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Elemental Analysis of Some Vegetables Cultivated in Delta Tuban, Lahej Governorate –Yemen

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Abstract:- This study involves identifying the levels of some essential and heavy elements (i.e., sodium (Na), potassium (K), magnesium (Mg), phosphorus (P), calcium (Ca), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), cadmium (Cd), and lead (Pb)) in red onion (*Allium cepa L.*) bulbs and leaves, white radish (*Rphanus sativus L.*) roots and leaves, and cucumber (*Cucumis melo var.*) fruit cultivated in three distinct villages (Haran Dian, Althaalab, and Abrlasloom) in Delta Tuban (Lahij Governorate/ Yemen). The collected samples had been wet digested using aqua regia. Then, metal concentrations were measured using inductively coupled plasma-optical emission spectrometry (ICP-OES). All samples showed high concentrations of essential elements. On the other hand, heavy metals (Mn, Fe, and Cu) exceeded the limit allowed by FAO/WHO while Zn was under allowed limits. Moreover, Cr, Co, Ni, As, Cd, and Pb revealed a varied range of concentration levels in the targeted samples.

Keywords:- *Essential Elements, Heavy Elements, Vegetables of Lahij, Concentration Determination.*

I. INTRODUCTION

Some elements are necessary for many vital functions, especially enzyme functions, and they have a positive effect on the growth of livestock and poultry, such as zinc, copper, and manganese, so they are sometimes added to feed as nutritional supplements because of the low content of these minerals in some animal feeds [1-3].

The variation in the content of heavy metals in vegetables and fruits is not only caused by the accumulation of these metals during growth, but also by their contamination during the harvesting process [4]; The technological processes that are used to bring food (such as vegetables and fruits) and distribute the product (transportation and marketing) to places of sale or factories significantly increase the mineral content of food, due to the uncleanliness of the tools and equipment used for collecting food, in addition to the poor health conditions of the market [5].

We are living today in a global awakening that is heading towards medicinal plants because they contain chemical compounds that can be considered raw materials that can be a first step in preparing therapeutic compounds of great medical importance [6], and many plants contain functional nutritional components and some of them help in alleviating the risk of many diseases such as cancer [7-9].

The elements and their chemical compounds in food affect human health, some of them have a useful and known biological function, and others have no known biological function, and may be harmful to human health, including lead compounds that affect the neuropsychological nervous system and inorganic arsenic, carcinogen substance, when it is present in high concentrations. Cadmium element can affect renal function. Some other elements cause health effects for a short period when a person is exposed to a high level of them, such as exposure to a high level of tin, which causes an upset stomach, and there are other elements such as copper, chromium, selenium, and zinc that are necessary for health and life, and can be toxic if a person is exposed to a high level of them [10].

In a study conducted in Greece [11], it was found that adding industrial waste rich in manganese (Thermanox) (containing 14% manganese, high amounts of (Al, K, Ca, Fe), and large amounts of heavy elements such as (Cu, Zn, Co, Cr, Ni, As, Cd, and Sn) in different amounts (0, 400, 500, 600) tons/hectare to the soil to improve it before planting it shows that the productivity of crops was improved when adding (500, 600) tons/ha of this mixture, while the concentrations of these mineral elements in plants were high compared to plants to which (Thermanox) was not added.

The current study aims to estimate the concentrations of some essential and heavy elements in onions, radish, and cucumber vegetables grown in Delta Tuban-Lahej and compare the values of these concentrations with the permissible limits FAO/WHO [12].

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II. MATERIALS AND METHODS

Three different areas were randomly selected, and the edible parts of three vegetable crops were studied from each of the three regions, which are onions and leaves of red onion (*Allium cepa L.*), leaves and roots of white radish (*Rphanus sativus L.*), and the fruits of local cucumber (*Cucumis melo var.*). Samples were collected during the period from September 2018 to April 2019 and placed in paper bags to be transported to the laboratory. They were washed with tap water and then distilled water, then cut and placed in paper bags and dried inside the drying oven at a temperature of 70 degrees Celsius for 24 hours. The samples were crushed, sieved, and then placed in plastic containers, ready for analysis.

A. *Chemicals & Instruments*

All chemicals used were of high purity and did not require additional treatment for this purpose. Deionized water was used to prepare the solutions required for standard curves and to prepare samples for analysis.

Instruments were the burning furnace (Malzemeleri) made in Turkey, sensitive balance (Balingen) made in Germany, and Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) (Thermo Scientific, iCAP 6000) made in the USA.

B. *Determination of Elements*

The plant samples were digested according to what was stated in [13] with some modifications:

0.5 g of dry, crushed and sifted plant sample was weighed on a sensitive scale, then placed in a conical flask, then moistened with 0.5 ml of deionized water, then 6 ml of concentrated hydrochloric acid was added to it, and quickly (to form aqua regia) 2 ml was added of nitric acid drop by drop to reduce smoke, then put the condenser on the conical flask during digestion, then leave the sample for the next day at room temperature to be the process of oxidation of the organic matter, then put the tubes on an electric heating stove at a temperature of 130 ºC for two hours and then left to cool.

The residue was washed then the suspension was filtered into a 50ml standard flask and the final volume was filled with deionized water to the mark.

The explored elements in the vegetable samples were consecutively determined using ICP-OES instrument supported by ISDS software and the standard method was followed. The operating parameters of ICP-OES are given in Table 1 below.

Table 1 ICP–OES Conditions

Radio Force (RF) power	1200 W
Carrier gas flow rate	0.26 L/min
Plasma gas (Ar) flow rate	10 L/min
Pumping rate	1.50 mL/min
Sweeping rate	0.8 L/min
Plasma position	Axial
Correlation factor	0.98
Signal background correction	Fixed
Analytical wavelength (nm)	Selective

C. *Laboratories Analysis and Measurement*

Samples were processed, prepared, and digested in the master's laboratories -Department of Chemistry, College of Education, Aden, University of Aden. Essential and heavy metals were analyzed and measured in the laboratories of PetroMasilah -Oil - Shabwa Governorate - Republic of Yemen.

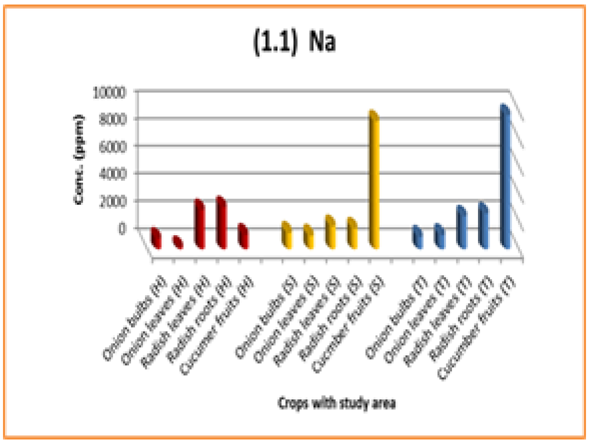
D. *Statistical Analysis*

The analysis of variance (ANOVA) was conducted according to a completely randomized design using Genstat program, version 3.2, 2018 (National Statistical Services Center), where the experiments were factorial (two factors) namely the location of sampling, the type and parts of the vegetables studied, that is, 15 treatments (3 sites and 5 types and parts of the studied vegetables). The averages of the treatments were compared using the least significant difference (LSD) at the 5% level of significance.

