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RECYCLING OF GREYWATER FOR AGRICULTURAL IRRIGATION: PANACEA TO HOUSEHOLD WASTE WATER MANAGEMENT

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Abstract
Greywater has been identified as a widespread problem in all categories of dense settlements in Africa, due to poor or absence of waste management, thus, the quest for sustainable wastewater management. The suitability of greywater for growth and yield improvement in tomato (Solanum lycopersicum L.) and sweet pepper (Capsicum annuum L.), widely grown as field and home garden vegetables in Nigeria were tested. Seedlings grown in perforated plastic pots filled with 10 Kg top soil were irrigated till maturity with 20, 40, 60, 80 or 100% greywater while those irrigated with tap water served as the control (0%). Greywater-irrigated vegetables were taller with more number of branches and leaves than tap water-irrigated ones, but there was a general growth reduction at 100% grey water regime. Yield parameters including fruit fresh weight, fruit dry weight and number of fruits/plant were also enhanced by tap water-diluted greywater with a reduction at 100% concentration. Greywater increased mineral nutrients including N, P, K, Ca, Mg and Na in soil and fruits of test plants relative to the control. The soil and fruits of greywater-treated plants had higher concentrations of heavy metals; Cu, Zn, Pb and Cr but at a permissible level. Fruit percentage crude fibre was unaffected, protein, soluble carbohydrate and ash were generally increased in both plants while fat content was reduced by greywater at 100% regime in tomato fruits only. Reuse of greywater by dilution at 20-80% have a double-edged positive impact; it responds to the perennial quests for sustainable wastewater management and contributes to sustainable agriculture. However, there should be appropriate guidelines through research on the control and amelioration of the negative environmental impacts of repeated greywater re-use, which will further help improve overall wastewater usage and promote public acceptance of the concept.

Keywords: **Tomato, pepper, yield, fruit nutrient and proximate, domestic waste recycling, soil.**

Introduction
Tomato (*Solanum Lycopersicum* L.) and sweet pepper (*Capsicum annum* L.) are high-value vegetable crops with high nutritive value, which occupy an important place in healthy daily diet They are widely grown in Nigeria both on the field and home gardens. The continuous demand for these vegetables has increased the need to cultivate them all year round, hence, the dependence on greywater or its use to augment the freshwater during the dry seasons or periods of drought becomes necessary.

Increasing world population and industrial as well as urban expansion have increased water demand. Since 1950, the world population has doubled while water consumption has increased six-fold, and it is expected that 3.4 billion people will be living in countries defined as water-scarce by 2025 (DFID, 2007). Research estimation shows that 37% of the global population will face severe water stress by 2020, and war experts believe it will lead to the next world war. There will be no choice but to fight, and maybe even kill, for the remaining glass of dirty water for survival (Rodda et a., 2011). Hence, scientists around the globe are working on new ways of conserving water. One major way has been to refocus on how to recycle water through the use of wastewater for irrigation and other purposes. In recent times, production of wastewater and its reuse has grown rapidly. Rough estimates indicate that at least 20 million hectares of land in 50 countries are irrigated with raw or partially treated wastewater (Van der Hoek *et al,* 2001). In many countries where sanitation and treatment facilities are poorly developed, and are not a priority, untreated wastewater is a major source of irrigation water and the farmers' livelihood depends on it, particularly in areas where there exists no central source of freshwater supply. Research has shown that farmers use waste water due to lack of freshwater, high cost of fresh water supply from private owners and nutrient availability in waste water as a cheaper alternative to fertilizer application (Emenyonu *et al*., 2010).

