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Moringa oleifera Seed Treated Sanitized Water Effect on Growth and Morpho-physiology of Commonly Consumed Vegetables of Malaysia

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Abstract: *Moringa oleifera* seed solution was used in this study to treat municipal wastewater that were used as the treatment in this study. There were 3 treatments used; treated wastewater, normal tape water and untreated wastewater. The wastewater were collected at main drainage at Batu 7 (5º52'57.2''N 118º02'39.7"E) and diagnosed based on the pH and EC. Data on plant height (cm), number of leaves, leaves length (cm), chlorophyll, and number of primary branches were taken every week until week 4. For root length (cm), fresh weight (g), dry weight (g) and moisture were taken after the harvesting. The data collected were analyzed by using Statistical Analysis Software (SAS) version 9.4 computer program with experimental design was Randomized Complete Block Design (RCBD). The means were separated and compared using Duncan's Multiple Range Test (DMRT) at 0.05 significant level. *M. oleifera* seeds solution treated irrigation exhibited positive outcomes for most of the parameters recorded, but response of different vegetables were also different on varied parameters. The increase of pH from untreated waste water (6.40) to sanitized/treated waste water (6.73) and reduction of EC from untreated waste water (367.9) to sanitized/treated waste water (359.1) is the proof of making nutrients more available for plants uptake. From the overall study it is proved that *M. oleifera* seeds are suitable as the replacement and an alternative besides chemical coagulant to treat wastewater which is cheaper, eco-friendly and sustainable to be used in agricultural irrigation based on all the parameters evaluated in this study.

Keywords: *Moringa oleifera*, Sanitization, Toxicity, Water pollution, Vegetables.

Introduction

According to the Malaysian Meteorological Department, Malaysia recorded the range of rainfall is 100 mm to 400 mm in September 2018. In the North peninsular areas monthly rain was recorded below the average level where Subang Station recorded the highest monthly rainfall which was 375.6 mm and also recorded the highest daily rainfall record which was 86 mm. While Kluang Station recorded the lowest monthly and daily rainfall record which was 124 mm and 24 mm daily rainfall record. In Sabah, it has been recorded that the rainfall record is below the long-term average level especially in Labuan, Kota

Kinabalu and Sandakan compared to other areas. The highest monthly rainfall was in Sri Aman which is 490.4 mm and Labuan recorded the highest daily rainfall record of 143.0 mm (Fig. 1). While Keningau recorded the lowest monthly and daily rainfall record of 112.8 mm and 32.2 mm (http://www.met.gov.my/forecast/weather/state/St502).

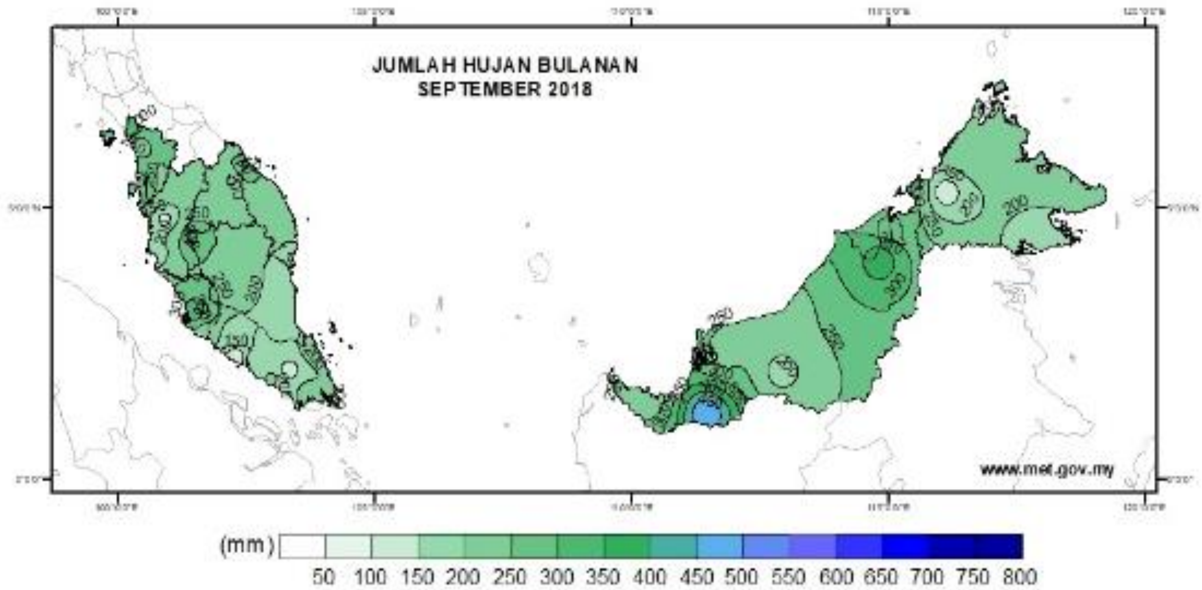

Fig. (1): Rainfall average of all states in Malaysia

This different rainfall lead to a different flooding phenomenon for different areas. Generally, throughout the year 2016 to March 2017, all states in Malaysia experienced floods. Where Selangor is the most frequent flooded state in Malaysia that experienced 115 flood events followed by Pahang, 69 flood events and Perlis with only 2 flood events (Fig. 2).

