Al-Imam Mohammad Ibn Saud Islamic University

College of Science

Department of Chemistry

Spectrophotometric Determination of Heavy Metal In the Leaves of (*Phoenix dactylifera*) to Monitor Pollution in the University Campus

A graduation Research Project

Submitted to the Department of Chemistry in Partial Fulfillment of the Requirement for the Completion of the degree of Bachelor of Science in Chemistry

by

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I would like to sincerely and profusely thank my supervisor Dr. Kamal K. Taha for his guidance and the laboratory staff for supporting me to finish this project.

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<div align="right">Ebrahem Aaleh Saeed Alkhebari</div>

Abstract:

The objective of this study was to analyze the effect of the continuously increasing anthropogenic activities around the Al Imam Mohammad Ibn Saud Islamic University, Saudi Arabia on the accumulation of heavy metals in palm date (*Phoenix dactylifera*)leaves. This study determined whether these leaves could accumulate the heavy metals Cu, Mn, Cr, Cd, Fe, Co, Ni and Zn under conditions with ambient air pollution from heavy traffic and construction activities in the campus. The effect of the air pollution was examined by quantifying the level of these metals in the leaves from the main road side (A_{out} and B_{out}) and in the boys hostels as a control group (A_{in} and B_{in}). Some samples were washed (B_{out} and B_{in}) and the others were left without washing (A_{out} and A_{in}) . The concentration of trace metals were found to be: Co (1.39, 0.65, 0.32 and 0.11), Cu (1.88, 0.71, 0.20 and 0.06), Fe (568, 270.5, 158.9 and 107), Mn (9.97, 3.28, 3.3 and 0.85), Ni (0.39, 0.14, 0.18 and 0.11), Zn (8.13, 2.15, 4.05 and 1.9) mg/kg for samples A_{out}, A_{in}, B_{out} and B_{in}. Analysis of the results indicated that air pollution significantly increased the heavy metal Fe, Mn and Zn concentrations in the leaves. Concentrations of the heavy metals were found to be low. In conclusion, the air pollution increases as the traffic and construction activities in the campus.

الخلاصة

وكان الهدف من هذه الدراسة تحليل أثر الأنشطة البشرية المتزايدة باستمرار حول جامعة الإمام محمد بن سعود الإسلامية، في المملكة العربية السعودية على تراكم المعادن الثقيلة في النخيل (*Phoenix* dactylifera) السعف. حددت هذه الدراسة إذا كانت هذه الأوراق يمكن أن تتراكم عليها المعادن الثقيلة مثل النحاس والمنجنيز والكروم والكادميوم و الحديد و كوبر و النيكل والزنك في ظل الظروف مع تلوث الهواء المحيط من الأنشطة الثقيلة مثل الحركة والبناء في الحرم الجامعي. تمت دراسة تأثير تلوث الهواء عن طريق قياس مستوى هذه المعادن في الأوراق من جانب الطريق الرئيسي (A_{out} and B_{out}) و في سكن الطلاب (A_{in} and B_{in}). وغسل بعض العينات (B_{out} and B_{in}) وتركت الآخرى بدون غسل (A_{out} and A_{in}) . تم العثور على تركيز المعادن الثقيلة أن يكون:

كروم (١.٣٩، ٠.٦٥ ، ٠.٣٢ ، ٠.١١) ، والنحاس (١.٨٨، ٠.٧١، ٠.٢٠ ، ٠.٠٦)، الحديد (٥٦٨، ٢٧٠.٥، ١٥٨.٩ ، ١٠٧) والمنجنيز (٩.٩٧، ٣.٢٨، ٣.٣، ٠.٨٥)، نيكل (٠.٣٩، ٠.١٤، ٠.١٨ ، ٠.١١) والزنك (٨.١٣، ٢.١٥، ٤.٠٥ ، ١.٩) مل/ جرام. للعينات B_{in}, B_{out} , A_{in} , A_{out}. وأشار تحليل النتائج أن تلوث الهواء زاد بشكل كبير من الحديد والمنجنيز والزنك تركيزات المعادن الثقيلة في الأوراق. تم العثور على تركيزات المعادن الثقيلة إلى أن تكون منخفضة. ويزيد من تلوث الهواء مثل أنشطة الحركة والبناء في الحرم الجامعي

1. INTRODUCTION

1.1 ENVIRONMENTAL POLLUTION

Developmental activities such as construction, transportation and manufacturing produce large amount of wastes that leads to pollution of air, water, soil, and sea, global warming and acid rains. Untreated or improperly treated waste is a major cause of pollution of rivers and environmental degradation causing severe health problems to habitants. Pollution may be defined as addition of undesirable material into the environment as a result of human activities. The agents which cause environmental pollution are called pollutants. A pollutants may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms. There are more than ١٣١٤٠٠ cars moving in the university campus that may induce a considerable extent pollution.