Although, there are other sources, domestic waste water, farmhouse wastewater from livestock farmers and flood water are the major sources of wastewater used for irrigation in Nigeria, in which domestic wastewater (greywater) has been identified to be the most easily available to farmers particularly in their home gardens (Emenyonu et a., 2010; Nwajuaku *et al*., 2015a, 2015b). Greywater is the non-toilet component of household wastewater that originates predominantly from laundries, bathrooms and kitchen (Rodda *et al*., 2011; Nwajuaku *et al*., 2015a, 2015b). It comprises 50-80% of residential wastewater (Ukpong and Agunwamba**,** 2012). It usually contains varying levels of suspended solids, salts, nutrients, organic matter and pathogens (Howard *et al*., 2005). Greywater contains surfactants, builders, bleaching and auxiliary agents or additives from soap and detergents as well as other household cleaning and personal care products. Although, this used water may contain grease, oil, food particles, hair and a number of other impurities, it often contains nutrients such as nitrogen (N), ammonia (NH_3) and phosphate (PO_4), and increases the total organic matter load in the soil, which are useful for plant growth and productivity (Ahmed *et al*., 2001).

Greywater disposal in Nigeria is by means of dug pit and through sewers connected to soak away tanks. The most common means is by allowing it to flow on roads or in open streets channels (gutter), which provides convenient ground for breeding germs, disease vectors and an eye sore with offensive odour (Kagu *et al*., 2013).

Most research on greywater has focused on the public health risks associated with it (Ottoson and Stenstrom, 2003; Gross *et al*., 2005) with little information on its potential reuse for agricultural productivity and the interaction of soils and plants with it.

There are insufficient reports currently available to indicate how growth and nutrient deficiency or toxicity symptoms may arise in plants if irrigated with it. Also, there is the need to go beyond the reuse of greywater in relation to its quality and effect on crop biomass to investigating the yield and quality of edible vegetable crops. In view of the foregoing, this study is targeted towards recycling greywater for growth and yield improvement in tomato and sweet pepper. The fruit nutritional quality of the crops were also investigated to ascertain their suitability for consumption. This will not only prevent water wastage, it will also respond to the perennial quests for sustainable wastewater management and contributes to sustainable agriculture.

Materials and Method

Plant materials: Seeds of two vegetable crops widely grown in Nigeria, local tomato variety and sweet pepper purchased from the Agricultural Development Programme Office in Ondo State, Nigeria were used to raise seedlings in large perforated plastic bowls. The tomato and pepper seedlings were transplanted into perforated plastic pots (30 cm diameter and 33 cm depth) filled with 10 kg of top soil at 3 and 4 weeks respectively after sowing.

Experimental location and set up: The study was conducted at the screen house of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria ($7^0 37^1$N latitude, $5^0 44^1$E Longitude and 100 m above the mean sea level). Five seedlings of each plant not used for the experiment but part of the seedlings raised were accessed for the initial biomass before the commencement of treatment. Treatment of plants commenced at one week after transplanting by irrigating plants separately with 250 ml (volume enough to keep the soil moist) of either 0 (tap water control) or 25, 50 and 75% greywater prepared by dilution with tap water or with 100% greywater. Irrigation was done at the root zone three times per week till maturity. Each treatment was replicated five times with single plant replicate per pot, and were arranged on the screen house bench in a completely randomized form.

Plant height was measured from the base of the stem to apical bud, using meter rule while stem girth was measured using digital Vernier caliper at 5cm from the base of the stem. Plant fruits were harvested at the end of the experiment, they were counted and weighed. The plants were carefully uprooted after soaking the soil with water to prevent root damage. The roots were washed, counted and their length measured. The leaves, branches and fruits were counted. Fresh plant parts were weighed fresh and after drying in an oven at 80^0 to constant weight, the root dry mass was divided by that of the shoot to give root: shoot ratio. The dry mass of leaf, stem and root made up the total biomass. Relative growth rate was calculated using the formula:

Relative growth rate = In mass 2 –In mass 1/tpime (days), where mass 1= the initial biomass at the commencement of the experiment, mass 2= total biomass at the end of the experiment, time = the period interval between the two biomass determination in days.

