Using the magnetic and nanotechnology in the treatment of wastewater and its effect on the growth and yield Vigna radiata L.

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Abstract:

Two laboratory experiments were conducted, the first to obtain the best concentration of nanomaterial's used Fe3O4 in removing heavy elements from wastewater, and the concentrations were (50, 100, 150, 200, 250) mg.L⁻¹, and the concentration was chosen 100 mg. L⁻¹ was the best concentration after achieving the highest rate of removal of heavy elements from wastewater, and the second to test the effect of treated nanoparticles and magnetic particles, and the interference between them in the germination rate of livestock seeds used as a biomarker in sterile plastic plates at a rate of three iterations per treatment and experiment parameters were water treatment River T0 and T1 treatment untreated wastewater and T2 wastewater treatment with nanomaterial's treatment, T3 magnetic treatment wastewater treatment and T4 treatment, which overlap between the two treatments, and T3 and T4 treatments achieved the highest germination rate of 100% for the two treatments. A field experiment was conducted in Al-Mu'tasim area, 20 km south of Samarra - Salah Al-Din area located at latitude 37°71’30”7 and longitude 41°32’24” in July 2019 to see the effect of experiment treatments on some characteristics of the growth of Vigna radiata L. plants, and the results showed that the T4 treatment significantly exceeded all treatment treatments in some plant growth characteristics such as plant height, leaf area, dry vegetable weight, dry root weight and percentage (43.00, 14.60, 77.95, 71.87)% for trait respectively when compared to T1 treatment which achieved lower mean for the mentioned traits.

Keyword: Fe₃O₄, Magmatic, Wastewater, Mungbean
1-Introduction

Water is one of the most important natural resources on the surface of the earth, without which there is no life, as the world uses about 70% of the fresh water that is taken from lakes, rivers, and groundwater for agricultural purposes (1), and Iraq suffers a shortage of fresh water resources as a result of the geographical location within the dry and semi-dry region that suffers from a lack of rainfall, in addition to the increase in population growth and the pursuit of the use of agricultural lands. It is necessary to work on providing alternatives to fresh water, such as re-use of treated wastewater for irrigation of agricultural crops, in order to meet the expected shortage in the water source during the coming years (2).

The scarcity of water in the Arab region in general and Iraq in particular, especially in the last decades of the last century, encouraged these countries to use modern technologies in various fields that contribute to preserving the environment on the one hand and improving agricultural reality on the other hand. Therefore, it is necessary to reduce the concentrations of heavy elements by treating them before dumping them into rivers and streams and using them for agricultural purposes (3), due to the great importance of modern technologies in agriculture and water, it become possible to put several important technologies into effect, such as use of magnetization in water treatment (4), Magnetic water treatment technology is one of the important methods that improve many of the characteristics of water by influencing a group of physical and chemical properties, such as reducing the viscosity of water by 30%, Reducing the tensile strength from 1-3 Newton.M⁻¹ and increasing solubility, which increases the eagerness of nutrients in the soil (5). Magnetic treatment was used in various fields such as the agricultural field, which can improve growth and enhance production quantity and quality as well as being one of the promising methods in protecting the environment from pollutants and enhancing agricultural production (6).

Sewage contains solids (organic and mineral) and elevated concentrations of heavy elements. This water consists of 99.9% water, 0.1% suspended matter, such as fats, organic compounds, and heavy elements such as cadmium, arsenic, mercury, chromium, copper, etc., so it is necessary to reduce the concentrations of these heavy elements by treating them before they are put into the rivers and streams or used for agricultural purposes (7).

One of the important methods in treating Sewage from pollution is adsorption, which is a very effective and economical way to remove metal ions from wastewater, and there
must be a good choice of adsorbent type in terms of density, surface area, high absorption capacity, and it has been observed that a significant change in the properties of adsorbents (chemical, physical, optical, and mechanical) when the particle size drops to a Nano level (8). Increasing the surface area of the nanomaterial increases the adsorption capacity to remove heavy metals (9).

