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The physiological response of mint plant (*Mentha spicata*) growing with soil contaminated with heavy metals

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ABSTRACT

The following research was conducted to study the affection of cobalt element at the two concentrations (30) and (60) mg / kg soil and the nickel element at the two concentrations (30) and (60) mg / kg soil on growth and some physiological characteristics of the mint plant. It was found that the treatment of the soil with a nickel element at the concentration of (60) mg / kg of soil led to a reduce in the weight of the shoot and root groups and the concentration of chlorophyll in leaf tissues and an increase in the infiltration of potassium , sodium ions and the evidence of damage in the leaf tissues of the mint plant, which amounted to (0.171) g and (0.030 g / m (0.717 mg / g in lean weight, (50) mg, (5) mg, and (96.842)%, respectively compared to the control treatment and other treatments . While it was observed that the treatment of the soil with a cobalt element at a concentration of (60) mg / kg of soil led to a decrease in the concentration of calcium and magnesium in the shoot and root groups of the mint, as it reached (21.0), (6.0), (3.2) and (18) mg respectively. Compared to the comparison and other transactions. As for the effect of the element type, we note that the nickel component was more effective in reducing the dry weight of the two shoot and root groups, the concentration of chlorophyll, and the increase in potassium infiltration compared to the effect of the cobalt element, which in turn affected more on other traits compared to the effect of the nickel element.

Keywords: Effect of Ni and Co on plant growth, Infiltration of K and Na, Chlorophyll

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INTRODUCTION

Environmental pollution can be defined as the change in the composition of one of the main elements in the environment, and this change may occur naturally or by the influence of humans or animals, and that most of the current environmental problems are the result of unacceptable behavior of a person, which causes environmental pollution to achieve a self-interest, as pollution can be defined As a quantitative or qualitative change in the components of the globe in terms of chemical, physical or biological characteristics of environmental elements, pollutants are defined as substances or microbes that violate ecosystems and endanger human life or threaten the safety of confiscation directly or indirectly. Natural phenomena contribute to the natural degradation of minerals on Earth, such as volcanic eruptions, as well as human activities that often alter the rate of emission and transport of these minerals (Alessio and Luigi, 2020). In addition, heavy metals and minerals come from natural and anthropogenic sources. Natural sources include flow variations, benthic activities, rock erosion etc. (Hasan et al., 2018) and (Zhu et al., 2019) . Heavy metals are a dangerous environmental pollutant today as a result of industrial development in many countries. It causes many dangerous diseases and has toxic effects on human health. Many methods have been used to remove heavy element pollutants from the environment, but these methods faced many obstacles, such as their need for not short periods of time and a lot of money in addition to many problems and uneasy things, whether in the auxiliary or mechanical aspects (Sumiahadi and Acar, 2018). Various human activities, including industrialization, agricultural production, mining and transportation contribute to the addition of harmful heavy elements into the environment that become in The end is part of the environment (Sharma et al., 2017) .The rapid development of society has led to the release of many unwanted pollutants into the environment (Zada et al. 2018). Due to the increase in their concentrations in the surrounding environment and the foods eaten by humans, and from the heavy pollutant elements that are often present in plants that are eaten by humans, they are lead, cadmium and arsenic, which are not needed by humans, and can represent a harmful source to human health, especially when they are in high concentrations (Gupta et al.2008) Heavy elements remain in the land environment for non-short periods without damage or any chemical changes, so they are among the most dangerous substances that the soil is exposed toHeavy metals include chromium, cobalt, copper, zinc, nickel, lead, cadmium, mercury and many other elements. These elements differ in their effect and toxicity if some of them are considered to have a significant impact on the environment. (Sandeep et al. 2019). Despite the toxicity of heavy elements on plants, plants need some of these elements as micronutrients to benefit from them in growth and to carry out some vital processes. However, high concentrations of it lead to great damage to plants, and these elements include zinc, nickel, copper, and finally it can be said that pollution Soil with heavy metals has harmful and dangerous effects on the life of living organisms, especially humans (Mario et al 2019).

MATERIAL AND METHODS

The soil was treated with two types of heavy elements, namely, cobalt and nickel at the two concentrations (30) and (60) mg / kg soil for each element. Where the cobalt was used in the figure of ($CoSo_4$) and the element nickel in the form of ($NiCl_2$). Each concentration of each component was mixed with the soil outside the pots, to ensure good mixing. Then the treated soil with the heavy component was returned to the pots and at three replications per treatment and the capacity of the single anvil was the size of five kilograms. The mint plant (*Mentha spicata*) whose seeds were obtained from the local market was planted on 3/4/2020 and after six weeks of planting the plants were extracted and the following experiments were performed:

Dry weight of the shoot and root: The weight of the dry matter was measured for the root and the shoot of the plant, using an electric oven of (75) C and for 48 hours until the weight was stable.