III. RESULTS AND DISCUSSION

E. *Essential Elements*

The essential elements (Fig.1) in the studied vegetable samples showed significant variation among them in one sample as well as among them in all samples. Below we review the results of these elements arranged according to their order in the periodic table.



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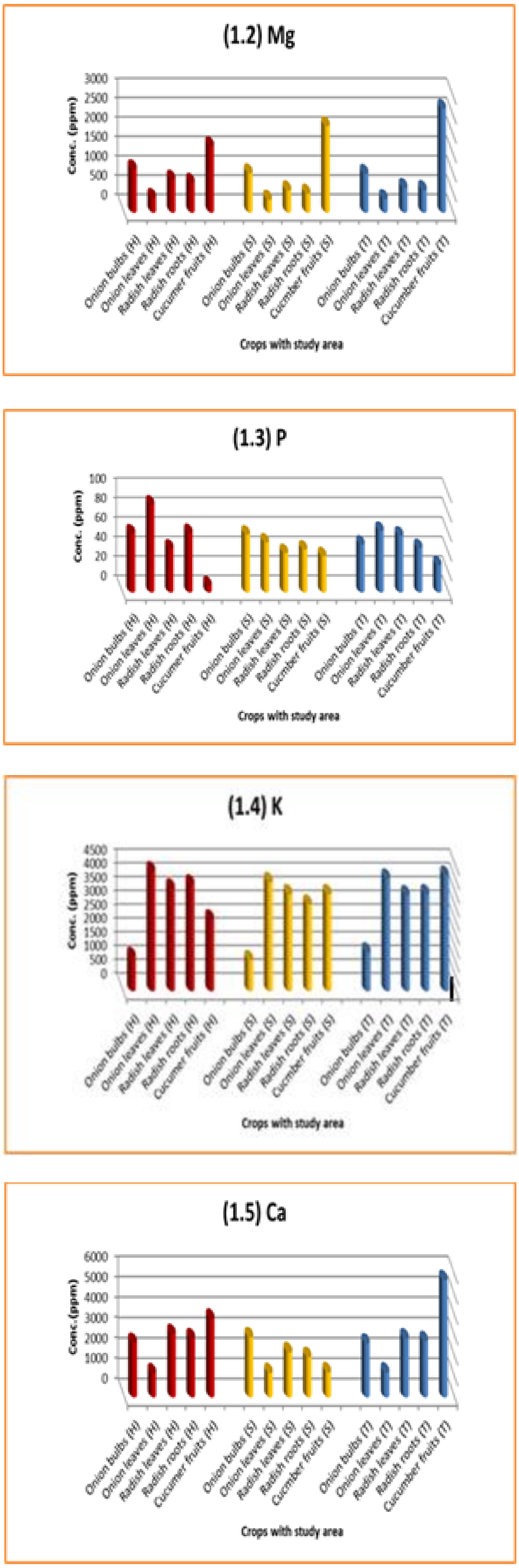


Fig 1 Essential Elements Concentration (ppm) in the Studied Samples (1) Sodium (Na), (2) Magnesium (Mg), (3) Phosphorus (P), (4) Potassium (K), (5) Calcium (Ca)

➢ *Sodium (Na):*

Through Figure (1.1) and the statistical analysis, it was found that the effect of the location on the concentration of the element sodium was significant, as the concentrations of the element sodium in the study areas ranged between (3316.87) ppm as a maximum in Althaalab area (T) with significant differences compared to the rest of the areas and (1560.93). ppm as a minimum in the region of Haran Dian (H), where the decrease in concentration was significant, and this is consistent with Al-Mashreqi [14], which found that many of the dry and semi-dry areas in Yemen, especially Delta Tuban (the area of our study), contain irrigation water from wells.

Underground water contains most of the salts, whether chlorides, sulfates, carbonates, or bicarbonates of calcium, magnesium, sodium, and potassium, as each of these salts has a different degree of solubility, according to the composition of the mineral materials through which the water passes. The effect of the plant species on the concentration of sodium was significant. Cucumber fruits showed the highest concentration of sodium (6685.00) ppm, where this increase in concentration was significant, while onion leaves achieved the lowest sodium concentration (722.44) ppm with a significant difference with all study samples. In terms of interaction between the two factors' location and plant type, the cucumber fruits in Althaalab area (T) and Abrlasloom area (S) achieved the highest concentration of sodium, reaching (9730.67, 9291.33) ppm, respectively, with a significant difference with the rest of the samples, while onion leaves and bulbs in Haran Dian region (H) has the lowest concentration of sodium, which reached (163.00, 772.66) ppm, respectively, and this decrease in concentration was significant with the rest of the study samples. We noted that all study samples contained sodium in different concentrations, and when comparing sodium concentrations with what was mentioned in the previous studies, we found that the sodium concentration in onion bulbs and cucumber fruits (953.33, 6685.00) ppm, respectively, is greater than what was recorded (280, 2200) ppm, respectively, in the city of Taif [15], and we also find that onion bulbs recorded a concentration greater than the concentration observed by Garba and Jimoh [16] at analyzing the sodium element in some vegetable crops grown in Challawa-Yandanko State in Nigeria, where onion bulbs achieved (58.54) ppm. When comparing these results with the standards of some countries, we find that the concentration of sodium exceeded the standards proposed by the United States, South Africa, Tanzania, Malaysia, Denmark, Finland, and Japan [17], and we attribute the reason for this to irrigation water, agricultural soil and the excessive use of pesticides and agricultural fertilizers rich in this element. Accordingly, the concentration of sodium can be summarized as:

- Haran Dian/ Radish Roots > Radish Leaves > Cucumber Fruits > Onion Bulbs > Onion Leaves.
- Abrlasloom/ Cucumber Fruits > Radish Leaves > Radish Roots > Onion Bulbs > Onion Leaves.
- Althaalab/ Cucumber Fruits > Radish Roots > Radish Leaves > Onion Leaves > Onion Bulbs.

- *Magnesium (Mg):*

We notice from Figure (1.2) that the average concentration of magnesium in Althaalab region (T) was high, reaching (1045.3) ppm in the studied samples, where the increase in magnesium concentration was significant compared with the two regions of Haran Dian (H) and Abrlasloom (S), which was magnesium concentration in them is (961.9 and 924.3) ppm, respectively, and in terms of the concentration of magnesium in the types of vegetables studied, magnesium concentration in cucumber fruits and onion bulbs was high, reaching (2205.0 and 1040.6) ppm, respectively, with a significant difference in the all study samples, while onion leaves showed the lowest concentration of magnesium (350.9) ppm with significant differences with all study samples, and these results are close to the results of Mohamed et al [15] who found that the magnesium concentration in cucumber fruits (1591.0) ppm. We found that the concentration of magnesium in onion bulbs was lower than the concentration (1709) ppm that was monitored by [15], and greater than the concentration (15.56) ppm monitored by Kitata [18] in onion bulbs. In terms of the interaction between the regions and the types of vegetable crops studied, the cucumber fruits in the three study regions, Althaalab (T), Abrlasloom (S), and Haran Dian (H) achieved the highest concentration of magnesium (2675.0, 2230.7 and 1709.3) ppm.

