Evaluation of Growth, Yield and Proximate Composition of Food Industrial Wastewater-irrigated Vegetables

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ABSTRACT

Aims: To evaluate performance of growth, yield and proximate compositions of three vegetables namely; spinach (*Spinaciaoleracea*), roselle (*Hibiscus sabdariffa*), and scent leaf (*Ocimumgratissimum*) irrigated with wastewater from some selected food processing industries in Makurdi and river water as control.

Place and Duration of Study: The Potted experimental study was carried out in a net house in December 2022 at a school farm space in Benue State University Makurdi, the capital of Benue State, Nigeria, between December 2022 and February 2023.

Methodology: Samples: We included four water sources for irrigation (Seraph Oil wastewater, MIVA rice wastewater, Chile fish farm wastewater and River Benue water as a control) Ten (10) vegetable samples (Spinach 3, roselle 3 and scent leaf 4).
Viable seeds of the vegetables were sown in a randomized complete block design in triplicates. Assessment of growth and yield was done by measurement of plant height, stem size, leaf length, leaf width and number of leaves from 1 week after sowing of seeds to week six (6) of maturity. Proximate composition were determined for the parameters such as moisture content, crude protein, lipids, crude fibre, ash content, and carbohydrates were examined.

Results: The growth parameters and yield for all the investigated vegetables were in the order Chile farm wastewater (CFWW) > MIVA rice wastewater (MRWW) > River Benue Water (RBW$_{\text{control}}$) > Seraph Oil wastewater (SOWW).The vegetables grown with CFWW significantly had higher moisture content, protein and total fats than the vegetable irrigated with other samples. While those grown with RBW (control) had higher fiber, ash content and carbohydrate than the ones irrigated with other sources of wastewater.

Conclusion: The waters used for irrigating the vegetables had essential nutrients that favoured their growth and yields but subjective to proximate composition differently.

Keywords: wastewater, irrigation, proximate composition, growth evaluation, vegetables

1. INTRODUCTION

The reuse of wastewater is one method of addressing the issue of huge volumes of wastewater generated by the food processing industries as an outcome of the rapid increase in industrialization and economic development Minhas et al., [1] 2015). Wastewater discharge into the environment is becoming more challenging nowadays. This is due to high cost of the wastewater treatment especially for underdeveloped nations, using wastewater for irrigation in agriculture helps to prevent its indiscriminate discharge into river bodies and the environment (Drechel, 2010[2]).Wastewater can be used to improve soil organic matter and provide essential nutrients to plants. It also lowers pollution levels in the environment and can be a reliable irrigation source during periods of water shortage (Nikolaou et al., 2020 [3]).

However, inappropriate methods of reusing wastewater might cause danger to the environment and the health of farmers and consumers by accumulated harmful substances (Qadir et al., 2010 [4,5] and Murtaza et al., 2010).

Nitrogen, phosphorus, potassium, and other elements that are vital to plant growth are commonly found in irrigation water, which can also provide a great portion of the nutrients required by crops. The concentration of these nutrients in wastewater, the quantity of water applied, the time or duration of application, the type of crop and soil, all influence the uptake of these nutrients by plants (Machado and Serralheiro, 2017 [6]).Although the primary objective of wastewater irrigation is supplying water and nutrients to plants, applying adequate levels is also important due to potential negative effects from overuse, including moisture retention, lodging, and the subsequent loss of crop yields (Minhas et al., 2015[1]). Since wastewater is always applied in conjunction with irrigation for fertilization, farmers that use wastewater have less control over the rate of absorption, the proper administration of nutrient proportions, and the timing of nutrient applications. Research has shown that vegetable requires more water, than the nutrient supplied, in general determination of the rate at which wastewater irrigation is applied is crucial (Soklow et al., 2019;Erni et al., 2010; Hanjra et al., 2012 [7,8,9]). Therefore, choices regarding the accurate amounts and suggestions for fertilizers, as well as its application time, should be made in a different way for crops that are irrigated by wastewater. The current study aims to assess the growth, yield and proximate composition of vegetables irrigated with wastewater from various food processing industries.

2. MATERIAL AND METHODS

2.1 Study Area

The Potted experimental study was carried out in a net house in December 2022 at a local farm space in Makurdi, the capital of Benue State, Nigeria, which is located in the north central region and is 0 feet above sea level at 7.73° latitude and 8.54° longitude. The area experiences approximately 134.92 mm (5.3 inches) of precipitation annually, temperature varies between 24.15 -33.02℃, approximately 61.38% humidity, and two distinct seasons: dry season (December to March) and wet season (April to November).

