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Effect of Oily waste Water from the Dora Refinery on Some Vegetative Growth Characteristics of Radish (*Raphanus sativus* L.)

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Abstract

The study aimed to determine how the oil refinery water affected the growth characteristics of the radish plant. The refinery's water treatment unit's main isolation basins, representing the first factor, pre-treatment water, initiate the cycle, while the final sedimentation basin provides the second factor, post-treatment water. It was used two factors and three replications, with each factor containing seven volumes: 0.00, 0.05, 0.1, 0.15, 0.2, 0.25, and 0.3 Ml/kg. After soil preparation, wastewater was added. It was sowed radish seeds and, after 55 days, doubled the quantity of oil waste water to irrigate the plants. It was harvested the plants during the flowering stage, 129 days after sowing and measured the plant's height, number of leaves, leaf area, total chlorophyll content, root length and diameter, and fresh weight and dry weight. The pre-treatment water had a positive effect on the total chlorophyll content, the length of the roots, and the fresh weight of the root part. These two factors went up by the most, by 12.37%, 26.7%, and 17.05%, respectively. The effect of the pre-treatment water ranged from a decrease to an increase in the average number of leaves, root diameter, fresh weight of the vegetative part, and dry weight of the vegetative and root parts. While its effect was negative for all volumes in the characteristics of plant height and leaf area, it gave the lowest rate of decrease by 20.2% and 26.63% compared to untreated plants. The post-treatment water had a positive impact on the plant height, number of leaves, total chlorophyll content, and fresh weight of the root part. However, it recorded the highest average increases of 61.26%, 36.12%, 6.71%, and 141.71%. While its effect varied according to the amount of water in terms of leaf area, root length, root diameter, and dry weight of the root part, it gave a negative effect in all treatments in terms of the fresh and dry weight of the vegetative part.

Keywords: Oil residue, waste water, radish, chlorophyll, leaf area.

1. Introduction

Radish (*Raphanus sativus* L.) is a root vegetable of the Brassicaceae family. People grow Radishes all over the world due to their wide range of shapes, volumes, colors, and varieties. The world produces about 7 million tons of radish annually, which is equivalent to 2% of the total vegetable production. In the field, all parts of radish, from roots to leaves to seeds, are important foods and medicines [1]. Plant cultivation depends on the amount of water and the type of water used for irrigation, as both of them affect the chemical and physical properties of the soil and plant growth. The presence of large quantities of elements in the irrigation water is a determining factor for agricultural production [2]. At present, the world is witnessing a great shortage of usable water, as the percentage of salty water that is not suitable for human or agricultural use is approximately 97%, which makes only 1% of the fresh water suitable for consumption after deducting the percentage of groundwater [3]. The utilization of water resources in agriculture plays a crucial role in determining the stability of the agricultural situation in Iraq. As the level of the Tigris and Euphrates rivers declines and the demand for water resources rises due to continuous population growth, it has become imperative to devise solutions and alternative strategies to address the issue of water resource scarcity [4]. Recently, the practice of reusing wastewater to irrigate various crops has garnered attention. Plant irrigation with sewage or industrial water is a very sensitive issue. Treated or untreated wastewater can have harmful effects on the environment, soils, and plants [5]. Estimates suggest that wastewater accounts for about 8% of the world's water, or 332 km3 annually [6]. Various human activities, both agricultural and industrial, generate wastewater, with oil wastewater from refineries and oil refining processes, along with its derivatives, being one of the most prominent forms. Large quantities of this wastewater, thrown into rivers, contribute to pollution [7]. While oil refinery wastewater contains toxic substances such as phenols, polycyclic hydrocarbons, and petroleum hydrocarbons that inhibit plant and animal growth [8]. It is also characterized by large quantities of dissolved salts, acids, fluorides, elements, fertilizers, and pesticides, the elements of which are toxic, such as barium, cadmium, lead, and mercury, while the non-toxic elements include calcium, magnesium, sodium, iron, and copper. It also contains pesticides and detergents. Fertilizers include nitrogen and phosphorus, and their presence in the water helps plants grow [9]. This research aims to determine the extent of the effect of the oil refinery water on some growth characteristics of the radish plant.