Consecutively and with significant differences with all study samples and with each other, while onion leaves in the three study areas Haran Dian (H), Althaalab (T), and Abrlasloom (S) showed the lowest concentrations of magnesium (377.3, 346.0, and 329.3) ppm respectively, and with a significant difference between them and with the rest of the studied samples. When comparing these results with the standards of some countries, we find that the concentration of magnesium exceeded the standards proposed by the United States, South Africa, Tanzania, Denmark, Finland, and Japan, and it agrees with the standards of Malaysia for onion samples only [17] and we attribute the reason for this to the excessive use of pesticides and agricultural fertilizers rich in this element, such as CaO-MgO fertilizer. Accordingly, the magnesium levels in vegetable crops for the studied sites can be arranged in descending order as follows:

- Haran Dian / Cucumber Fruits > Onion Bulbs > Radish Leaves > Radish Roots > Onion Leaves.
- Abrlasloom / Cucumber Fruits > Onion Bulbs > Radish Leaves > Radish Roots > Onion Leaves.
- Althaalab / Cucumber Fruits > Onion Bulbs > Radish Leaves > Radish Roots > Onion Leaves.

- *Phosphorous (P):*

The results of the study in Figure (1.3) indicate that Haran Dian region (H) recorded the highest concentration of phosphorous element (52.73) ppm with a significant difference over the two regions of Althaalab (T) and across Abrlasloom (S), where the concentration of phosphorous in them reached (48.82 and 46.40) ppm, respectively.

We may attribute the increase in the concentration of the phosphorous element to the excessive use of phosphate fertilizers, and the most prevalent is triple superphosphate fertilizer, where the concentration of phosphorous pentoxide varies (46-50% P_2O_5), which is made from the interaction of phosphoric acid with a concentration of at least 32% with apatite ore [19]. In terms of phosphorous concentration in the studied vegetables, the results showed significant differences between the study samples, and onion leaves recorded the highest concentration of phosphorous element (68.16) ppm, while cucumber fruits recorded the lowest concentration of phosphorous element (24.01) ppm with a significant difference in all samples of vegetables studied. To the multiple agricultural activities represented in the irrigation, drainage, and spraying of pesticides, the addition of fertilizers rich in phosphorous, and the use of industrial and sewage water is one of the most important sources of pollution of the agricultural environment [20]. In terms of interaction between the site workers and the studied vegetables, we find that the bulbs, leaves of onions, and radish roots in Haran Dian region (H) and the onion leaves in Althaalab region (T) achieved high phosphorous concentrations with significant differences from the rest of the samples, while the cucumber fruits showed in the three study areas, Haran Dian (H), Althaalab (T) and Abrlasloom (S) (7.14, 27.83 and 37.07) ppm, respectively, have the lowest concentration of phosphorous with significant differences, ppm. When we compare these results with the standards of some countries, we find that the concentration of phosphorus is less than the standards proposed by the United States, Malaysia, Tanzania, Denmark, Finland, and Japan, it did not agree with the standards of South Africa in which the concentration of phosphorous element was less than the detection limit in onions and cucumbers [17]. Accordingly, the levels of phosphorous in vegetable crops for the studied sites can be arranged in descending order as follows:

- Haran Dian / Onion Leaves > Radish Roots > Onion Bulbs > Radish Leaves > Cucumber Fruits
- Abrlasloom / Onion Bulbs > Onion Leaves > Radish Roots > Radish Leaves > Cucumber Fruits
- Althaalab / Onion Leaves > Radish Leaves > Onion Bulbs > Radish Roots > Cucumber Fruits.

- *Potassium (K):*

Figure 1.4 shows that the average potassium concentration in Althaalab region (T) was high, reaching (3344.2) ppm in the studied samples, where the increase in potassium concentration was significant compared with the two regions of Haran Dian (H) and Abrlasloom (S), which potassium concentration in them was 3166.7 and 3059.5 ppm respectively, and this is in agreement with [14]. According to potassium concentration in the types of vegetables studied, its concentration in onion leaves was high, reaching 4138ppm. Mohamed et al. [13] found that the potassium concentration in onion leaves (2360 ppm as well as superior to Garba & Jimoh [16] who found that potassium concentration in onions is 19.43 ppm, and when we compare these results with the standards of some countries, we find that the concentration of potassium in all samples exceeded the standards proposed by the United States, Malaysia, Tanzania, Denmark, South

Africa, Finland, and Japan, except for onion bulb samples [17]. The onion leaves in the areas of Haran Dian (H) and Abrlasloom (S) and the cucumber fruits in the area of Abrlasloom (S) had a high potassium concentration with significant differences compared with the rest of the treatments, where potassium reached (4360.3, 4092.0, and 4197.0) ppm respectively.

Moreover, the onion bulbs in the three study areas, Haran Dian (H), Abrlasloom (S), and Althaalab (T) were the lowest as they reached (1246.0, 1130.3 and 1413.3) ppm, respectively, and this decrease in the concentration of potassium is significant compared with the rest of the treatments, and we infer from this that the increase in concentration is due to the number of pesticides sprayed and not from the agricultural soil. The potassium levels in vegetable crops for the studied sites can be arranged in descending order as follows:

- Haran Dian / Onion Leaves > Radish Roots > Radish Leaves > Cucumber Fruits > Onion Bulbs.
- Abrlasloom / Onion Leaves > Radish Leaves = Cucumber Fruits > Radish Roots > Onion Bulbs.
- Althaalab / Cucumber Fruits > Onion Leaves > Radish Roots > Radish Leaves > Onion Bulbs.

➢ *Calcium (Ca):*

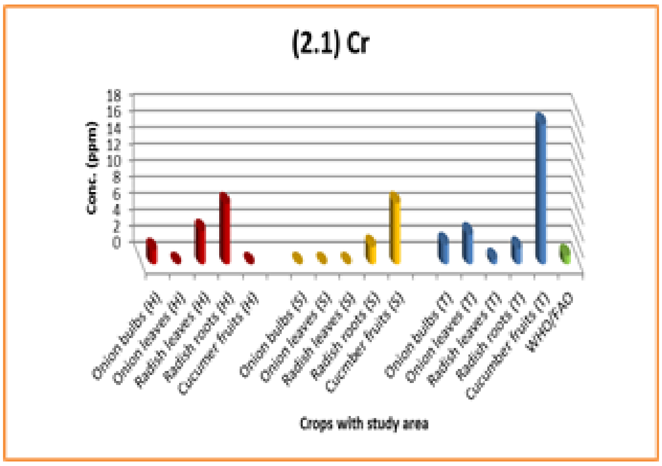
The results of the study in Figure (1.5) showed that the effect of the location on the concentration of calcium was significant. Althaalab area (T) recorded the highest concentration of calcium (3046.00) ppm with a significant difference with all other areas, while the area of Abrlasloom (S) recorded the lowest concentration of calcium element (1907.20) ppm with a significant difference over Haran Dian (H) region, which achieved (2736.27) ppm. The effect of the plant species on the calcium concentration was significant. Cucumber fruits showed the highest concentration of calcium element (3608.11) ppm, where this increase in the concentration of calcium element was significant, while onion leaves achieved the lowest concentration of calcium element (1193.67) ppm with a significant difference in all samples. The study and when comparing these results with the standards of some countries, we find that the concentration of calcium in all samples exceeded the standards [17]. The interaction between the two factors site and plant type showed a significant interaction.