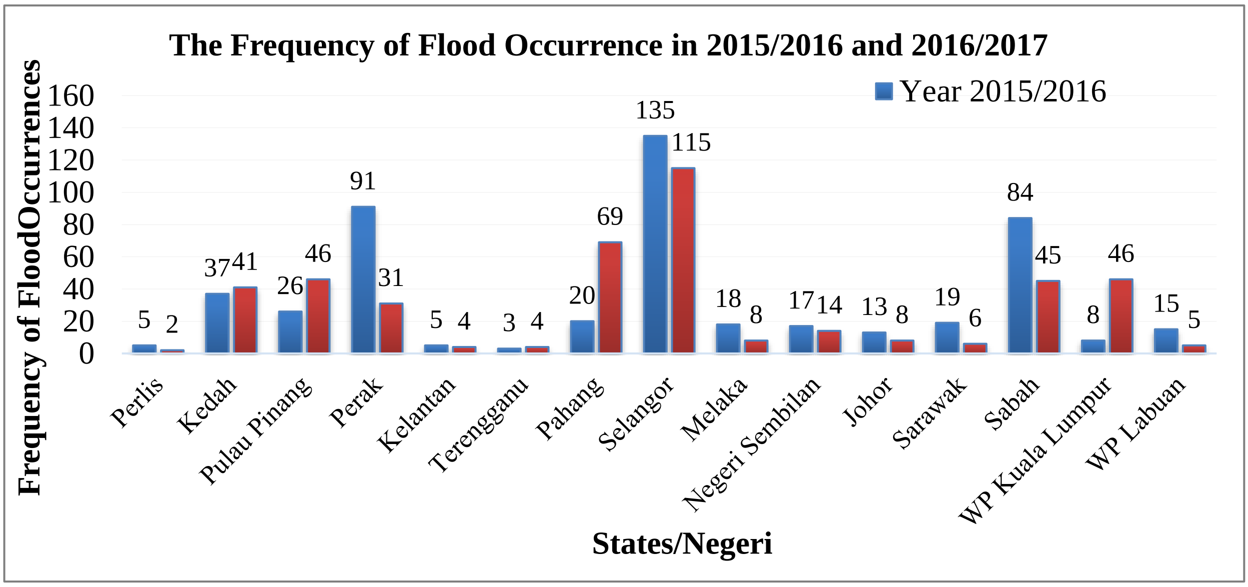

Fig. (2): The Frequency of Flood Occurrence in 2015/2016 and 2016/2017 in Malaysia
(http://www.met.gov.my/forecast/weather/state/St502)

This flooding event creates difficulties to get clean water source immediately to be used as drinking and to meet their daily needs. By using *Moringa oleifera* seeds, they can solve their problems easily to treat the water from the flood.

Some other problems that lead to the difficulties of getting clean water source is the pollution of main water source which is river. This problem always cause by the discharged of industrial wastewater to the river without treated the wastewater first.

According to Utusan Online 25 May 2016, the quality of river water is at an alarming level in Malaysia with 229 out of 473 rivers are found to be polluted due to the industrial disposal. The Department of Environment has stated that only 244 rivers are cleaned from any pollution and are safe to be used. This incident is maybe because of the clarification process of wastewater is expensive and need to use high amount of chemical coagulant to clarify the wastewater. Wastewater need to be clarify first before discharging it to the river. This is importance to maintain the quality of human life, aquatic life and even any living things around the rivers. This is because all of this life need clean water to live.

In Malaysia, for wastewater treatment usually used chemical as coagulant which is Aluminium sulphate. According to Meghzili *et al*. (2016), by using aluminium sulphate to treat wastewater often resulted of overdose or no favorable condition to the hydrolysis which is the pH and the temperature. If the treatment process meets the favorable condition, the particles of wastewater and the aluminium will be bind together at the bottom of flocculators and decanter. It will precipitate as a sludge. But the aluminium will remain in the solution if the process didn't meet the favourable condition. Moreover there is also a studies show that the over dosage of aluminium can result to Alzheimer's disease (Dzulfakar *et al*., 2011). According to Dzulfakar *et al*. (2011), the over dosage of aluminium could resulted in chronic toxicity and linked with severe disease such as Parkinson's dementia amyotrophic lateral sclerosis and Alzheimer's disease. All these diseases are related to nervous system of human.

Natural polyelectrolytes of plant origin have been used for many centuries in developing countries for clarifying turbid water (Babu & Chaudhuri, 2005). For home water treatment, the materials have to be used in the form of powder or paste, 90% of which consists of natural substances other than the polyelectrolytes. They may be manufactured from plant seeds, leaves, and roots (Asrafuzzaman *et al*., 2011). These natural organic polymers are interesting because, comparative to the use of synthetic organic polymers containing acrylamide monomers, there is no human health danger and the cost of these natural coagulants would be less expensive than the conventional chemicals alike since it is locally available in most rural communities.

Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification. Considering the above issues this experiment was conducted to treat/sanitize municipal waste water using Moringa seed powder as a source of irrigation water for the production of commonly consumed leafy vegetables of Malaysia.