Greywater: Greywater was collected early in the morning from several households in Akungba Akoko by placing plastic containers at sewers connected to their soak away tanks. The different levels of treatment was prepared from thoroughly mixed greywater generated overnight for irrigation at approximately 0800hr. The plastic containers were always returned to the households at the day preceding treatment applications. Ten water samples were taken after preparation at different proportions for some chemical characteristics following the standard procedure of AOAC (1998).

Planting medium: Top soil collected from the experimental farm of the Department of Plant Science and Biotechnology was used as planting medium. Samples of the soil were collected from the experimental pots at the end of the experiment immediately after plants were removed. The samples were shade-dried, passed through a 2-mm sieve, and analyzed for the physico-chemical parameters according to AOAC (1998). Particle distribution was obtained using the rapid method, while pH was measured in 1:1 soil: water suspension with pH meter. Nitrogen was determined by the modified Kjeldahl method while phosphorus was assayed by Bray's P1 solution and read on a spectrophotometer. Cations were extracted with 1.0 M ammonium acetate solution at pH 7.0; Na and K were determined by flame photometry while Ca, Mg, Zn, Cu, Pb and Cr were obtained by atomic absorption spectrophotometry. Organic carbon was determined by the wet oxidation method while cation exchange capacity (CEC) was by ammonium distillation method. Soil analysis took place at the Central Laboratory of National Institute for Oil Palm Research (NIFOR), Nigeria.

Phytochemical analysis**:** Three plant samples from each treatment were oven- dried at a pre-set temperature of 195^0 for 24 hours and thereafter milled into fine powder with the aid of a milling machine. Moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents of the dry tomato and pepper flours were determined according to AOAC (1998). Sodium and potassium were determined using a flame photometer (Corning, UK model 405). Phosphorous was determined colourimetrically using spectronic 20 (Gallenkemp, UK). Mg was determined by EDTA titration while Ca, Cr, Cu, Pb and Zn were determined using Atomic absorption spectrophotometer (Buck 210). Phytochemical analysis took place at the Central Laboratory of National Institute for Oil Palm Research (NIFOR), Nigeria.

Statistical analysis: All data were statistically analyzed using the statistical package for Social Sciences (SPSS Version 20.0). Statistical means were separated using Tukey Honest Significant Difference (HSD) test at 95% level of significance.

Results and Discussion

Water analysis**:** The pH of greywater showed that it was more acidic than that of tap water (control), with values that did not significantly differ from the control (Table 1). The pH tending towards acidity can be attributed to the presence of acid foods like tomato, which contains 9% of citric acid, 4% malic acid and 2% dicarboxylic acid (Petro-Turza, 1987) as well as cooking oil containing different kinds of fatty acids (Noureddini *et al*., 1992). The pH range of the greywater at all levels in this study falls within an accepted range between 6.5 and 8.4 pH indicating the likelihood that this water is suitable for irrigation (Mzini, 2013). The electrical conductivity, turbidity, biological oxygen demand, chemical oxygen demand, total suspended solid, sodium and chloride ions were significantly higher under greywater than in the control. All concentrations were lower in diluted greywater than in the concentrated greywater solution. Greywater often contains excessive salts, total suspended solids, with elevated biochemical oxygen demand and nutrients such as nitrogen, ammonia and phosphate (Ahmed *et al*., 2001). The increase in Na and Cl concentrations is an indication that greywater contains salts, which must have arisen from cooking activities. In previous studies, Al-Jayyousi (2004) and Mzini (2013) reported higher salinity in greywater than in those diluted with rainwater.

***Soil analysis*:** Soil pH was observed to be reduced by greywater treatment (Table 2). Researchers have previously found that pH of soils irrigated with greywater become significantly lower than that of the freshwater irrigated soils due to probability of enhanced bacterial activities such as respiration (Weil-Shafran *et al*., 2006). The concentration of soil Na was more in soil irrigated with greywater similar to the report that Na was found to be almost three times higher in greywater-treated soil compared to that of potable water irrigated soils.