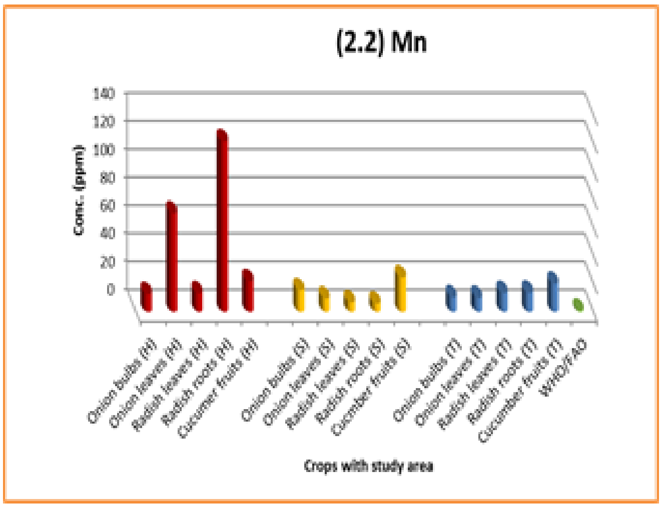
The cucumber fruits in Althaalab region (T), followed by the fruits of Haran Dian region (H), and then the radish leaves in Haran Dian region (H) recorded the highest concentration of calcium, reaching (5746.00, 3851.33, 3103.00) ppm, respectively and with a significant difference with each other and with the rest of the samples, while the onion leaves in the three study areas, Althaalab (T), Abrlasloom (S), and Haran Dian (H) had the lowest concentration of calcium, reaching (1215.67, 1192.67, 1172.67) ppm respectively, where this decrease in concentration was significant with each other and with the rest of the study samples. It is clear that all studied samples contained calcium in different proportions, and these results are superior to the results of Kitata [18], which found that the calcium concentration in onion bulbs (599 ppm, but less than the results obtained by Mohamed et al. [15] who found that the calcium concentration in cucumber fruits (4220) ppm and onion bulbs (7450) ppm, but it agrees with Garba & Jimoh [16] who found that the calcium concentration in cucumber fruits (2084.46) ppm and in onion bulbs (1772.39) ppm The calcium levels in vegetable crops for the studied sites can be arranged in descending order as follows:

- Haran Dian / Cucumber Fruits > Radish Leaves > Radish Roots > Onion Bulbs > Onion Leaves.
- Abrlasloom / Onion Bulbs > Radish Leaves > Radish Roots > Cucumber Fruits > Onion Leaves.
- Althaalab / Cucumber Fruits > Radish Leaves > Radish Roots > Onion Bulbs > Onion Leaves.

F. Heavy Elements

The heavy elements in the studied vegetable samples showed a significant variation among them in one sample as well as among them in all samples. The results of those elements (Fig.2) are arranged according to their increasing number and atomic weight.





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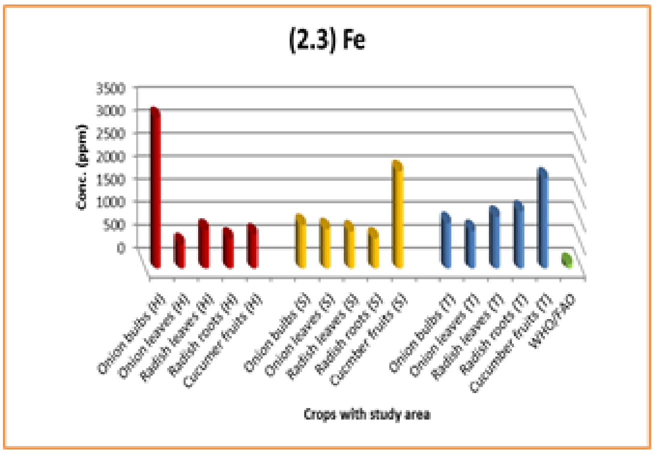