2.2 Experimental Design

The potted experiment was set up at the Local Farm space, where 16 plastic pots measuring 15 cm in diameter and 25 cm in depth were filled with 10 kg of loam-sandy soil. In addition to being well-aired and exposed to sunlight, each plastic pot was perforated to reduce overflow and water stagnation. It was also housed in a net house to reduce insect and rodent infestations. The experimental pots were placed in a complete randomized design (CRD), while the irrigation systems were set up in cans as surface treatments comprising three different types of wastewater and river water as a control.

2.3 Cultivation

Scent leaf (*Ocimumgratissimum*), roselle (*Hibiscus sabdariffa*) and spinach (*Spinaciaoleracea)* seedlings were separately sown in pots by December and harvested February, 2023. The vegetables were regularly watered twice a day for six (6) weeks using 1L from each water source. The best three (3) vegetables were preserved and tagged as 1-3 in each pot. During the study, weekly measurements were taken of the following parameters for each tagged plant in each pot: plant height, stem size, leaf width, leaf length, and number of leaves.

2.4 Collection of Wastewater

For the experiment, four water samples were simultaneously obtained from three food processing companies and one from the river Benue (control). The plastic bottles were cleaned with deionized water and then rinsed with 3 % nitric acid. Samples of wastewater were collected from different locations in 20 L plastic bottles, and stored in big jars for the experiment.

2.5 Collection of Vegetables

Ten (10) irrigated vegetables in total, along with 5 g of tender stem and leaves, were gathered in triplicate and cleaned with deionized water to get rid of pollutants and surface impurities. The vegetables were well labeled and stored in a polyethylene bag after a two-hour air-drying period. These samples were then transferred into a silica plate and dried in an oven at 70 °C.

2.6 Plant Measurement

Plant height, stem size, leaf length, leaf width, and number of leaves were among the measured parameters. A graduated metre rule was used to measure plant height from the plant stem to the tallest leaf apex. A screw gauge was used to measure the stems size, three centimetres above the soil level in each potted plant. Leaf width was measured with a graduated meter rule by aligning it across the leaf at the centre on the stem's first leaves. When that specific leaf was shaded out, the next fresh leaf was considered for measurement.The metre rule was placed in the centre of the leaf and moved along the apex to the end of the stalk to measure the length of the leaf. The number of leaves were determined by counting each plant's leaf in accordance with the methodology (Balkhair and Ashraf, 2016; [10,11] Hussain et al., 2011). The growth rate per day was determined by dividing the difference between the first and second measurements by the equal number of days between each measurement.

2.7 Determination of Proximate Composition

Proximate analysis of the three irrigated vegetable leaf samples including parameters such as moisture content, crude protein, lipids, crude fibre, ash content, and carbohydrates were examined. Using a hot air oven set at 105 °C and weighing the leaf samples, the moisture content was measured until a constant weight was reached (AOAC 952.08, 2016 [12]). The Kjeldahl procedure was used to determine the crude protein, which was then multiplied by a protein factor of 6.25 using total nitrogen (AOAC 992.23, 2016 [12]). With a Soxhlet extractor at 60 °C until constant weight, lipids were measured via the acid hydrolysis method (AOAC 948.15, 2016).The enzymatic gravimetric method was used to assess the crude fibre content of leaf samples that had been heated to 60 °C using an alpha-amylase, protease, and amyloglucoside. The samples were then mixed with ethanol to precipitate the fibre (AOAC, 2016). The ash content was determined by gravimetric method at 550 ^{o}C to a constant weight (AOAC, 930.30, 2016). The percentage difference by all the other proximate characteristics was used to calculate the amount of carbohydrates. The amount of energy was calculated using the total summation and factors of 4, 9, 4 for each amount of protein, lipids, and carbohydrates respectively.

