

Anatomical Study of Leaf Characteristics of Some Plants Growing in Polluted and Non-Polluted Soils in Kirkuk City

Hiyam Jamal Ibrahim

Biology Dept., College of Education for Pure Sciences, University Kirkuk, Iraq

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Annotation: Environmental pollution decreases the growth rate of trees and shrubs, and may even result in the decline of whole forest stands. To a large extent this may be due to soil pollution, which has a negative effect on the development of root systems, especially in long-lived organisms, such as trees. Therefore, the current study aims to study the characteristics of the leaves of some plants growing in polluted and unpolluted soils. The study samples were collected from two different locations: The North Oil Company, an area contaminated with petroleum derivatives, and Kirkuk University, an uncontaminated area, for the period from November to December 2024. the results showed some anatomical characteristics of leaves of plants that were taken from an area with polluted soil, North Oil Company, where it is noted that the thickness of the leaf was the highest in eucalyptus, reaching 680 mm, while the minimum thickness was 200 mm in the mulberry plant. As for the vascular cylinder, it reached 600 mm in the eucalyptus plant, while the minimum size was in La Niña, reaching 250 mm. The epidermis reached

the highest thickness of 50 mm in the mulberry plant and the minimum thickness in the eucalyptus plant. As for the cortex, the highest thickness was 160 mm in the La Niña plant and the minimum thickness in the eucalyptus, reaching 28 mm. Figures (1-10) also show the anatomical characteristics of each plant. These results were different from those of plant leaves taken from healthy soil. On the other hand, it is noted that in the La Niña leaves collected from polluted soil, the number of pores was 12, while it was 15 in the La Niña leaves collected from healthy soil. Likewise, for eucalyptus, the number of pores in the leaves of polluted soil was 22, while it was 50 in the leaves collected from healthy soil. In the mulberry leaves collected from polluted soil, the number of pores was 20, while it was 40 in the leaves collected from healthy soil. In the Citrus aurantium leaves collected from polluted soil, the number of pores was 20, while it was 32 in the leaves collected from healthy soil. Based on the results of the current study, it appears that soil contamination, especially with phytochemical derivatives, led to changes in the anatomical characteristics of the leaves of the study plants compared to leaves collected from plants growing in healthy soil.

Keywords: Citrus aurantium, La Niña, eucalyptus, anatomical characteristics.

Introduction

A high level of agricultural productivity depends on productive soils [1]. Anything that contaminates soil and lowers its quality is referred to as soil pollution [2, 3]. It happens when pollutants lower soil quality and make the soil uninhabitable for macroorganisms and

microorganisms [4,5]. Any unwanted changes to the environment, whether partial or complete, brought on by various human activities are collectively referred to as environmental pollution. It is sometimes referred to as the atmosphere that arises from human-induced modifications to the ecological environment. One could argue that environmental contamination is the root cause of illness, death, damage, or inconvenience [6,7]. When foreign objects enter the soil and alter its chemical and physical makeup, this is known as soil pollution. This is frequently caused by fertilizer and pesticide application, acid rain that alters soil pH, radioactive radiation, and other factors [8,9]. Tree defense mechanisms against the effects of industrial pollution are poorly understood. Compared to conifers, deciduous trees are less vulnerable to environmental pollutants, according to numerous studies [10]. However, several broad-leaved trees, like birch, which were once thought to be reasonably tolerant, have been shown to show a drop in growth in industrial areas. Reducing industrial air pollution is the best way to prevent the harmful effects of metal ions on plants. The hazardous substances that have accumulated in the soil, however, may have a detrimental effect on the growth of the root system for many years, even if emissions are significantly decreased [11]. The overall health of plants has a significant impact on how sensitive they are to pollution. The condition of birch trees growing in poor soils at industrial sites has significantly improved by fertilization (e.g., with nitrogen and phosphorus compounds) [12]. Soil microbes, mycorrhizal fungi, and fungi hostile to pathogens may all contribute positively to plants' defense against the impacts of toxic metals [13]. Microbial activity declines and the makeup of the soil microflora varies in deteriorated soils [14,15]. There is typically a negative correlation between mycorrhizal colonization and high amounts of harmful metal ions, such as aluminum [16]. Therefore, the current study aims to study the characteristics of the leaves of some plants growing in polluted and unpolluted soils.

Materials & Methods

The study samples

The samples were collected from two different locations, North Oil Company, an area contaminated with petroleum derivatives, and Kirkuk University, an uncontaminated area, for the period from November to December 2024. The leaves were collected and the following characteristics were taken for the purpose of the study:

Anatomical study

A table microtome (Ranvier type) was used to create cross-sections. Acid dissociation was used to create paradermal portions [17]. Slides were created using traditional plant anatomy techniques [18]. Each person utilized at least four samples. An Optica microscope was used to examine the slices, and a Leica photomicroscope was used to capture the photos.