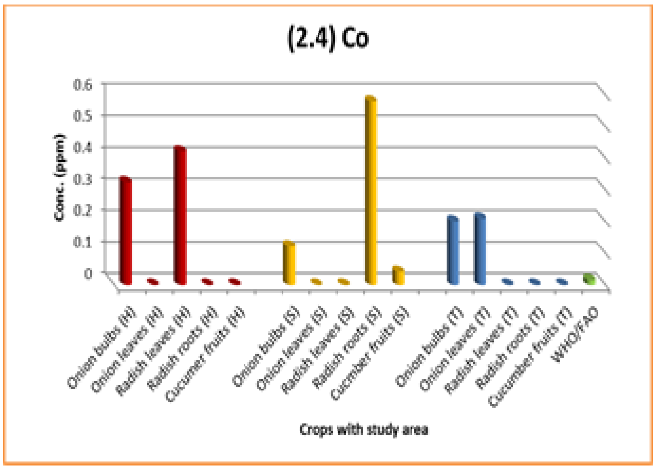

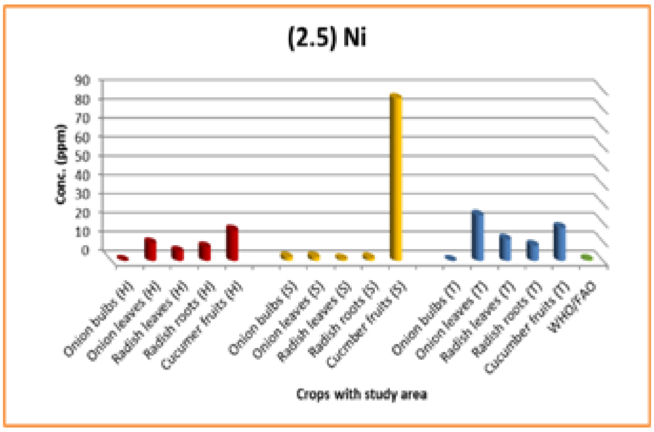

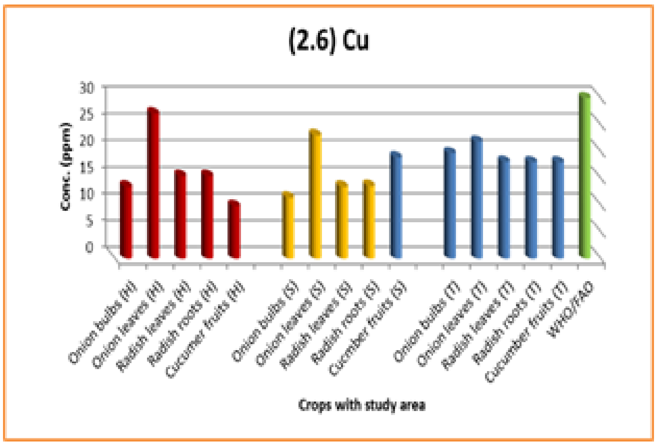

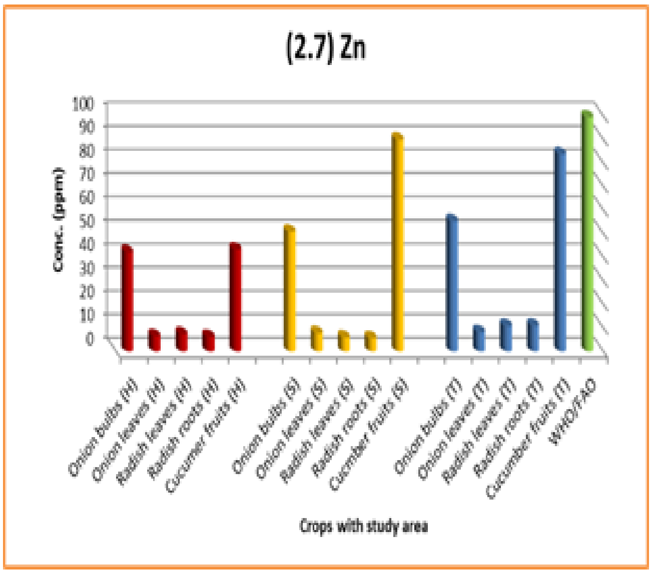

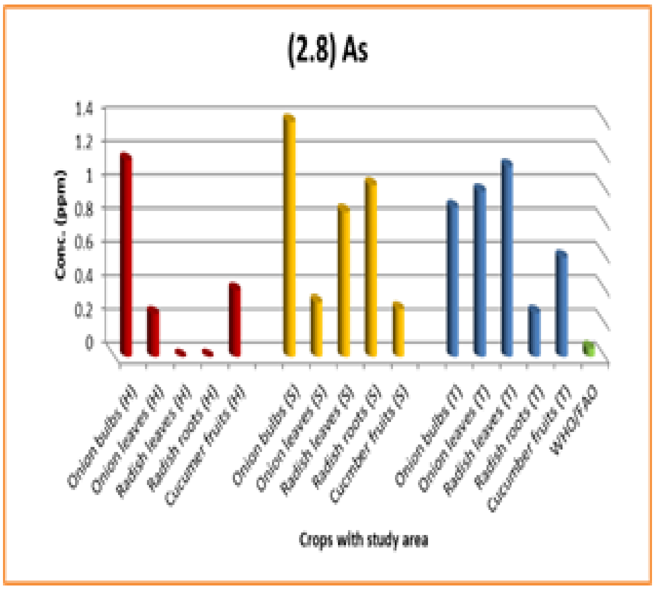

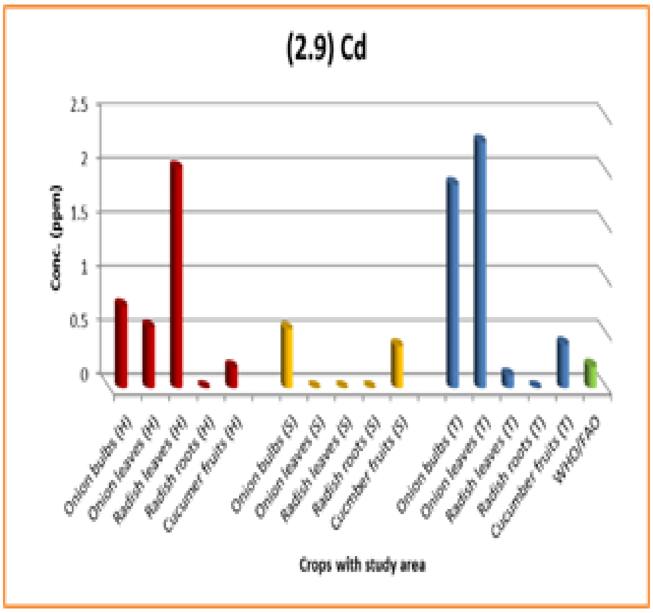

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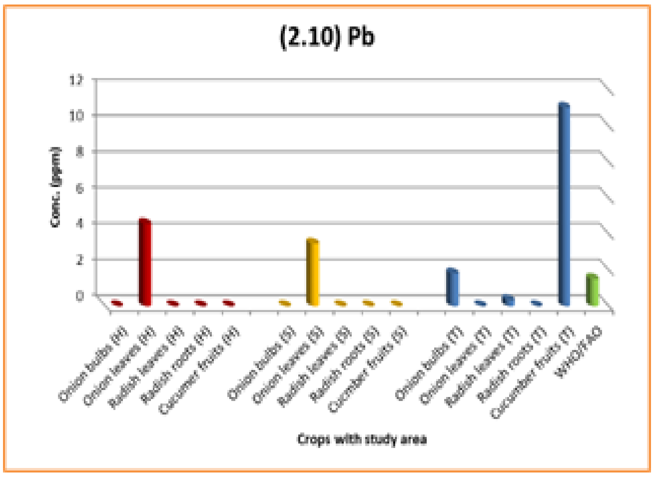

Fig 2 Heavy Elements Concentration (ppm) in the Studied Samples (1) Chromium (Cr), (2) Manganese (Mn), (3) Iron (Fe), (4) Cobalt (Co), (5) Nickel (Ni), (6) Copper (Cu), (7) Zinc (Zn), (8) Arsenic (As), (9) Cadmium (Cd), (10) Lead (Pb).

- *Chromium (Cr):*

We note from Figure (2.1) that the highest value of chromium was in Althaalab region (5.077) ppm with a significant difference in the regions of Haran Dian (H) and Abrlasloom(S), where the chromium concentration in them reached (2.603 and 1.901) ppm and we attribute the increase in concentration to agricultural activity represented in the use of agricultural chemicals, which is one of the important sources of pollution with heavy elements, the most prominent of which are pollutants and impurities in fertilizers such as cadmium, chromium, lead, uranium, and zinc [19]. The fruits of cucumber and radish roots recorded the highest concentration of chromium (8.130 and 3.766) ppm, respectively, where the increase in concentration was significant compared to the rest of the studied samples, while the leaves and bulbs of onions and radish leaves were recorded. The lowest concentration of chromium was (1.199, 1.364, and 1.508) ppm, respectively. These results are less than what was observed by [16] when analyzing chromium (7.00) ppm in some vegetable crops grown in Challawa-Yandanko State in Nigeria, and less than what was observed by Samina and Al-Jabbah [10] in Damascus, where the general average of chromium in the studied vegetables was 146.25 ppm, and in terms of the interaction between the two factors, the location and the type of plant, the cucumber fruits in the areas of Althaalab (T) and Abrlasloom (S) showed the highest concentration of chromium, where the concentration of chromium reached (16,993 and 7.398) ppm with significant differences with the rest of the samples. Except for the roots of the radish of Haran region (H) and the fruits of the cucumber of Abrlasloom region (S), the difference between them did not reach a significant level, while the onion leaves in Haran Dian region (H) showed the lowest concentration of chromium (0.005) ppm and less than the permissible limit (1.00) ppm according to FAO/WHO [12] while we did not find chromium in bulbs of onions samples and radish leaves in Abrlasloom region (S) and the fruits of the cucumber Haran Dian region (H), where its concentration was less than 0.0001 ppm.