The *Vigna radiata* L. is one of the most important crops in Iraq because its seeds contain proteins, carbohydrates, fats and some amino acids such as Lysine, and for its short life cycle. It is cultivated for many purposes, including the production of seeds (10; 11; 12) for use as a good food for humans and animals, as well as used to increase soil fertility by stabilizing nitrogen because of the coexistence relationship between plants and bacteria, such as the genus Bradyhizobium, and due to the scarcity of water in the summer and the abundance of wastewater (13), the desire came to know the effect of magnetic and nanomaterial and their interaction in the germination rate of *Vigna radiata* L. seed.

2-Material and methods

2-1- Accomplishing the experiments:

Two experiments were conducted, the first in the laboratories of the Department of Environment / College of Engineering / University of Samarra, in order to choose the optimal concentration of ferric oxide to be used in removing some heavy elements (copper, nickel, chrome, zinc, iron) from Sewage that selected in the study, Concentrations that used was 50, 100, 150, 200, and 250 mg/L depending on description of (14). The water to be treated (choose the best concentration) was put in the 1000 mL Container. Then the nanomaterial was added gradually according to the concentrations at pH 7 and a temperature of 24 discretely and the solutions were mixed with the nanomaterial using the JAR TEST device for 120 minutes and then the concentrations of the heavy elements that mentioned above were measured by Atomic Absorption Spectrometer (AAS) to find out which concentrations achieved the best removal for heavy elements and the results showed that the concentration of 100 mg. Liters \(^{-1}\) achieved the best removal rate for heavy elements. Based on this result, this concentration had used in the field experiment.

The second experiment was carried out in Postgraduate laboratories biology department / Samarra University, and it was represented by measuring the effect of nanotreatment of ferric oxide and magnetizing treatment and their interaction in sewage compared to river water on one side and untreated sewage on the other hand on the rate of germination of seed of *Vigna radiata* L. The seeds were put in sterile plastic plates of 10 cm diameter. There were filter papers inside each dish. In each dishes 10 seeds and three replicates. The seeds were watered with water treatments in the above experiment.
Then the dishes were placed in the incubator at a temperature of 25 °C and the germination rate was recorded 7 days after the start of the experiment. The percentage of seed germination was calculated according to the previously mentioned formula:

\[
\text{Germination rate} = \frac{\text{Number of germinated seeds}}{\text{Total seeds}} \times 100\%
\]

In the third experiment, a soil sample was taken from the study area before planting and air-dried, then it was ground and sifted with a sieve with a diameter of 2 mm, and then mixed well to ensure its homogeneity. A sample was analyzed laboratory to identify some of its physical and chemical properties. In the Laboratory of Soil Department / Faculty of Agriculture / Tikrit University and Chemical Engineering Laboratory / College of Engineering / Tikrit University as shown in table 1.

This field experimental study was carried out in Al-Mu'tasem, which located 20 km south of Samaraa _ Saleh Al-Din district,

Plastic containers (one-time drinking water cans of 18 liters capacity) that are a burden on the environment have been prepared as part of the use of these cans for other fields. After these cans were cleaned with sterile water, they were painted black on the outside, and punched from the bottom to drain the excess water from the plants. The pots were filled with 10 kg of pot-1, and the soil was fertilized with triple super phosphate fertilizer P₂O₅ 45% at a rate of 80 kg.H⁻¹, Mix the compost well with the soil of agriculture, then Vigna radiata L seeds planted with 10 seeds. Pot⁻¹ then watered according to treatments for sewage and control and with the same amount of water for each pot. The irrigation method was used by drip irrigation to water the pots and after the seed had been germinated, the plants were reduced to 5 seedlings in one pot.

Picture (1): The experiment coefficients are divided into three fields for each treatment
In this study, a 6000 gauss magnetic device manufactured by Mageco was used to treat water magnetically and its intensity was checked in the laboratories of the Department of Physics / College of Science / University of Samarra using the Tesla-meter device to verify efficiency, as was used Fe4O 3 ferric nanoparticles made in the US It is 20 nm in size, at 100 mg. Liter⁻¹.

