Investigation use irradiation to treat west water and their effects on plants

Muthik A. Guda

Hakeem G.L. alkareemaw

Maytham M. Alabassi

Mohammed O. Hamad

Hazim A. Naji

Abstract The use of high-energy radiation gamma ray. Although it is an effective way to treat Wastewater and it has been used for human well-being. The effect of such water on the biota has not been verified as it may be very harmful to living organisms, on this basis, the effect of irradiation on wastewater was studied before and after being treated with gamma rays on different doses, and then the effect of these treated water on three types of plants that are tolerant of the harsh environmental conditions: *Catharanthus roseus*, *Agave attenuta* and *Vachellia nilotica*. Three samples of wastewater were processed in the nuclear laboratory of the Physics Department, Faculty of Science, University of Kufa. With 0, 11, 30 and 70 krad doses using a Cs^{137} source with 5 µCi from the International Atomic Energy Agency (IAEA) in a close system, using a Cs^{137} radiation source so that all samples could be simultaneously irradiated. A Plants brought from the secretariat of the Kufa Mosque at the age of one year in Najaf province . Each of the small plants was planted in a container (surface area 15 cm^2 and 10 cm^2) planted in 6 kg / pot of air dried soil and eight replicates per plant in November 2018. Plant development in the experimental field of the Faculty of Science / Kufa University for Environmental Studies for 30 days. Morphological and physiological measurements [total chlorophyll, proline, malondialdehyde, CAT and SOD enzymes] were taken every 10 days after irrigation with irradiated water. The main results were to reduce TOC, TU, DO, BOD5, COD, TSS, TDS in wastewater significantly in all radiation doses. The responses were different in the studied plants. *Agave attenuta* plants have the best response followed by *Vachellia nilotica* and then *Catharanthus roseus* in both morphological traits (total plant length, number of branches, length and width of leaves) as well as the physiological characteristics (total chlorophyll, proline and SOD, CAT). This shows the effectiveness of irradiation technology in wastewater treatment and the possibility of using *Agave attenuta* and *Vachellia nilotica* plants in irradiated contaminated areas or areas watered with treated wastewater due to capable of high radiation doses. The *Catharanthus roseus* plant can also be used as biological indicator for radiation contamination due to its sensitivity to radiation.

Keywords: irradiation ; west water ; biological treatment ; TOC; COD

1. Introduction

The gamma rays are the most powerful form of electromagnetic radiation. It has a power level of 10 keV (kilo-electron-volt) for several hundred keV. It is considered the most penetrating radiation compared to other sources such as alpha and beta rays [1]. Since its discovery, scientists have been racing to find new ways to treat contaminated water, especially sewage. There has been hope of using this new technology as a tool in plant improvement programs [2, 3]. Mutations in the plant by exposing seeds or plants to low doses of ionizing radiation or the use of radioactive fertilizers, [4]. Gamma ray belongs to the category of ionizing radiation that interacts with atoms or molecules to produce free radicals in cells that destroy or create mutations or changes in plant cell components, depending on the level of irradiation. These effects include changes in plant cellular structure and metabolism, for example, cellular membrane expansion, change in photosynthesis, modification of the antioxidant system, and accumulation of phenolic compounds [5]. These effects include changes in plant cellular structure and metabolism, for example, cellular membrane expansion, change in photosynthesis, modification of the antioxidant system, and accumulation of phenolic compounds [5]. In this study, a sample of wastewater was irradiated with gamma rays with three doses of radiation. The turbidity tests(tu), EC, and pH, dissolved oxygen (DO), BOD5 and Oxygen (COD), total suspended solids (TSS), total dissolved solids (TDS), total organic carbon (DOC) for water samples before and after irradiation. The morphological, physiological, and biochemical responses [proline, Malondialdehyde (MDA), Chlorophyll, Catalase and SOD enzymes] have been identified for three types of plants that are tolerant of the harsh environmental conditions: *Catharanthus roseus*, *Agave attenuta* and *Acacia vacellia nilotica* and successive intervals after irrigation with irradiated water . The purpose of these experiments was to know the effects of radiolysis and radiocatalysis on wastewater and to try to determine the effects of irradiated water on the morphological, physiological and biochemical characteristics of the studied plants.