The total chlorophyll: The total chlorophyll was estimated according to (Abdul Jaleel et al., 2009) method and according to the following equation:

Total Chlorophyll (mg/gm) = (0.0202) * (A.645) +(0.00802)*(A.663)

A 663 = absorbance at wavelength of 663 nm. A 645 = absorbance at wavelength of 645 nm.

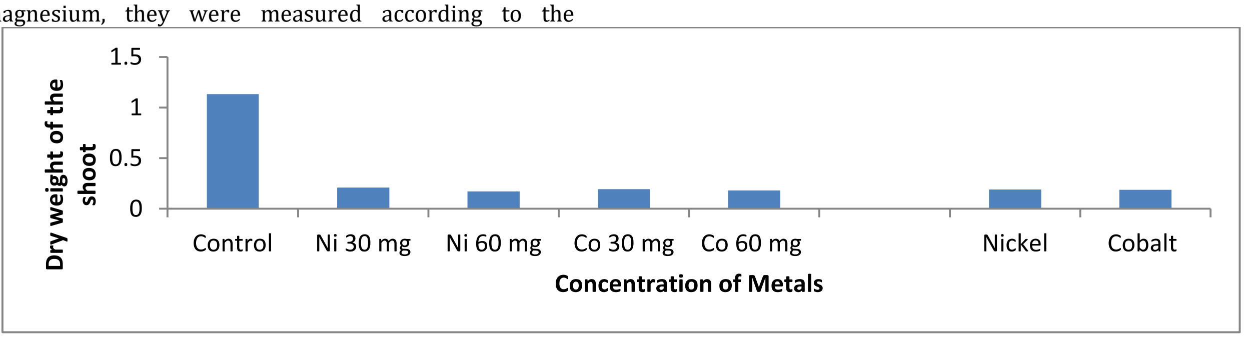
The stability of the plasma membranes :The degree of damage to the plasma membranes in the leaf tissues of the spinach and chard plants was estimated using the method (Bandurska, 1998).

concentration of sodium and potassium: The concentration of sodium and potassium ions in leaves tissue filters was measured by Flame Photometer According to the method (Tendon,2005).

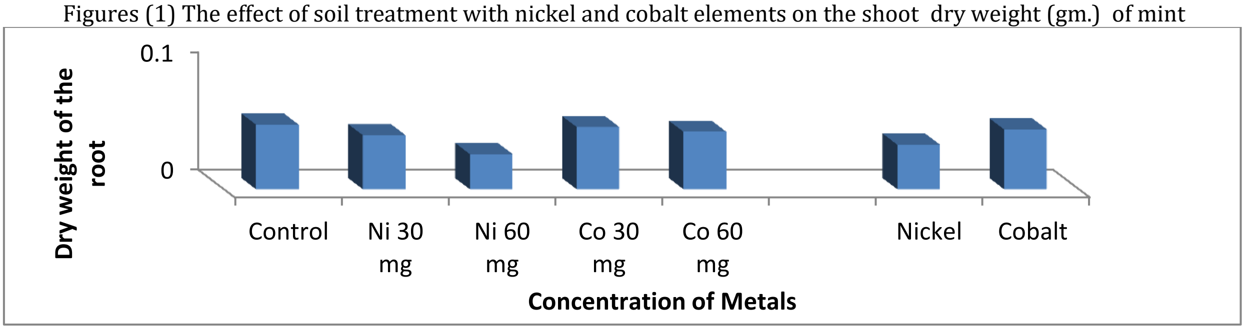
The concentration of calcium and magnesium : The concentration of calcium and magnesium in the shoot and root of the plant was measured by drying and grinding the plant sample and then followed (Jackson,1985) by taking 0.5 g. of dried plant samples were taken in digestion tubes. Nitric acid and perchloric acid in the ratio of 2:1 were taken for digestion. calcium and magnesium, they were measured according to the method of Cheng and Bray (1951) by correction with versenate.