2. Materials and Methods

2.1. Experiment design

The Botanical Garden of the Department of Biology, College of Education for Pure Sciences, Ibn Al-Haitham, conducted a potting experiment for the season 2022-2023 to plant radish seeds of the *Raphanus sativus* L. Indian variety. We used soil from the college's field, sifted it through a 3 mm sieve, air-dried it, and then packed it in plastic pots, packed with plastic bags (**Table 1**).

Table 1. Chemical and physical properties of used soil

	%Soil components			**The content of elements in the ppm soil**				**μs/cm**		**ppm**	**%**
Soil class	**sand**	**Silt**	**Mud**	**N**	**P**	**K**	**Mg**	**EC**	**pH**	**TDS**	**O.M.**
Mud	8.3	50.8	40.9	23.3	18.16	119.6	230	4.2	6.1	601	2.05

2.2. Bring samples

The refinery collected oil waste water from the main isolation basins in the water treatment unit of the Dora refinery on 9/9/2022, representing the first factor, pre-treatment water, and the second factor, post-treatment water, from the final sedimentation basin. The refinery then conducted the analysis. For sample (2), the experiment was carried out with a completely

Randomized Design (C.R.D.) with two factors and three replications; each factor has seven volumes, which are 0.00, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, Ml/kg, and thus the number of experimental units became 42 units.

2.3. Cultivation steps

After preparing the soil on September 12, 2022, we placed the waste water and left it under the sun until the planting date. We planted 20 radish seeds per pot on September 19, 2022, and watered them with tap water to meet their needs. Ten days after planting, we isolated the plants as they grew. Each pot contains eight plants. After 45 days, I took the first batch of two plants per pot and measured their dry and fresh weights. On November 13, 2022, we doubled the amount of oil waste water to irrigate the plants, resulting in volumes of 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, and 0.6 Ml/kg. For both reasons, the harvest occurred after a 129-day cultivation period. Three plants randomly blossomed in each pot (**Table 2**).

Table 2. Physical and chemical analysis of oil waste water samples from the Dora refinery**.**

Test	Water pre- treatment	Water post-treatment	ppm
pH	7.2	7.3	H
Turbidity	87.1	6.3	NTU
T.D.S	1089	900	Mg/L
C.O.D	400	56	Mg/L
B.O.D	109	26	Mg/L
Oil	95.4	1.4	Mg/L
Phenol	2.4	0.039	Mg/L
S^-	0.193	0.041	Mg/L
S.S	371	46	Mg/L
SO_4	370	350	Mg/L
Cl^2	396	316	Mg/L
D.O	0.0	7.2	Mg/L

2.4. Studied traits

2.4.1. Height of the vegetative group (cm)

Using a measuring tape, we measured the average height of three randomly selected plants from each experimental unit from the plant contact area with the root to the highest growing apex in the flowering stage, or 129 days after the date of planting.

2.4.2. The number of plant leaves (plant.pot^{-1})

The average number of leaves of three random plants was taken from each experimental unit at the harvesting stage.

2.4.3. Leaves area (cm^2)

Using the discs method, we measured the leaf area of three randomly selected plants from each experimental unit during the harvesting stage. We took the leaves from the first, second, and third rings, and then calculated the number of discs based on their weight. The following equation was used to calculate the paper space.

$$\text{Paper area (cm}^2\text{)} = \frac{Sheet\ Weight}{Disc\ weight} \text{ x Disk space Information space} \quad (1)$$

2.4.4. Total Chlorophyll Index Estimation (SPAD)

The total chlorophyll content was measured by a Japanese SPAD device for three plants before the flowering stage for each experimental unit randomly.

2.4.5. Root length (cm)

We used a measuring tape to measure the average root length of three randomly selected plants from each experimental unit, starting from the plant connection area and ending at the end of the root branching during the harvesting stage.

2.4.6.Root diameter (cm)

The average root diameter of three random plants from each experimental unit was taken using the Vernier caliper at the harvesting stage.