2. LITERATURE REVIEW

The rapid urbanization and industrialization have induced considerable environmental changes due to heavy traffic and industrial activities in Saudi Arabia and Riyadh city in particular. Emissions from traffic and industrial activities contain airborne particulate-bound heavy metals which deposited in roadside soils and up taken by plants from rain and dust or from the soil through the root system [1]. Soil is polluted with heavy metal, such as Pb, Cd, Cu, Ni, Cr and Zn due to industrial activity. Farmaki and Thomaidis [2] reported high concentrations of heavy metals Pb, Cu, Zn, Pt and Pd in the urban environment especially streets and highways. A four-fold concentrations of trace metals Mn, Pb, Cu and Fe in plants grown on roadside in comparison to control was reported by Çelik, et al. [3] reported four times higher concentrations of trace metals Fe, Pb, Cu and Mn in roadside plants compared with the control sites plants. Klumpp, et al. [4] reported significant accumulation of Pb and Cu in plants from traffic-exposed sites in city centers or close to major roads and moderate to low levels at suburban or rural sites. Alyemeni and Almohisen [5] studied the extent of pollution in Riyadh by heavy metals and found that the levels of Cu, Mn, Pb and Zn were higher in traffic exposed areas compared to less traffic ones. Heavy metal toxicity in plants results in weak plant growth and decreased crop yield and may be accompanied by reduced nutrient uptake and plant metabolism disorders [6].

Dust can be defined as a solid matter, formed from soil, anthropogenic metallic constituents, and natural biogenic materials [7]. Soil is a blend of heavy metals, mineral, organic matter, living organism, air, and water. The anthropogenic materials are mainly vehicle exhaust particles, lubrication oil residues, tire wear particles and the natural biogenic materials like tree leaves and other plant parts grinded by passing traffic [8]. The particles of dust that deposit from the atmosphere and accumulate along roadsides are called road dust particles which originate from the interaction of solid, liquid and gaseous metals [9].

The main sources of road dust that contain heavy metals are:

      i. deposition of suspended particles (atmospheric aerosols)

      ii. displaced soil

      iii. emissions from vehicular traffic, heating systems,

      vi. building deterioration, construction and renovation,

      v. corrosion of galvanized metal structures.

Road dust does not remain in its deposited place for long, but gets re-suspended back into the atmosphere, where it contributes a significant amount of trace elements. In addition precipitation may wash away road dust enabling it to enter water bodies as dissolved solids in street run-off .

Dust borne heavy metals accumulate in topsoil plant leaves due to atmospheric deposition by sedimentation, impaction, and interception. The most common heavy metals released from vehicles on road are Cadmium (Cd), Copper (Cu), Lead (Pb), Nickel (Ni) and Zinc (Zn), chromium (Cr), arsenic (As). [10]. Ayodele and Oluyomi [11] reported high concentrations of trace metals emitted by vehicles in Kano, Nigeria that were deposited on grass growing by the road sides.   Many heavy metals become bound to the surface of soil and roadside dust. Elevated emissions and their depositions over time can lead to anomalous enrichment, causing metal contamination of the surface environment. Metals being non-biodegradable accumulate in the environment and reside for long time and become hazardous to human health. To maintain a clean environment and protect living organisms from heavy metal contaminants, it is vital to understand the nature and extent of heavy metal pollution.

Environmental contamination by such heavy metals and human exposure risk have increased dramatically recently [12]. The effect of the dust particles intake at high concentration of heavy metals poses potentially deleterious effects on the health of human

beings. Nonessential metals can be toxic even at trace levels, while biologically essential elements might even cause toxic effects at elevated concentrations.

Heavy metals accumulate in the fatty tissues and internal organs of human body. They can affect the central nervous system and may act as cofactors in other diseases. Young children are particularly vulnerable to heavy metal poisoning since this is the period for maximal brain growth and differentiation [13]. Sub-clinical chronic metal poisoning can be induced by long-term low-level exposure to the metal. This type of poisoning affects different metabolic and cognitive disorders; i.e. reduction in school performance and intelligent quotient (IQ) , learning disabilities, behavioral and developmental impairment, and disturbances in growth [14]. Dust also contaminates the foodstuff sold in roadside shops and markets hence it may also carry viral diseases.

Toxic pollutants have pronounced effects on more than 200 million people worldwide. In some of the world's worst polluted places, babies are born with birth defects, children have an IQ less by 30 to 40 points compared to unpolluted areas. Also, life expectancy may be as low as 45 years because of cancers and other diseases[15].