2. Material and methods

2.1 Collection of water samples

Wastewater samples were collected from the sewage treatment plant at Al-Barrakiya in Najaf city in Iraq on 15/10/2018 and three times from the main deposition tank using different types of clean containers. BOD_5 samples (255, 304 and 308 mg) / L.

2.2 Water irradiation

Three samples of wastewater were processed in the nuclear laboratory of the Physics Department, Faculty of Science, University of Kufa. The first group (G1) was irradiated by 11 krad (G2) irradiated by 30 krad (G3) irradiated by 70 krad using a Cs_{137} source with 5 μCi from the IAEA (International Atomic Energy Agency) in a closed system. The device used for irradiation is a Canadian made cell with a radioactive source Cs_{137} which calculates the dose rate of two Mrad / hr and radioactivity of 50 kCi in January 1985. The samples were arranged in the irradiation cylinder (16 cm diameter + 20 Cm) and then placed vertically under the source of radiation to ensure a homogenous dose of all samples (Fig. 1). [4] A Cs_{137} radiation source was used so that all samples could be irradiated simultaneously.

2.3 Physical and chemical measurements of water samples

The pH, EC, salinity, and dissolved oxygen (DO) were measured by a multi photometer and turbidity by a turbo meter. All of the above devices were calibrated prior to starting measurements. Total TDS, Total TSS, Total Organic Carbonate (TOC), BOD_5, and COD are measured by methods described in the American Public Heath Association (APHA) (2003).

The experiment was carried out on three types of plants that are tolerant of the harsh environmental conditions: the plant *Catharanthus roseus,* the agave plant *Agave attenuta* and the Egyptian acacia plant *Vaccellia nilotica* and was brought from the nursery of the secretariat of the Kufa mosque and one year in the province of Najaf and each of the small plants were planted in a pot (15 cm 2 and 10 cm 2) was planted in 6 kg / pot of dehydrated soils and eight replicates per plant in November 2018. Plants were developed in the experimental field of the Faculty of Science / Kufa University for Environmental Studies (32.03 "N and E" 4444.37,16348, for a period of 60 days, while maintaining as much as possible the conditions of development plants. It was taken morphological measurements and physiological and biochemical [Proline, and Melonaldyhde (MDA), chlorophyll, enzymes (Catalase CAT and SOD)] every 10 days after irrigation with Irradiated water.

3. Results and dissection

3.1 Wastewater testing before and after radiation treatment

Table 1 showed that the Ionizing Radiation has a radical effect on total organic matter (TOC) in wastewater due to the strong activity of Gamma rays which can change the properties of pollutants in wastewater [3]. (Table 1) indicated a decrease in turbidity in general after irradiation at 25 radradiation level. After that the turbidity began to increase with increasing radiation doses. This may be due to an increase soluble organic matter of sludge.

The results showed that EC and TH were stable with an increase in radiation dose (Table 1). This is because EC and hardness are caused by dissolved salts in water. Organic salts are not conductive, but inorganic salts are highly conductive when dissolved in water. Moreover, radiation doses not lead to degradation of inorganic substances and therefore the salinity value does not change with increased radiation dose. Therefore, values remained stable (Table 1) [7].

PH increased with increased radiation dose. (Table 1) This indicates that pH values tend to increase as a result of water irradiation. This increase was due to increased hydroxyl radicals due to the hydrolysis and increased degradation with increased radiation dose. The G value of OH (G-OH) rises as compared to other free radicals, causing a significant increase in concentration of free hydroxyl roots.

From Table 1, the DO concentration values decrease in increases radiation dose. These electrons interact with the oxygen in the presence of hydrogen, resulting from free radicals such as H_2O_2, HO_2, O_2 and C_6H_5OH (OH), which are strong oxygen receptors. Decreased concentration of dissolved oxygen.

The value of BOD_5 and COD values decreased with increasing radiation dose. This decrease resulted from the destruction of microorganisms responsible for oxygen consumption. It is known that microorganisms are very sensitive to radiation pulses. In addition, the radiation energy can decompose organic compounds found in biological systems (Table 1) [7].

Total solids (TSS) showed a decrease with increased radiation dose (Table 1). This was due to the fact that the radiation energy worked on solids analysis and increased the deposition process [12].

