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Reuse of Wastewater for Crop Production: Effects on Macronutrients Content of *Celosia Argentea* Vegetable

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Uses of wastewater in agriculture are a viable option in solving water scarcity, food security and improving environmental hygiene. Vegetable being a good source of plant protein, fat and carbohydrates is not readily available round the year due to shortage of irrigation water. Effect of wastewater irrigation on the macronutrients contents of *Celosia argentea* vegetable was investigated. Three wastewater types (laundry/bathroom, BW, abattoir wastewater, AW and cassava effluent, CE) were used to grow the vegetable in potted experiment. The vegetable was also grown with rainwater to serve as a control. Harvested vegetable from the different wastewater treatments were analyzed for their macronutrient contents. The Analysis of variance (ANOVA) of the results was performed at a confidence level of 95 % ($p < 0.05$), and the mean was separated using DMRT in Statistical Package for Social Sciences (SPSS). Analyses revealed that protein content of the vegetable decrease in the order BW (18.03%) > AW (15.64%) > CE (8.68%) > RW (8.52%). The fat content was in the order AW (6.27%) > BW (5.95%)> CE (4.72%) > RW (4.22%). The effect of different wastewater used was not significantly different on carbohydrate content of the plant which is between 24.9 and 26.0%. The effect of the treatments on the moisture content of plant was found not to be significantly different from the control ($p< 0.05$) (AW (11.24%); BLW (11.01); CE (11.23) and RW (11.23)).

The results of the experiments show that irrigating with wastewater improves the macro nutrients of *Celosia argentea* vegetable. It however recommended that more works be done on wastewater effect on other proximate values of the vegetables.

Keywords: Wastewater, Slaughterhouse, Cassava effluence, Bathroom, Macronutrients.

Introduction

The current high demand for fresh water has made it a very important resource that must be carefully managed. The quantity of fresh water available

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for agriculture has been greatly reduced due to increase in population, low rainfall, frequent droughts, industrialization and urbanization. Due to this very reasons, adoption of wastewater has being in practice in most of the developing and the developed countries (World Bank 1995). Wastewater is being generated in a very large quantity in our day to day living and in all sectors for different purposes. This wastewater is generated in industries, food processing factories, other companies and even in the house by cooking, washing, bathing and for other purposes. The volume of water used for hygienic purposes per day is based on age, location and seasons. Each person in a household averagely uses 80 - 100 liters daily (U.S GeologicalSurvey 2013). According to the result released by the Nigeria National Bureau of Statistics; Nigeria population is 178,571,721 in the year 2014. Based on this information, average volume of wastewater generated in a day will be about 18 billion liters. The presence of this large amount of wastewater constitutes great environmental problems; it, among others, generates foul odour and serves as a breeding spot for mosquitoes (WHO 2006; Coker *et al*., 2001 and Osibajo and Adie 2007). The use of wastewater for irrigation purposes reduces the pollution of rivers which otherwise would serve as receiving bodies for discharged wastewater. It also reduces the cost of wastewater disposal (Scott *et al*., 2004).

Vegetable are good sources of oil, carbohydrates, mineral and vitamins depending on type (Ihekoronye and Ngoddy 1985). It has been reported that vegetable fat and oil reduce the incidence of high blood pressure (Onunogbu 2002). The demand for vegetables in the cities and towns has stimulated the growth of commercial production of the product. Vegetables are rich and comparatively cheaper source of nutrients in developing countries. Their consumption provides taste, palatability, increases appetite and provides fiber for digestion and prevents constipation. They also play key role in neutralizing the acids produced during digestion of pretentious and fatty foods, and provide valuable roughages which help in movement of food in intestine. Vegetables find their importance in many dimensions in that they can be taken as food, used in pharmaceutical companies and other industrial applications and serves as a source of employment and income for the grower.

Considering the importance of vegetables in human diet while trying to prevent environmental problems, the use of wastewater for the production of vegetable and its effect on the macronutrient of *Celosia argentea* will be a welcome investigation. *Celosia argentea* is a very popular vegetable that derived its name from the Greek word “kelos” meaning burned. It is called “sokoyokoto” in the south Western Nigeria, meaning the vegetable that make husbands look fresh. While the concern for human health and the environment are the most important constraints in the reuse of wastewater, the importance of this practice for the livelihoods of countless smallholders must also be taken into account.