3. Results and Discussion

Table 1: Plant height of irrigated vegetables with wastewater from 1 week to 6weeks after sowing

		Plant height (cm)						
Vegetables	**Treatment**	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**G. rate/day**
Spinach	Control	9.04±0.3	10.57±1.6	16.17±3.3	21.57±3.5	25.87±2.4	37.87±9.8	1.1
	SOWW		NG					
	MRWW	13.28±0.2	15.67±.2	23.07±1.1	39.77±3.2	42.60±2.9	64.27±3.5	1.8*
	CFWW	14.99±0.5	16.80±.1	29.73±3.0	40.47±6.1	49.30±5.7	63.30±5.7	1.8*
Roselle	Control	12.01±1.4	13.20±1.6	21.20±.08	26.53±1.8	30.37±1.5	39.17±3.1	1.1
	SOWW		NG					
	MRWW	15.73±1.7	17.00±1.1	24.47±2.2	33.37±4.2	37.47±.75	44.50±.86	1.3*
	CFWW	16.01±0.1	17.47±1.3	29.87±2.3	40.13±4.7	43.63±3.0	52.03±2.0	1.5*
Scent leaf	Control	2.8±0.5	3.50±1.1	8.07±2.1	14.53±1.7	16.00±5.0	23.83±9.9	0.7
	SOWW	NG		3.03±.47	3.23±.47	5.80±1.0	11.30±3.8	0.4
	MRWW	4.81±1.7	5.30±.98	10.53±2.0	10.63±2.3	16.20±2.1	17.30±3.8	0.5
	CFWW	5.8±0.2	6.83±1.2	13.57±2,0	15.57±2.0	18.33±1.5	36.50±4.0	1.0

*= *P* =.05

NG=No germination

Chile farm wastewater = CFWW, MIVA rice wastewater = MRWW, River Benue Water = $\text{RBW}_{\text{control}}$, Seraph Oil wastewater = SOWW.

Table 2: Stem size in three irrigated vegetables with wastewater from 1 week to 6 weeks after sowing

* = *P* = .05

		Stem size (cm)						
Vegetables	**Treatment**	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**G.R/day**
Spinach	Control	0.13±0.3	0.30±.59	0.47±.53	0.41±.17	0.49±.71	0.59±.53	0.17
	SOWW		NG					
	MRWW	0.10±.0	0.23±.05	0.53±.84	0.67±1.3	0.76±.90	0.89±.7	0.26*
	CFWW	0.10±.0	0.32±.2	0.59±1.1	0.76±1.3	0.77±1.3	0.85±1.4	0.24*
Roselle	Control	0.14±0.1	0.30±.63	0.42±.13	0.47±.45	0.47±.53	0.59±.85	0.17
	SOWW		NG					
	MRWW	0.10±0.0	0.25±.22	0.39±.48	0.49±.73	0.53±.12	0.63±.07	0.18
	CFWW	0.17±.2	0.36±.47	0.46±.06	0.56±.48	0.58±.53	0.65±.50	0.19
Scent leaf	Control	0.03±0.0	0.15±.12	0.27±.68	0.31±.55	0.39±.73	0.39±.70	0.11
	SOWW			1.57±.48	1.86±.48	2.12±.10	2.56±.51	0.09
	MRWW	0.1±0.0	0.13±.14	0.21±.05	0.23±.05	0.34±.38	0.36±.50	0.10
	CFWW	0.17±0.1	0.17±.58	0.29±.82	0.39±.82	0.42±.50	0.51±.72	0.15

***** *P= .05*

NG=No germination

Chile farm wastewater = CFWW, MIVA rice wastewater = MRWW, River Benue Water = $RBW_{control}$, Seraph Oil wastewater = SOWW.

Table 3: The leaf length of three irrigated vegetables with wastewater from 1 week to 6 weeks after sowing

Vegetables	Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	G.R/day
Spinach	Control	2.23±.44	2.67±.15	6.63±.55	7.60±1.4	7.87±1.4	9.53±2.1	0.27
	SOWW			NG				
	MRWW	2.7±0.36	3.17±.2	7.33±1.2	13.90±.75	14.37±.35	15.10±.26	0.43*
	CFWW	3.4±0.05	3.90±.2	8.30±.26	10.10±.70	11.60±1.3	15.10±1.6	0.43*
Roselle	Control	2.28±0.3	2.47±.20	2.87±.15	4.43±.51	7.03±.25	6.97±.15	0.19
	SOWW			NG				
	MRWW	2.45±1.34	2.70±0.1	2.80±.10	4.57±.20	7.80±.55	8.73±.56	0.25*
	CFWW	2.23±1.5	2.50±.17	4.00±1.1	5.87±.61	7.53±.45	9.60±.34	0.27*
Scent leaf	Control	1.8±.01	1.93±.20	4.30±.60	6.53±.35	6.93±1.1	7.07±1.6	0.20
	SOWW			2.57±.51	2.57±.61	5.27±1.6	6.23±1.6	0.22
	MRWW	1.63±0.60	1.83±.05	4.57±.20	5.57±.20	7.27±2.8	6.23±1.6	0.19
	CFWW	4.21±1.0	4.50±.55	5.20±.50	5.50±.50	10.17±1.0	12.17±1.0	0.35*

** =P =.05*

NG=No germination

Chile farm wastewater = CFWW, MIVA rice wastewater = MRWW, River Benue Water = $RBW_{control}$, Seraph Oil wastewater = SOWW.