Concentrations of heavy metals in soil increased with increase in the proportion of greywater in the water used for irrigation (Table 3). There was however no significant difference between the control and greywater-treated samples except for Cu and Zn at 80-100% greywater treatment levels. This agrees with the findings that greywater contained heavy metals including Zn and Cu (Mzini, 2013). Greywater was found to increase the soil organic content in this study. In a previous research, indiscriminate discharge of greywater into water bodies and environment was said to contribute to the alarming increase in total organic matter load in the soil (Ahmed *et al*., 2001). Greywater usually contains varying levels of suspended solids, salts, nutrients, organic matter and pathogens (Howard *et al*., 2005).

Plant growth and yield: A significant increase in growth and yield was observed in plants irrigated with diluted greywater compared to other treatments. All growth parameters including plant height, number of leaves and branches as well as the number of roots/plant were significantly improved by diluted greywater relative to the control (Table 4). A similar trend was obtained in fresh weight and dry weight of plant parts, total biomass and relative growth rate (Table 5). Diluted greywater also increased number of fruits/plant, fruit fresh weight, fruit yield/plant as well as fruit moisture content (Table 6). There was a general decrease in all the parameters under 100% greywater treatment compared to others except in stem girth, which did not show any significant difference from the control (Table 4). Similarly, diluted municipal greywater at a rate of 1:1 resulted in taller *Gossypium spp* with more vegetative growth (Day *et al*., 1981), and Misra *et al*. (2009) reported similar results in S*olanum lycoperscum*, which they attributed to the presence of essential nutrients in greywater. The root: shoot ratio of plants irrigated with diluted greywater has lower values than that of the control, showing that more resources were allocated to shoot growth at the expense of root, thus shoot productivity was favoured. The increase in root: shoot ratio at 100% greywater treatment however was suggestive of the shoot growth more negatively affected than the root growth by greywater. The general decrease in growth and yield at 100% grey water treatment can be attributed to multiplicity of factors. For example, high Na content in soil had the effect of disturbing soil structure through swelling and dispersion phenomena (Halliwell *et al*., 2001). They explained that Ca flocculate and Na disperse soil particles, resulting in soil crusting, which in turn adversely affects infiltration and permeability of water. The presence of oil and grease makes soils to form scums, reduces soil aeration and causes water repellence. All these might have been responsible for the negative effect on plant productivity. It is evident in this study that greywater had no effect on soil structure considering the soil textural components.

Phytochemical analysis: The nutritional qualities of the crops were improved by greywater irrigation (Tables 7 and 8). The nutrient uptake of Na had also been observed in a study done by Misra *et al*. (2009) on tomato plants irrigated with greywater whereby 83% of Na from the soil was removed compared to that of test using tap water. In another study, tomatoes and beans were observed to contain an increase of Na content when they were irrigated by greywater compared to that of tap water (Holtzhausen, 2005). The results from this study concur with the results of vegetable plants absorbing more sodium from greywater treated soil (Mzini, 2013). Crops irrigated with greywater showed higher fruit nutrient macro-elements than in those irrigated with tap water. In contrast, Al-Hamaiedeh and Bino (2010) observed no difference in the absorption of macro nutrients by plants when irrigated with greywater and fresh water. The result obtained in this study was however consistent with the observations of Mzini (2013) on some vegetables. Crude protein was significantly higher in cabbages and lettuce that were irrigated with diluted greywater (Mzini, 2013). This can be attributed to addition of Nitrogen to soil by greywater.

Heavy metals in crop fruits: Results indicate that heavy metals were higher in the fruit of plants irrigated, tomato (Table 7) and pepper (Table 8), with greywater than in the control (Table 9).
A previous study also reported significantly higher Zn, Mn and Fe in cabbages and onions irrigated with diluted greywater (Mzini (2013). It was further observed that fruit of cabbage and onion Fe and Ni were significantly higher due to treatments of diluted greywater.

