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Air Pollution and Concentration of Heavy Metals in The leaves of Plant

Research project

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Supervisor's Certification

I certify that this project was prepared under my supervision at the Department of Biology, College of Education, Salahaddin University-Erbil, and I do hereby recommend it to be accepted as partial fulfillment of the requirements for the BSc. in Biology.

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Abstract

Air pollution is one of the serious problems faced globally due to increased industrialization and human activities. Air pollution has been described as an additional stress on the plant since they respond to it in the same way as they respond to drought and any other environmental stress. The present study examined the air pollution and concentration of heavy metals in the leaves of a plant (*Vitis Vinifera*) within Erbil City. The leaves sample were collected from September (2023) in 2 regions within Erbil city, which are Shawes as well as Choman mountain as a control region. The concentration of (Zn, Ni, Pb, Cu, Co, Te, Mn, Se, Cr, Hg, As, Cd, V, and Sb) were measured by using an XRF (x_ray fluorescence spectrophotometer). The maximal values of these metals were found on Shawe's site. Furthermore, sites with an electrical generator and high traffic density and frequency of cars stoppage showed a high heavy metal concentration of all metals showed that the (Zn, Ni, and Pb) had the highest concentration of all. The value of all heavy metals analyzed in the polluted site is more significant than the control site in (Leaf, Root, Stem, and Soil). The presence of these metal ions in plant leaves explains the fact these plant leaves are good bioindicators and can be used in air pollution monitoring studies in industrial areas. Finally, the cultivation of the appropriate plant in urban areas can help to remediate soil and air pollution resulting from HMs.

Keywords: *Vitis vinifera*, Heavy metal, Air pollution

1. Introduction

Air pollution is a major problem in modern society. It is also a bigger problem in cities, as air pollutants spread everywhere. These pollutants include different gases and particulate matter that can harm human health and the environment. The relationship between plants and different types of contaminants has been investigated by many researchers (Kovacs et al., 2018) Emissions from cars, buses, minibusses, wagons, motorcycles, and trucks may be a major source of urban air pollution. These sources produce different types of pollutants in the environment such as (nitrogen oxides, sulfur oxides, hydrocarbons, ozone, particulate matter, etc.). These pollutants not only affect human and animal health but also threaten plant life in many areas (Santini, 2017).

Urban air pollution is a major environmental problem, Particulate matter (PM) is a typical pollutant in urban areas; it is usually rich in toxic organic components and heavy metals (Chori and Baker, 2019). Thus, PM pollution proposes serious health issues for the urban population (Baker, 2019). As a result of human activities, the natural concentrations of heavy metals increase, and they can accumulate in the soil and the vegetation due to their non-biodegradable nature (Babalola, 2006). Urban trees are used for indirect monitoring of PM and heavy metals in urban environments due to their distribution and cost-effectiveness (Zintr, 2020). The accumulation of air contaminants by plants is widely documented (Qiu and Molnar, 2020). Trees are particularly efficient in trapping; thus, reducing airborne particles that can deposit in tree leaves' stomatal openings and waxy cuticles (Pandey, 2019). (HMs) are defined as those elements having an atomic number greater than 20 and atomic density above 5 g cm^{-3} and must exhibit the properties of metal (Sebastien et al., 2020).

The HMs can be broadly classified into two categories: essential and nonessential heavy metals. Essential HMs are those required by living organisms for carrying out the fundamental processes like growth, metabolism, and development of different organs. There are numerous essential heavy metals like Cu, Fe, Mn, Co, Zn, and Ni required by plants as they form cofactors that are structurally and functionally vital for enzymes and other proteins (Desa, 2007). Essential elements are often required in trace amounts at the level of 10–15 ppm and are known as micronutrients (Guo, 2019). Nonessential heavy metals like Cd, Pb, Hg, Cr, and Al are not required by plants, even in trace amounts, for any of the metabolic processes.

Heavy metals in soils, which are characterized by high stability in the environment and are generally not biodegradable, can be released from terrestrial environments into other ecosystem compartments such as groundwater, rivers, atmosphere, and others (Mmolawa et al., 2011; Mazurek et al., 2017). Understanding the effects of heavy metals on plants and resistance mechanisms would help use plants clean and remediate heavy metal pollution. In China, there are many reports on the interaction of heavy metals and plants (Zhao and Bi 1999, Zhang and Huang 2000). Many initiatives, such as phytoremediation, have attempted to create strategies to remove heavy metals from contaminated soils (Qiu et al., 2020).

Phytoremediation has a scientific interest, and it has been the focus of several recent studies (Qiu et al., 2020). Phytoremediation using higher plants is an environmentally beneficial method that cleanses toxins from the environment utilizing plants and their related microorganisms (Babalola, 2006). Thus, studies on the impact of heavy metal pollution on natural vegetation could contribute to the evolution of species that are both sensitive and tolerant in response to heavy metal pollution (Santini, 2017). As a result, stress-tolerant plants play a significant part in many environmental processes, incorporating a variety of protective mechanisms (Bayoult, 2021).