Table 4: leaf width of three irrigated vegetables with wastewater from 1 week to 6 weeks after sowing

		Leaf width (cm)						
Vegetables	Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	G.R/day
Spinach	Control	1.75±0.12	1.93±.37	3.77±.49	4.10±.45	4.47±.68	5.13±.98	0.15
	SOWW		NG					
	MRWW	1.2±0.43	1.43±.11	4.37±.72	4.73±.49	5.47±.68	5.50±.50	0.16
	CFWW	1.46±0.27	1.63±.3	4.50±.10	4.67±1.1	5.00±1.7	6.10±.85	0.17
Roselle	Control	2.6±0.18	2.83±.05	2.97±.06	3.30±.85	5.50±.36	5.83±.66	0.17
	SOWW		NG					
	MRWW	2.89±1.3	3.10±.28	3.13±.15	3.33±.40	3.93±.58	7.33±.70	0.21
	CFWW	2.38±0.5	2.63±.23	1.33±.15	4.77±.37	5.87±1.1	8.03±.55	0.23
Scent leaf	Control	1.33±0.9	1.50.10	2.77±.25	4.07±.11	5.77±1.4	6.27±1.1	0.18
	SOWW			1.73±.25	1.73±.25	3.57±1.1	4.00±1.0	0.14
	MRWW	1.37±0.13	1.50±.10	3.17±.25	3.57±.25	4.07±.94	4.70±1.0	0.13
	CFWW	3.1±0.8	3.23±.20	3.53±.16	4.53±.15	5.20±.20	6.70±.43	0.19

** P= .05*

NG=No germination

Chile farm wastewater = CFWW, MIVA rice wastewater = MRWW, River Benue Water = RBW$_{control}$, Seraph Oil wastewater = SOWW.

Table 5: Number of leaves in three irrigated vegetables from 1 week to 6 week after sowing

		Number of leaves						
Vegetables	**Treatment**	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**G.R/day**
Spinach	Control	2.0	4.0	9.00	10.0	16.0	19.0	0.5
	SOWW							
	MRWW	6.0	7.0	12.0	19.0	28.0	38.0	1.0
	CFWW	6.0	8.0	16.0	20.0	39.0	43.0	1.0
Roselle	Control	6.0	8.0	10.0	14.0	25.0	35.0	1.0
	SOWW							
	MRWW	8.0	10.0	11.0	16.0	33.0	48.0	1.0
	CFWW	17.0	19.0	28.0	33.0	49.0	53.0	2.0*
Scent Leaf	Control	5.0	7.0	10.0	13.0	14.0	16.0	0.5
	SOWW			5.0	6.0	8.0	9.0	0.3
	MRWW	6.0	8.0	11.0	14.0	16.0	17.0	0.5
	CFWW	9.0	11.0	15.0	20.0	28.0	32.0	1.0*

* *P= .05*

NG=No germination

Chile farm wastewater = CFWW, MIVA rice wastewater = MRWW, River Benue Water = $RBW_{control}$, Seraph Oil wastewater = SOWW.

Table 6: Proximate Composition of three vegetables irrigated with wastewater

Vegetable	Treatment	%Moisture	%Protein	%Lipid	%Fibre	%Ash	%Carbohydrate	%Energy
Spinach	Control	59.03±.99	9.05±.03	1.99±.01	4.10±.45	7.88±.06	9.467±.96	91.97
	SOWW				NG			
	MRWW	60.82± .05*	9.55±.03*	2.06±.03*	12.09±.02*	7.65±.05	7.83±.06	88.06
	CFWW	61.78±.65*	9.72±.52*	2.11±.09*	11.53±.51*	7.57±.52	7.37±.31	87.29
Roselle	Control	44.75±.92	7.11±.41	2.32±.03	9.05±.03	6.13±.30	30.65±1.1	171.87
	SOWW				NG			
	MRWW	45.60±.17*	7.74±.03*	2.45±.02*	8.15±.02*	5.78±.03	30.27±.14	174.10*
	CFWW	46.86±.53*	7.97±.34*	2.55±.07*	7.63±.07*	5.63±.10	29.38±.76	172.38*
Scent leaf	Control	55.44±.43	11.89±.17	2.18±.01	9.96±.07	3.83±.22	16.68±.27	133.96
	SOWW	56.52±1.1*	12.09±.00*	2.20±.01	9.53±.04	3.10±.03	16.55±1.1	84.74
	MRWW	56.36± .77*	12.11±.00*	2.10±.00	9.57±.02	3.15±.03	16.60±.80	134.56
	CFWW	57.45±.65*	12.05±.19*	2.21±.01	9.07±.08	2.89±.27	16.36±.78	133.55