Conclusion

Reuse of greywater by dilution at 20-80% has a double-edged positive impact; it responds to the perennial quests for sustainable wastewater management and contributes to sustainable agriculture. Homeowners should therefore divert their greywater to home gardens or back to septic system for crop irrigation. However, there is the need to formulate appropriate guidelines through research on the control and amelioration of the negative environmental impacts of repeated greywater re-use, which will further help improve overall wastewater usage and promote public acceptance of the concept. Also, there is need to investigate a long time influence of greywater on soil physicochemical parameters and the market value of crops irrigated with greywater.

Table 1: Chemical parameters of water containing different proportions of greywater used for irrigating tomato and sweet pepper under screen house condition

Proportion of greywater in irrigation water (%)	pH	EC	Turbidity	BOD	COD	TSS	TDS	Na	Cl
		(mS/m)	(NTU)	(mg/l)					
0	6.96^{a}	6.00^{d}	1.12^{d}	7.02^{d}	0.37^{d}	7.57^{c}	12.46^{d}	1.11^{c}	13.04^{ab}
20	6.77^{a}	39.46^{c}	17.48^{c}	38.39^{c}	41.88^{bc}	32.98^{bc}	100.36^{c}	4.96^{ab}	13.47^{ab}
40	6.61^{a}	77.50^{bc}	27.37^{b}	65.28^{bc}	63.94^{b}	42.45^{b}	252.10^{b}	8.57^{a}	17.65^{a}
60	6.51^{a}	104.71^{b}	35.73^{b}	87.84^{b}	95.04^{b}	61.23^{b}	278.46^{b}	10.57^{a}	17.87^{a}
80	6.59^{a}	141.65^{a}	51.36^{a}	152.03^{a}	213.11^{a}	79.47^{b}	333.68^{b}	12.58^{a}	17.46^{a}
100	6.45^{a}	150.08^{a}	62.15^{a}	174.23^{a}	235.23^{a}	181.34^{a}	534.39^{a}	17.01^{a}	17.00^{a}

Each value is a mean of 10 replicates. For each parameter, means with the same letter(s) in superscript on the same column are not significantly different at P>0.05 (Tukey HSD test). EC = Electrical conductivity, BOD = Biological oxygen demand, COD = Chemical oxygen demand, TSS = Total suspended solid, TDS = Total dissolved solid.

Table 2: Physicochemical parameters of soil used for growing tomato irrigated with water containing different proportions of greywater under screen house condition

Proportion of greywater in irrigation water (%)	pH	CEC	N	P	K	Mg	Na	Ca	OC	Clay	Silt	Sand
		(meg/100g soil)							(%)			
0	6.20[a]	14.59[a]	0.15[b]	31.36[c]	107.67[c]	117. 45[b]	45.67[d]	68.35[d]	1.66[ab]	4.1[a]	2.7[a]	92.3[a]
20	6.23[a]	14.64[a]	0.17[b]	45.23[b]	212.45[b]	1191.60[a]	60.87[bc]	100.61[c]	1.72[ab]	4.1[a]	2.7[a]	92.3[a]
40	6.24[a]	14.71[a]	0.23[ab]	59.16[b]	266.13[b]	1211.09[a]	92.08[b]	197.96[b]	2.88[a]	4.1[a]	2.7[a]	92.3[a]
60	6.18[a]	14.77[a]	0.25[ab]	58.93[b]	287.34[b]	1298.58[a]	102.43[b]	132.54[b]	3.14[a]	4.1[a]	2.7[a]	92.3[a]
80	6.19[a]	15.03[a]	0.28[a]	76.76[a]	301.09[a]	1356.97[a]	143.33[a]	206.66[a]	3.23[a]	4.1[a]	2.7[a]	92.3[a]
100	6.18[a]	15.14[a]	0.37[a]	85.18[a]	346.76[a]	1447.67[a]	219.09[a]	250.00[a]	4.45[a]	4.1[a]	2.7[a]	92.3[a]

Each value is a mean of 3 replicates. For each parameter, means with the same letter(s) in superscript on the same column are not significantly different at P>0.05 (Tukey HSD test). CEC = Cation exchange capacity, OC = Organic content.