- *The levels of chromium in vegetable crops for the studied sites can be arranged in descending order as follows:*

  - ✓ Haran Dian / Radish Roots > Radish Leaves > Onion Bulbs > Onion Leaves > Cucumber Fruits.
  - ✓ Abrlasloom / Cucumber Fruits > Radish Roots > Onion Leaves = Onion Bulbs = Radish Leaves.
  - ✓ Althaalab / Cucumber Fruits > Onion Leaves > Onion Bulbs > Radish Roots > Radish Leaves

- *Manganese (Mn):*

Figure (2.2) represents that Haran Dian region (H) achieved the highest concentration of manganese (47.82) ppm, where the increase in concentration was significant compared with the regions of Abrlasloom (S) and Althaalab (T), where the concentration of manganese reached (13.489 and 12.472) ppm. Also, the studied vegetable samples showed that radish roots, followed by onion leaves and cucumber fruits, achieved high concentrations of manganese, with significant differences with all studied samples, where the manganese concentration reached (46.978, 29.887, 22.123) ppm, respectively, while radish leaves and onion bulbs had the lowest concentrations of manganese, where the concentration of manganese in them reached (11.124 and 12.854) ppm, respectively, and this decrease in concentration was significant, and in terms of the interaction between the sampling site (area) and the type of vegetables studied, shows that radish roots and onion leaves in Haran Dian region (H) had the highest concentration of manganese with significant differences with all studied samples, where the concentration of manganese in them reached (121.37 and 70.12) ppm respectively, while the roots and leaves of radish in Abrlasloom region (S) showed the lowest concentration of manganese. There were significant differences with all study samples, where the concentration of manganese in them reached (5.933 and 6.807) ppm, respectively. Manganese content of the studied vegetables was higher than the permissible limit according to FAO/WHO (1 ppm) [12]. This is what was found [22-24] when analyzing manganese in some types of vegetables found in Nigeria, China, and Japan, respectively.

- *Manganese Concentration has the Order:*

  - ✓ Haran Dian / Radish Roots > Onion Leaves > Cucumber Fruits > Radish Leaves > Onion Bulbs.
  - ✓ Abrlasloom/ Cucumber Fruits > Onion Bulbs > Onion Leaves > Radish Leaves > Radish Roots.
  - ✓ Althaalab / Cucumber Fruits > Radish Roots > Radish Leaves > Onion Bulbs > Onion Leaves.

- *Iron (Fe):*

Based on the results shown in Figure (2.3), Althaalab region (T) showed the highest concentration of iron, as its concentration reached (1223.0) ppm with a significant difference on the regions of Haran Dian (H) and Abrlasloom (S), where its concentration reached (1204.3 and 1073.0) ppm. Straight in terms of iron concentration in the studied vegetable crops, onion bulbs, and cucumber fruits showed the highest concentration of iron, where the increase in concentration was significant compared to the rest of the studied vegetable samples, reaching (1733.7 and 1604.0) ppm respectively, while onion leaves showed the lowest concentration of iron. Iron and with significant differences with all study samples, where the iron concentration reached (731.7 ppm), and these results outperformed the results of [15], which found that the iron concentration in cucumber fruits and onion bulbs was (83.5 and 93.6) ppm respectively, and also outperformed the results of Mohamed et al [15]. Jawad [25] found that the concentration of iron in onion leaves falls within the range (of 0.56- 329.7 ppm). In terms of the interaction between the type of plant and the location of sample collection, the onion bulbs of Haran Dian region (H) and the cucumber fruits in Abrlasloom region (S) recorded the highest concentrations of iron, and the increase in concentration was significant compared to all study samples, as its concentration reached (3272.3 and 2117.0) ppm respectively, while onion leaves and radish roots in Haran Dian region (H) and radish roots in Abrlasloom region (S) recorded the lowest iron concentration with a significant difference overall study samples, where its concentration reached (530.3, 647.7, 647.3) ppm respectively. It is clear that vegetable samples contained iron in different proportions, but all concentrations of iron exceeded the permissible limits (100 ppm) according to [12]. In all studied vegetable samples. The iron levels in vegetable crops for the studied sites can be arranged in descending order as follows:

- Haran Dian / Onion Bulbs > Radish Leaves > Cucumber Fruits > Radish Roots > Onion Leaves
- Abrlsloom/ Cucumber Fruits > Onion Bulbs > Onion Leaves > Radish Leaves > Radish Roots
- Althaalab / Cucumber Fruits > Radish Roots > Radish Leaves > Onion Bulbs > Onion Leaves

➢ *Cobalt (Co):*

The results in Figure (2.4) indicate that the cobalt concentrations were superior in Haran Dian area (H) and reached (0.1492) ppm with a significant difference over Althaalab area that achieved (0.0823) ppm, while there were no significant differences in the cobalt concentrations with Aberlasloom area (1.487) ppm when compared to the concentration of Haran Dian region (H). As for the concentrations of cobalt in the studied vegetable crops, the results listed show that onion bulbs and radish roots recorded the highest concentrations of cobalt with significant differences in overall study samples, which amounted to (0.2157, 0.1933) ppm, respectively, while cucumber fruits achieved. The lowest concentration of cobalt with a significant difference in all study samples where it reached (0.0139) ppm. Cobalt was found in some vegetable crops, including radish leaves and onion bulbs in Haran Dian region (H), where it reached (0.4223 and 0.3237) ppm, respectively, and radish roots, onion bulbs, and cucumber fruits in the area of Abrlasloom (S) where reached (0.580, 0.1217, 0.0417) ppm respectively, and bulbs and leaves of onions in Althaalab region (T) where it reached (0.2100 and 0.12017) ppm respectively and it was higher than the permissible limit according to [12] (0.015 ppm) and with significant differences between them. While cobalt was not found in some crops, including onion leaves, radish roots, and cucumber fruits in Haran Dian area (H), onion leaves and radish leaves in Abrlasloom area (S), radish leaves and roots and cucumber fruits in Althaalab area (T), where they were all less than the detection limit of the device <0.0001, and this is what was reached [26-28] when analyzing cobalt in vegetables in Nigeria, Australia and the United States of America, respectively. Perhaps the reason for the difference between the concentrations of the cobalt element in the studied vegetable samples is due to the different levels of environmental pollution with cobalt in the sites where they are cultivated. Therefore, the cobalt levels in vegetable crops for the studied sites can be arranged in descending order as follows:

- Haran Dian / Radish Leaves > Onion Bulbs > Onion Leaves = Radish Roots = Cucumber Fruits
- Abrlasloom / Radish Roots > Onion Bulbs > Cucumber Fruits > Onion Leaves = Radish Leaves
- Althaalab / Onion Leaves > Onion Bulbs > Radish Root = Radish Leaves = Cucumber Fruit.