2.4.7.The wet weight of the vegetative and root system (g. plant $^{-1}$)

Three random plants were taken from each experimental unit and weighed using a Sensitive Balance.

2.4.8.Dry weight of vegetative and root system (g. plant $^{-1}$)

Three random plants from each experimental unit, the vegetative group, were dried with an electric dryer (Oven) at 65 °C until weight stability, using a Sensitive Balance. For the root group, we cut the roots of three randomly selected plants from each experimental unit into rings, exposed them to the sun until the weight stabilized, and then weighed them using a (sensitive balance).

2.5. Statistical analysis

We utilized the Statistical Packages of Social Sciences (SPSS) (2016) for data analysis, examining the impact of various coefficients on the traits under investigation. Completely Randomized Design (CRD), the significant differences between the means were compared with the Least Significant Difference-LSD test.

3. Results and Discussion

3.1.Plant height (cm)

The results demonstrated a significant impact on the use of oil waste water, with the water pre-treatment showing less significant differences than the untreated plants. The untreated plants had the highest mean of the trait, reaching 74.10 cm, while the volumes of 0.05, 0.10, and 0.15 Ml/kg recorded a successive decrease in the rate of plant height. The percentage decrease was 2.12%, 6.88%, and 12.42%, whereas the volume of 0.20 Ml/kg recorded the lowest rate of plant height, reaching 59.13 cm with a decrease of 20.2%. As for the volume of 0.30 Ml/kg, it recorded 67.1 cm, a decrease of 9.45% compared to untreated plants. The higher concentrations of ammonia, NH_3, in the oil waste water pre-treatment may have poisoned the cells responsible for elongation and increased their respiration, as [2, 11] found. As for the water post-treatment, the volume of 0.10 Ml/kg recorded the highest average plant height among the treatments, which reached 110.56 cm, an increase of (61.26%) compared to the untreated plants, which gave an average of 68.56 cm. The volumes of 0.15, 0.20, and 0.30 Ml/kg demonstrated a higher growth rate than the untreated plants, with increases of 4.04% and 1.95% (6.77%), respectively. The results show that the amount of waste water had a big effect on the height characteristic. The volume of 0.10 Ml/kg helped improve the characteristic, while adding more used water may have the opposite effect [12].

3.2.Number of leaves (plant. pot^{-1})

The average number of leaves shows that there is a significant difference between the treatments. The water pre-treatment had a volume of 0.15 Ml/kg, and the highest mean for this trait was 19.66 leaves, which is 5.30 percent more than the plants that were not treated, which had 18.67 leaves. For the volume of 0.30 Ml/kg, the average number of leaves decreased to 16.33, a decrease of 12.53%. This suggests that increasing the waste water pre-treatment inhibits the leaf number characteristic. During the water post-treatment, the average volume of 0.30 Ml/kg recorded the highest in the trait among the treatments, reaching 21.33 leaves, an increase of 36.12% compared to the untreated plants, which recorded 15.67 leaves. The water post-treatment volumes of 0.05, 0.10, 0.15, 0.20, and 0.25 Ml/kg yielded higher averages in the trait compared to the untreated plants, with increased rates of 12.76%, 23.36%, 8.49%, 27.63%, and 23.36 percent. The increase in foliar growth results in the radish plant can be attributed to the waste water containing large quantities of organic substances that aid in plant growth, as well as the presence of hydrocarbon compounds (diesel oil) in the pre-treatment water. These hydrocarbon compounds, which are toxic to plants and have varying effects on different plants, contribute to the increase in foliar growth [13]. These results align with the findings of [14], indicating that the effectiveness of wastewater irrigation relies on both the volume of wastewater and the crop type.