Table 3: Heavy metals of soil used for growing tomato irrigated with water containing different proportions of greywater under screen house condition

Proportion of greywater in irrigation water (%)	Zn	Cu	Pb	Cr
	mg/l			
0	0.05[b]	12.68[ab]	5.56[a]	28.56[a]
20	0.74[a]	15.49[a]	5.72[a]	28.87[a]
40	0.94[a]	15.84[a]	6.28[a]	28.34[a]
60	0.99[a]	17.69[a]	6.27[a]	29.87[a]
80	1.09[a]	21.78[a]	6.34[a]	29.12[a]
100	1.15[a]	21.55[a]	6.56[a]	31.57[a]

Each value is a mean of 3 replicates. For each parameter, means with the same letter(s) in superscript on the same column are not significantly different at $P>0.05$ (Tukey HSD test).

Table 4. Growth parameters of tomato and sweet pepper grown in soil irrigated with water containing different proportions of greywater under screen house condition

	Vegetable species	Proportion of greywater in irrigation water (%)					
		0	20	40	60	80	100
Plant height (cm)	*Solanum lycopersicum* (Tomato)	74.91^{ab}	77.52^{b}	84.86^{a}	85.26^{a}	95.31^{a}	62.24^{c}
	Capsicum annum (Sweet pepper)	76.07^{b}	79.07^{b}	85.06^{a}	85.50^{a}	97.74^{a}	61.11^{c}
Number of leaves/plant	*Solanum lycopersicum* (Tomato)	162.84^{bc}	173.56^{b}	183.34^{b}	239.43^{a}	241.47^{a}	112.27^{d}
	Capsicum annum (Sweet pepper)	140.00^{bc}	161.12^{b}	183.63^{b}	237.63^{a}	202.01^{a}	126.07^{d}
Number of branches	*Solanum lycopersicum* (Tomato)	14.08^{b}	21.02^{a}	18.62^{a}	24.37^{a}	29.08^{a}	15.63^{b}
	Capsicum annum (Sweet pepper)	16.38^{b}	22.32^{a}	18.63^{a}	25.36^{a}	30.05^{a}	13.64^{b}
Stem girth (cm)	*Solanum lycopersicum* (Tomato)	8.26^{a}	8.92^{a}	8.80^{a}	8.98^{a}	9.44^{a}	8.01^{a}
	Capsicum annum (Sweet pepper)	4.60^{a}	4.94^{a}	5.28^{a}	5.98^{a}	6.42^{a}	5.29^{a}
Root length	*Solanum lycopersicum* (Tomato)	13.06^{b}	19.90^{a}	21.21^{a}	21.69^{a}	21.84^{a}	12.45^{b}
	Capsicum annum (Sweet pepper)	15.43^{b}	19.33^{a}	25.30^{a}	24.33^{a}	26.66^{a}	17.83^{ab}

Each value is a mean of 5 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at $P>0.05$ (Tukey HSD test).

Table 5. Dry mass, Root: shoot ratio and Relative growth rate of tomato and sweet pepper grown in soil irrigated with water containing different proportions of greywater under screen house condition