Total dissolved solids (TDS) showed a different result according to (Table 1). The soluble solids concentration was reduced at the beginning of the treatment at the low radioactive doses , followed by an increase in soluble solids concentration with an increase in absorbed radioactive dose. This may be due to the conversion of dissolved organic matter into simple molecular compounds or the formation of dimmers or trimmers .Then, in high concentrations of radiation, solids and sludge at the bottom were melted by high dose effect, thus increasing TDS concentration. The values did not reach the start of the experiment [1].

Table 1 Mean values of chemical parameters for wastewater samples studied before and after irradiation with different doses

Parameter	Initial value (mg/l)	First Affect dose (krad)	Second Affect dose (krad)	Third Affect dose (krad)	Final Value (mg/l)
TOC	1870	11			460*
			30		254*
				70	30*
Turbidity	143 (NTU)	11			68* (NTU)
			30		92* (NTU)
				70	118* (NTU)
EC	2.3 (mmhos/cm)	Does not affect	Does not affect	Does not affect	n
TH	750 (mg/l)	Does not affect	Does not affect	Does not affect	n
PH	6.8	11			7.3
			30		8.6*
				70	8.9*
DO	9.6	11			7.4*
			30		7.6*
				70	7.8*
BOD5	302	11			32*
			30		42*
				70	47*
COD	1676	11			85*
			30		120*
				70	130*
TSS	380	11			60*
			30		55*
				70	51*
TDS	11250	11			1460*
			30		1780*
				70	2132*

The data marked with * were significantly different by Duncan Multivariate, $P \leq 0.05$.

3.2 Plant parameters

3.2.1 Appearance characteristics

The total length of the plant, the number of branches, length and width of the leaves were measured before irrigating with irradiated water and after irrigation for ten days, in addition to observation of general plant condition.

The results showed that *Agave attenuta* was superior in irrigated water irradiation and decreased changes in morphological characteristics compared to Egyptian acacia *Vaccellia nilotica* and *Catharanthus roseus*. The studied parameters of plant height, length and width of the leaf increased the number of branches in the third treatment at a concentration of 70 krad. The same was not changed, but the plant Alonka lost his leavesls completely after ten days of the third treatment (Table 2 and Fig. 1)

Table 2 Variation in the morphological characteristics of the studied plants after irrigation with irrigated sewage with different dose

Parameter	*Agave attenuta*			*Vachellia nilotica*			*Catharanthus roseus*		
	11 (krad)	30 (krad)	70 ((krad)	11 (krad)	30 (krad)	70 ((krad)	11 (krad)	30 (krad)	70 ((krad)
Total Length (cm)	26	30	32	60	65	65	57	64	64
Leave length (cm)	24	25	26	11	15	15	1.5	4	0
Leave width (cm)	3	3	3.5	3	8.5	8.5	1	1.5	0
Number of branch	21	21	24	5	7	7	6	6	6