Objectives: The objective of this work is to determine the potential of using

Waste water for the production of *Celosia argentea.*

Materials and methods

The experiment was carried out in the screen house of the Agricultural Engineering Department, Ladoke Akintola University of Technology, Ogbomoso between the month of January and September 2014. The effect of wastewater irrigation on *Celosia argentea* was carried out using three types of wastewater viz; laundry/bathroom wastewater (BW), slaughterhouse (AW), cassava effluent (CE). Rainwater (RW) was used as control. The three wastewater types that were used for this work were collected and kept in different water drum within the experimental site during the experiment. Three types of raw untreated wastewaters were collected and rainwater (RW) was used as the control. The waste waters are abattoir wastewater (AW), bathroom and laundry wastewater (BW) and cassava effluent (CE). AW was collected from the outlet of the drain of the slaughtering slab at Atenda abattoir in Ogbomoso. This was done immediately after the animals were slaughtered and the slab flushed. BW was collected from bathrooms and laundries in some student hostels of LAUTECH, while the CE was collected from a garri processing factory at Aarada market in Ogbomoso. RW was collected through a clean roof gutter attached to the roof of the screen house. The raw wastewater samples were kept in bottles that have been soaked for 24 h in HNO3 solution to kill any microbes. The bottles were labeled accordingly, sealed, refrigerated and taken to the laboratory within 24 h of collection for analysis. The chemical properties analyzed include HCO^{3-}, Na^{+}, Ca2+, Mg^{2+}, Total suspended solid (TSS), Total Dissolved Solid (TDS), Biochemical Oxygen Demand (BOD5), pH, Electrical Conductivity (EC) and CN^{-}, using standard laboratory procedures. All analyses on the wastewater were done according to the standard procedure of (APHA 1998).

The effects of the selected wastewater (BW, AW and CE) on the macronutrient of the plant was investigated by using lysimetric experiment. The lysimeter was made of zero tension circular mini-lysimeters of 0.255 m diameter and 0.22 m height. The vegetable were planted and nursed before transplanting them into the lysimeters. The transplanted vegetables were adequately irrigated with rain water for one week. The major treatment with the wastewater started after a week of transplanting. The *Celosia argentea* stands were regularly wetted with wastewater as assigned to each lysimeter during the growing period. The same volume of waste water (as well as rainwater) was used to irrigate the vegetable as designated. Each treatment of the waste water as well as the control was replicated three times, making a total of twelve lysimeters with three stand of *Celosia argentea* vegetable on each. The fully grown vegetables leaves were harvested and thoroughly washed with distilled water to remove any dust particles and then air dried for an hour before dried in the electrical oven at 70 ^{o}C for a day to remove all moisture content. The dried samples were ground and sieved to obtain fine powder. All the samples were sealed and labeled in polythene bags for further analyses.

The samples were tested for macronutrient (protein, fat and carbohydrates) composition. Moisture content was determined by oven drying method. This was done by oven drying the vegetable leave at 70 ^{o}C to a constant weight. Crude protein was determined by estimating the nitrogen of the powdered samples using Kjeldhal method. Crude fat was determined by ether extraction method using Sohetech. The experiments were replicated three times in accordance with (AOAC 1997).

Statistical Analysis

The Analysis of variance (ANOVA) of the results was performed at a confidence level of ($P<0.05$) using Statistical Package for Social Scientist (SPSS).

Results and Discussions

Results of chemical composition of the waters

The chemical characteristics of the wastewaters and rainwater used are presented in Table 1. The pH of the wastewaters was very low compare to the rainwater (control) which means the wastewater is more acidic. The pH of all the three wastewaters used except CE (pH = 4±0.4) are within the range (4.5-6.5) recommendation by the WHO for wastewater use for irrigation purposes (WHO 2006). The total suspended solid (TSS) in AW was found to be within the acceptable range of WHO (50 mg/l), while the TSS of BWL and CE was found to be outside the acceptable limits of the WHO wastewater regulation. This necessitates the needs for wastewater treatments before using for irrigation.