	Vegetable species	Proportion of greywater in irrigation water (%)					
		0	**20**	**40**	**60**	**80**	**100**
Root dry mass (g)	***Solanum lycopersicum*** **(Tomato)**	2.13^{a}	2.23^{a}	2.33^{a}	2.36^{a}	2.56^{a}	2.06^{a}
	Capsicum annum **(Sweet pepper)**	2.5^{b}	2.9^{ab}	3.03^{a}	3.13^{a}	3.86^{a}	2.16
Shoot dry mass (g)	***Solanum lycopersicum*** **(Tomato)**	4.3^{b}	5.06^{a}	5.75^{a}	6.17^{a}	6.63^{a}	3.03
	Capsicum annum **(Sweet pepper)**	3.3^{bc}	4.13^{b}	5.86^{b}	7.86^{a}	7.73^{a}	2.56^{c}
Total biomass (g)	***Solanum lycopersicum*** **(Tomato)**	6.43^{b}	7.29^{ab}	8.08^{ab}	8.53^{a}	9.19^{a}	5.09^{cd}
	Capsicum annum **(Sweet pepper)**	5.8^{c}	7.03^{ab}	8.89^{ab}	10.99^{a}	11.59^{a}	4.72^{c}
Root: shoot ratio	***Solanum lycopersicum*** **(Tomato)**	0.50^{ab}	0.44^{b}	0.41^{b}	0.38^{b}	0.39^{b}	0.68^{a}
	Capsicum annum **(Sweet pepper)**	0.76^{b}	0.70^{b}	0.52^{c}	0.4^{c}	0.50^{c}	0.84^{a}
Relative growth rate (mg/g dry weight)	***Solanum lycopersicum*** **(Tomato)**	0.013^{c}	0.017^{b}	0.018^{b}	0.027^{a}	0.024^{a}	0.09^{d}
	Capsicum annum **(Sweet pepper)**	0.008^{c}	0.014^{b}	0.025^{ab}	0.035^{a}	0.033^{a}	0.006^{c}

Each value is a mean of 5 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at P>0.05 (Tukey HSD test).

Table 6. Yield of tomato and sweet pepper grown in soil irrigated with water containing different proportions of greywater under screen house condition

	Vegetable species	Proportion of greywater in irrigation water (%)					
		0	20	40	60	80	100
Number of fruits/plant	***Solanum lycopersicum* (Tomato)**	23.33^{b}	33.33^{a}	33.66^{a}	35.33^{a}	37.33^{a}	12.07^{c}
	***Capsicum annum* (Sweet pepper)**	20.34^{b}	36.67^{a}	37.14^{a}	36.87^{a}	35.41^{a}	8.13^{c}
Fruit fresh weight/plant (g)	***Solanum lycopersicum* (Tomato)**	116.26^{b}	227.04^{a}	224.63^{a}	228.45^{a}	225.23^{a}	92.79^{c}
	***Capsicum annum* (Sweet pepper)**	93.43^{b}	207.97^{a}	216.50^{a}	215.11^{a}	222.54^{a}	56.19^{c}
Fruit yield/plant (g)	***Solanum lycopersicum* (Tomato)**	9.44^{b}	14.19^{a}	13.75^{a}	12.93^{a}	13.33^{a}	9.49^{b}
	***Capsicum annum* (Sweet pepper)**	15.76^{b}	32.59^{a}	31.67^{a}	34.12^{a}	33.09^{a}	13.00^{b}
Fruit moisture content (%)	***Solanum lycopersicum* (Tomato)**	92.14^{a}	93.75^{a}	93.88^{aa}	94.34^{a}	94.08^{a}	88.69^{b}
	***Capsicum annum* (Sweet pepper)**	83.13^{a}	84.33^{a}	85.37^{a}	84.14^{a}	85.13^{a}	76.87^{b}

Each value is a mean of 5 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at $P>0.05$ (Tukey HSD test).

Table 7: Nutritional and proximate composition of fruits produced by tomato grown in soil irrigated with water containing different proportions of greywater under screen house condition

