater under screen house condition.
Table 5. Proximate and nutritional composition of *Telfairia occidentalis*

| Nutritional and proximate composition | Concentration of beauty salon wastewater applied (%) |
|--------------------------------------|-----------------------------------------------------|
|                                      | 0        | 25       | 50       | 75       | 100      |
| N (%)                               | 1.64     | 1.66     | 1.67     | 1.65     | 1.65     |
| P (%)                               | 0.13     | 0.12     | 0.11     | 0.14     | 0.12     |
| K (%)                               | 0.85     | 0.88     | 0.87     | 0.86     | 0.89     |
| Ca (%)                              | 0.67     | 0.69     | 0.68     | 0.68     | 0.68     |
| Mg (%)                              | 0.28     | 0.26     | 0.29     | 0.27     | 0.26     |
| Na (%)                              | 0.03     | 0.03     | 0.04     | 0.03     | 0.04     |
| Ash(%)                              | 4.43     | 4.57     | 4.75     | 5.00     | 4.50     |
| Fibre(%)                            | 9.37     | 9.10     | 8.78     | 8.88     | 8.86     |
| Protein(%)                          | 10.25    | 10.38    | 10.44    | 10.86    | 10.31    |
| Lipid(%)                            | 1.56     | 1.59     | 1.57     | 1.61     | 1.65     |
| NFE(%)                              | 74.39    | 74.36    | 74.35    | 73.95    | 73.98    |

Fig. 6. Nutritional and proximate composition of fruits produced by *Abelmoschus esculentus* (Okra) grown in soil irrigated with water containing different proportions of beauty salon wastewater under screen house condition

Table 6. Proximate and nutritional composition of *Abelmoschus esculentus*

| Nutritional and proximate composition | Concentration of beauty salon wastewater applied (%) |
|--------------------------------------|-----------------------------------------------------|
|                                      | 0        | 25       | 50       | 75       | 100      |
| N (%)                               | 2.46     | 2.52     | 2.49     | 2.50     | 2.51     |
| P (%)                               | 0.17     | 0.18     | 0.17     | 0.16     | 0.18     |
| K (%)                               | 0.91     | 1.02     | 1.01     | 0.92     | 0.95     |
| Ca (%)                              | 0.86     | 0.87     | 0.87     | 0.90     | 0.85     |
| Mg (%)                              | 0.33     | 0.31     | 0.31     | 0.34     | 0.33     |
| Na (%)                              | 0.06     | 0.09     | 0.09     | 0.07     | 0.07     |
| Ash(%)                              | 7.90     | 8.98     | 9.45     | 7.86     | 8.50     |
| Fibre(%)                            | 17.74    | 17.94    | 19.27    | 17.86    | 18.19    |
| Protein(%)                          | 15.38    | 15.75    | 15.56    | 15.63    | 15.69    |
| Lipid(%)                            | 11.33    | 11.74    | 11.07    | 10.85    | 10.97    |
| NFE(%)                              | 52.35    | 44.61    | 44.05    | 47.80    | 46.65    |
diluted with groundwater at 50:50 mixtures improved Gossypium spp yield when compared to groundwater alone from wells in Arizona [19]. Kiziloglu et al. showed that wastewater irrigation treatments increased the availability of N, P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu, to plant which led to increase of red cabbage yields [20]. Gatta et al. observed that the source of irrigation water did not affect significantly tomato yield traits except tomato quality [21]. Results of this experiment show the effect of beauty salon wastewater on the yield and nutritional value of Telfairia occidentalis (Fluted Pumpkin) and Abelmoschus esculentus (Okra).

Table 1. shows that plant irrigated with 25-75% concentrations of beauty salon wastewater had higher yield than the control. This concur with the previous finding of Bedbabis et al. that found that wastewater irrigation of olive trees resulted in significant yield increase when compared to yields from plot using well water [22]. Qaryouti et al. concluded that, raw wastewater irrigation increased significantly tomato crop parameters, cucumber plant height and fruit yield and average fruit weight, and tomato leaf area and plant dry weight [23]. Day et al. also compared the effect of irrigation with wastewater and pump water on wheat. They concluded that wastewater irrigation produced taller plants, heavier seeds and higher grain yields than pump water [24]. Wastewater has the potential to increase plant yield than the control. Similar results were also recorded by Juwarkar et al. in Arachis hypogea [25]. Nissim et al. showed that, irrigation with wastewater had a positive effect on willow growth and biomass yield [26]. Jiménez et al. concluded that, reuse wastewater increased significantly crop productivity to five crops/year of alfalfa, fodder oats, tomato, barley and maize and the yield was higher than those obtained with rain [27]. Golchin et al. indicated that use of wastewater could improve morphological characters, yield and yield components of alfalfa as compared to control treatment. Increasing wastewater concentration more than 45 % caused poisoning effects on plants which decreased biological yield [28].