Materials & Methods

Experimental site and materials

The study was carried out inside the insect-resistant house 3 (RKS-3) at the Faculty of Sustainable Agriculture, Universiti Malaysia

Sabah (UMS) Sandakan campus from March 2019 to July 2019. Fully matured and ripened *Moringa oleifera* seeds were harvested at the morning to enhance the freshness from Taman Bunga Matahari, Mile 4, Sandakan Sabah with the coordinate N 5°55'10.8984 E 118°0'14.8644. Four different types of leafy vegetable (green amaranth, red amaranth, kangkong and pak choi) seeds were bought from Hient Huat Seeds Sdn. Bhd. Mile 7 Sandakan. Black colored polybags (15 cm x 18 cm) were filled up using the planting media preppared by mixing top soil, sand and well decomposed chicken dung at the ratio of 3:2:1, respectively. The municipal wastewater was collected from the main drainage at Batu 7 (5^{o}52’57.2’’N 118^{o}02’39.7”E), Sandakan city.

Preparation of Moringa seed aqueous solution

The Moringa seeds were separated from freshly harvested pods. After that, the seed coat and the wings were removed to use the white seeds only. It was then crushed using mechanical blender to produce the powder. After that, 4.0 g of this powder was diluted into 1.0 litre of distilled water which was considered as stock solution. The wastewater was treated using 2.0 ml of that stock solution against every 1.0 litre of wastewater (Fig. 3).

Experimental units and data collection

All those four types of vegetables seeds were sown directly into polybags arranged in Randomized Complete Block Design (RCBD) with five replications and watered using normal tape water supply to make sure the plants are well germinated.

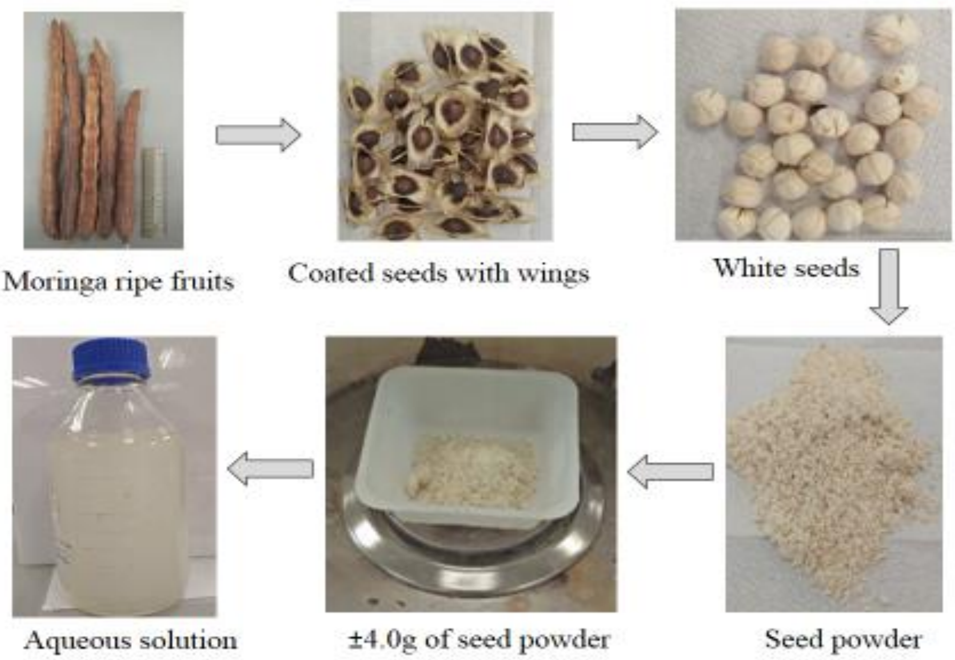

Fig. (3): The process of preparing the *M. oleifera* seed aqueous solution.

The wastewater was treated a day before the wastewater use to irrigate all the plants. Before treating the wastewater, the pH and EC of the wastewater were checked and after 24 hours the wastewater were checked again to see the reading changes of the sanitized wastewater. After seven days of well germination all the replicates were irrigated daily using 300ml of treated/sanitized wastewater (T1), untreated wastewater (T2), and control (T3); just using the normal tape water until four weeks after sowing.

So, in total there were 60 replicates of vegetables with three water treatments, four different vegetable species per treatment with five replicates of each vegetable's. As all those seeds were directly broadcasted into the polybags so thinning was done after two weeks of sowing keeping five plants in every polybags for better growth and development. In this experiment the effectiveness of *M. oleifera* seeds was also tested as organic coagulant to wastewater based on the water pH and the EC of the treated water through the growth and morho-physiological development of those vegetables.

The growth parameters of those vegetables were determined based on the plant height (cm) with other morphological attributes; numbers of leaves, numbers of branches recorded in every week interval, while the root length (cm), fresh weight (g), dry weight (g), and moisture content were determined after harvesting. The dry weight of the plants were taken from the oven dried samples at 45^{o}C until stable weight gaining. The moisture content was measured by following the equation of [(fresh weight – dry weight)/ dry weight] x 100. On the other hand, for physiological characteristics; total chlorophyll contents (nmol/cm^2) was also measured using portable SPAD meter.

Statistical analysis

The growth development of the vegetables was sorted out by running Randomized Complete Block Design (RCBD) and the data was subjected to analysis of variance (ANOVA) using SAS 9.4 software. When F was significant at the $P<0.05$ level, treatment means was compared and separated using the Duncan's Multiple Range Test (DMRT).