Table (1): Some chemical and physical properties of the soil before planting

| Measuring unit | Value | Property |
|----------------|-------|----------|
| PH             | 7.92  |          |
| EC             | 3.48  |          |
| TDS            | 7.62  |          |
| % sand         | 38    |          |
| % Caly         | 24    | Soil arthropods |
| % Silt         | 38    |          |
| Loam           | 1     | Organic matter |
| Mg.L⁻¹         |       |          |
| Ca             | 1584  |          |
| Mg             | 569   |          |
| Na             | 415   |          |
| N              | 17    |          |
| P              | 13    |          |
| K              | 30    |          |

2-2 Water samples collection and treatment methods

Sewage samples were taken from the primary wastewater treatment basins in Samarra, and samples were taken with 20 liter plastic containers. Nanoparticles were carried out with wastewater by adding 100 mg.L⁻¹ of Fe34O nanoparticles to it and mixed well with a locally-made mixer used as needed. The treated solution was left for 120 minutes, then the leachate was transferred from the treated water to the reservoir designated for watering the plastic pots grown with Vigna radiata L seeds.
While the magnetic treatment of Sewage was carried out at the study site after it was placed in the tank designated for it, as the magnetic treatment device was connected on the plastic tube directly outside the tank to treat the water passing through the tube and then passes to the pots planted for irrigation.

The overlapping treatment with nanomagnetic material of Sewage was carried out in the same way above used in treating nanoparticles Sewage and then the passing of treated nanoparticles from a tube with a magnetizing device.

(Table 2) Some physical and chemical properties of water before and after treatment

| Measuring unit | T4  | T3  | T2  | T1  | T0  | Property |
|----------------|-----|-----|-----|-----|-----|----------|
|                |     |     |     |     |     | PH       |
| Ds.m⁻¹         |     |     |     |     |     | BOD5     |
| 127            | 125 | 131 | 146 | 5   |     | COD      |
| 430            | 427 | 433 | 448 | 52  |     | N        |
| 8.80           | 8.75| 8.81| 8.73| 2.8 |     | P        |
| 0.252          | 0.244| 0.221| 0.231| 0.187|     |
| 88             | 89  | 86  | 88  | 12  |     | K        |
| 173            | 194 | 207 | 252 | 22  |     | Na       |
| 0.041          | 0.21| 0.072| 0.25| 0.01|     | Cr       |
| 0.14           | 0.63| 0.17| 0.68| 0.03|     | Fe       |
| 1113           | 1218| 1327| 1536| 283 |     | TDS      |
| Mg.L⁻¹         | 2.885| 2.937| 2.906| 3.020| 0.812| EC       |

2-3- Definition of the experiment coefficients

T0 Treating river water

T1. Sewage treatment

T2. Treatment of nanostructures for Sewage

T3. Treatment of magnetic Sewage treatment

T4. Interference treatment between nanomagnetization and magnetic therapy

3- Results and Discussion
Table 3 shows the effect of treated sewage in the magnetic field and ferric oxide Fe₃O₄ nanoparticles and the interference between them in the percentage of laboratory seed germination, as T4 treatment was significantly higher in the average seed germination and achieved 100% germination percentage when compared with the T1 treatment that achieved the lowest germination rate of 71.06% with an increase of 28.93%, and the increase in the average seed germination percentage for the treatment of T4 may be attributed to the improvement of the physical and chemical sewage properties due to the combined effect of the ferric oxide nanomaterial and magnetic field as the nanomaterial reduced the percentage of pollutants in the water, especially the percentage of salts and toxic heavy elements present in the sewage as in Table 2) that has a negative effect on the germination process by its effect on the physiological processes that take place inside the seeds (15), and that magnetic treatment increases the solubility of water compared to untreated water as well as the exposure of water to a magnetic field that gives it higher energy than its original energy due to the increase in the activity of ions and its wide movement and this increases the susceptibility of water to the dissociation of ions attached to it and thus increases the ability of salts to dissolve, disintegrate and spread. And that the treatment T3 was significantly higher than the average germination of the treatment of T1 in the average seed germination rate by 29.93%, and that the increase in the average germination rate may be due to the magnetic treatment of the water increasing the amount of water absorbed containing ions by the seed, which is reflected in the increase in the proportion Germination of seeds by changes in the concentration of ions of the cell wall, which leads to an effect on the negativity of the osmotic potential of the seeds (16), these results were consistent with the results obtained by (17) when using magnetically treated water and its effect on germination of chickpea seed which exceeded by 20.00% compared to untreated magnetically, and varies with what it reached (18) when he used treated water magnetically and its effect on seed germination percentage.