2.1 Essential heavy metals

Heavy metals like (Fe, Cu and Zn) are considered as essential for plants and animals and their availability varies according to the medium and environment. Though metals such as Cu, Zn, Fe, Mn, Mo, Ni and Co are essential micronutrients (Reeves and Baker 2000), still uptaking them in excess to the plant requirements result in toxic effects [16]. They are also called as trace elements due to their presence in trace (10 mg kg^{-1} , or mg L^{-1}) or in ultra trace (1 μg kg^{-1}, or μg L^{-1}) quantities in the environmental matrices

Cadmium

Cadmium is a low abundance heavy metal, found naturally in combined with other metals. Due to its presence in automobile fuel and in soil cadmium can been detected in road dust. Consequently inhalation exposure from road dust is highly likely. Depending on particle sizes and their solubility, the absorption of Cd compounds after inhalation varies accordingly. Cadmium metal, which impose severe toxicity in humans and other organisms. Cadmium exposure for a long period of time can affect many organs especially kidney. Cadmium is toxic even at extremely low levels and long time exposure can cause

renal dysfunction. If inhaled from dusts and fumes, it is can induce chest pain, cough and other respiratory health problems.

Copper

Copper is found naturally as an element or as a component of a number minerals. It is an essential trace element of wide distribution in the environment. Due to its relative stability elemental Cu does not break down in the environment. Copper can be found in plants and animals tissues, foods and drinking water. Inhalation of 0.075-0.12 mg m^{-3} concentration of copper dust in can cause muscle ache muscle ache and cough. The permitted safe and adequate dietary intake for Cu is 1.5-3.0, 0.7-2.5 and 0.4-0.7 mg d^{-1} for adults, children and infants respectively [17].

Nickel

Nickel exist naturally in combined form with other elements in the earth's crust and in soils. In the environment, it is mainly found combined with sulfur or oxygen as sulfides or oxides. Oil and coal burning power plants, and trash incinerators are the primary sources to release nickel into the atmosphere. Occupational health hazards associated with worker's exposure to Ni are primarily from inhalation. A high sensitivity to nickel is about 10% among women and 2% among men in the population. Such sensitive people can get symptoms of nickel dermatitis on exposure to nickel through direct contact [18].

Lead

Lead exists in all industrial areas, where its negative effects on human populations has been reported for centuries together. Due to their similar chemical properties, our bodies confuse Pb with calcium, ingested and incorporate it into the bone marrow, nerve tissue, brain, and kidneys. Lead poses a huge threat to developing minds and learning capacities of young children. Children can get exposed to Pb contamination by eating Pb-based paint chips or playing in contaminated soil. Lead can tremendously affect the nervous system, kidneys, and reproductive system.

Zinc

Zinc is an essential trace element, which is present in soil. Soil microbial processes are particularly sensitive to Zn. Zinc can cause symptoms of deficiency and can be toxic when exposures exceed physiological needs. People are exposed to Zn primarily from food, although oral exposure can become excessive through non-dietary sources. Certain

occupational exposures can be hazardous. High levels of Zn may disrupt the functions of other essential elements.

Arsenic

Arsenic is a toxic element, whose toxicity, depends on its chemical (valency) and physical form of the compound (organic or inorganic), the route by which it enters the body, the dose and duration of exposure and several other biological parameters. When water contains a levels of 0.05 ppm arsenic it is considered as not suitable for drinking purpose. Arsenic is commonly associated as an alloying additive with lead solder, lead shot, battery grids, cable sheaths and boiler piping. Nowadays, most arsenic originates from paints or pharmaceuticals and is commonly found in sewage. The concentration of arsenic in sea water is around 0.002 ppm. It is carcinogenic at high level of consumption [19].

2.2 Toxicity of Heavy Metals:

The toxic and poisoning effects of heavy metals are due to their interference with the normal body biochemistry in the normal metabolic processes. They are converted to their stable oxidation states (As^{2+}, Ag^+, Hg^{2+}, Cd^{2+}, Zn^{2+}, As^{3+}, and Pb^{2+}), when ingested, in the acid medium of the stomach. They, then bind with the body's biomolecules such as proteins and enzymes to form strong and stable chemical bonds and inhibit their functions. Biological indicators have been used for many years to detect the deposition, accumulation and distribution of heavy metal pollution. During the past few decades there has been an increase in the use of higher plant leaves as biomonitors of heavy metal pollution in the terrestrial environment [20]. Plant leaf is the most sensitive part to be affected by air pollutants as major physiological processes are concentrated in the leaf [21]. Uptake and accumulation of elements in plants may follow different paths, i. e. the foliar surface and the root system.