Results & Discussion

Effect of treatments to plant height

Table (1) showed that all plant species experienced a significant increase in plant height on a weekly basis. Red amaranth showed the highest plant height among all four plant species on week 4 but differed non-significantly ($p>0.05$) among treatments. Among the three water treatments, treated wastewater (T1) showed the highest plant height followed by untreated wastewater (T2) and control (T3). The growth rate of red amaranth was also the highest among all species followed by green amaranth, Pak Choy, and kangkong (Table 1).

For the plant height of pak choi significant ($p<0.05$) difference was observed at week1, week 3 and week 4 with T1, T3 and T4 but only values were non-significantly differed ($p>0.05$) at week 2. The highest overall pak choi growth rate (93.68%) was seen under untreated wastewater treatment (T2). On the other hand, significant ($p<0.05$) plant height variation was observed for kangkong in all 4 weeks, mainly in between T1 and T2 treatments. Among all three treatments the highest plant height was recorded at T1 (sanitized water) but the overall highest growth rate (89.54%) was observed for control treatment (T3). Red amaranth also showed significant differences ($p<0.05$) for plant height for the entire time periods. The plant height of red amaranth exhibited that treated wastewater (T1) was the best among all 3 treatments. In 4 weeks period, treated wastewater (T1) displayed non-significant differences with untreated wastewater (T2) but had significant differences ($p<0.05$) with control treatment (T3), while the highest overall growth rate (97.49) was seen under treatment 2 (T2). Green amaranth exhibited significant variation ($p<0.05$) in between T1 and T3 at week 1, week 3 and week 4 but at week 2 in between T2 and T3. Furthermore, non-significant variations ($p>0.05$) were observed in between T1 and T2 under all 4 weeks period. On the other hand, overall the highest growth rate (96.51%) was recorded at control treatment (T3) which was similar with kangkong growth rate (Table 1).

All four types of plant species showed significant differences in week 1 although it was watered the same type of normal tape water because the germination rate and periods of seeds were not the same. Moreover, the significant may also be due to soil compaction and minor planting/soil depth variations as all seeds were broadcasted randomly. According to Mao *et al*. (2019), intermediate burial of seeds plays a significant role in seed germination. Too deep of planting may lead to insufficient oxygen for plant germination. This may cause some of the seed germinated later than the other seed.

The results also proved that *M. oleifera* seeds sanitized/treated wastewater (T1) had the same effect as fresh tape water. Municipal wastewater (T2) had low balanced nutrient content which is NPK that can lead to a low growth rate compared to sanitized wastewater and control treatment (Zavadil, 2009).

Table (1): Effect of different water treatments on plant height of different leafy vegetable species.

Species	Plant Height (cm)					
	Treatment	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Growth rate (%)**
Pak Choi	T1	1.40^{ab}	6.84^{a}	13.44^{a}	19.00^{a}	92.63
	T2	1.16^{b}	6.70^{a}	10.58^{b}	18.34^{ab}	93.68
	T3	1.64^{a}	6.96^{a}	10.40^{b}	17.26^{b}	90.49
Kangkong	T1	4.80^{a}	14.7^{b}	26.44^{a}	34.76^{a}	86.19
	T2	3.26^{b}	12.6^{c}	22.92^{b}	28.00^{b}	88.36
	T3	3.30^{b}	17.0^{a}	21.40^{b}	31.54^{ab}	89.54
Red Amaranth	T1	3.16^{a}	12.9^{a}	24.36^{ab}	49.00^{a}	97.14
	T2	2.24^{ab}	13.5^{a}	27.72^{a}	46.14^{ab}	97.49
	T3	2.06^{b}	6.82^{b}	20.16^{b}	45.24^{b}	96.38
Green Amaranth	T1	1.90^{a}	9.0^{ab}	17.52^{b}	32.40^{b}	94.14
	T2	1.54^{ab}	10.9^{a}	17.98^{b}	34.08^{ab}	95.48
	T3	1.40^{b}	5.9^{b}	40.92^{a}	40.06^{a}	96.51

Note; Table followed by the same alphabet showed non-significant difference at F>0.05.

Neha & Karar (2017) also said that wastewater contained heavy metals and other chemicals that can help as the fertilizer constituent in the agriculture field. But these heavy metals and other chemicals may also affect plant growth and development very badly if it is not treated well. So, the addition of *M. oleifera* seed aqueous solution can keep those contents in a good range or neutralize for healthy plant growth. This is why treated wastewater shows positive results in plant growth rate. Marobhe & Sabai (2021) also reported that, there has been a growing interest in *M. oleifera* seed as a natural coagulant. It is a nontoxic and drought tolerant tree which possesses medicinal and nutritional properties, including water-purification properties (Hellsing *et al*., 2014).

Effect of treatments to the number of leaves

Results presented in table (2) shows the mean number of leaves of different species and treatments. Every week until week 4, it shows a rise in numbers of leaves, where green amaranth produced the highest followed by red amaranth, kangkong, and pak choi. There was a significant difference between treatment in week 2 and 3 for green amaranth. Where at week 1 and 2 for both cases control treatment (T3) showed the highest numbers of leaves (3) and (9.2) in kangkong, respectively. For kangkong, in week 1 and 2 the numbers of leaves in T1 was varied significantly ($p<0.05$) with both the T2 and T3. On the other hand, T2 at week 2 also produced the highest numbers of leaves (6.0) which was significantly different with T3. Similar types of findings have been reported by Biswas *et al*. (2015) in red amaranth; who opined that the highest numbers of leaves were counted under control treatment over other wastewater treatments.