RESULTS AND DISCUSSION

Dry weight of the shoot and root: Figures (1) and (2) show that the treatment of the soil with a nickel element at concentration (60) mg / kg of soil led to a decrease in the dry weight of the shoot and root groups of the mint plant, as it reached (0.171) and (0.030) g respectively, compared to the dry weight of the two groups In plants growing in soil contaminated with nickel element at concentration (30) mg / kg soil and treatment with cobalt element at concentrations (30) and (60) mg / kg soil and control treatment. As for the effect of the element type, Figure (1) shows that the soil treatment with the cobalt element resulted in a decrease in the dry weight of the shoot group of the mint plant as it reached (0.188) g while a decrease in the root weight of the plant when the treatment with the nickel element reached (0.038) g compared to plants The cobalt element is treated as shown in Figure (2).The presence of heavy elements in the environment, especially soil, in large quantities may inhibit photosynthesis, water absorption and cell division, old leaf wilting, dark green leaves, reduced nutrient absorption and disturbances in plant metabolism (Jawala et al., 2010). Among the general symptoms of heavy metal toxicity that can be seen are rapid stopping of root growth, backward growth of the plant, discoloration of the root group to black and chlorine (Farouk and Muhammad, 2018). This is consistent with the presence of heavy metals inhibiting plant growth, general metabolism disturbance and immediate inhibition of cell division (Satish et al, 2015).

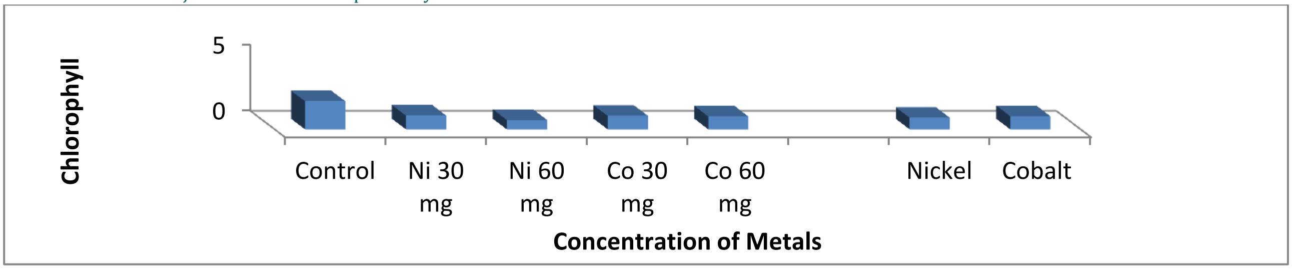


Figures (1) The effect of soil treatment with nickel and cobalt elements on the shoot dry weight (gm.) of mint



Figures (2) The effect of soil treatment with nickel and cobalt elements on the root dry weight (gm.) of mint

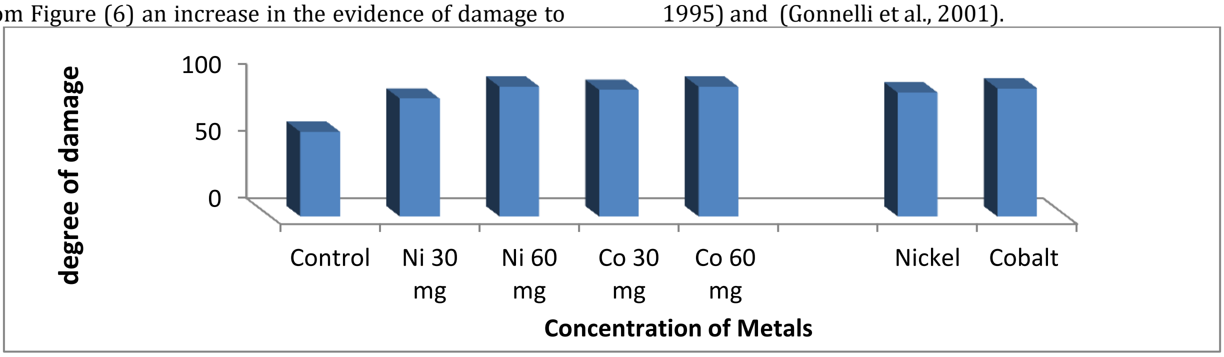
The total chlorophyll : Table (3) shows that the treatment of the soil with a nickel element at a concentration of (60) mg / kg of soil led to a decrease in the concentration of chlorophyll in the leaves of the mint plant, as it reached (0.717) mg / g fresh weight compared to the comparison treatment and other treatments.