Table 1: Characteristics of Different Wastewater types used for irrigating the *Celosia argentea*

Parameters	RW	BLW	CE	AW

Ca (ppm)	1010.5 ±26.5	1980.3± 20.5	1510.24±26.23	2120.33 ± 32.5
Mg (ppm)	2100.0± 29	2300.7±32.	3200±30.3	2200.3±22.1
Na (ppm)	2000.2± 34.2	5000.0± 25.5	2800± 25.6	4800.0 ± 53.2
Conductivity(µS/cm)	53.9± 2.1	836.2± 15	4.08± 0.8	2.81 ±0.03
TDS (mg/l)	34.7± 5.2	589.0± 32.0	3.09± 0.03	2.29 ±0.07
TSS (mg/l)	260.56±8.0	104.4± 2.4	312 ± 9.5	1875.0 ± 30.4
BOD (mg/l)	6.75±0.6	67.4± 3.1	73.44± 2.3	455.2 ± 3.4
Oil & Grease (mg/l)	462±12	412.6± 22.1	6856 ± 55.6	158.05 ±3.5
pH	4.8±0.02	5.7.3± 0.7	4.0± 0.4	6.7 ± 1.2
CN^- (mg/l)	0.021±0.002	0.04± 0.004	0.08 ±0.01	0.016 ± 0.001
HCO_3- (g/l)	0.186±0.03	0.246± 0.01	0.96 ± 0.01	1.48 ± 0.02

The TDS of the wastewaters was found to be within the recommended values of 450 mg/L, except that of BLW which is higher (589 mg/L). It was observed that the total dissolved solid (TDS) measured here was found to be lower than those reported by (Josef 2009). Most organic compounds of animal or plant origin contain in swage are rapidly decomposed in soil which means its presence may increase the soil fertility if properly handled.

(Darrel 2002) reported that BOD between 110 and 400 mg/L improves microbial activity and soil fertility thereby increases productivity. The BOD reported in this experiment is in the range (100 mg/L) prescribed in WHO standard for wastewater for irrigation. The result of the experiment also shows that the HCO_3 was also within the WHO recommendations.

Effect of Wastewater type on the Macronutrients

The results of the experiment on the effect of wastewater on the macronutrients (Protein, Fat Carbohydrate and Moisture content) composition of *Celosia argentea* vegetables are as presented in Tables 2.

Table 2: Proximate Composition of *Celosia argentea*

Parameters	AW	BW	CE	RW
Protein (%)	15.64^{b}	18.03^{b}	8.68^{a}	8.52^{a}
Fat (%)	6.27^{a}	5.95^{a}	4.83^{a}	4.72^{a}
Carbohydrate (%)	25.4^{a}	25.8^{a}	26.0^{a}	24.9^{a}
Moisture content (%)	11.24^{a}	11.01^{a}	11.23^{a}	11.23^{a}

It was observed that except for the moisture content where the value (11.01 %) for BW treatment is less than that of the RW, the macronutrient values of the vegetable increase generally with the use of wastewater. There were no statistical significant differences in all the macronutrients for all the wastewater treatments and control except in protein content.

Effect of Wastewater type on the Protein content of Celosia argentea

The result of the statistical analysis shows that the higher protein content of the plant irrigated with BL and AW was significant ($P < 0.05$) while protein of the plant irrigated with CE was not significantly different with the protein in the control (RW) (Table 2). The use of wastewater lead to an increase in protein content of the vegetable when compared with the control (RW); the protein content increase from 8.52 to 8.68 % (for CE), 8.52 to 15.64 (for WA) and 8.52 to 18.03 (for BW). Fig. 1 shows the protein content of the wastewater treatments and the control. The protein content recorded was higher than the one reported for same crop by (Ajiboye *et al*., 2014) and (Leung *et al*., 1968) which is 6.2 % and 4.7 % respectively and also higher than that reported for *Alchornea cordifolia* (4.3 %) (Philip and Owen 2014), cabbage (1.6 %), lettuce (1.2 %) and spinach (2.1%) as reported by (Rumeza et al., 2006). However the protein content was lower than those of *Heinsia crinite* (11.38 %) as reported (Asaolu *et al*., 20012) and 30.79 % as reported by (Yakeen *et al*., 2013) for same crop. These differences may be due to soil type, components of the wastewater used and other treatment applied.