Number of leaves among all species were not exactly comparable due to its different morphological characteristic where kangkong morphologically had highest number of leaves and pak choi had the lowest number of leaves compared to the other species. Both type of amaranth is the only species that can be compared where red amaranth produced more leaves than green amaranth in the earlier week but started to slow down at week 4 and vice versa for green amaranth where in the earlier week the leaves produced slowly and started to produce vigorously at week 4.

For Pak Choy, a significant differences were observed at week 1 and week 4; at week 1, T1 and T3 showed significant differences, while at week 4 significant differences were observed in between T1 and T2, respectively. But non-significant variation was seen in case of both T2 and T3. For kangkong, generally there was a moderate trend of significant differences among all three treatments where treated wastewater had the highest rank. Treated wastewater showed a significant difference with both control and untreated wastewater. For green amaranth also the significant differences observed in case of T2 and T3 but T1 and T4 showed non-significant variation (Table 2).

Table (2): Effect of different water treatments on numbers leaves and leaf length of different leafy vegetable species.

Species	Treatment	Number of Leaves				Leaf length (cm)			
		Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4
Pak Choy	T1	2^{b}	5.4^{a}	5.4^{a}	14.6^{a}	0.76^{b}	4.2^{a}	9.4^{a}	13.96^{a}
	T2	2.4^{b}	5.4^{a}	5.4^{a}	12.6^{b}	1.04^{a}	4.6^{a}	9.62^{a}	14.3^{a}
	T3	3^{a}	5.4^{a}	5.4^{a}	13.6^{ab}	1.06^{a}	4.44^{a}	9.3^{a}	14.12^{a}
Kangkong	T1	3^{a}	9.2^{a}	28^{a}	46.2^{a}	4.68^{a}	9.9^{a}	13.84^{a}	15.96^{a}
	T2	2.2^{b}	7.8^{b}	31.2^{a}	43.8^{a}	3.96^{a}	8.4^{a}	13.48^{a}	16.02^{a}
	T3	2^{b}	7^{b}	8.2^{b}	13.6^{b}	3.94^{a}	9.6^{a}	13.54^{a}	16.46^{a}
Red Amaranth	T1	2^{b}	5.6^{a}	14.8^{b}	43^{a}	1.36^{a}	2.94^{a}	9.38^{a}	13.22^{a}
	T2	2.6^{a}	5.6^{a}	17.6^{a}	35^{b}	1.46^{a}	3.68^{a}	10.94^{a}	13.86^{a}
	T3	2^{b}	5.4^{a}	10.2^{c}	35.8^{b}	1.34^{a}	3.3^{a}	9.06^{a}	12.22^{a}
Green Amaranth	T1	2^{a}	5.4^{ab}	12.4^{b}	45.2^{b}	1.42^{a}	3.58^{b}	10.20^{a}	14.54^{a}
	T2	2^{a}	6^{a}	16.4^{a}	55.4^{a}	1.2^{ab}	4.28^{a}	10.98^{a}	14.12^{a}
	T3	2^{a}	5^{b}	11.4^{b}	53.8^{a}	1.1^{b}	3.56^{b}	11.16^{a}	14.16^{a}

Note; Table followed by the same alphabet showed non-significant difference at $F>0.05$. Here T1 is treated waste water, T2 is non-treated waste water and T3 is control (normal tap water).

Overall, treated wastewater still can be considered as good as control as these two treatments showed a very little difference. According to Ci *et al*. (2015), the production of leaves usually not affected either the plant in a good condition or otherwise. But the density of the leaves must be reasonable. This experiment showed that application of treated wastewater contributed to produce a good number of leaves compared to untreated wastewater except for kangkong where in week 4 non-significant variations was observed, but interestingly control treatment (T3) produced the lowest numbers of leaves.

Effect of treatments to leaves length

Just like numbers of leaves, the leaves length is also not exactly comparable among all four types of vegetables due to their morphological variations of leaves structure. However, among the four types of vegetables; kangkong had the longest leaf length and Pak Choy had the shortest leaf length compared to red and green amaranth (Table 2).

Based on the results presented in Table 2 only significant ($p<0.05$) variations were observed for length of leaves in Pak Choy at week 1 and in green amaranth at week 1 and 2. For all others found some variations but were statistically non-significant ($p>0.05$). As the increasing rate of plant growth from the beginning leaves lengths of all plants were also increased from week 1 until week 4. For pak choy at week 1 the highest leaves length (1.06 cm) was seen in T3 (control), followed by T2 (non- treated waste water) and the lowest was seen in T1 (treated waste water), respectively. But very interestingly Ali *et al*. (2019) reported significantly very high increase of leaves length in three different crops; Purslane (*Portulaca oleracea*), Coriander (*Corianderum sativum*) and Lactuca (*Lactuca sativa*) after irrigation with varied concentrations of waste water over control treatment. On the other hand in case of green amaranth at week 1, the highest leaves length (1.42 cm) was observed at T1 (treated waste water) which was significantly ($p<0.05$) higher compared to T3 (control) and also was higher than T2 (non-treated waste water) but statistically non-significant ($p>0.05$). While the highest Lettuce leaf yield was reported in control treatment over secondary treated wastewater irrigation by Zavadil (2009) in the Mělník town, Czech Republic. Furthermore, at week two also seen significant variation with T1 and T2 or T2 and T3 with the highest value in T2 (4.28 cm) but T1 and T3 differed non-significantly. Overall at week 3 and week 4 leaves length were increased significantly but were statistically non-significant among both treatments. The same results were seen for both kangkong and red amaranth for all three (3) treatments and all four (4) weeks of interval (Table 2). Zavaldil (2009) further reported that Lettuce leaves yield were increased significantly after irrigation using primary treated wastewater.