3.3.Leaf area (cm^2)

The results show that there is a significant effect on the leaf area of the plant, as the untreated plants recorded the highest average in the trait, which amounted to 104.53 cm^2, while the effect of pre-treatment water was negative on the trait, as the leaf area rates decreased with an increase in the volume of water, as the volume of 0.30 Ml/kg gave the lowest mean for the trait, which amounted to 76.69 cm^2 with a decrease rate. 26.63% The reason may be due to the difference in oil concentration between the pre-treatment and post-treatment waters [15]. The growth of plants in soil contaminated with crude oil depends on the concentration of contamination in that soil. While the effect of post-treatment water varied in leaf area characteristics, the volume of 0.10 Ml/kg post-treatment water recorded the highest mean of 82.32 cm^2 with an increase of 20.1% compared to untreated plants that gave 68.57 cm^2. As for the volumes (0.15, 0.20, 0.25) Ml/kg, it was recorded that the increase rates amounted to (13.13%, 2.04%, and 0.86%), respectively, while the average trait decreased by 0.30, with a decrease of 11.43%.

3.4.Total Chlorophyll Content (SPAD)

The average total chlorophyll results revealed significant differences in the effect of liquid oil residues on the radish plant, with an average close to the untreated plants' average of 35 spad. As for the volume of 0.20, 0.25 Ml/kg, it showed an increase rate compared to the untreated plants, amounting to (10.46%, 5.71%), while the volume of 0.30 Ml/kg recorded the highest mean for the trait among the treatments, which reached 39.33 spad, with an increase rate of 12.37%). While the post-treatment water recorded a volume of 0.20 Ml/kg, the highest mean for the trait was 42.33 spad, indicating an increase rate of 6.71 percent compared to untreated plants that produced a spad of 38.66 (**Table 3**). The volumes of 0.25 and 0.30 Ml/kg, on the other hand, went up at a faster rate (**Table 4**). This aligns with the findings of [7], which indicate an increase in chlorophyll a and b levels in papyrus and reeds in areas contaminated by the Doura refinery's waste. He attributed this to the oil waste water's retention of minerals, which heightens the chlorophyll dye concentration. According to [16], the formation of chlorophyll depends on the presence of basic elements like calcium and magnesium, and iron plays a significant role in the absence of many coenzymes.

Table 3. The average effect of waste water type on plant height, number of leaves, leaf area, and total chlorophyll content of radish plant

Waste water	Plant height (cm)	Number of leaves (plant, pot-1)	Leaf area (cm2)	Total chlorophyll (SPAD)
Water Pre-treatment	67.43	18.24	91.34	36.52
Water Post-treatment	76.82	18.62	71.29	39.95
L.S.D.(0.05)	9.528 NS	1.970 NS	16.15 *	1.644 *

Table 4. Effect of type and volume of oil waste water on plant height, number of leaves, leaf area, total chlorophyll content of radish plant.

Waste water Ml/Kg	plant height (cm)		Number of leaves (plant, pot-1)		Leaf area (cm^2)		Total chlorophyll (SPAD)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
0.00	74.10	68.56	18.67	15.67	104.53	68.57	35.00	39.67
0.05	72.53	81.00	18.67	17.67	96.12	70.67	35.00	38.33
0.10	69.00	110.56	19.00	19.33	99.23	82.32	35.00	38.37
0.15	64.90	73.20	19.66	17.00	83.98	77.57	35.67	39.00
0.20	59.13	71.33	17.33	20.00	89.81	69.97	38.66	42..33
0.25	65.23	67.20	18.00	19.33	88.99	69.16	37.00	40.33
0.30	67.10	69.90	16.33	21.33	76.69	60.73	39.33	41.33
L.S.D.(0.05)	25.211 *		5.212 *		42.744 *		4.351 *	

3.5.Root length (cm)

The pre-treatment water, on average, significantly increased the root length of volumes 0.05, 0.10, and Ml/kg. This increase was 6.7% greater than that of untreated plants, which had an average root length of 10 cm. Additionally, it increased volumes of 0.15, 0.20, 0.25, and 0.30 at rates of 13.3%, 20%, 26.7%, and 23.3% respectively. While the post-treatment water recorded volumes (0.10, 0.15, and 0.20) Ml/kg, the highest average for the trait was recorded with an increase of (15.56%, 24.93%, and 21.84%) compared to untreated plants, which recorded an average of 10.67 cm, while the average length decreased with the effect of 0.30 volume by 21.93%. The increase in root length may be due to the fact that oil waste water contains large amounts of bacteria [17], which may contribute to stimulating root growth. Microorganisms also alter the pH of the soil surrounding the roots, promoting their growth, increasing nitrogen and phosphorus uptake, and increasing the root's physiological and metabolic activities [18].