Higher concentration of beauty salon wastewater decreased the dry weight of the root, stem and leaf of A. esculentus and T. occidentalis. The reduction in the dry weight might be due to the poor growth of the seedlings under effluent stress. According to El Youssfi et al. who studied the effect of wastewater irrigation on three varieties of quinoa. The salinity caused the depression of plant's height, and reduced fresh and dry weights of different parts of three varieties of plants tested. The plant biomass of the two vegetables increased at 25-75% treatment levels of the wastewater [29]. It was reported by Misra et al. that Solanum lycopersicum irrigated with greywater obtained higher nutrient uptake and biomass at the flowering stage when compared to tap water [30]. Also, Gupta et al. reported that plant irrigated with wastewater resulted in significant increase in plant height, number of leaves per plant, leaf area index, leaf to stem (green and dry) biomass and green fodder yield of fodder sorghum and significant decrease in dry matter content as compared to well water [31]. Zema et al. investigated the biomass yield of T. latifolia which increased by irrigation with wastewater [32]. Ntzala et al. found that the treated wastewater affected significantly the dry matter yield and non-significantly the plant height on Lactuca sativa L. crop [33].

The proximate analysis of Telfairia occidentalis shows that Beauty salon wastewater increased leaf N, K, and Ca while other nutrients were not affected. Similarly, percentage ash, lipid and protein increased in the leaves of beauty salon waste treated plants (Fig. 3). This finding is in accordance with Babyshakila et al. that biochemical content of lipid, ash and protein increased at 50 and 75% concentrations of wastewater in the leaf samples of Vigna radiate [34]. The Fibre and carbohydrate contents decreased relative to the control. The proximate analysis of Abelmoschus esculentus shows that Beauty salon wastewater increased the composition of N, K, Ca and Na at all treatment levels in the fruits of Abelmoschus esculentus in comparison to the control (Fig. 4). Al- Jaloud et al. reported elevated concentration of N, Ca, Mg, and Na in leaves of Sorghum when the crop was irrigated with wastewater [35]. Moreover, Vazquez-Montieletal found that irrigation of maize (Zea mays. L.) with treated wastewater resulted in increase in N, P, K and Mg concentration in leaves [36]. Fonseca et al. also obtained similar results in a greenhouse experiment with maize [37]. Also, there was an increase in the percentage ash, fibre and protein at all treatment levels whereas the lipid and carbohydrate contents decreased in comparison to the control.

Figs. (3 and 4) show the effects of beauty salon wastewater on the chlorophyll content of T. occidentalis and A. esculentus. Beauty salon
wastewater treatments reduced the chlorophyll content of *Abelmoschus esculentus* but at non-significant level when compared to the control. The Chlorophyll content of *Telfairia occidentalis* reduced significantly with a significance difference at 25-75% concentrations when compared to the control upon treatment with beauty salon wastewater. Many authors have reported adverse effect of wastewater on chlorophyll content and metabolism 38, 39 and 40]. Agrawal et al. suggested that heavy metals can inhibit chlorophyll formation by preventing magnesium uptake 41].