There was no previous study or information regarding heavy metals in road dust of Al Imam Mohammad Ibn Saud Islamic University main campus and their relationship with environmental factors. Therefore this study was carried out to determine the concentration of common heavy metals Cd, Cu, Ni, Pb and Zn in road dust and background soil samples of the campus. The technique of Inductively Coupled Plasma spectroscopy (ICP) was applied for elemental analysis. The measured concentrations values were compared with

those given in literature and pollution level of every metal has been evaluated and discussed.

2.3 Inductively coupled plasma :

(**ICP**) is a type of mass spectrometry that is capable of detecting metals and a number of non-metals at concentrations as low as one part in 10^{-15}. This is achieved by ionizing the sample with ICP and then using a mass spectrometer to separate and quantify those ions. Compared to atomic absorption, ICP-MS has greater speed, precision, and sensitivity in addition to being multi-elemental. The following is a list of some of the most beneficial characteristics of the ICP source.

- high temperature (7000–8000 K)
- high electron density.
- appreciable degree of ionization for many elements
- simultaneous multielement capability (over 70 elements including P and S)
- low background emission, and relatively low chemical interference.
- high stability leading to excellent accuracy and precision.
- excellent detection limits for most elements (0.1–100 ng mL1)
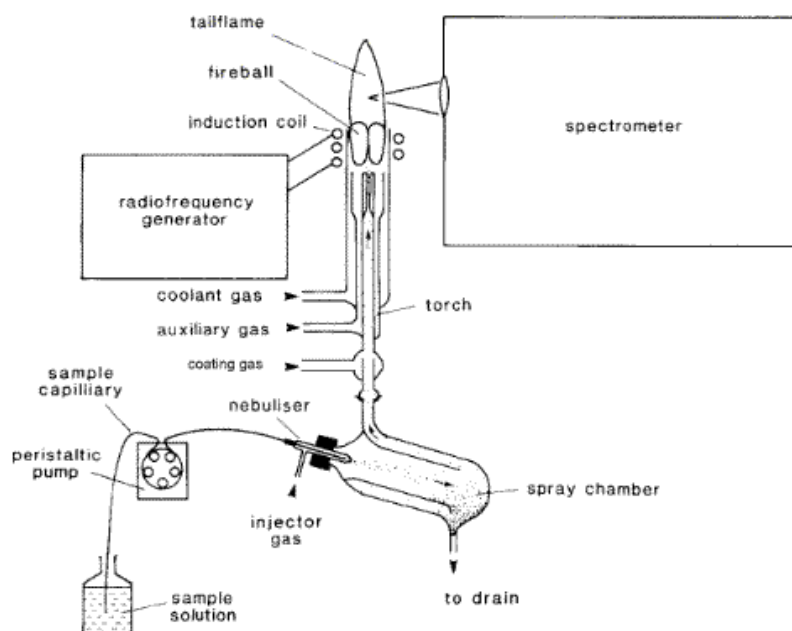
Fig. (2.1): Inductively Coupled Plasma Spectrometer

2.4 Atomic absorption spectroscopy:

Is a technique for determining the concentration of a particular metal element in a sample. Atomic absorption spectroscopy can be used to analyze the concentration of over 62 different metals in a solution. The technique typically makes use of a flame to atomize the sample, but other atomizers such as a graphite furnace are also used .Three steps are involved in turning a liquid sample into an atomic gas:

1. Desolvation – the liquid solvent is evaporated ،and the dry sample remains

2. Vaporization – the solid sample vaporizes to a gas

3. Volatilization – the compounds making up the sample are broken into free atoms .

The light that is focused into the flame is produced by a hollow cathode lamp. Inside the lamp is a cylindrical metal cathode containing the metal for excitation, and an anode. When a high voltage is applied across the anode and cathode, the metal atoms in the cathode are excited into producing light with a certain emission spectrum. The type of hollow cathode tube depends on the metal being analyzed. For analyzing the concentration of copper in an ore, a copper cathode tube would be used, and likewise for any other metal being analyzed.

3. Materials and Methods

3.1 Sample Collection

A total of 40 fresh leaves samples were collected from the main roadside at Gate I of the University campus. The sample were cut from the trees using stainless steel scissors. Similarly twenty samples were collected from inside the student's hostels as control. The samples were divided into two groups: one groups was washed and the other was left without washing. Samples were cleaned with tap water then distilled water. The leaves were left to dry in air then put into an oven at 70 °C for an overnight to dry completely. The dry leaves were ground to powder using a stainless steel grinder. The leaves dry powder was kept in polythene bags for analysis.