Effect of treatments on total chlorophyll content (SPAD value; nmol.cm^{-2})

SPAD reading showed the increased trend for total chlorophyll content of all four vegetable species starting from week 2 to 4 (Table 3). Among all four vegetables the highest SPAD value was found in kangkong may be due to the deep green colored leaves, but there was no significant differences among treatments. The second highest chlorophyll content was recorded in green amaranth, followed by Pak Choy, and red amaranth, respectively (Table 3).

At week 2 significant variation was observed for pak choy among all three treatments with the highest in T3 (36.5 nmol/cm^2) and the lowest was in T1 (24.4 nmol/cm^2). While at week 4 significant variation was seen in between T1 and T3, but T1 and T2 varied non-significantly. For red amaranth and green amaranth, the significant differences were only found at week 2 in between T2 and T3 but week 3 and week 4 didn't show any significant variations, the same non-significantly status goes to kangkong for all three weeks and treatments (Table 3).

Red amaranth had the lowest SPAD reading among all due to the physiological status of red pigmented leaves containing lower amount of chlorophyll content compared to others. In addition, photosynthetic potential and primary production of red amaranth also lower than the other plant species (Riccardi *et al.*, 2014).

Table (3): Effect of different water treatments on SPAD chlorophyll content of different leafy vegetable species.

Species	Treatments	SPAD Chlorophyll Content (nmol/cm^2)			
		Week 1	Week 2	Week 3	Week 4
Pak Choy	T1	0	24.26^c	35.82^a	38.9^b
	T2	0	30.7^b	35.68^a	36.78^b
	T3	0	36.5^a	35.42^a	41.52^a
Kangkong	T1	0	38.22^a	45.48^a	50.7^a
	T2	0	36.56^a	43.66^a	50.26^a
	T3	0	37.72^a	45.14^a	51.72^a
Red Amaranth	T1	0	22.28^{ab}	28.46^a	31.48^a
	T2	0	23.82^a	28.8^a	33.5^a
	T3	0	19.74^b	29.76^a	33.8^a
Green Amaranth	T1	0	25.8^{ab}	34.22^a	38.796^a
	T2	0	28.1^a	36.16^a	42.64^a
	T3	0	24.7^b	35.2^a	44.12^a

Note; Table followed by the same alphabet showed non-significant difference at $p \geq 0.05$

Effect of treatments on numbers of primary branches and root length

Data presented in table (4) showed the emergence of primary branches of four different vegetable species starting from week 2 until week 4. The first plant that emerged the primary branches were kangkong and green amaranth in week 2 and had significant differences between treatments. At week 2 kangkong plants irrigated using treated wastewater (T1) produced significantly ($p<0.05$) higher numbers of branches than control and untreated wastewater, but at week 4 significantly the lowest umbers of branches (9.0) was produced by the plants irrigated with non-treated wastewater (T2) compared to both T1 and T3. Red amaranth showed the slower emergence of primary branches among all plant species where it starts to emerged primary branches two weeks later from other plant species. For red amaranth significant variations were seen for both week 3 and 4, where at week 3 the untreated waste water (T2) produced the higher numbers of branches over control treatment, but at week 4 the highest numbers of branches (9.0) were counted in treated waste water (T1). On the other hand treated wastewater for green amaranth showed the first emergence of primary branch while other treatment didn't show any emergence. For green amaranth the highest numbers of branches were produced by the plants irrigated with non-treated waste water at week 3 compared to both the control and treated waste water treatments, but at week 4 the variations were statistically non-significant (Table 4). Kumar & Reddy (2007) reported that Tomato plants produced significantly the highest numbers of branches treated with non-treated wastewater over control treatment. On the other hand production of increased numbers of branches in Tea plants have been reported after irrigation with treated wastewater over fresh water irrigation (Bozdogan, 2015).

Table (4): Effect of different water treatments on numbers of branches and root length of different leafy vegetable species.