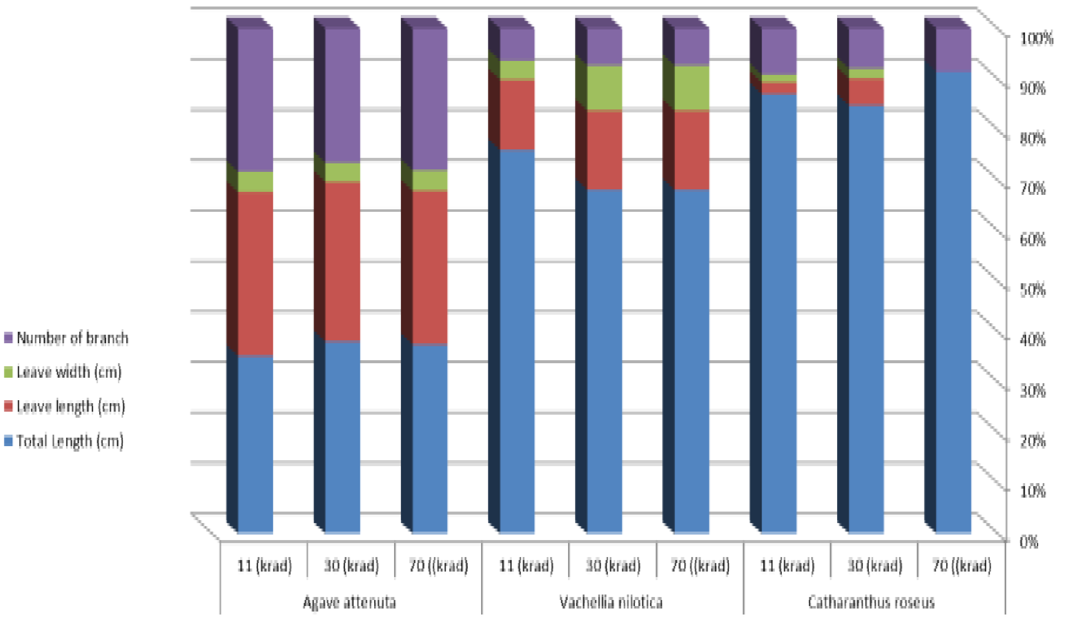

Figure 1 shows the variation in the effect of irradiated sewage with a different dose on the vegetative properties of Agave attenuta, Vachellia nilotica, Catharanthus roseus plants

3.2.2 Physiological traits

A. Total chlorophyll content

The results showed that the total chlorophyll content was significantly different between the studied plants (LSD = 0.1) and doses (LSD = 0.12) ($P < 0.05$). The chlorophyll content in the Agava and Acacia plants increased, while the Alonca plant decreased by increasing the doses Fig. 2.

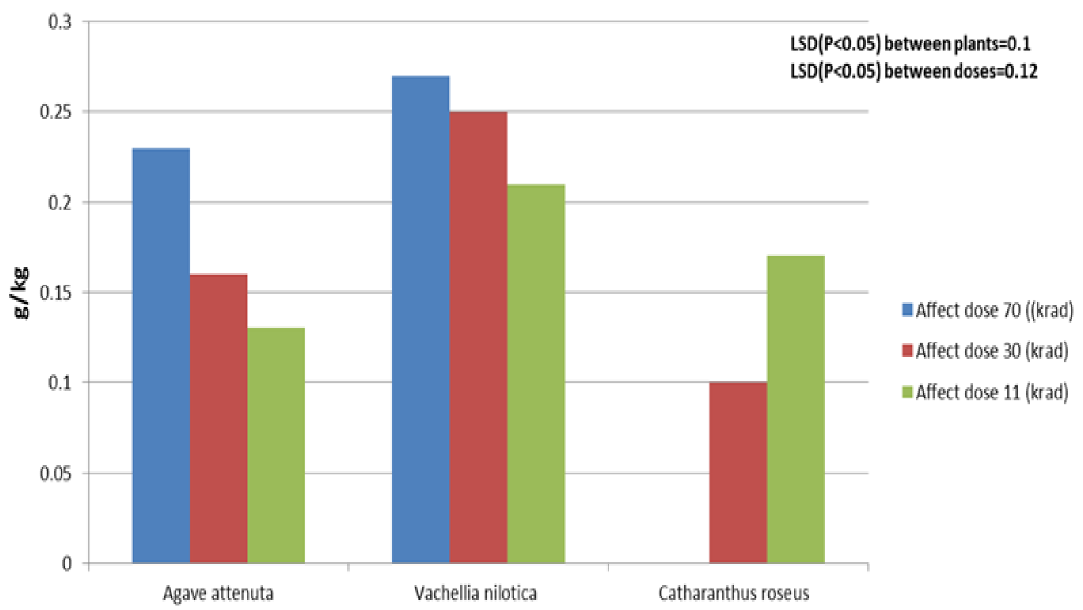

Figure 2 shows the variation in the effect of irradiated water on a different dose on the total chlorophyll content in the studied plants

B - Proline content

When the radiation dose was increased in water over 30 krad, the proline content was increased in all studied plants. The most significant increase in Acacia was observed after irrigation irradiated water 30 krad (Fig. 3). The results showed that the proline content was significantly different between the studied plants (LSD = 0.08) and the doses (LSD = 0.09) within a significant level (P <0.05). As for the plant of Agava and Alonca, increased the content of proline by increasing doses Fig. 3.