3.2 Sample Digestion

Wet digestion was carried out according to [22]. About 1.0 g of each of the dry leaves samples was accurately weighed into a beaker. A digestion mixture consisting of 5 ml of 40 % HCl, 5.0 mL of 65% HNO_3 (Merck) and 5.0 mL of 35% H_2O_2 (Merck) was added to the sample. The beaker content were heated at 130 °C for about four hours until the sample completely dissolved [23]. The beaker was uncapped and the sample was evaporated to near dryness. Double distilled water was added to dissolve the beaker's residue. The solution was then filtered into 10.0 mL volumetric flak and completed to the mark with double distilled water.

3.3 Sample Analysis

Samples were analyzed for all elements under investigation using inductively coupled plasma-atomic emission spectrometry (ICP-OES) model SPECTRO-GENESIS EOP, Germany. Empirical calibration curves were generated using a series of dilutions from a multi-element calibration standard (Spectro-ICP solution: 21 standard elements). Two way Analysis of variance (ANOVA) was performed, in order to evaluate differences in accumulation patterns between the samples and site of collection and washed and unwashed samples. A correlation between the tested elements was calculated. Values were significantly different at $p > 0.05$.

4. RESULTS AND DISCUSSION:

Tables 1 (a -d) show the concentrations of the elements under study for samples from the main roadside (A_{out} and B_{out}) along with the samples collected from inside the boys hostels as the control group (A_{in} and B_{in}). The concentrations were calculated according to the equation:

Concentration (mg/kg) = instrument reading (mg/L) x sample volume (0.010 L)

Table (4.1 a): the concentration of elements (mg/ kg) in unwashed leaves samples from road side (A_{out})

Sample	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn	Ce
A1	N.D	1.54	N.D	1.67	234.1	10.3	0.14	3.93	N.D
A2	N.D	1.23	N.D	1.87	621.9	24.25	0.12	12.78	N.D
A3	N.D	0.09	N.D	2.77	732.7	41.23	0.56	5.32	N.D
A4	N.D	2.44	N.D	0.87	703.1	12.8	0.83	3.57	N.D
A5	N.D	3.98	N.D	1.54	541.9	16.2	1.24	7.76	N.D
A6	N.D	2.35	N.D	3.76	854.8	17.39	0.87	6.5	N.D
A7	N.D	1.08	N.D	1.22	468.3	23.4	0.23	14.5	N.D
A8	N.D	2.57	N.D	1.07	463.8	26	0.18	13.85	N.D
A9	N.D	2.98	N.D	1.55	520.06	10.34	0.87	12.43	N.D
A10	N.D	2.34	N.D	2.52	494.39	59.07	0.65	11.98	N.D
A11	N.D	1.21	N.D	1.98	646.3	13.5	0.5	2.31	N.D
A12	N.D	2.76	N.D	2.77	554.49	29.68	0.64	7.75	N.D
A13	N.D	1.08	N.D	2.38	603.53	37.81	0.76	7.67	N.D
A14	N.D	2.3	N.D	1.01	552.64	19.66	0.87	5.34	N.D
A15	N.D	2.35	N.D	1.65	714.45	15.05	1.34	4.87	N.D
A16	N.D	1.75	N.D	1.2	789.17	13	2.67	4.86	N.D
A17	N.D	1.34	N.D	2.34	648.8	23.31	1.09	3.44	N.D
A18	N.D	2.74	N.D	1.56	455.6	26.7	0.87	13.75	N.D
A19	N.D	1.45	N.D	1.19	615.78	14.34	0.72	3.09	N.D
A20	N.D	1.23	N.D	2.08	406.88	9.63	0.63	12.33	N.D
Average		1.39		1.88	568	9.97	0.39	8.13	
Range		0.09 - 3.98		0.087 - 3.76	234.1- 854.8	9.63 - 59.07	0.12- 2.67	2.31 - 13.85	

Table (4.1 b): the concentration of elements (mg/ kg) in unwashed leaves samples from road side (A_{in})

Sample	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn	Ce
A21	N.D	1.22	N.D	0.87	265.27	4.2	0.15	0.9	N.D
A22	N.D	0.67	N.D	1.05	398.57	6.7	0.21	1.56	N.D
A23	N.D	2.3	N.D	0.87	367.1	8.75	0.08	2.34	N.D
A24	N.D	0.09	N.D	0.96	142.7	12.23	0.17	2.7	N.D
A25	N.D	0.78	N.D	1.34	451.92	23.62	0.54	2.4	N.D
A26	N.D	1.89	N.D	0.08	281.53	1.35	0.05	2.8	N.D
A27	N.D	2.09	N.D	2.02	257.82	2.87	0.14	1.5	N.D
A28	N.D	0.87	N.D	0.76	391.6	5.67	0.25	1.8	N.D
A29	N.D	0.65	N.D	0.62	750.78	8.56	0.06	2.6	N.D
A30	N.D	0.08	N.D	0.54	275.68	2.35	0.13	3.4	N.D
Average		0.65		0.71	270.5	3.28	0.14	2.15	
Range		0.09 - 2.09		0.08 - 1.34	142.7- 750.82	1.35 - 23.62	0.06 - 054	0.9 - 3.4	