Species	Treatments	Numbers of primary branches				Root length (cm)
		Week 1	Week 2	Week 3	Week 4	At harvest
Pak Choy	T1	-	-	-	-	8.28[b]
	T2	-	-	-	-	12.6[a]
	T3	-	-	-	-	8.92[b]
Kangkong	T1	0	3.2 [a]	6.2 [a]	11.2[a]	20.8[a]
	T2	0	1.2[b]	6.4 [a]	9 [b]	23.92[a]
	T3	0	1.4 [b]	3.6 [b]	11.8 [a]	22.0[a]
Red Amaranth	T1	0	0	3.8[a]	9[a]	16.74[a]
	T2	0	0	4.6[a]	7[b]	15.34[a]
	T3	0	0	2[b]	7.4[b]	18.28[a]
Green Amaranth	T1	0	1 [a]	2.8[b]	8.2[a]	17.54[b]
	T2	0	0[b]	4.2 [a]	8.6 [a]	14.82[b]
	T3	0	0[b]	2.2[b]	7.8 [a]	21.74[a]

Note; Table followed by the same alphabet showed no significant difference at $p \geq 0.05$

In table (4) also presented the root length of different plant species that were affected by varied water treatments. Root length were measured in week 4 during harvesting and recoded that kangkong had the longest roots among all followed by green amaranth, red amaranth, and Pak Choy. This is because, Pak Choy has shorter growing period compare to other plant species (Thorup-Kristensen, 2001). According to Thorup-Kristensen (2001), longer growing period may lead to longer root length. This can be proved by having longer root length of kangkong because kangkong may have longer growing period compare to other plant species. According to the findings for Pak choy significantly the highest root length (12.6 cm) was recorded in T2 (untreated waste water) followed by T3 (control) and T1 (8.28 cm), respectively. On the other hand the highest root length (21.74 cm) for Green Amaranth was measured in T3 (control) followed by T1 (treated waste water) and T2 (untreated waste water) but they were statistically similar (Table 4). Furthermore, treatment wise though there were variations for root lengths of both Kangkong and Red Amaranth but the variations were statistically non-significant ($p > 0.05$).

In case of Pak choy and Kangkong, the longest root length was observed for untreated wastewater compared to treated wastewater and control. This is may be due to unreadily available nutrient in soil so the roots tended to grow longer for the sake of the nutrients and chemicals in the root environment (Marciniak, 2019). With the presence of *M. oleifera* seed solution the treated wastewater, it can help to make the nutrient in the wastewater to readily available for the plant up taken by the roots (Neha & Karar, 2017). Marobhe & Sabai (2021) reported that *M. oleifera* seed extract have the capability on the removal of suspended particles (turbidity) from waste water and removal of residual bacteria in the water pretreated using seed extract.

Effect of varied water treatments on fresh, dry weight and moisture content (%) of different vegetable species

Results presented in table (5) shows the fresh weight, dry weight and moisture content (%) of different vegetables harvested at the end of water treatment application. The fresh weight were taken right after harvesting where red amaranth was the heaviest plant (210 g at T3) followed by green amaranth (175 g at T1), Pak Choy (162 g, T3), and kangkong (153 g at T1), respectively. Non-significant variations was seen among all three treatments in case of green amaranth while for others, the highest fresh weight was recorded at control treatment (T3) compared to T1 and T2. Furthermore, the highest dry weight (62.0 g) was recorded in Green amaranth at T2 followed by kangkong (59.25 g) at T3 (control), red amaranth (56.77 g) at T3 and the lowest (36.62 g) was in pak choy at T1, respectively. Considering water treatments in different vegetables the highest dry matter content was achieved in control treatment (T3) for kangkong and red amaranth, in untreated waste water (T2) for green amaranth and also in sanitized waste water for pak choy (Table 5). Moisture content percentages were determined from the variation of fresh weight and dry matter content of different vegetables. From the analysis output it was seen that moisture percentage was the highest (454%) in pak choy as the pak choy leaves were very thick and succulent. The highest moisture content in pak choy was recorded at T3 which was significantly higher compared to T1 but non-significantly differed with T2. Furthermore, among all the vegetables the lowest moisture content (107%) was found in kangkong at T3 (control) but interestingly in kangkong significantly the highest moisture content (197%) was produced in T1 (sanitized waste water) compared to T3 (control) and untreated waste water (T2). On an average kangkong had the lowest amount of moisture content compared to other vegetables may be due to the hollow stem and narrow leaves structure (Prasad *et al*., 2008). From the results it is observed that in most cases the highest dry weight was recorded in untreated waste water (T2), it is may be due to the heavy metals up taken by those vegetable plants (Zhou *et al*., 2016; Galal *et al*., 2021). Plant moisture content showed that the water content in the plants which can also show how fresh the plants are (Oulaï *et al.*, 2016). But it also shows that the plant is more prone to rotting if not store in good condition. According to Gupta *et al.* (2013), the high moisture content in plants make the plants shows it have high component of dietary fiber which can lead to the high development of fiber and micronutrient rich food. This can be used to produce feasible food-based product against malnutrition.

Wastewater

The changes in pH and EC of municipal waste water after treating using *M. oleifera* seed solutions are presented in table (6).

Electrical conductivity (EC) is the indication of total nutrients that present in the water. The satisfactory of EC should be in acceptable amount to prevent the plants from getting overdose or insufficient amount of nutrient. According to Ding *et al*. (2018), plant growth will be increased if the EC is increased but the growth will be decreased if there is too much of EC in the water. Table (6) showed the decrease of EC to make sure that the level of nutrient in the wastewater is acceptable amount.

Table (5): Effect of varied water treatments on fresh weight, dry weight and moisture content of different leafy vegetable species.