Nutritional and proximate composition	Proportion of greywater in irrigation water (%)					
	0	20	40	60	80	100
N (mg/l)	1.20^{b}	1.60^{a}	1.64^{a}	1.60^{a}	1.55^{a}	1.68^{a}
P (mg/l)	0.11^{b}	0.16^{a}	0.21^{a}	0.21^{a}	0.26^{a}	0.22^{a}
K (mg/l)	1.03^{b}	1.97^{a}	0.73^{a}	1.79^{a}	1.82^{a}	1.80^{a}
Ca (mg/l)	0.15^{ab}	1.97^{a}	0.19^{a}	0.19^{a}	0.24^{a}	0.27^{a}
Mg (mg/l)	0.14^{b}	0.35^{a}	0.44^{a}	0.44^{a}	0.37^{a}	0.32^{a}
Na (mg/l)	0.24^{b}	0.44^{a}	0.45^{a}	0.48^{a}	0.45^{a}	0.46^{a}
Cu (mg/l)	7.47^{b}	12.57^{a}	15.18^{a}	14.93^{a}	17.18^{a}	18.78^{a}
Zn (mg/l)	8.42^{b}	11.61^{b}	17.32^{a}	15.03^{a}	17.55^{a}	19.13^{a}
Pb (mg/l)	0.28^{b}	0.61^{a}	0.66^{a}	0.53^{a}	0.69^{a}	0.76^{a}
Cr (mg/l)	1.50^{b}	1.74^{b}	2.60^{a}	2.50^{a}	2.81^{a}	2.83^{a}
Ash (%)	7.25^{b}	13.82^{a}	13.89^{a}	4.98^{a}	14.84^{a}	15.87^{a}
Fibre (%)	7.45^{a}	7.22^{a}	7.17^{a}	7.61^{a}	7.23^{a}	7.24^{a}
Protein (%)	11.76^{b}	14.00^{a}	15.25^{a}	15.06^{a}	19.69^{a}	14.50^{a}
Fat (%)	1.61^{a}	1.74^{a}	1.69^{a}	1.63^{a}	1.79^{a}	0.48^{b}
CHO (%)	0.55^{b}	87.18^{a}	87.10^{a}	87.22^{a}	87.55^{a}	86.77^{a}

Each value is a mean of 3 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at P>0.05 (Tukey HSD test). CHO = carbohydrate.

Table 7: Nutritional and proximate composition of fruits produced by tomato grown in soil irrigated with water containing different proportions of greywater under screen house condition

Nutritional and proximate composition	Proportion of greywater in irrigation water (%)					
	0	20	40	60	80	100
N (mg/l)	1.32[b]	1.71[a]	1.75[a]	1.85[a]	1.67[a]	1.78[a]
P (mg/l)	0.42[b]	0.46[b]	0.56[b]	0.63[a]	0.66[a]	0.73[a]
K (mg/l)	1.45[b]	1.92[b]	1.68[b]	2.15[a]	2.40[a]	2.62[a]
Ca (mg/l)	0.34[a]	0.41[a]	0.46[b]	0.59[a]	0.77[a]	0.69[a]
Mg (mg/l)	0.56[b]	0.56[b]	0.73[a]	0.68[a]	0.79[a]	0.70[a]
Na (mg/l)	0.44[b]	0.86[a]	0.88[a]	0.87[a]	1.03[a]	1.06[a]
Cu (mg/l)	11.95[b]	14.21[a]	16.20[a]	16.95[a]	6.45[a]	18.78[a]
Zn (mg/l)	16.56[b]	20.09[a]	20.08[a]	21.40[a]	21.69[a]	19.02[a]
Pb (mg/l)	0.60[c]	1.05[b]	1.60[b]	1.16[b]	2.39[a]	2.05[a]
Cr (mg/l)	0.47[c]	1.87[b]	2.77[a]	2.50[a]	2.81[a]	2.83[a]
Ash (%)	3.06[a]	52.14[b]	5.31[a]	52.14[a]	5.60[a]	5.57[a]
Fibre (%)	3.57[a]	3.37[a]	3.65[a]	3.31[a]	3.29[a]	3.28[a]
Protein (%)	2.17[b]	2.81[b]	4.41[a]	4.17[a]	5.00[a]	4.93[a]
Fat (%)	1.55[a]	1.69[a]	1.66[a]	1.59[a]	1.60[a]	1.52[a]
CHO (%)	5.78[a]	7.24[a]	7.74[a]	8.37[a]	8.91[a]	8.00[a]

Each value is a mean of 3 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at P>0.05 (Tukey HSD test). CHO = carbohydrate.

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