Table (4.1 c): the concentration of elements (mg/ kg) in unwashed leaves samples from road side (B$_{out}$)

Sample	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn	Ce
B1	N.D	0.19	N.D	0.19	234.1	3.34	0.13	3.59	N.D
B2	N.D	0.98	N.D	0.17	145.5	4.4	0.25	4.98	N.D
B3	N.D	0.15	N.D	0.12	183.3	5.17	0.45	3.32	N.D
B4	N.D	0.26	N.D	0.16	222.9	5.3	0.32	6.98	N.D
B5	N.D	0.95	N.D	0.22	182.2	3.03	0.55	7.1	N.D
B6	N.D	0.13	N.D	0.43	215.4	3.04	0.11	2.3	N.D
B7	N.D	0.14	N.D	0.18	143.4	3.95	0.24	3.4	N.D
B8	N.D	0.28	N.D	0.15	171	3.05	0.54	3.95	N.D
B9	N.D	0.33	N.D	0.09	145	3.08	0.43	4.5	N.D
B10	N.D	0.88	N.D	0.14	194.4	6.57	0.98	2.22	N.D
B11	N.D	0.15	N.D	0.26	152.8	3.09	0.76	2	N.D
B12	N.D	0.14	N.D	0.35	152.4	6.8	0.12	2.98	N.D
B13	N.D	0.23	N.D	0.06	213.8	3.35	0.08	2.3	N.D
B14	N.D	0.15	N.D	0.15	295.9	4.6	0.07	3.2	N.D
B15	N.D	0.22	N.D	0.11	171.8	3.07	0.14	1.5	N.D
B16	N.D	0.45	N.D	0.27	170.5	3.1	0.25	3.75	N.D
B17	N.D	0.26	N.D	0.17	243.9	3.42	0.24	2.35	N.D
B18	N.D	0.23	N.D	0.29	195.7	3.4	0.11	1.89	N.D
B19	N.D	0.19	N.D	0.45	119.5	3.15	0.13	2.57	N.D
B20	N.D	0.18	N.D	0.08	83.7	3.25	0.22	4.5	N.D
Average		0.32		0.20	158.9	3.3	0.18	4.05	
Range		0.13 - 0.98		0.09 - 0.45	119.5- 295.	3.01 - 6.8	0.11 - 0.98	1.5 - 6.98	

Table (4.1 d): the concentration of elements (mg/ kg) in unwashed leaves samples from road side (B_{in})

Sample	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn	Ce
B21	N.D	0.15	N.D	0.09	90.6	1.23	0.15	1.23	N.D
B22	N.D	0.07	N.D	0.08	129.1	0.8	0.08	3.65	N.D
B23	N.D	0.09	N.D	0.12	124.9	1.9	0.28	2.12	N.D
B24	N.D	0.23	N.D	0.19	155.2	0.05	0.19	1.45	N.D
B25	N.D	0.08	N.D	0.08	120.6	1.16	0.07	1.09	N.D
B26	N.D	0.19	N.D	0.09	88.9	0.05	0.13	2.87	N.D
B27	N.D	0.22	N.D	0.23	115.6	0.09	0.16	1.97	N.D
B28	N.D	0.05	N.D	0.15	78.7	1.05	0.14	2.78	N.D
B29	N.D	0.07	N.D	0.22	170.2	2.34	0.11	2.8	N.D
B30	N.D	0.09	N.D	0.03	123.3	0.07	0.06	2.56	N.D
Average		0.11		0.06	107	0.85	0.11	1.9	
Range		0.05-0.22		0.03 - 0.23	78.7-170.2	0.05 - 2.34	0.06 - 0.28	1.09 - 3.65	

Cobalt (Co)

There were significant differences in the Co concentration in the plant leaves at A_{out} sampling location where it was 1.39 mg kg^{-1} compared with washed sample B_{out} and B_{in}. The concentration of Co in the control samples is 0.65 mg kg^{-1} in the unwashed control sample indicating that the element was accumulated more in the leaves of plant in proximity to the main road.
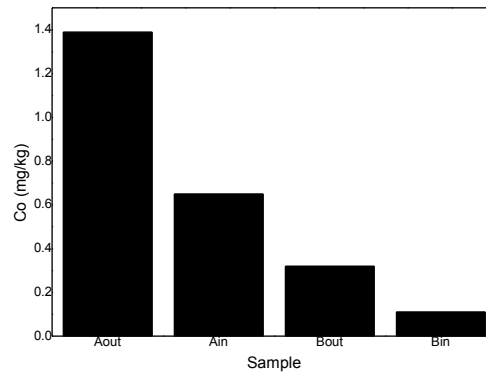