Figures (3) The effect of soil treatment with nickel and cobalt elements on the chlorophyll (mg / gm. of fresh weight) of mint

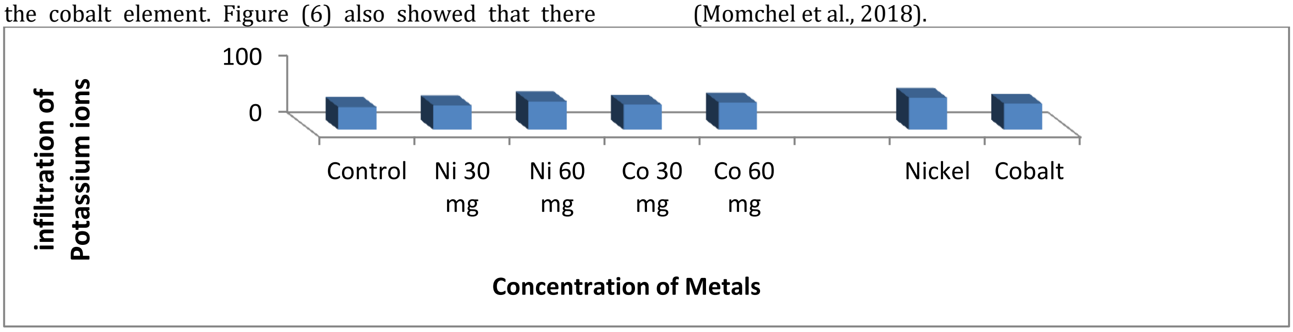
It was also found that the treatment of soil with a nickel component led to a decrease in the concentration of chlorophyll in the leaves of mint and reached (0.878) mg / g fresh weight compared to the concentration of chlorophyll in plants growing with soil treated with cobalt. The concentration of the heavy element increases dramatically in different parts of the plant depending on its concentration in the medium and the duration of exposure to the heavy element (Mustafa et al., 2020). Heavy metals affect chlorophyll concentration by disrupting the chloroplast infrastructure or blocking electron transport and restricting chlorophyll biosynthesis, inhibiting the activities of the Calvin cycle enzymes, and reducing carbon dioxide due to stomatal closure (Seregin and Ivanov, 2001).

The stability of the plasma membranes : We observe from Figure (6) an increase in the evidence of damage to the plasma membranes of the plant leaves of mint plants grown with soil treated with nickel at the concentration (60) mg / kg of soil as it reached (96,842)% compared to the Others treatment and comparison treatment. As for the effect of the element type, we note that the treatment with the cobalt element was more effective on the stability of the plasma membranes, through the increase in the evidence of damage to the plasma membranes, as it reached (95.524)% compared to the evidence of damage in the leaf tissues of plants grown with soil contaminated with the nickel element. The damage to the plasma membrane may be due to it being the first component of the plant cell that comes into contact with toxic heavy metals. It is the plasma membrane that shows the negative effect of heavy metals on the function of the membrane by inducing a strong change in the lipid structures in the different cell membranes (Fodor et al., 1995) and (Gonnelli et al., 2001).

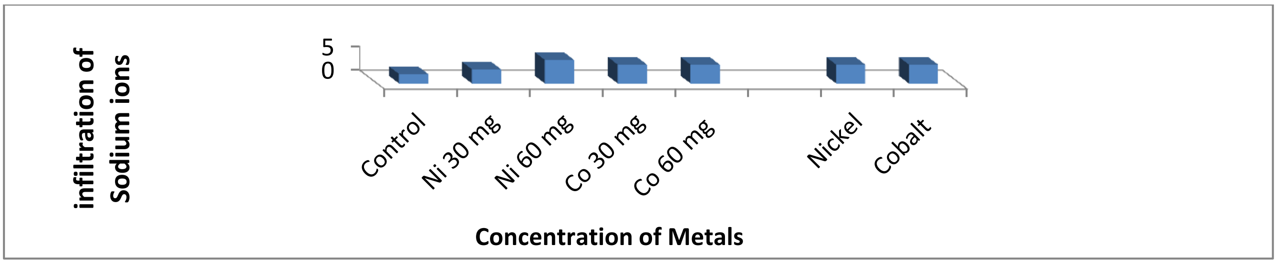


Figures (4) The effect of soil treatment with nickel and cobalt elements on the stability of the plasma membranes (%) of mint