The results of the table (3) shows a significantly higher mean plant height of T4 treatment in the over all experiment parameters after 45 day of planting, when the height of the plant reached 25.73 cm compared to the treatment of T1, which reached 14.66 cm, with an increase of 43.00,%. 

The reason for the increase in the average height of T4 treatment may be due to the combined effect of the nanomaterial and the magnetic field. Nanomaterial adsorbs heavy elements such as copper, nickel, zinc, cadmium and chromium from sewage (This is shown by the results of Table 2). Thus it reduces the damage caused by its accumulation in plants (19), and the increase in the average height may be due to the fact that the ferric nanoparticle oxide increases the activity of some enzymes, such as the peroxidase enzyme, which stimulates the process of photosynthesis and thus reflects an increase in plant growth. The increase in the average height of the plant in this treatment may be attributed to the role of magnetic treatment of water in increasing the readiness of the elements present in the soil and increased efficiency of their transportation and absorption by the root cells (20). The increase in the average plant height may be due to the ease of penetration into the cell membranes by treated water molecules due to their small molecular groups because magnetic treatment works to reduce the number of water molecules in the clusters that make up them, and the number of molecules is 6 - 7 molecules compared to non-magnetic processing, whose number of molecules is (12 – 13) molecules, and these results were consistent with what he got (22), of a significant increase in the mean height of chickpea, the type of irrigated Chamchamal, with magnetically treated water which reached 17.97 cm in height compared to the control treatment which height was 15.49 cm.

The results of Table (3) showed the in significant differences in all treatments, the average dry root weight was 0.32 g compared to the lowest average weight for a T1 treatment that reached 0.08 g and at an increase rate of 75%. Perhaps the reason for the increase in the dry root weight in a T4 treatment was for the same effect resulting from interference of the two treatments in dry vegetative weight, in addition to irrigating the treated water magnetically, increases the readiness of the elements and encourages the roots to penetrate the soil to obtain more nutrient materials. In addition to reducing the water molecule by reducing the angle of association between the two hydrogen atoms and the oxygen atom, which leads to facilitating the process of absorbing water and its soluble through the tissue of the root system. These results were consistent with the results of (23) who obtained when exposing the seeds of the pea crop to a magnesium intensity of 180 m.Tesla and a period of 10 minutes to increase it in the average dry root weight of 47.45% when compared to untreated seeds.

The results of Table (3) showed the in significantly differences superior T4 was to all trial treatments, as the average weight of dry vegetables was 2.55g compared to the T1 treatment that achieved the lowest average weight of 54.5g with an increase rate of 78.61%, followed by the T3 treatment, which was marked by significant differences over the rest of the trials of the experiment, as the average dry vegetative weight reached 2.4800 mg, and the reason for the significant increase in the dry vegetative total of plants achieved by the treatment of T4 may be due to the combined effect of the two treatments.
and their role in increasing the readiness of some elements in the water and reducing the proportions of some harmful elements as well as the role of ferrous nanomaterial of plants, because of its effect on the absorption of some compounds such as nitrates and its effect on the activity of enzymes such as nitrate reduction as a catalyst. This enzyme plays a crucial role in the production of plant receptors such as chlorophyll, nucleic acids, proteins and other plant materials, which thus affects photosynthesis, plant growth and development (24), and magnetic treatment has an important role in decreasing surface tension, density and viscosity of water as well as on the formation of small groups of water molecules bound together by the breakdown of some of the hydrogen bonds of water, which leads to the ease of penetration into the cell membranes and this leads to an increase in the food elements entering the cells that result in an increase in the growth of the vegetative group and thus leads to an increase in the dry weight of the vegetative group of the plant (25). These results were consistent with (26), who obtained an increase in the dry vegetative group of bean plants Vigna unguiculata L. Walp irrigated with magnetically treated water by a rate of 20% compared to its irrigated with non-magnetized water.