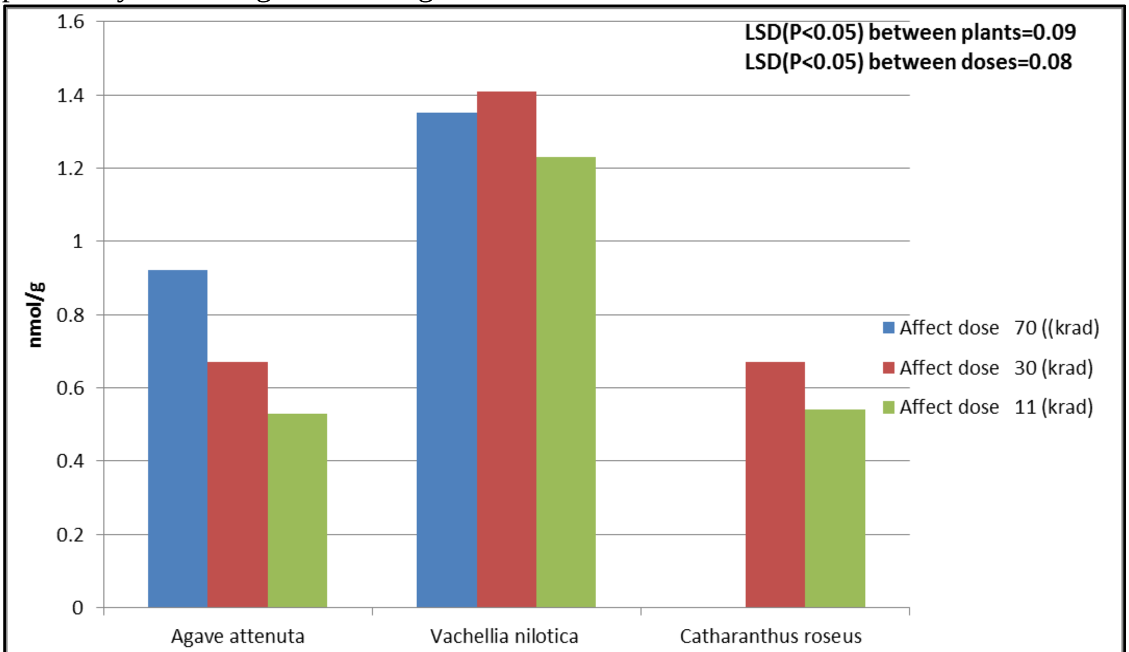

Figure 3 shows the variation in the effect of irradiated sewage with a different dose on the proline content in the studied plants

C- Content of melonaldehyde

MDA was used as an indicator of membrane lipid oxidation. However, the increase in the level of radiation doses caused changes in the levels of MDA concentration, which increased the dose of radiation in all the studied plants. This is a guide for all plants but in varying degrees (Fig. 4). Where the highest value of the Acacia plant in the concentration of 30 krad and was the lowest value of the Alonca plant.