Results & Discussion

Table (1) shows some anatomical characteristics of leaves of some plants that were taken from an area with polluted soil, North Oil Company, where it is noted that the thickness of the leaf was the highest in eucalyptus, reaching 680 mm, while the minimum thickness was 200 mm in the mulberry plant. As for the vascular cylinder, it reached 600 mm in the eucalyptus plant, while the minimum size was in La Niña, reaching 250 mm. The epidermis reached the highest thickness of 50 mm in the mulberry plant and the minimum thickness in the eucalyptus plant. As for the cortex, the highest thickness was 160 mm in the La Niña plant and the minimum thickness in the eucalyptus, reaching 28 mm. Figures (1-10) also show the anatomical characteristics of each plant.

Table (1) Measures of anatomical characteristics of leaves in a polluted area - North Oil Company

| Measures | La Niña | Eucalyptus | Mulberry | Citrus aurantium |
|-------------------|---------|------------|----------|------------------|
| Leaf thickness | 300mm | 680mm | 200mm | 300mm |
| Vascular cylinder | 250mm | 600mm | 300mm | 350mm |

| | | | | |
|-----------|-------|------|-------|-------|
| Epidermis | 50mm | 10mm | 50mm | 10mm |
| Cortex | 160mm | 28mm | 150mm | 100mm |

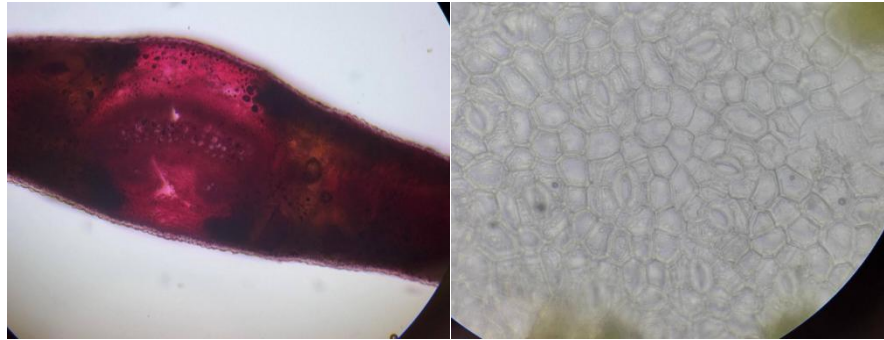


Figure (1): contaminated eucalyptus leaf.

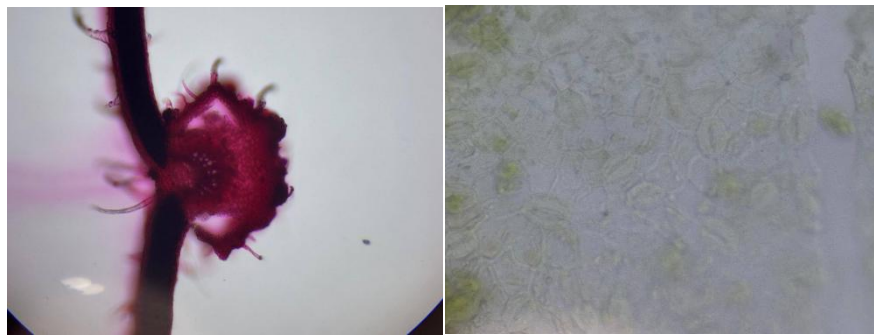


Figure (2): contaminated mulberry leaf.

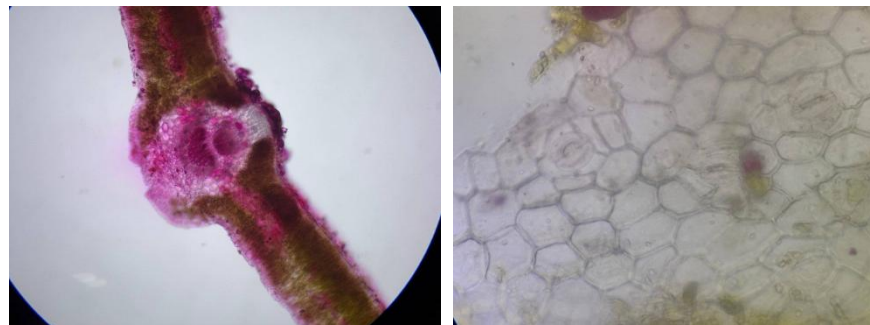


Figure (3): contaminated La Niña leaf.