Our study aims to determine heavy metal in the tree leaves of *Vitis vinifera.* in urban and rural areas and to reveal the potential of tree leaves as an indicator of the environmental state.

2. Materials and Methods

2.2 Soil Samples Collection

To analyze heavy metals, soil samples were gathered from several locations within the investigated areas. The samples came from a certain depth of 0 to 30 cm, were put in polyethylene bags, and transported back to the lab where they were air-dried, sieved, and stored for chemical analysis (Ismaeel, 2015).

2.3 Plant Samples Collection and Analysis

This study had been carried out on 2 selected sites. The sample was collected from the control(Choman) and polluted site (Shawes) on 19 September 2022, vitis vinifera leave were evaluated as the possible biomonitors of heavy metal air pollution in Erbil city. Three samples from healthy and mature leaves of each plant were excised with a clean scissor from the different sides of a small lower branch from the apical bud and were placed in labeled plastic bags and then brought to the laboratory for analysis of various biochemical parameters. For determining heavy metal concentrations of Zn, Ni, Pb, Cu, Co, Te, Mn, Se, Cr, Hg, As, Cd, V, and Sb in plant leaves, leaf samples were oven _dried at 70°C for 48 hrs, crushed, homogenized and sieved at 200 μm particle sizes.

2.4. Determination of heavy metals in plant and soils

The powdered sample was analyzed by XRF(x_ray fluorescence spectrophotometer) sky Instrument Genius.XRF analyses were carried out at the laboratory of the Agriculture College, the University of Salahaddin, using a handheld thermal scientific Genius 9000 XRF (27) (Radtke et al.,2017).

2.5 Statistical analysis :

Analysis of the data was performed using SPSS (Version 17). Results are expressed as means ± standard error. An independent t-test was used for the comparison of the studied parameters between polluted and control sites. A p-value equal to or less than 0.05 was considered to be statistically significant.

Results and Discussion

Table 1 shows the concentration of heavy metal in (leaf, stem, Root, and soil) samples in control and polluted site in Erbil city. Environment pollution with toxic metals has increased dramatically since the increase of the industrial (Zaidi et al., 2005). Pollution by heavy metals such as (Zn, Ni, Pb, Cu, Co, Te, Mn, Se, Cr, Hg, As, Cd, V, and Sb is a problem of concern (Onder et al., 2007). Heavy metals levels in the plant have increased considerably due to traffic pollution and the electric generator, especially from the usage of leaded petrol and exhaust combustion. So it has become necessary to conduct this study to exhibit and determine the kind of environmental pollution and how far they exhibit and efficient as the bioindicator in reducing the degree of pollution in environment. level of heavy metal in plant samples collected from different Site in Table 1 and variance analyses of plants sample with heavy metal are given (Zn, Ni, Pb,Cu, Co, Te, Mn, Se, Cr, Hg, As, Cd,V, Sb) increasing in polluted site when compered with the control site in both (Leaf, Stem, Root) . The Zn level increased significantly in the leaf, stem, and root of a polluted plant (63.5091, 116.407, and 173.687 mg/kg respectively) compared to the control (38.5127, 151.728, and 98.8593 mg/kg respectively) ($p<0.001$ for all).

Ni concentration also increased in all parts (32.9091, 41.8039, and 84.0673 mg/kg in polluted compared to 32.3953, 30.6864, and 17.4196 mg/kg in control respectively; $p<0.001$, 0.001, and 0.001 respectively). Pb accumulation was higher in the leaf, stem, and root of the polluted plant (51.35, 59.69, and 47.28 mg/kg respectively) than control (26.172, 27.70, and 21.49 mg/kg respectively) ($p<0.001$ for all). Cu, Co, and Mn levels increased in leaf, stem, and root in the polluted site compared to control (7.879 vs 0.760, 6.8339 vs 1.4764, 20.337 vs 17.68 mg/kg for Cu; 1.7704 vs 1.6037, 2.688 vs 1.8013, 4.2136 vs 1.9937 mg/kg for Co; and 0.3597 vs 0.2826, 0.6759 vs 0.337, 1.1943 vs 0.3889 mg/kg for Mn respectively; $p<0.001$, <0.001 and 0.001 respectively).

Se, Cr, Hg, As, Cd, V, and Sb levels remained unchanged in all parts ($p>0.05$).The heavy metals released from vehicular emissions and electric generators directly get deposited in soil and are thus translocated into the plant via the root system (Shparyk and Parpan 1990). Accumulation of selected heavy metals at the control and polluted sites has been depicted. Elements with metallic properties and atomic numbers of more than 20 are usually referred to as heavy metals. Heavy metal pollution is a significant environmental issue as these metals are likely to have toxic effects with increased concentration or ac- cumulation in the plant. The accumulation of heavy metals in plants leads to physiological toxicity in plants, animals, and microorganisms. Due to the accumulation of heavy metals, the leaves may get damaged and cause serious ecological and health problems if the heavy metals enter the food chain. Heavy metal pollution does not undergo biodegrading -tion and harms biological systems.

Table 1. The concentration of heavy metals in the leaf, stem amd root parts of the *Vitis Vinifera* plant in the control and polluted sites.