The results of Table (3) showed the superiority of the T4 treatment and significant differences in the mean total score for all trial treatments, as the average total score for it was 888.03 kg.H⁻¹ compared to the lowest average score in the total T1 treatment of 327.45 kg.H⁻¹, the percentage of its superiority over the T1 treatment was 63.46%, and it also outperformed the significant differences in the T3 treatment over the T1 and T0 treatment, and by a percentage of (48.01, 20.70)%, respectively, And that the reason for the superiority of T4 treatment over all treatments of the experiment may be due to the role of interference between the nanomagnetic and magnetic treatments in water treatment, as the nanomaterial has an important role in improving the properties of water and increasing its absorption by the plant while increasing the nutrients entering with it, which led to increased vegetative growth of the plant And the improvement of some vital processes in the plant and the increase in the weight of seeds, which reflected positively on the yield of the plant kg.H⁻¹, and the reason may be the increase in the total seed yield to the role of nan iron in increasing respiration and restoration processes Carbon drip and protein production leading to an increase in plant biological processes, which reflected positively on the increase in the number of pods and the number of seeds per pod resulting in an increase in the total seed yield in the plant (27), and the increase may be due to the role of magnetic treatment of water in improving the properties of the region Root by washing salts and improving soil permeability by increasing the solubility of minerals and salts and increasing the readiness of nutrients as well as the role of magnetic treatment of water in stimulating vital processes within the plant, especially photosynthesis, carbohydrate use, nutrient balance, increasing plant overall growth from plant height, leaf area, cell growth, expansion and manufacture Biological compounds and then increase the yield (21), and these results are consistent with the results obtained
(28) when using magnetic treatment in irrigation of barley plant, as it obtained an increase rate of 60.08% on the untreated treatment magnetically.

Table (3): Ratios of germination of livestock seeds and some characteristics of plant growth and Production

| Properties                  | Dry root weight (gm. plant⁻¹) | Dry vegetative weight (gm. plant⁻¹) | yield total plant (kg. H⁻¹) | Height of the plant (sm) | germination (%) | Transactions |
|-----------------------------|-------------------------------|------------------------------------|-----------------------------|--------------------------|-----------------|--------------|
| Transactions T₀             | 0.19 b                        | 0.73 d                             | 499.50 b                    | 15.00 c                  | 97.76 a         | T₀           |
| Transactions T₁             | 0.08 d                        | 0.54 c                             | 327.45 c                    | 14.66 c                  | 71.06 c         | T₁           |
| Transactions T₂             | 0.09 c                        | 0.86 c                             | 346.87 c                    | 15.93 c                  | 80.30 b         | T₂           |
| Transactions T₃             | 0.31 a                        | 2.48 b                             | 629.92 b                    | 23.66 b                  | 100.00 b        | T₃           |
| Transactions T₄             | 0.32 a                        | 2.55 a                             | 888.03 a                    | 25.73 a                  | 100.00 a        | T₄           |

Figure 1: The effect of wastewater treated with magnetic field and ferric oxide nano (Fe₃O₄)

4- Conclusion

There is a significant effect of the use of ferric nanoparticle oxide and magnetization in Sewage treatment, on the germination percentage of Vigna radiata L plant seeds, plant height, leaf area, number of pods, and total proportion.

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