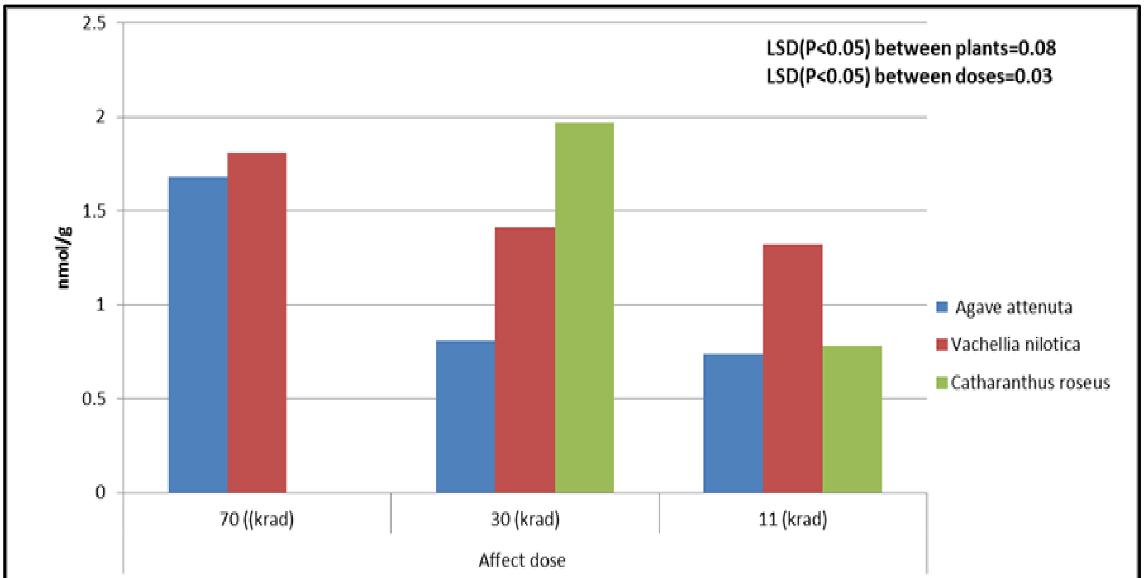

Figure 4 shows the variation in the effect of irradiated sewage with a different dose on the melonaldehyde (MDA) content of the studied plants

D. SOD enzyme

The SOD enzyme activity is the digital scale to resist free radicals in the plant. The higher value of the enzyme, mean more resistant and tolerant the stress. In this study, the Agava plant was the most effective enzyme followed by the Acacia and the Alonca. Although all studied plants showed the same reaction as the enzyme was increased by increasing the dose of radiation (Fig. 5).

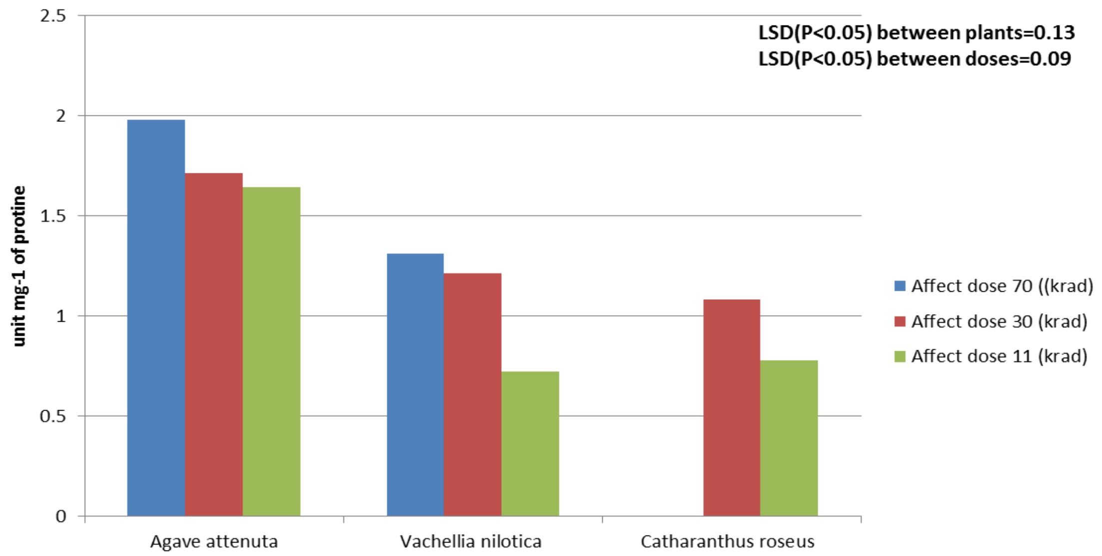

Figure 5 shows the variation in the effect of irradiated sewage with a different dose on the efficacy of SOD in the studied plants

E. CAT enzyme

Fig. 6 showed variation in enzyme values. Studied plants increased effectiveness of enzyme by increasing radiation dose . Agava plant showed the highest value and lowest in Alonica plant and significant differences between plants on the one hand and radiation doses on the other P ≤ 0.05 Fig. 6