➢ *Nickel (Ni):*

Figure (2.5) shows that the area of Abrlasloom (S) achieved the highest concentration of nickel, reaching (18.330) ppm with significant differences in the areas of Haran Dian (H) and Althaalab (T), where its concentration reached (7.536, 12.149) ppm, respectively. The reason for this may be due to the differences in the environmental pollution of these sites with the element nickel due to the increased addition of waste and residues to the soil. Soil and plant content of these minerals. In terms of nickel content of the studied vegetables, cucumber fruits, and onion leaves recorded very high concentrations with significant differences, reaching (39.769, 11,734) ppm, respectively, while onion bulbs recorded the lowest concentrations of nickel, reaching (0.605) ppm. In terms of the interaction between the location of sample collection and the type of plants studied, cucumber fruits in the area of Abrlasloom (S), cucumber fruits and onion leaves in Althaalab area (T) and cucumber fruits in Haran Dian area (H) recorded high concentrations of nickel that exceeded the permissible limits (0.5 - 0.1 ppm) [12] may reach toxicity levels (10 - 100) ppm according to Alegria et al. [29], with clear significant differences between them and with the rest of the study samples, which amounted to (85,723, 17,457, 24.00, 16.127) ppm respectively, while no nickel was found in the onion bulbs of Haran Dian (H) and Althaalab (T) regions, where its concentration was less than the detection limit of the device (i.e. <0.0001 ppm) and this is consistent with what was stated by [30-32] when analyzing some vegetable crops in India, southwest China, and England.

- *The Levels of Nickel in Vegetable Crops for the Studied Sites follow the Order:*

✓ Haran Dian / Cucumber Fruits > Onion Leaves > Radish Roots > Radish Leaves > Onion Bulbs
✓ Abrlasloom/ Cucumber Fruits > Onion Leaves > Onion Bulbs > Radish Roots > Radish Leaves

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- ✓ Althaalab / Onion Leaves > Cucumber Fruits > Radish Leaves > Radish Roots > Onion Bulbs.

- *Copper (Cu):*

It is evident from Figure (2.6) that the Althaalab region (T) recorded the highest concentration of copper, with an average concentration of (19.156) ppm with significant differences compared with the regions of Haran Dian (H) and Abrlasloom (S), where the average concentration of copper in them was (16.328 and 16.067) ppm respectively. Regarding the copper content of the studied vegetables, they contained copper in different proportions, where the average concentration of copper was (24.029) ppm as a maximum in onion leaves with significant differences compared with all study samples, while the average concentration of copper was (14,842) ppm as a minimum in onion bulbs with a significant difference over the rest of the study samples, and in terms of the interaction between the location of sample collection and the type of plants studied, the onion leaves in the three study areas are Haran Dian (H), Abrlasloom (S) and Althaalab (T) recorded high concentrations of copper compared to the concentration of copper in the rest of the study samples, where its average concentration reached (27.137, 23.070, 21.880) ppm, respectively, with significant differences with all study samples, but did not exceed the permissible limit (30 ppm) according to [12] and this is what was reached by [25,33,34], while the cucumber fruits in the Haran Dian region (H) recorded the lowest concentration of copper, with an average concentration of (9.841) ppm with a significant difference with the rest of the studied samples. Accordingly, the copper levels in vegetable crops for the studied sites can be arranged in descending order as follows:

- Haran Dian / Onion Leaves > Radish Leaves = Radish Roots > Onion Bulbs > Cucumber Fruits
- Abrlasloom / Onion Leaves > Cucumber Fruits > Radish Roots > Radish Leaves > Onion Bulbs
- Althaalab / Onion Leaves > Onion Bulbs > Radish Leaves > Radish Roots > Cucumber Fruits

- *Zinc (Zn):*

We note from Figure (2.7) that Althaalab region (T) achieved the highest concentration of zinc, where the average concentration of zinc in it reached (33.751) ppm, where the increase in concentration was significant compared to the average concentration in the regions of Haran Dian (H) and Abrlasloom (S), where it reached (31.994, 21.075) ppm, respectively, as for the concentration of zinc in the studied vegetable crops, the fruits of cucumber and onion bulbs recorded high concentrations relative to the rest of the studied vegetable crops, but within the permissible limit according to FAO/WHO [12] (99.4 ppm), with the average zinc concentration in them reaching (72.278, 49.417) ppm, respectively, with significant differences with the rest of the studied vegetable crops, while onion leaves, radish leaves, and roots recorded the lowest concentration of zinc and within the permissible limit according to FAO/WHO, 2003 (99.4). ppm), with an average concentration of (7.472, 7.997, 7.537) ppm, respectively. As for the interaction between the site of sample collection and the type of plants studied, the fruits of cucumber and onion bulbs in all study areas Abrlasloom (S) and Haran Dian (H), and Althaalab region (T) recorded high concentrations of zinc compared with the rest of the studied vegetable crops but within the permissible limit, as the average zinc concentration in them was (89.887, 50.830), (43.217, 42.110), (83.730, 55,310) ppm, respectively, with significant differences compared with the rest of the studied vegetable crops, while onion leaves and radish roots in Haran Dian area (H), the leaves and roots of the radish in Abrlasloom area (S), and the onion leaves in Althaalab area (T) recorded the lowest concentrations of zinc compared with the rest of the studied vegetable crops. The average concentration was (6.490, 6.213), (5.913, 5.566), and (8.150) ppm, respectively, with significant differences with each other and with the rest of the studied vegetable samples. The order is:

- Haran Dian / Cucumber Fruits > Onion Bulbs > Radish Leaves > Onion Leaves > Radish Roots
- Abrlasloom/ Cucumber Fruits > Onion Bulbs > Onion Leaves > Radish Leaves > Radish Roots
- Althaalab / Cucumber Fruits > Onion Bulbs > Radish Leaves > Radish Roots > Onion Leaves

- *Arsenic (As):*

The results in Figure (2.8) indicate the effect of location on the concentration of arsenic. The area of Abrlasloom (S) showed the highest concentration of arsenic (0.779 ppm), with a significant difference over Haran Diane area (H), where the concentration of arsenic reached (0.364 ppm), Althaalab region (T) came in second place (0.772 ppm) with a significant difference over the Haran Dian region (H) while the difference between Althaalab region (T) and Abrlasloom (S) in the concentration of this element did not reach the level of significance. The effect of the plant type on the concentration of arsenic was significant, as onion bulbs recorded the highest concentration of arsenic (1.153 ppm) with a significant difference with all studied vegetable crops, while cucumber fruits recorded the lowest concentration of arsenic (0.424 ppm) and with a significant difference with all studied vegetable crops except radish roots (0.428 ppm), whose difference in the concentration of this element did not reach the level of significance. The interaction between the two factors, the location, and the plant type showed a significant interaction, as the highest concentration of zinc was recorded in the onions of Abrlasloom region (S), in which the concentration of arsenic reached (1.399 ppm), followed by the onions of Haran Dian region (H), in which the concentration of arsenic reached (1.171 ppm), and this is consistent with what was found by Duressa et al, [35] when analyzing arsenic in some vegetables grown in Oromia state, eastern Ethiopia, which showed the presence of average concentrations of arsenic (0.57) ppm and higher than the permissible limit (0.05) ppm [12]. The lowest concentration of this element was recorded in the leaves of the onions of Haran Diane region (H) and the roots of radish in Althaalab (T), where its concentration was (0,256, 0.264) ppm, respectively, while no arsenic was found in the leaves of Althaalab region. And the roots of the radish of Haran Dian region (H) where the concentration of arsenic was less than the device detection limit.