Species	Treatments	Fresh weight (g)	Dry weight (g)	Moisture content
		At harvest	At harvest	%
Pak Choy	T1	154.4[b]	36.62[a]	321.63[b]
	T2	158.8[ab]	35.8[a]	343.58[ab]
	T3	162.4[a]	29.294[b]	454.38[a]
Kangkong	T1	153.6[a]	51.62[b]	197.56[a]
	T2	111[b]	52.4[b]	111.83[b]
	T3	123.2[ab]	59.252[a]	107.93[b]
Red Amaranth	T1	156.6[b]	49.0[b]	219.59[b]
	T2	160.6[b]	54.2[a]	196.31[c]
	T3	210.8[a]	56.77[a]	271.32[a]
Green Amaranth	T1	175.6[a]	57.4[b]	205.92[a]
	T2	170.4[a]	62.0[a]	174.84[c]
	T3	174.4[a]	59.806[b]	191.61[b]

Note; different mean values followed by the same alphabet showed non-significant difference at $p \geq 0.05$.

Table (6): Changes of pH and EC of different water used to irrigate different leafy vegetables after treating using *M. oleifera* seed solutions.

Water sources	Before		After	
	pH	**EC**	**pH**	**EC**
Normal tape water	6.68	322.1	6.68	322.1
Wastewater	6.40	367.9	6.40	367.9
Treated Wastewater	6.40	367.9	6.73	359.1

pH shows the acidity and alkalinity of the water where it is the indication of nutrient availability. If the pH value goes out of range, the nutrient in the water cannot be taken up by the plants (Grace, 2016). Moreover, this wastewater had some bad odor but after the treatment, this odor were all gone. This proved that the moringa seed solution can also remove bad odor from polluted water. A significant changes of EC and pH of waste water has also been reported by several researchers after treatment using moringa seed powders to make the water suitable of using (Sengupta *et al*., 2012; Beltrán-Heredia *et al*., 2012; Basra *et al*., 2014; Shan *et al*., 2017).

Conclusions

Based on the effect of treatments type to all the parameters, most of the parameter gave positive outcome for sanitized/treated wastewater. This proved that *M. oleifera* seed solution can be another alternative to treat wastewater since this solution are able to neutralize the amount of heavy metals may present in the wastewater to be readily available and not affecting soil structure and plant growth. Moreover, *M. oleifera* seed solution is easily available, cheaper and environmental friendly. This is because, with only 2 ml can treat every 1 litre of wastewater and it is obtained from plants. Throughout this study, untreated wastewater shows some unusual signs to the plants which is wilting even though it provides same amount of water with all the replicates. Other than that, it is also shown some insect attack signs on the plants leaves compared to treated water and control. Pest attack which was white flies also seen on the kangkong's stems. Pests attacked sign was not seen on all plants except for untreated wastewater. This mean that, untreated wastewater promotes more pests attract to the plants. Different from other treatments, the plants didn't show any unusual signs on it. Depending of plant types the growth of the plants that were watered using wastewater may show no differences with tape water (control) and treated wastewater as the survival mechanisms varied with plant varieties.

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تأثير المياه المعقمة المعالجة ببذور *Moringa oleifera* على نمو فسلجة مظهرية للخضروات الشائعة الاستهلاك في ماليزيا

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المستخلص: تم استخدام مستخلص بذور *Moringa oleifera* في هذه الدراسة لمعالجة مياه الصرف الصحي المحلية التي استخدمت كعلاج في هذه الدراسة. تم استخدام 3 معاملات مياه الصرف الصحي المعالجة والمياه الشريطية العادية ومياه الصرف الصحي غير المعالجة. تم جمع مياه الصرف الصحي في الصرف الرئيسي في Batu 7 (5o52’57.2’N 118o02’39.7 “E)) وتم تشخيصها بناءً على الأس الهيدروجيني و EC. تم أخذ بيانات عن طول النبات (سم) وعدد الأوراق وطول الأوراق (سم) والكلوروفيل وعدد الأفرع الأولية كل أسبوع حتى الأسبوع الرابع. لطول الجذر (سم)، والوزن الطازج (جم)، والوزن الجاف (جم) وأخذت الرطوبة بعد الحصاد. تم تحليل البيانات التي تم جمعها باستخدام برنامج الكمبيوتر الإصدار 9.4 من برنامج التحليل الإحصائي (SAS) بتصميم تجريبي كان تصميم القطاعات العشوائية الكاملة (RCBD). تم فصل الوسائل ومقارنتها باستخدام اختبار Duncan متعدد المدى (DMRT) عند مستوى هام 0.05. أظهر محلول بذور*M. oleifera* الري المعالج نتائج إيجابية لمعظم المتغيرات المسجلة ، لكن استجابة الخضار المختلفة كانت مختلفة أيضًا في المتغيرات المتنوعة. إن زيادة الرقم الهيدروجيني من مياه الصرف الصحي غير المعالجة (6.40) إلى مياه الصرف الصحي المعالجة / المعالجة (6.73) وتقليل EC من مياه الصرف غير المعالجة (367.9) إلى مياه الصرف الصحي/ المعالجة (359.1) هي دليل على إتاحة المزيد من العناصر الغذائية للنباتات المستغلة. من الدراسة الشاملة ثبت أن بذور *M. oleifera* مناسبة كبديل إلى جانب التخثر الكيميائي لمعالجة مياه الصرف الصحي وهي أرخص وصديقة للبيئة ومستدامة لاستخدامها في الري الزراعي بناءً على جميع المعايير التي تم تقييمها في هذه الدراسة.

الكلمات الدالة: *Moringa oleifera*، التعقيم، السمية، تلوث المياه، الخضروات.