Concentration of Sodium and Potassium : Figures (5) and (6) showed that the treatment of the soil with nickel at the concentration (60) mg / kg of soil led to an increase in the concentration of potassium and sodium ions filtered from the leaves of the mint plant, as it reached (50) and (5) mg, respectively, compared to The rest of the transactions. Figure (5) also showed that the treatment of the soil with the nickel element led to an increase in the infiltration of potassium ions from the tissue and reached (56.5) mg compared to the infiltration of the ion from the leaf tissues of plants growing with soil contaminated with the cobalt element. Figure (6) also showed that there were no differences between the effect Element nickel compared to the element cobalt in the infiltration of sodium ions from the leaves of the mint plant, which amounted to (4) mg. The presence of heavy metals in cultivated soils may lead to disturbance in plasma membrane functions and impaired nutrient balance as well as may affect lipid formation and H-ATPase activity of the plasma membrane (Ross et al., 1992). It may also be due to stronger inhibition of the growth of length of roots and branches, while exposure to heavy elements leads to lighter-colored roots and less diameter. (Momchel et al., 2018).

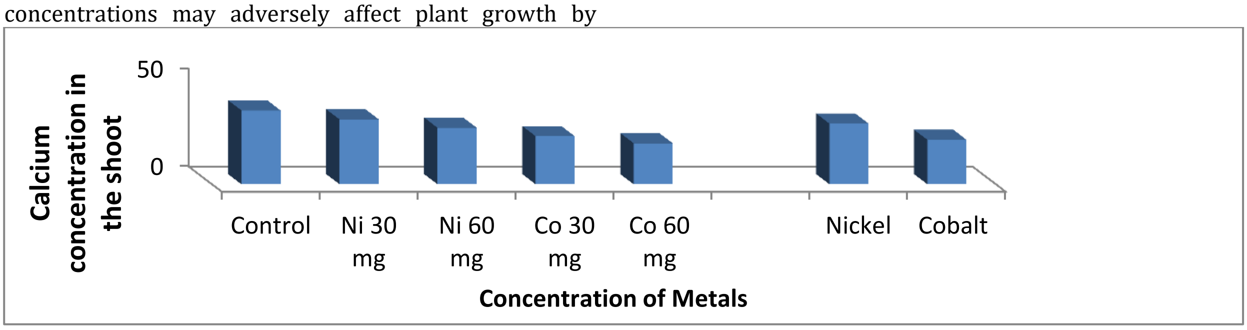


Figures (5) The effect of soil treatment with nickel and cobalt elements on the infiltration of potassium (%)from the leaves of mint

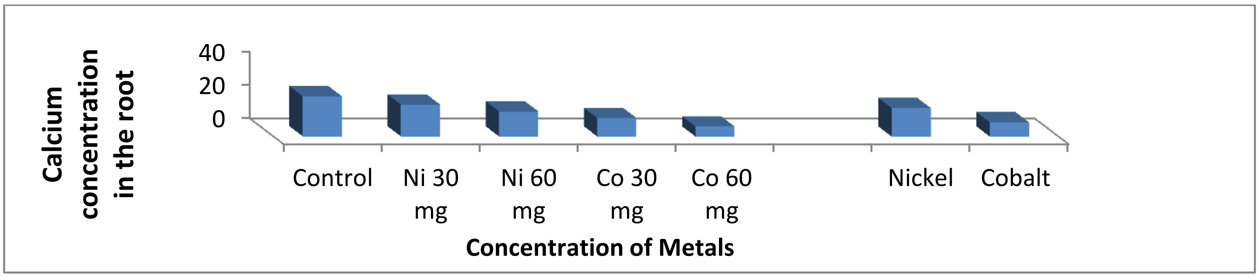


Figures (6) The effect of soil treatment with nickel and cobalt elements on the infiltration of sodium (%) from the leaves of mint

Concentration of Calcium : We find from Figures (7) and (8) that treating the soil with a cobalt element at a concentration of (60) mg / kg of soil led to a decrease in the concentration of calcium in the shoot and root group of mint plants, as it reached (21.00) and (6.00) mg, respectively, compared to a treatment Soil with comparison and other treatment. As for the effect of the element type, we also note that the treatment with the cobalt element was more effective than the nickel element in the content of the shoot and root parts of calcium, reaching (22.9) and (8.52) mg, respectively. The presence of heavy metals in soils with high or low concentrations may adversely affect plant growth by inhibiting photosynthesis, respiration, and cellular degeneration of organelles, leading to plant death (Schmidt 2003) and (Schwartz et al. 2003). Heavy elements also accumulate in the vegetative and root parts of the plant and negatively affect many different processes that occur in the plant. These physiological processes include respiratory gas exchange, transport of nutrients into the plant, photosynthesis, properties of membranes in cells, the structure of these membranes, and gene expression.(Farouk and Mohammed, 2018). This negatively affects the calcium ion concentration in different parts of the plant.