* *P* = .05

NG=No germination

Chile farm wastewater = CFWW, MIVA rice wastewater = MRWW, River Benue Water = $RBW_{control}$, Seraph Oil wastewater = SOWW.

3.1. Growth Yield Parameters of Irrigated Vegetables

The growth yield of the vegetables grown in this study was generally enhanced by the wastewaters used for the irrigation. After one week of seed sowing, it was evident from the physical characteristics, that there was a continuous and irreversible increase in growth parameters of the three vegetables (spinach, roselle, and scent leaf). The shortest distance from ground level to the upper limits of a plant's major photosynthetic tissue is known as plant height. The irrigated vegetables (spinach, roselle, and scent leaf) had varying heights: 37.8±9.8 to 64.3±3.5; 39.1±3.1 to 52.0±2.0; and 11.0±3.8 to 36.0±4.0 cm respectively. The experiments resulted in a remarkable increase in plant height. In comparison to the control and other wastewater samples, the spinach plant height in Miva rice wastewater (MRWW) was the tallest at week six (6). All through the six-week period, the roselle in Chile Farm wastewater (CFWW) and Miva rice wastewater (MRWW) was substantially higher than that of the control. Scent leaf plants exhibited shorter heights in CFWW compared to the plants in the control, this could be attributed to the vegetables slow response in the Seraph Oil wastewater (SOWW) irrigated soils during the experiment (Asaolu et al., 2012 [13]; El Naim et al., 2012[14] ; Gagliardi et al., 2019[15]; Casierra-Posada et al., 2012[16]; Hussian et al., 2011 [11] ; Okunlola et al., 2018 [17]; Enujeke and Egbuchua, 2022 [18]).

One of the most common parameters used to evaluate a plant's growth is its stem size. It is used to indicate phenotypic variations of the plants and reflects the elongation and expansion of the plant parts. The stem size measurements varied from 0.58 - 0.65±0.5 cm; 0.25±0.5 - 0.51±0.7 cm; and 0.59±0.53 - 0.88±0.7 cm. The vegetables watered by MRWW and CFWW samples had the largest stem size. The results aligned with earlier studies conducted by (Casierra-Posada et al., 2012 [16]; Hussain , 2011;Ghislain, 2014[19]; Tayyeb, 2017 [20]; El Naim et al., 2012 [14]; Okunlola et al., 2018 [17]; Enujeke and Egbuchua, 2022 [18]).

Leaf width is the longest extension of any two points on the blade edge perpendicular to the leaf length axis and that is the axes connecting to the leaf apex and base. The leaf width varied between 5.43±0.51 - 6.1±0.85 cm, 5.8±0.66 - 8.0±0.55 cm, and 4.0±1.0 - 6.7±0.43 cm respectively. The CFWW-irrigated vegetables had wider leaves than the other samples and control group. A similar trend was observed by research conducted by (Okinlola et al., 2018 [17]; Enujeke and Egbuchua, 2022 [18]; Brown et al., 2020 [21]).

The longest extension from the leaf apex to the base, which connects the petiole or leaf blade, is referred to as the leaf length. The wastewater irrigated vegetables (spinach, roselle, and Scent leaf) had leaf length measurements ranging from 9.5±2.1 - 15.10±0.26 cm; 6.9±0.15 - 9.6±0.34 cm; and 6.2±1.6 - 12.1±1.0 cm. Comparing the vegetables irrigated with CFWW samples with those irrigated with other wastewaters, the longest leaf length was from CFWW.

The number of leaves or branches that a particular plant produces is its total leaf count. The number of leaves on the irrigated vegetables; spinach, roselle, and scent leaf, varied from 2 - 43; 6 - 53; and 5– 33 respectively. All the vegetables irrigated with CFWW samples were shown to have the highest leaf increase.