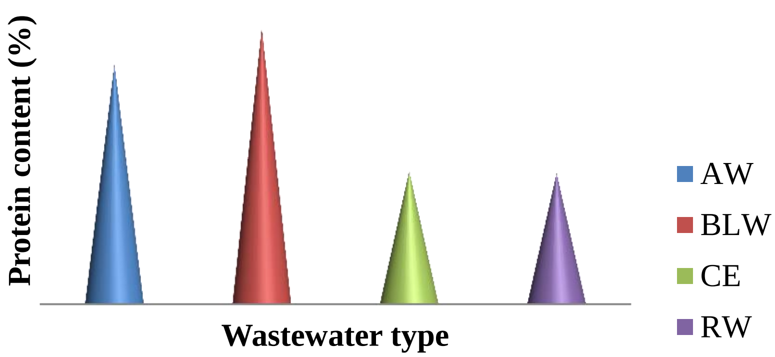

Fig. 1: Effect of waste water type on Protein content of *Celosia argentea*

Effect of Wastewater type on Fat Composition of Celosia argentea

It was observed that fat composition of *Celosia argentea* was highest (6.27 %) for AW irrigation treatment followed by BW (5.95 %) and CE (4.83 %). The fat compositions under different treatments are presented in Fig. 2. Although the fat composition of all the treatment was higher than that of RW (4.72 %), the control but the statistical analysis shows that the difference was not significant ($P < 0.05$). The fat composition of the treatment in this experiment was found to be higher than the one reported by (Yekeen *et al*., 2013) (0.22 %) for same crop (Ogungbenle and Otemuyiwa 2015) for *Forcelosia specata* leaves (1.15 %). The fat composition of the vegetable was found to be less than 10 % in all the four treatment (Fig. 2) which shows that the vegetable has low oil content. The low oil content of the vegetable will be of advantage when consumed in large quantity by people suffering from overweight or obesity (Saidu and Jideobi 2009).

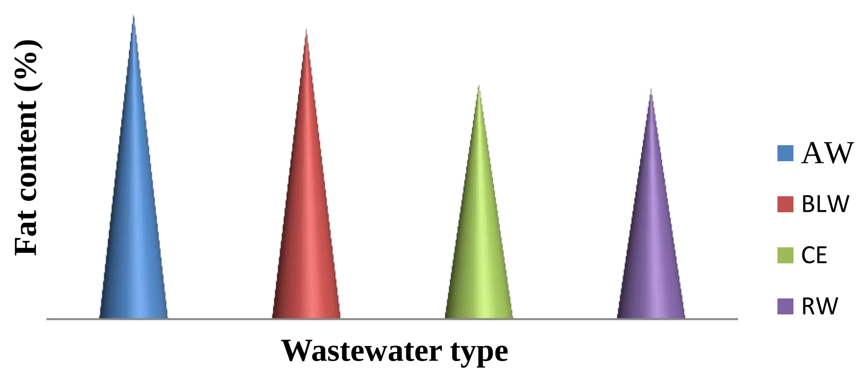

Fig. 2: Effect of waste water type on Fat content of *Celosia argentea*

Effect of Wastewater type on carbohydrate content of Celosia argentea

The carbohydrate content of the vegetable (Fig. 3) was found to be highest (26.0 %) in CE treatment followed by RW (24.2 %), BW (23.8 %) and AW (25.4 %). The results of the effect of wastewater on carbohydrate composition of the vegetable were found to be insignificant at ($P < 0.05$). The carbohydrate content was found to be lower than the one reported for *Celosia spicata* leaves (47.6 %) (Ogungbenle and Otemuyiwa 2015) and 31.41 % reported for same crop by (Yekeen *et al*., 2013). The low carbohydrate content of the crop would be very useful in the management of diabetes mellitus (Tanya *et al*., 1997) and overweight.