- *The levels of arsenic in vegetable crops for the studied sites can be arranged in descending order as follows:*

- ✓ Haran Dian / Onion Bulbs > Cucumber Fruits > Onion Leaves > Radish Leaves = Radish Roots
- ✓ Abrlasloom / Onion Bulbs > Radish Roots > Radish Leaves > Onion Leaves > Cucumber Fruits
- ✓ Althaalab / Radish Leaves > Onion Leaves > Onion Bulbs > Cucumber Fruits > Radish Roots

➢ *Cadmium (Cd):*

Figure (2.9) represents that the study areas showed a variation in the concentrations of cadmium, where Althaalab region recorded the highest concentration of cadmium, with an average concentration of (0.935) ppm with significant differences compared to the regions of Haran Dian (H) and Althaalab (T), where the average concentration of cadmium in them (0.708, 0.187) ppm respectively, and these results are consistent with the findings of [36] that the soil content of cadmium when it is high, the content of plant parts of this element is high. In terms of cadmium concentration in the studied vegetable crops, onion bulbs, and onion leaves showed high concentrations of cadmium, where the average concentration of cadmium was (1.061, 0.945) ppm, respectively, with significant differences in all the studied vegetable samples, while radish roots recorded the lowest concentration. For cadmium, it reached (0.063) ppm, with a significant difference also with all the studied vegetable samples. In terms of the interaction between the location of sample collection and the type of vegetables studied, cadmium was found in some of the studied vegetable crops with high concentrations that exceeded (0.2 ppm), the permissible limit [12], including onion bulbs and leaves, radish leaves and roots in Haran Dian (H) reached (0.757, 0.560, 2.035, 0.188) ppm respectively, as well as onion bulbs and cucumber fruits in the area of Abrlasloom (S) as it reached (0.547, 0.388) ppm respectively, as well as bulbs and leaves of onions, radish leaves and cucumber fruits in Althaalab area (T), the average concentration of cadmium was (1.880, 2.274, 0.118, 0.404) ppm, respectively, where this increase in concentration was significant compared to all samples of the study sites and these results are consistent with what was reached [29, 38] that factories, public roads, chemical fertilizers, city waste, and sewage are sources of cadmium pollution in addition to atmospheric deposits in industrial areas. While cadmium was not found in the fruits of cucumbers in Haran Dian region (H) and radish roots in Althaalab region (T), onion leaves, radish leaves and roots in Abrlasloom region (S), where it was found that the concentration of cadmium in them is less than 0.0001 ppm.

- *The levels of cadmium in vegetable crops for the studied sites can be arranged in descending order as follows:*

- ✓ Haran Dian / Radish Leaves > Onion Bulbs > Onion Leaves > Radish Roots > Cucumber Fruits
- ✓ Abrlasloom / Onion Bulbs > Cucumber Fruits > Onion Leaves = Radish Leaves = Radish Roots
- ✓ Althaalab / Onion Leaves > Onion Bulbs > Cucumber Fruits > Radish Leaves > Radish Roots

➢ *Lead (Pb):*

The results in Figure (2.10) summarize that the three study areas showed different averages of concentrations of lead, where Althaalab region (T) recorded the highest concentration of lead, where the average concentration of lead was (2,629) ppm with significant differences in the two regions of Haran Dian (H) and Abrlasloom (S) with an average lead concentration of (0.913, 0.693) ppm respectively, and the reason for this may be due to the proximity of the fields in which these plants were planted to the transportation areas and the different motorways. It was found [38] that the pollution by lead can extend to hundreds of meters from the main roads. Also, Al-Naimi [39] indicated that lead pollution depends on several factors, including distance from the external road, the nature of plant surfaces, the duration of pollution, traffic density, and wind direction. In terms of lead concentration in the studied vegetable crops, cucumber fruits, and onion leaves showed high concentrations of lead element that exceeded the permissible limits (1.5 ppm) [12], where the average concentration of lead in them was (3.673, 2.676) ppm, respectively and with significant differences on all study samples, while radish leaves and onion bulbs recorded low concentrations and less than the permissible limit, as the concentration of lead was (0.108, 0.601) ppm. The lead element in the radish roots was less than the detection limit of the device. As for the interaction between the location of sample collection and the type of plants studied (vegetables), it was shown that all vegetables collected from Haran Dian area (H) and Abrlasloom (S) were no lead found, as it was less than the detection limit except for onion leaves, lead was found in it and in an amount that exceeded the permissible limit (1.5 ppm) [12], where its average concentration reached (4.563, 3.466) ppm respectively with significant differences with all studied vegetable samples, while onion bulbs, radish leaves and cucumber fruits in Althaalab region showed high concentrations of lead that exceeded the permissible limits explained previously, with significant differences, where the average concentration of lead was (1.802, 0.323, 11.020) ppm, respectively, while no lead was found in onion leaves and radish roots where it was not detected. These results are consistent with what was observed by [15] when analyzing lead in some vegetable crops grown in the city of Taif. The levels of lead in vegetable crops for the studied sites can be arranged as follows:

- Haran Dian / Onion Leaves > Radish Leaves = Onion Bulbs = Radish Roots = Cucumber Fruits
- Abrlasloom / Onion Leaves > Radish Leaves = Onion Bulbs = Radish Roots = Cucumber Fruits
- Althaalab / Cucumber Fruits > Onion Bulbs > Radish Leaves > Radish Roots = Onion Leaves

IV. CONCLUSIONS

➢ *From the Results of the Study, we Conclude that:*

Most of the studied vegetable samples showed high concentrations of the studied elements compared to the concentrations of the studied vegetable samples in different countries, with which comparison was made possible through previous researches.

All samples showed high concentrations of essential elements in all three study areas, where Althaalab area recorded the highest concentrations compared to the two areas of Haran Dian and Abrlasloom, and this is due to the nature of the soil and groundwater rich in these elements as indicated by some works, as well as the use of pesticides and agricultural fertilizers rich in essential elements> The order is:

- *Althaalab* > *Haran Dian* > *Abrlasaloom*

The results of the study also showed that the elements (iron, manganese, copper, zinc) were found in all samples under study for the three regions, with high concentrations that exceeded the permissible limits according to the specifications of the Food and Agriculture Organization and the World Health Organization (FAO/WHO) for iron and manganese. The percentage of iron resulted from the use of iron agricultural tools and others, while it did not exceed the permissible limits for copper and zinc. The regions can be arranged as follows:

- *Althaalab* > *Haran Dian* > *Abrlasloom*

While the results of the study showed that the heavy elements (chromium, cobalt, nickel, arsenic, cadmium, lead) appeared in some samples under study with high concentrations that exceeded the permissible limits according to the specifications of FAO/WHO and with low concentrations also in some samples, while not found in some samples and were less than the detection limit of the device. The regions can be arranged as follows:

- *Althaalab* > *Haran Dian* > *Abrlasloom*

The previous results indicated that the cucumber fruits are the crop that contained high concentrations of the essential and heavy elements, and we attributed the reason for this to the cucumber fruits containing a large amount of water.

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