Fig. (4.1): Cobalt concentration

Copper (Cu)

There was high average concentration of Cu in the sample A_{out} similar to the trend observed in Co. The concentration is reduced in unwashed control sample. The concentration is even more reduced after washing where it drops to 0.20 and 0.06 mg kg^{-1} for B_{out} and B_{in}. Again we can say that more Cu is accumulated at leaves close to the main road.
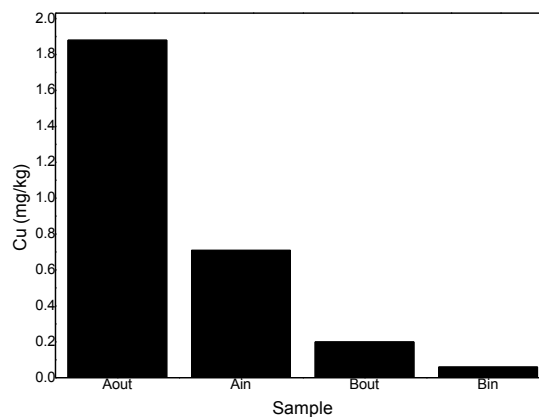

Fig. (4.2): Copper concentration

Manganese (Mn)

There were significant differences in the Mn concentrations in the leaves collected from the roadside where the value is 9.97 mg kg^{-1} for A_{out} which exceeded the 3.28, 3.3 and 0.85 mg kg^{-1} for A_{in}, B_{out} and B_{in} respectively. The same argument can be said here also that plants grown near the main road are more prone to Mn accumulation.
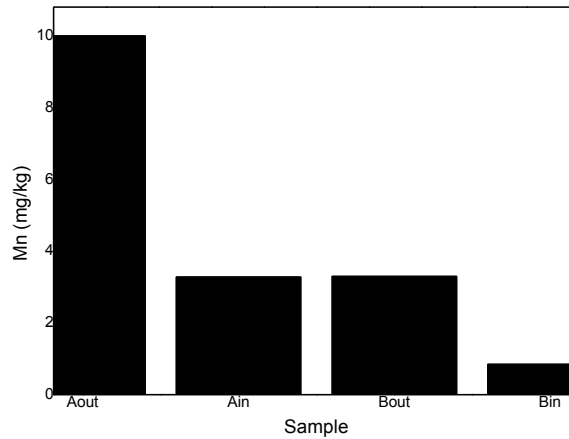

Fig. (4.3): Manganese concentration

Zinc (Zn)

The concentration of Zn increased in a similar manner where it was 8.13 in sample A_{out} compared to 2.15m 4.05 and 1.9 for A_{in}, B_{out} and B_{in} respectively. The concentration of Zn in washed sample from the roadside is still greater than that of the control. This may be due to the absorption of Zn from the soil by plants.
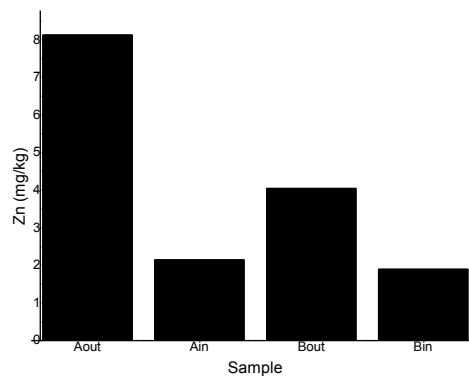

Fig. (4.4): Zinc concentration

Nickel (Ni)

There were no significant differences in the Ni concentration in the plant leaves at all collection sites. The A_{out} sample was $0.39\ \text{mg kg}^{-1}$ compared to 0.14, 0.18 and 0.11 mg kg^{-1} for A_{in}, B_{out} and B_{in}. Thus there is no correlation between the concentration of Ni and sampling site. Also there is accumulation of Ni in the leaves samples under study.
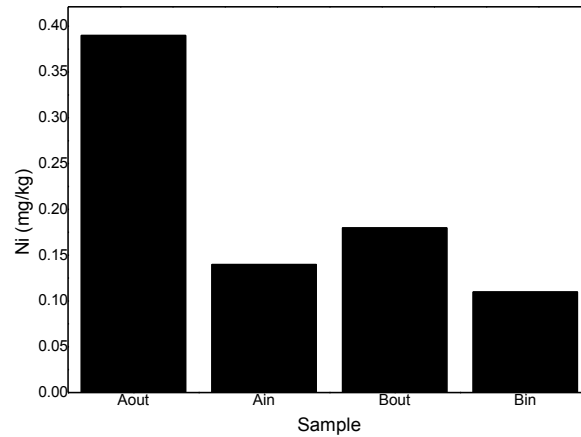