		Zn	Ni	Pb	Cu	Co	Te	Mn	Se	Cr	Hg	As	Cd	V	Sb
Leaf	Control	38.5127	32.3953	26.172	0.760	1.6037	0.2826	0	0.09	0	0	0	0	0	0
	Polluted	63.5091	32.9091	51.35	7.879	1.7704	0.3597	0	0.068	0	0	0	0	0	0
	p-value	0.001	0.75	0.001	0.001	0.05	0.05	–		–	–	–	–	–	–
Stem	Control	151.728	30.6864	27.70	1.4764	1.8013	0.337	0	0.266	0	0	0	0	0	0
	Polluted	116.407	41.8039	59.69	6.8339	2.688	0.6759	0	0.892	0	0	0	0	0	0
	p-value	0.001	0.001	0.001	0.001	0.01	0.001	–	0.05	–	–	–	–	–	–
Root	Control	98.8593	17.4196	21.49	17.68	1.9937	0.3889	0	0.125	0	0	0	0	0	0
	Polluted	173.687	84.0673	47.28	20.337	4.2136	1.1943	0	4.368	305.7	0.1697	0	0.017	0	0
	p-value	0.001	0.001	0.001	0.001	0.001	0.001	–	0.001	0.001	0.05	–	0.05	–	–

Table 2 shows The concentration of heavy metals in plants and soil in the studied sites. Heavy metals are inevitably drawing global attention due to their well-known toxicity effects on human health and the environment (Shaari et al., 2021). The recorded result presented in Table 2 showed that heavy metals concentration in the plant changed significantly at ($p<0.05$). How many heavy metals in the plant are more comparable to the soil of the polluted site with the control site they (Hg, Se, Pb, Zn) reached the rate (0.169,5.31,158.32,353.58) mg.kg-1 in the plant comparable to the soil that (0.05,0.98,16.3,187.75) mg.kg-1 came after each other on pollute site in the some of the heavy metal from the plant is less compared to soil in the pollute site and control site and they are (Ni, Cu, Co, Te, Mn, Cr, As, Cd, V, Sb) whose rate (158.32, 35.03, 8.66, 2.21, 0, 305.7, 0, 0.017, 0, 0) mg.kg-1 in the plant compared to soil whose rate (250.42, 44.85,14.54, 40, 305.01, 99.32, 111.61, 0.1, 84.05,0.1) mg.kg-1 in the same way in control site was considered respectively.

Factor affecting metal bioavailability From a plant uptake point of view, the bioavailable concentration of metal is of great concern. The term bioavailability can be defined as “ a part of the total concentration of a metal that is available to plants, microbes etc. And this bioavailable concentration of metal is important regarding its uptake and accumulation in the plant rather than the total metal concentration in the soil. Several factors control the bioavailability of metal in the soil including soil organic matter, soil pH, competitive ions concentration, root exudates and species of plant present in the soil, and plant age (Harter and Naidu, 2001; Jung, 2008). These factors either influence the release of metal ions into soil solution or affect plant uptake ability in soil. This result indicates heavy metals pollution resulting from the electrical generator is spread over large areas which in turn transmits those metals to soil and plants surrounding, while uptake of metals by plant and vegetable occurs through roots, stem, and leaves then causes damage to the plant by many ways such as necrotic lesions, change in color including mottling, bronzing, reddening, and chlorosis stunted plant growth. Hamdy et al., (2015) reported that plants take up heavy metals by absorbing them from deposited on part of the plant exposed to the air from a polluted environment as well as from contaminated soils.

Table 2. The concentration of heavy metals in the plant and soil in the control and polluted sites.

Heavy metals (mg.kg-1)	**Plant**			**Soil**		
	Polluted site	**Control site**	**p-value**	**Polluted site**	**Control site**	**p-value**
Zn	353.58	289.08	0.001	187.75	143.06	0.001
Ni	158.76	80.47	0.001	250.42	163.84	0.001
Pb	158.32	75.36	0.001	16.3	15.83	0.01
Cu	35.03	19.91	0.001	44.85	41.82	0.01
Co	8.66	5.39	0.001	14.54	11.07	0.01
Te	2.21	0.99	0.01	40	3.33	0.001
Mn	0	0	–	305.01	271.92	0.01
Se	5.31	0.47	0.001	0.98	0.09	0.01
Cr	305.7	0	0.001	99.32	58	0.001
Hg	0.169	0	0.001	0.05	0	0.05
As	0	0	–	11.61	11.36	0.45
Cd	0.017	0	0.05	0.1	0.068	0.05
V	0	0	–	84.05	11.32	0.001
Sb	0	0	–	0.1	0.36	0.05

Conclusions

The polluted sites with an electrical generator and high traffic density and frequency of cars stoppage showed a high heavy metal concentration of all metals. Also Zn, Ni, and Pb metals showed the highest concentration of all. The value of all heavy metals analyzed in the polluted site is more significant than the control site in the soil and different parts (Leaf, Root, and Stem) of the *Vitis Vinifera* plant.

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