5. CONCLUSION

The use of beauty salon wastewater improved yields and nutritional values of *A. esculentus* and *T. occidentalis* when diluted with water at 25-75%. Consequently, beauty salon wastewater can serve as an alternative liquid fertilizer in the production of *A. esculentus* and *T. occidentalis* if applied to soil at levels not above 75% concentration of the wastewater. This study coairms that high concentration (>75% concentration) of beauty salon wastewater can have negative impact on soil make it unfavourable for plant yields. Therefore, wastewater should not be used directly on crops without sufficient treatment or dilution with water. There is however the need for further evaluation or assessment of environmental health challenges associated with beauty salon waste disposal.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Raschid-Sally L, Jayakody P. Drivers and characteristics of wastewater agriculture in developing countries: Results from a global assessment, Colombo, Sri Lanka. IWMI Research Report, International Water Management Institute, Colombo. 2008:127.
2. Farahat E, Linderholm HW. The effect of long-term wastewater irrigation on accumulation and transfer of heavy metals in *Cupressus sempervirens* leaves and adjacent soils. Science of the Total Environment. 2015;512–5131-7.
3. Heidarpour M, Mostafazadeh-Fard B, Abedi Koupai J, Malekian R. The effects of treated wastewater on soil chemical properties using subsurface and surface irrigation methods. Agric. Water Manag. 2007;90:87-94.
4. Singh PK, Deshbhratrar PB, Ramteke DS. Effects of sewage wastewater irrigation on soil properties, crop yield and environment. Agric. Water Manag. 2011;103:100–104.
5. Rusan MJ, Hinnawi S, Rousan L. Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters. Desalination. 2007;215:143-152.
6. Ghanbari A, Abedikoupai J, Taie Semiromi J. Effect of municipal wastewater irrigation on yield and quality of wheat and some soil properties in sistan zone. J. Sci. Technol. Agric. Natural Recou. 2007;10:59-74.
7. Mohammad MJ, Ayadi M. Forage yield and nutrient uptake as influenced by secondary treated wastewater. Journal of Plant Nutrition. 2004;27(2):351-365.
8. Kiziloglu FM, Turan M, Sahin U, Angin I, Anapali O, Okuroglu M. Effect of wastewater irrigation on soil and cabbage-plant (*Brassica oleracea*) chemical properties. Journal of Plant Nutrition and Soil Science. 2007;170:166-172.
9. Siebe C. Nutrient inputs to soils and their uptake by alfalfa through long-term irrigation with untreated sewage effluent in Mexico. Soil Use Manage. 1998;13:1-5.
10. Aghtape A, Ghanbari A, Sirousmehr A, Siahsar B, Asgharipour M, Tavssol A. Effect of irrigation with wastewater and foliar fertilizer application on some forage characteristics of foxtail millet (*Setaria italica*). International Journal of Plant Physiology and Biochemistry. 2011;3(3):34-42.
11. Tavssoli A, Ghanbari A, Amiri E, Paygozar Y. Effect of municipal wastewater with manure and fertilizer on yield and quality characteristics of forage in corn. African Journal of Biotechnology. 2010;9(17):2515-2520.
12. Abu Nada Ziyad. Long term impact of wastewater irrigation on soil and crop quality parameters in Gaza strip. Master Thesis, Islamic University of Gaza; 2009.
13. Khurana MPS, Singh P. Waste water use in crop production: A review. Resources and Environment. 2012;2(4):116-131.

14. Nadav I, Tarchitzky J, Chen Y. Water repellency induced by Organic Matter (OM) in Treated Wastewater (TW) infiltration ponds and irrigation. In: Jianming X, Jianjun W, Yan H.(Eds.). Functions of Natural Organic Matter in Changing Environment. Springer, Netherlands. 2013:883–887.

15. Zavadil J. The effect of municipal wastewater irrigation on the yield and quality of vegetables and crops. Soil and Water Resource. 2009;4(3):91–103.

16. Ogle BM, Johansson M, Tuyet PV. Evaluation of the significance of dietary foliage from wild vegetables in Vietnam. Asia Pacific Journal of Clinical Nutrition. 2001:216-221.

17. Arai S. Global view on functional foods: Asian perspectives. British Journal of Nutrition. 2002;88:139-143.

18. Arnon DT. Copper enzymes in isolated chloroplast: Polyphenol oxidase in Beta vulgaris. Plant Physiology. 1949;24:1-15.

19. Day AD, Mc Fadyen JA, Tucker TC, Cluff CB. Effects of municipal wastewater on the yield and quality of cotton. Journal of Environmental Quality. 1981;10:47-49.

20. Kizilolgu FM, Turan M, Sahin U, Kuslu Y, Dursun A. Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (Brassica oleracea) grown on calcareous soil in Turkey. Agricultural Water Management. 2008;95:716-24.

21. Gatta G, Libutti A, Gagliardi A, Beneduce L, Brusetti L, Borruso L, Disciglio G, Tarantino E. Treated agro-industrial wastewater irrigation of tomato crop: Effects on qualitative/quantitative characteristics of production and microbiological properties of the soil. Agricultural Water Management. 2015;149:33-43.

22. Bedbabis S, Trigui D, Ahmed CB, Clodoveo ML, Camposeo S, Vivaldi GA, Rouina BB. Long-terms effects of irrigation with treated municipal wastewater on soil, yield and olive oil quality. Agricultural Water Management. 2015;160:14-21.