3.6.Root diameter (cm)

The results demonstrate significant differences in the trait mean, with water recorded pre-treatment. For three volumes (0.05, 0.20, and 0.30) Ml/kg, the highest average was 3.70 cm, indicating a 4.82% increase compared to untreated plants. For the volumes of 0.15 and 0.25 Ml/kg, they recorded a decrease of 2.83% and 1.98%, respectively (**Table 5**). The volume of 0.15 Ml/kg water post-treatment yielded the highest average trait of 3.76 cm compared to the untreated plants, showing a significant increase of 1.62 percent. Conversely, the volumes of 0.05, 0.20, and 0.30 Ml/kg showed a decrease of 19.73%, 5.40%, and 8.11% (**Table 6**). These results differ from those of [19], where there was a reduction in the growth of the roots of onions and beans due to the toxicity of the oil refinery wastes. The reason could be attributed to the water content from oil refineries, the type of water treatment, the type of crop, and the plant's sensitivity to environmental and climatic conditions. [13] The difference in the accumulation of microelements and heavy metals in plant parts, as well as between plant species, also contributes to this phenomenon [20].

Table 5. Mean effect of waste water type on root length and root diameter of radish plant

Waste water	Root length (cm)	Root diameter (cm)
Water Pre-treatment	11.38	3.58
Water Post-treatment	11.24	3.49
L.S.D.(0.05)	1.390 NS	0.261 NS

Table 6. Effect of type and volume of oil waste water on root length and root diameter of radish plant

waste water Ml/Kg	root length (cm)		root diameter (cm)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
0.00	10	10.67	3.53	3.7
0.05	10.67	10.67	3.7	2.97
0.10	10.67	12.33	3.56	3.63
0.15	11.33	13.33	3.43	3.76
0.20	12	13	3.7	3.5
0.25	12.67	10.33	3.46	3.5
0.30	12.33	8.33	3.7	3.4
L.S.D.(0.05)	3.68 *		0.691 *	

3.7.Fresh weight (g)

The results showed that waste water had a significant effect on the average fresh weight of the vegetative part of the radish plant, as the pre-treatment water recorded a volume of 0.10–0.20 Ml/kg, the highest average of the trait among the treatments, with an increase of 22%–22.71% compared to untreated plants that gave 90.26 g. While the volumes of 0.05 and 0.25 Ml/kg recorded a decrease in the trait amounting to 2.28% and 4.61%, In all of the treatments, the trait went down with post-treatment water, but the untreated plants had the highest average fresh weight of the vegetative part of the radish plant, at 154.06 g. The volume of 0.30 Ml/kg had the highest mean for the trait among the treatments, coming in at 13% less than the untreated plants. While the results of the pre-treatment of waste water resulted in a significant increase in the root part's fresh weight. The volume of 0.05 Ml/kg recorded the highest average for the trait, reaching 183.33 g, an increase of 17.05% compared to the untreated plants that produced 156.63 g. The plants produced volumes of 0.15, 0.2, and 0.25 Ml/k. The rates of increase were 3.17%, 1.53%, 0.96%, and 1.96%, respectively. The water post-treatment showed a significant increase in all treatments compared to untreated plants, with an average of 87.06 g. However, the volume of 0.15–0.2 Ml/kg recorded the highest average among the treatments, reaching 210.43–172.1 g, an increase of 141.71% or 97.68% compared to untreated plants. The increase in the tender weight of the root and vegetative part can be attributed to the presence of nutrients and organic materials in the oil waste water, which enters the photosynthesis process and subsequently increases the plant mass. These results are consistent with [21].