Fig. (4.5): Nickel concentration

Iron (Fe)

There was high average concentration of Fe in the sample A_{out} ($568\ \text{mg kg}^{-1}$) compared to the other samples. The values were 270.5, 158.9 and 107 mg kg^{-1} for A_{in}, B_{out} and B_{in} respectively. It is similar to the trend observed for other metals. The concentration is even more reduced after washing. As Fe is an essential element for photosynthesis and respiratory enzymes it is absorbed from soil at high concentration. this may explain the high concentration of Fe is all samples analyzed [24].
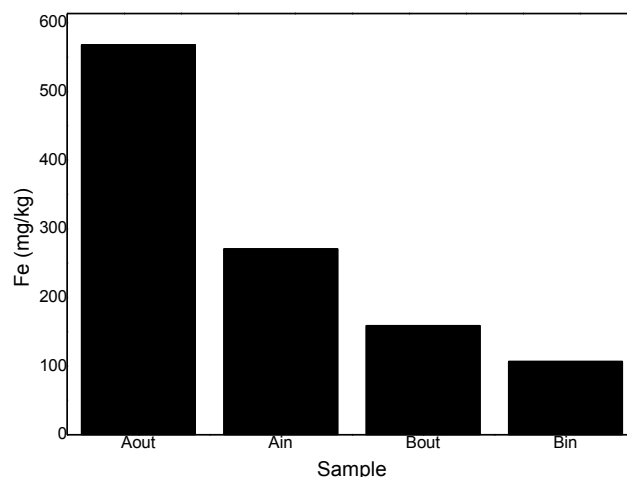
Fig. (4.6): Iron concentration

When the values obtained in this study are compared with a previous study in Riyadh where the range was found to be Zn (113-1135), Mn (51 - 228) and Cu (26 - 71) mg kg^{-1}, it can be seen that the values reported here are relatively small indicating less accumulation of these metals[25]. In a similar study carried out in Jeddah the concentration of trace metals in residential area was lower than the traffic affected area where the values were : Ni (0.92, 17), Co (0.11, 1.96), Zn (1.23, 140), Fe (106, 3005), Cu (0, 13.8), Cr (0, 56.8) [26]. These result are in agreement with this work results where it can be observed that the control area has less concentration that the roadside collection sites. Mansour [27] reported the following values 0.430, 4.260, 0.33, 2.53, 50.35, 1.67 for Ni, Co, Cd, Cr, Zn and Cu in Syria which is comparable with the findings of this study. The elements, Cd, Cr and Ce concentrations were below the detection limit.

It can be observed that the level of trace metals is lower than the previous data locally and worldwide. This indicates that there is no significant accumulation of the metals under study in the leaves of date trees. The study noticeably reported higher concentrations of Fe, Mn and an Zn in samples collected from the roadside compared to the control samples as well as the washed ones. This indicates that there is no heavy metal pollution in the campus. The high concentrations of Fe, Zn and Mn may be coming from the dust as these elements have high concentration in soil. Moreover the constructions going on in the campus may have increased the concentration of such elements.

4.1 STATISTICAL ANALYSIS

Correlation statistics were carried out between washed B_{out} and B_{in} and unwashed (A_{out} and A_{in})samples and the results are shown in tables 4.2 (a and b):

Table (4.2 a): Correlation of metals concentrations in samples A_{out} and B_{out}

Element	Co	Cu	Fe	Mn	Ni	Zn
Correlation coefficient	0.33	0.19	0.09	0.63	-0.11	0.11

Table (4.2 b): Correlation of metals concentrations in samples A_{in} and B_{in}

Element	Co	Cu	Fe	Mn	Ni	Zn
Correlation coefficient	0.24	0.42	0.39	0.31	-0.40	0.13

It can be observed that the correlation coefficient are small in the washed and unwashed samples. This may indicate that washing has an effect on metal removal from the leaves surface. The observation may support the fact that the metals source is the dust that can be removed by washing. The same trend does not apply to the control samples.

5. CONCLUSIONS:

The following conclusions can be deduced from the study:

1. The concentration of the elements under study were higher by the roadside than in the   boys hostel (control samples).

2. The concentrations of Fe, Zn and Mn were higher than the other elements in all samples.

3. Washing the leaves had decreased the concentrations of metals. This fact supported that the main source of elements is the dust.

6. RECOMMENDATIONS:

The authors is making these recommendations:

1. Measurement of lead and arsenic (were not determined in this study as there was no standards for them).

2. Carrying out the same study at the different seasons.

3. Analysis of the palm dates fruits to check the extent of pollution if any.

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