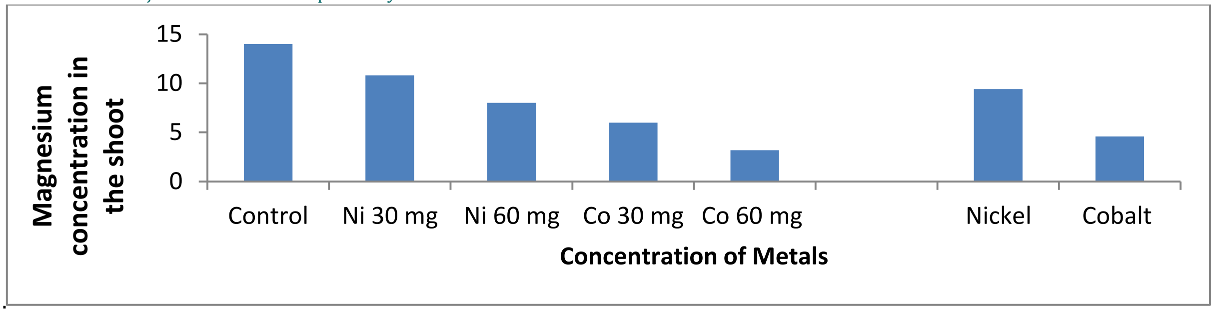


Figures (7) The effect of soil treatment with nickel and cobalt elements on the calcium concentration in the shoot (mg) of mint

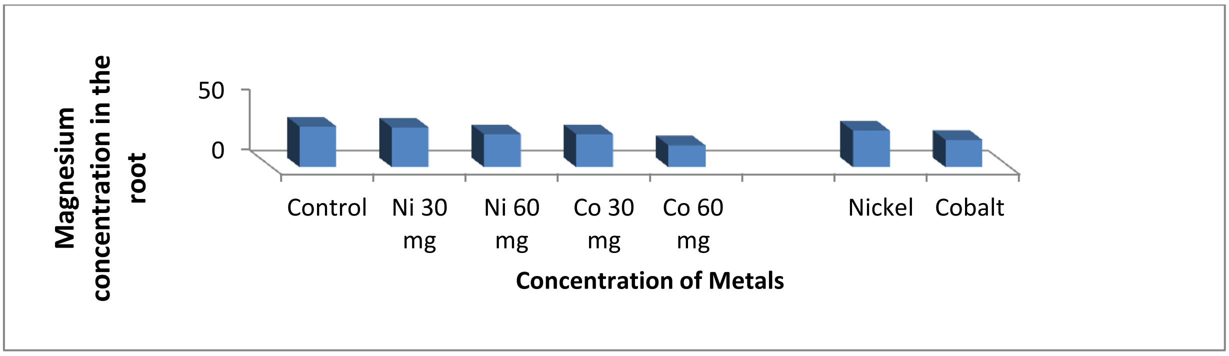


Figures (8) The effect of soil treatment with nickel and cobalt elements on the calcium concentration in the root (mg) of mint

Concentration of Magnesium : Figures (9) and (10) showed that the treatment of soil with a cobalt element at the concentration (60) mg / kg of soil led to a decrease in the concentration of magnesium in the shoot and root groups as it reached (3.2) and (18) mg respectively compared to the soil treatment with the cobalt element At concentration (30) mg / kg soil and soil treatment with nickel element at concentrations (30) and (60) mg / kg soil and control treatment. As for the effect of the element type, we note that the soil treatment with the cobalt element resulted in a decrease in the concentration of magnesium in the shoot and root groups, which amounted to (4.6) and (22,6) mg, respectively, compared to the concentration of magnesium in the shoot and root groups of the mint plants growing with soil treated with the element nickel, which amounted to (9.4) and (30.0) mg. The presence of nickel may lead to increase or decrease in mineral nutrient contents in plant organs, and one possible mechanism to reduce absorption of macro- and micronutrients depends on competition for co-binding sites due to the comparative ions radius of Ni^{2+} and other cations. (Barsukova and Gamzikova, 1999). This is in agreement with (Ertan et al., 2019) that heavy metals negatively affect plant growth, photosynthetic activity and chlorophyll content and this may affect the concentration of some nutrients



Figures (9) The effect of soil treatment with nickel and cobalt elements on the magnesium concentration in the shoot (mg) of mint



Figures (10) The effect of soil treatment with nickel and cobalt elements on the magnesium concentration in the root (mg) of mint

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