The physiology of the plants, the physicochemical and mineral elements of the wastewaters, the application rate, the absorption rate, salt accumulations, the type of seeds, and soil-related indicators like pH, moisture content, and cation exchange capacity may be responsible for differences in growth parameters. The SOWW-irrigated spinach and roselle did not germinate following careful observation of typical germination days. This might be as a result of the physicochemical composition of the wastewater used for the irrigation. Some of which includes high viscosity and COD, the lack of viability of the seeds, and soil related factors. For all vegetables under investigation, the plant growth yield measurements were as follows: CFWW > MRWW > RBW (control) > SOWW.

Vegetable growth rate refers to the increase in growth per unit time or the continuous, irreversible expansion of plant part sizes. According to the findings, the daily growth rates of scent leaf, spinach, and roselle vegetables varied from 0.40 - 1.04, 1.12 - 1.47, and 1.10 - 1.84 cm/day. The growth rate was in the order CFWW > MRWW > RBW (control) > SOWW. Vegetable development rates can vary depending on a number of factors, including climatic conditions, water availability, mineral availability, and other related growth components.

3.1.2 Proximate Composition of irrigated vegetables

The amount of water and volatile compounds lost during the drying process is known as the moisture content. The moisture content of the irrigated vegetables (scent leaf, roselle, and spinach) varied between 59.03- 61.77 %; 44.7 - 46.8 %; and 55.44 - 57.45 %, respectively. The vegetables that were irrigated using CFWW wastewaters demonstrated higher moisture contents than the vegetables irrigated with other water sources. This difference in moisture retention and nutrient delivery to the plants, as well as differences in soil properties and absorption rates, may be the cause of this phenomenon. In contrast to the current investigation, Ladi (2016 [22]) observed low moisture content of 14.36% in spinach and roselle. For all irrigated vegetables, the trend of the findings was observed in the order: CFWW > MRWW > RBW > SOWW.

The amount of total nitrogen multiplied by protein components is known as crude protein. The irrigated vegetables (spinach, roselle, and scent leaf) had crude protein levels ranging from 9.04 - 9.72; 7.10 -7.97; and 11.89 - 12.10 % respectively. Irrigated spinach and roselle with CFWW samples yielded the highest crude protein content, while irrigated scent leaves with MRWW samples produced high protein content. This could be as a result of the wastewaters' nutritional compositions, the seed viability, the characteristics of the soil, the rate of absorption, and the application time.

According to Ganugpichayagrai and Suksaard (2020 [23]), total fat is the sum of all fat components, including fatty acids, oil-soluble dyes, fat-soluble vitamins, and steroids. For spinach, roselle, and scent leaf, the ranges for crude oil and fat content were 1.9 - 2.10; 2.31 - 2.55; and 2.18 -2.21 %, respectively, in the vegetables irrigated with wastewater.

According to the investigation, all of the irrigated vegetables with CFWW samples had crude fats within the same range. This could be caused by the CFWW nutritional content, factors relating to plants and soil, application and absorption rates. The results corresponded to the previous studies by (Singh et al., 2018 [24]; Iqbal et al., 2016 [25]; Ladi, 2016 [22]; Casierra-Posada et al., 2012 [16]).

Crude fibre is the total amount of dietary fibre in the food sample (Ganugpichayagraiand Suksaard, 2020 [23]). Consuming fibre provides several health advantages such as lowering the risk of cancer and cardiovascular diseases in humans. For the irrigated vegetables, the crude fibre content varied from 11.53 - 12.58; 7.6 - 9.04; and 9.07 - 9.96%.Similar findings to (Gagliardi 2020 [15]; Enujeke and Egbuchua, 2022 [18]). The trend was seen for the vegetables in the order; (RBW (control> MRWW> CFWW> SOWW).

Ash content is the amount of total mineral residue left after incineration of leaf samples to constant weight (Ganugpichayagrai and Suksaard, 2020 [23]). The ash level of irrigated vegetables (spinach, roselle and scent leaf) varied from 7.56 - 7.88; 5.6 - 6.1;2.89 - 3.8 % respectively. All the irrigated vegetables with river Benue had the greatest ash content, indicating that vegetables had more nutrients from the water source and the rate of application of the water source. Ladi (2016 [22]), reported 9.95 % ash and was slightly above that reported in this study. In this finding, the ash content of irrigated vegetables showed the following trend; RBW > MRWW > CFWW > SOWW.