23. Qaryouti M, Bani-Hani N, Abu-Sharar TM, Shnikat I, Hiari M, Radiadeh M. Effect of using raw waste water from food industry on soil fertility, cucumber and tomato growth, yield and fruit quality. Scientia Horticulturae. 2015;193:99–104.

24. Day AD, Rahman A, Katterman FR, Jensen V. Effects of treated municipal wastewater and commercial fertilizer on growth, fibre, acid-soluble nucleotides, protein and amino acid content in wheat hay. Journal of Environmental Quality. 1974;3:17-19.

25. Juwarkar AS, Juwarkar A, Deshratbar PB, Bal AS. Exploration of nutrient potential of domestic and sludge through and land application. RAPA Report. 1990;178-201.

26. Nissim WG, Jerbi A, Lafleur B, Fluet R, Labrecque M. Willows for the treatment of municipal wastewater: Performance under different irrigation rates. Ecological Engineering. 2015;81:395-404.

27. Jiménez B, Chávez A, Hernández C. Alternative wastewater treatment intended for agricultural use. Water Science and Technology. 1999:40(4-5):355-362.

28. Golchin L, Salmasi SZ, Shafagh-Kolvanagh J, Shahin Oustan, Shokati B, Hashemi-Amidi N, Haghverdi H. Effects of irrigation times and wastewater concentration of a leaven producing factory (Iran Mayeh) on some morphological characters of alfalfa. Int J Agri Crop Sci. 2013;5 (23):2831-2836.

29. El Youssfi L, Choukr-Allah R, Zaatrani M, Mediouni T, Ba Samba M, Hirich A. Effect of domestic treated wastewater use on three varieties of quinoa (Chenopodium quinoa) under semi arid conditions. International Science Index. 2012;6(8):116-119. Available:waset.org/Publication/8903.

30. Misra RK, Patel JH, Baxi VR. Removal of pollutants by tomato plants during-use of laundry greywater for irrigation. International Conference on Food Security and Environmental Sustainability (FSES). 2009:6(2):407-409.

31. Gupta SP, Gajender Yadav RK, Magan S, Koushik P. Effect of irrigation schedules of domestic waste water on growth and yield of fodder sorghum. Indian Journal of Small Ruminants. 2015;21:2,257-263. DOI : 10.9598/0973-9718.2015.00073.2.

32. Zema DA, Bombino G, Andioloro S, Zimbone SM. Irrigation of energy crops with urban wastewater: Effects on biomass yields, soils and heating values. Agricultural Water Management. 2012;115:55-65.
33. Ntzala G, Kalavrouziotis IK, Koukoulakis PH, Papadopoulos AH. Impact of sludge and wastewater on Lactuca sativa L. Growth and on soil pollution. Global Nest Journal. 2015;17(1): 148-161.

34. Babyshakila P, Usha K. Effect of diluted effluents on soil properties and plant growth. Journal of Advanced studies in Biology, 2009;1(8):391-398.

35. Al-Jaloud AA, Hussain G, Al-Saati AJ, Karimulla S. Effect of wastewater irrigation on mineral composition of corn and sorghum plants in a pot experiment. Journal of Plant Nutrition. 1995; 18:1677-1692.

36. Vasquez-montiel O, Horan NJ, Mara DD. Management of domestic wastewater for reuse in irrigation. Water Science Technology. 1996;33(10–11):355–362.

37. Fonseca AF, Melfi AJ, Montes CR. Maize growth and changes in soil fertility after irrigation with treated sewage effluent, plant dry matter yield and soil nitrogen and phosphorus availability. Journal of Soil Science. 2005;36:1965-1981.

38. Sahai R, Singh SP. Effect of domestic waste on the growth performance of Ceratophyllum demersum Linn. Indian J. Ecol. 1977;4:118-120.

39. Banerji D, Kumar N. The twin effect of growth and heavy metal accumulation in certain crop plants by polluted irrigation water. Indian J. Ecol. 1979;6:82-87.

40. Singh A, Srivastava ON. Effect of pesticides on the growth of Azolla pinnata R. Brown. Indian J. Ecol. 1984;11:12-14.

41. Agarwal SC, Kumar A, Sharma OP. Effect of excess supply of heavy metals on barley during germination with special reference to catalase and peroxidase. Nature. 1961;191:720-727.