3.8.Dry weight (g)

The results show that water pre-treatment has a significant effect on the vegetative part's dry weight, as volumes of 0.10, 0.15, 0.20, and 0.30 Ml/kg recorded a significant increase compared to untreated plants, amounting to 31.54%, 3.02%, 21.81%, and 6.04%, respectively. There was a 23.49% and a 0.67% drop in the average trait at volumes of 0.05 and 0.25 Ml/kg, but water post-treatment made the trait worse in all of them (**Table 7**). Volumes of 0.10 and 0.30 Ml/kg caused the smallest drop in the average trait, by 4.54% and 2.15%, respectively. Untreated plants recorded an average weight of 4.19 g (**Table 8**). There was no difference in the weight of the plants when treated with 0.05 and 0.25 Ml/kg of waste water. However, when treated with 0.20 Ml/kg of waste water, the plants' weight dropped the most, by 27.45% compared to plants that had not been treated. This showed that waste water had a significant effect on the trait. As the pre-treated water gave a volume of 0.30 Ml/kg, the highest average of the grade amounted to 4.19 g, an increase of 23.6% compared to the untreated plants, which gave 3.39 g. As for the volume of 0.10 Ml/kg, it recorded an increase of 9.44%, while the volumes of 0.15, 0.20, and 0.25 Ml/kg showed a decrease in weight compared to untreated plants by 4.72%, 10.32%, and 5.02%. The post-treatment water had a positive impact on the dry weight of the roots in volumes of 0.15, 0.20, 0.25, and 0.30 Ml/kg, resulting in increases of 25%, 33.9%, 3.08%, and 23.97% compared to the untreated plants, which yielded 2.92 g. However, the average volume decreased. 0.05, 0.10 Ml/kg by 21.58%, 9.59% These results are consistent with [22, 13]. As we demonstrated, the variation in the effects of waste water stems from its inclusion of elements and nutrients that promote plant growth, as well as hydrocarbon compounds that have a strong tendency to inhibit root grow early planting can impede the plant's ability to access available nutrients. As aromatic hydrocarbons accumulate in the plant's root cover and their percentage differs between plant species [23], some polycyclic aromatic hydrocarbons are considered to have a toxic or mutagenic effect and cause cancer, according to the World Health Organization [24].

Table 7. Average effect of waste water type on fresh weight and dry weight of radish plants**.**

waste water	Fresh weight (g)		dry weight (g)	
	Vegetative group	root group	Vegetative group	root group
Water Pre-treatment	96.67	161.31	3.14	3.45
Water Post-treatment	115.93	143.65	3.67	3.15
L.S.D.(0.05)	20.26 NS	34.68 NS	0.601 NS	0.655 NS

Table 8. Effect of type and volume of oil waste water on fresh weight and dry weight of radish plant**.**

waste water Ml/Kg	Fresh weight (g)				dry weight (g)			
	Vegetative group		root group		Vegetative group		root group	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
0.00	90.26	154.06	156.63	87.06	2.98	4.19	3.39	2.92
0.05	88.20	93.55	183.33	119.36	2.28	3.37	3.39	2.29
0.10	110.13	119.7	150.76	148.23	3.92	4.00	3.71	2.64
0.15	95.90	108.0	161.6	210.43	3.07	3.58	3.23	3.65
0.20	110.76	97.40	159.03	172.1	3.63	3.04	3.04	3.91
0.25	86.10	104.73	158.13	130.5	2.96	3.37	3.22	3.01
0.30	95.36	134.03	159.7	137.83	3.16	4.10	4.19	3.62
L.S.D. (0.05)	53.61 *		91.757 *		1.591 *		1.732 *	

4. Conclusion

The findings of the study can be explained by the following: All volumes of pre-treated water had a positive impact on total chlorophyll content, root length, and root fresh weight. While its effect varied between a decrease and an increase in the average number of leaves, root diameter, fresh weight of the vegetative part, and the dry weight of the vegetative and root parts, its effect was negative for all volumes in plant height and leaf area. The post-treatment water exhibited a positive impact on plant height, leaf count, total chlorophyll content, and the fresh weight of the root section across all water volumes. While its effect varied according to the amount of water in terms of leaf area, root length, root diameter, and dry weight of the root part, it gave a negative effect in all treatments in terms of the fresh and dry weight of the vegetative part.

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Conflict of Interest

There are no conflicts of interest.

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