Total carbohydrate is the amount of carbohydrate, which is one of the main components of structural materials in plants (Enujeke and Egbuchua, 2022 [18]). Carbohydrate (CHO) content ranged from 7.36 - 9.46; 29.37 - 30.6; 16.35 - 16.68 % for irrigated spinach, roselle and scent leaf respectively. The results show that, for all the vegetables, the fiber, ash content and CHO follow a similar trend in the order RBW (control)> MRWW > CFWW > SOWW which could be attributed to the physicochemical features of water samples, application rate, soil and plant related properties.

4. Conclusion

In the order CFWW > MRWW > RBW (control) > SOWW, each growth yield measurement (plant height, stem size, leaf length, leaf width, and number of leaves) that was analyzed showed a substantial boost in growth rate per day from Week 1 after sowing to Week 6.

Compared to the crops watered with other samples, the vegetables produced with CFWW exhibited significant increases in moisture content, protein, and total fats. In contrast, the plants cultivated under RBW (control) revealed higher amounts of fibre, ash, and carbohydrates than the plants irrigated with other wastewater sources due to the nutritional composition of the water source. When consumed, they could be regarded as valuable sources of nutritional composition, particularly in terms of protein, fibre, and carbohydrate.

The three wastewater treatments and the control (RBW) both are safe and can be used for irrigation of vegetables in terms of nutrient and water enrichment. The findings revealed that the irrigation of the selected vegetables were improved in nutritional composition, and its growth and yield performance.

REFERENCES

AOAC International. Official Methods of Analysis of AOAC International. 20th ed. Gaithersburg, MD, USA, 2016; p. 3172.

Asaolu SS, Adefemi OS, Oyakilome IG, Ajibulu, KE, and AsaoluMF.Proximate and Mineral Composition of Nigerian Leafy Vegetables. *Journal of Food Research.*2012;1 (3), 214–218.

Balkhair, KS., and Ashraf, MA. Field Accumulation Risks of Heavy Metals in Soil and Vegetable Crop Irrigated with Sewage Water in Western Region of Saudi Arabia. *Saudi journal of biological sciences*, 2016; *23*(1), S32-S44.

Brown, F, González, J, Cejas, EC., Monan, M, and Sayago, IS. Bromatological Analysis and Antioxidant Capacity of *Hibiscus sabdariffa* L. in Cuba. *Open Access Library Journal*, 2020; *7*(1), 1-7.

Casierra-Posada, F., Briceño-Pinzón, ID, and Carreño-Patiño, JA.Tolerance of Spinach (*Spinaciaoleracea*) Plants to Partial Defoliation. *GesundePflanzen*,2021; *73*(4), 427-434.

Drechsel P, Scott C, Raschid-Sally L, Redwood M, and Bahri A. Wastewater Irrigation and Health: Assessing and Mitigating Risk in low-income Countries. *International Water Management Institute and International Development Research Centre*, 2010; Battaramulla.

Ehilé, S. E., Kouassi, N. K., N'Dri, D. Y., Camille, A. K., and Amani, G. N. G.Proximate Composition of Five Varieties of Spontaneous Leafy Vegetables Regularly Consumed in Côte d'Ivoire Areas. *International Journal of Current Microbiology Applied Science*, 2017; *6*, 3536-3542.

El-Naim, AM, Khaliefa, EH, Ibrahim, KA, Ismaeil, FM, and Zaied, MM. B. Growth and Yield of (*Hibiscus sabdariffa* l.) Influenced by Plant Population in Arid Tropic of Sudan under Rain-fed. *International Journal of Agriculture and Forestry*, 2012; *2*(3), 88–91.

Enujeke, EC, and Egbuchua,C.Growth and Yield Response of Fever Plant Scent leaf (*Ocimumgratissimum*) in Degraded Oxisols using Different Soil Media. *International Journal of Biosciences (IJB)*, 2022; 21(2), 411-418.

Erni, M, Drechsel, P, Bader, HP, Scheidegger, R, Zurbruegg, C, and Kipfer, R. Bad for the Environment, Good for the Farmer? Urban Sanitation and Nutrient Flows.*Irrigation and drainage systems*, 2010;*24*, 113-125.

Gagliardi, A., Giuliani, MM., Carucci, F, Francavilla, M, and Gatta, G. Effects of the Irrigation with Treated Wastewaters on the Proximate Composition, Mineral, and Polyphenolic Profile of the Globe Artichoke Heads [*Cynaracardunculus (L.*)].*Agronomy*, 2019; *10* (1), 53.