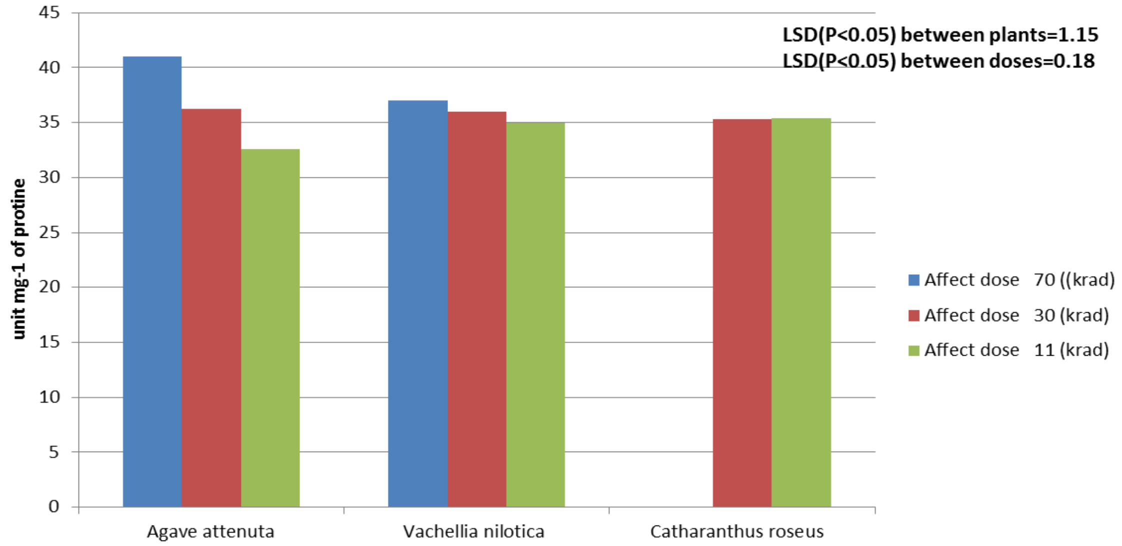

Figure 6 shows the variation in the effect of irradiated sewage on a different dose on the effectiveness of the CAT enzyme in the studied plants

3.3. Discussion

The water was used in watering three types of plants, namely, Agava, Acacia, and Alonka. The responses were varied in the studied plants. The best response was for the Agava plant followed by Egyptian Acacia and then in each of the morphological characteristics of the total plant length, number of branches, length and width of the leavesl, Total chlorophyll, proline and SOD, CAT. This is a response to the superiority of the antioxidants in the Agava plant to the rest of the studied plants. In the alonca plant, in the concentration of 70 leaves, the leaves of the plant are completely reduced. This is due to the irradiation of the water. (O2), hydroxyl roots (OH-) and H_2O_2 roots [6], which interact rapidly with almost all structural and functional organic molecules, including proteins, lipids, and nucleic acids Which cause cellular metabolic disorder [7] The roots of hydroxyl are generated by ionizing radiation either directly by water oxidation, or indirectly by oxidation of secondary compounds, ROS production is widespread in biological materials and oxygen-derived roots include species such as peroxyl (ROO-) and oxaloxyl (RO-) and The most prominent results of oxidative stress is cell damage due to a hydroxyl radical attack that can react rapidly with different types of molecules, including lipids, proteins, and especially DNA. However, some resulting infections can be easily repaired, depending on the dose and plant type.

5. Conclusion

1 -Radiation irradiation gave effective results in the treatment of wastewater, where the most powerful effect in the reduction of organic matter. Where the values of TOC, TU, DO, BOD5, COD, TSS, TDS decreased.

2-The morphological characteristics of the total plant length and number of branches and the length and width of the varied results in terms of radiation dose and plant type Alonica plant fell leaves after irrigation with a dose of 70 krad. The Egyptian acacia plants did not get an increase in growth. Agava plant was the best species in terms of growth And carry it to the radiation dose

3-The studied plants, especially the Egyptian acacia and Alonica, showed a great ability to tolaranse the effect of increasing the dose of radiation on the water treated with radiation by maintaining the safety of cellular membranes and the content of chlorophyll and proline and the effectiveness of antioxidants SOD, CAT. During the growth period. And the possibility of using Egyptian acacia and Agava plants capable of carrying high radiation doses in areas contaminated with radiation or areas watered with treated sewage water

4- Alonica plant showed a high sensitivity to the radiation dose through the fall of leaves and lack of growth.It can also be used as a biological evidence on the contamination of radioactive materials of the physiology of this plant.

Acknowledgements

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