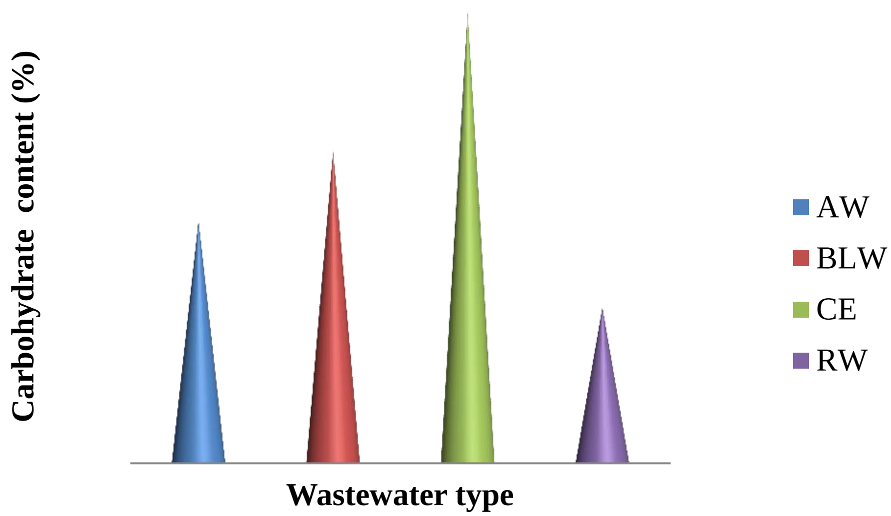

Fig. 3: Effect of waste water type on Carbohydrate content of *Celosia argentea*

Effect of Wastewater type on Moisture Content of Celosia argentea

It was observed that *Celosia argentea* has a close range of moisture content (11.01 – 11.24 %) in all treatments (Fig. 4). The result on the moisture was found to be insignificant (P <0.05) different from all the treatments. The moisture content was found to be higher than those reported for *Amaranthus viridis* (10.4 %) (Olaofe *et al*., 2013) and *Velvet fermarind* (8.22 %) (Ogungbenle and Ebadan 2014). The higher moisture content in the vegetable will help in aiding digestion processes in the stomach. Fig. 4 shows the moisture content of the vegetable under different wastewater treatments.

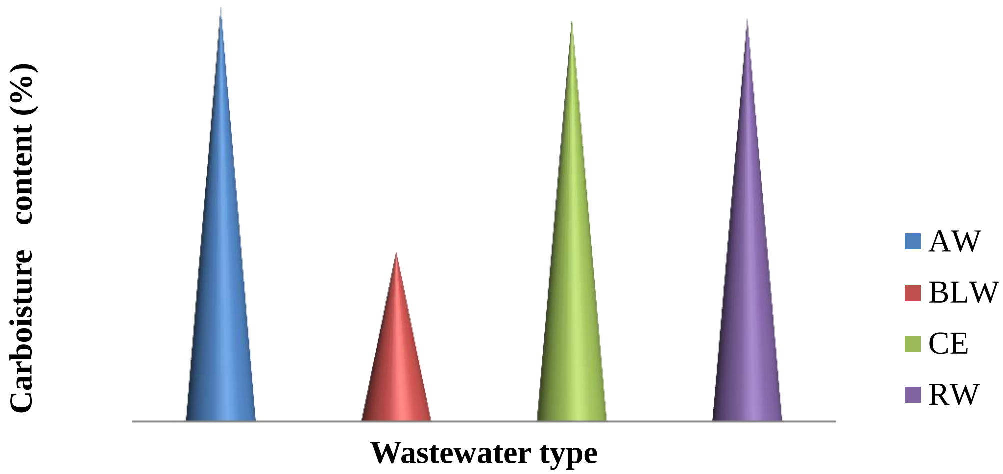

Fig. 4: Effect of wastewater type on Moisture content of *Celosia argentea*

Conclusions

This paper presents the results of the effects of using three different wastewaters on some selected macronutrients characteristics of *Celosia argentea*. A significant difference in the protein content of the vegetable was observed with the wastewater treatments. The protein content of the vegetable was highest when bathroom/laundry wastewater was used. Although statistically not significant, the fat, carbohydrate and moisture content were found to increase under this treatments of selected wastewaters when compare with the results from rainwater treatment. The values of the micronutrients obtained from the work make the vegetable to be consumable. However, further works on such things as heavy metal uptake of the vegetable under similar treatments are recommended to ensure the complete safety on consumption of the vegetable grown with wastewater irrigation.

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