Ganogpichayagrai A, and Suksaard C. Proximate Composition, Vitamin and Mineral Composition, Antioxidant capacity, and anticancer activity of *Acanthopanax trifoliatus*. *Journal of Advanced Pharmaceutical Technology & Research*,2020;11:179-83.

Ghislain, M. T., Etengeneng, A. E., Sonia, M. N. H., Noelle, K. S. C., and Innocent, G.Proximate and Mineral Composition, Protein Quality of *Hibiscus sabdariffa*L.(Roselle) Seeds Cultivated in two Agro Ecological Areas in Cameroon.*International Journal of Nutrition and Food Sciences*, 2014; *3*(4), 251-258.

Hanjra, MA., Blackwell, J, Carr, G, Zhang, F, and Jackson, TM. Wastewater Irrigation and Environmental Health: Implications for Water Governance and Public Policy. *International journal of hygiene and environmental health*, 2012; 215(3), 255-269.

Hussain, J., Rehman, N., Al-Harrasi, A, Ali, L, Ullah, R., Mabood, F, and Ismail, M. Nutritional Prospects and Mineral Compositions of Selected Vegetables from Dhoda Sharif-Kohat. *Journal Medicine Plants Res*, 2011; *5*(29), 6509-6514.

Iqbal, M, Iftikhar, M., Aqeel Ahmad, MS., Hameed, M., Noreen, A., et al., Vegetation Dynamics of Anthropogenically Disturbed Ecosystem in Hilly Areas around Sargodha, Pakistan. *International Journal of Agriculture and Biology*, 2016;*18*(04), 830–836.

Ladi, OJ.,Ojo, OC, Awodi, YP., and Alfa, IN. Proximate Composition, Mineral and Phytochemical Contents of Some Leafy Vegetables Native to Igala Kingdom Kogi State Nigeria. *International Journal of Biochemistry Research & Review*, 2016; 15(4), 1–11.

Machado RMA, Serralheiro RP. Soil Salinity: Effect on Vegetable Crop Growth. Management Practices to Prevent and Mitigate Soil Salinization. *Horticulturae*. 2017; 3(2):30. https://doi.org/10.3390/horticulturae3020030

Minhas, PS, and Samra, JS.Wastewater Use in Peri-urban Agriculture: Impacts and Opportunities. 2004;75-pp.

Minhas, PS, Yadav, RK, Dubey, SK., and Chaturvedi, RK. Long term impact of Waste water Irrigation and Nutrient rates: Performance, Sustainability and Produce Quality of Peri urban Cropping Systems. *Agricultural Water Management*, 2015; 156, 100-109.

Murtaza, G, Ghafoor, A, Qadir, M, Owens, G, Aziz, MA., and Zia, M.Disposal and Use of Sewage on Agricultural Lands in Pakistan: A review. *Pedosphere*, 2010;*20* (1), 23-34.

Okunlola, GO, Jimoh, MA.,Olatunji, OA., Rufai, AB., and Omidiran, AO. Proximate Analysis, Mineral Composition, and

Antioxidant Properties of Bitter leaf and Scent leaf. *International journal of vegetable science*,2019; *25*(4), 346-354.

Qadir, M, Wichelns, D, Raschid-Sally, L., McCornick, PG., Drechsel, P., Bahri, A., and Minhas, PS.The Challenges of Wastewater Irrigation in Developing Countries. *Agricultural water management*, 2010; *97*(4), 561-568.

Singh, SP., Singh, S, Kumar, V., Kumar, RR., and Singh, M. Effect of Integrated Nutrients Management and Iodine Fertilization on Sulphur Content in Spinach (*Spinaciaoleracea L.*). *International Journal Current Microbiology Applied Science*, 2018; *7*(2), 2355-2361.

Sokolow,J, Kennedy,GAttwood, S. Managing Crop tradeoffs: A methodology for comparing the water footprint and nutrient density of crops for food system sustainability,Journal of Cleaner Production,Volume 225,2019,Pages 913-927, https://doi.org/10.1016/j.jclepro.2019.03.056

Tayyeb, M., Achakzai, NRSUK.,Rehman, SU., Akhtar, W, Baseer, K, and Sabir, M. Mineral Profile and Proximate Analysis of Fresh and Waste water Irrigated Cabbage from Quetta Balochistan. *Pure and Applied Biology (PAB)*, 2017;*6*(3), 882-888.

WHO. FAO. Vitamin and Mineral Requirements in Human Nutrition. 2nd edition world health organization. *food and agriculture organization:* 2004 geneva, switzerland