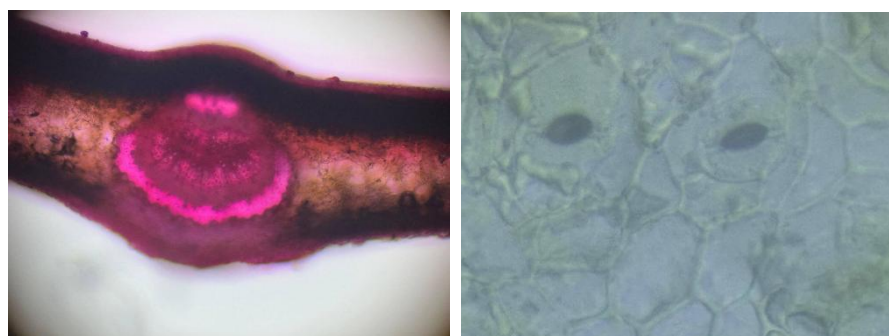


Figure (4): contaminated Citrus aurantium leaf.

Table (2) shows some anatomical characteristics of leaves of some plants that were taken from an area with normal soil, Kirkuk University, where it is noted that the thickness of the leaf was the highest in eucalyptus, reaching 350 mm, while the minimum thickness was 200 mm in the

mulberry plant. As for the vascular cylinder, it reached 450 mm in the *Citrus aurantium*, while the minimum size was in *La Niña*, reaching 300 mm. The epidermis reached the highest thickness of 30 mm in the *Citrus aurantium* and the minimum thickness in the eucalyptus plant. As for the cortex, the highest thickness was 160 mm in the *Citrus aurantium* and the minimum thickness in the eucalyptus, reaching 15 mm. Figures (5-8) also show the anatomical characteristics of each plant.

Table (2) Measures of anatomical characteristics of leaves in unpolluted area – Kirkuk University

| Measures | La Niña | Eucalyptus | Mulberry | Citrus aurantium |
|-------------------|---------|------------|----------|------------------|
| Leaf thickness | 320mm | 350mm | 200mm | 300mm |
| Vascular cylinder | 300mm | 400mm | 350mm | 450mm |
| Epidermis | 10mm | 10mm | 10mm | 30mm |
| Cortex | 150mm | 15mm | 80mm | 150mm |

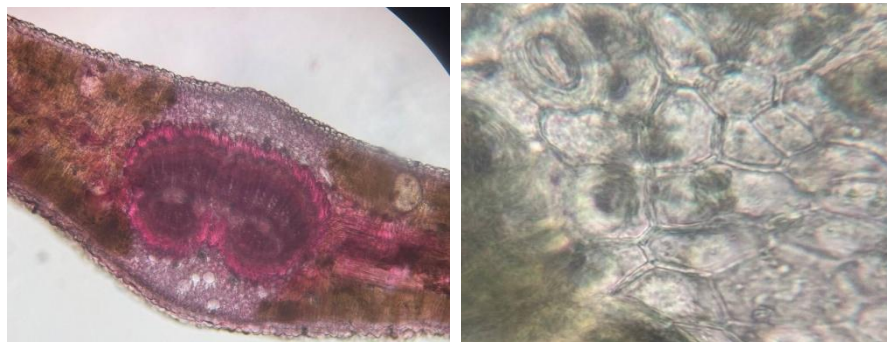


Figure (5): normal eucalyptus leaf.

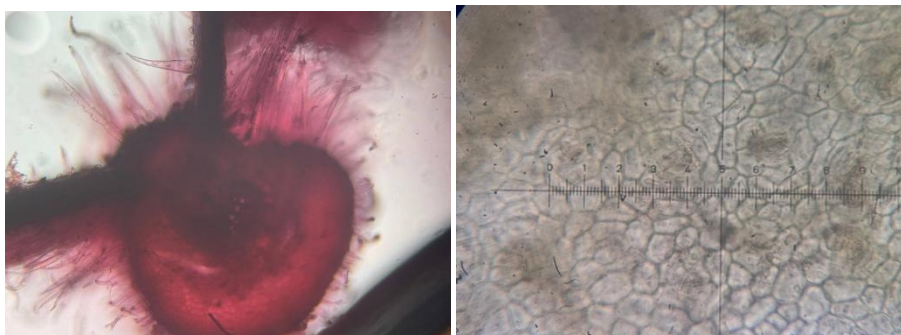


Figure (6): normal mulberry leaf.

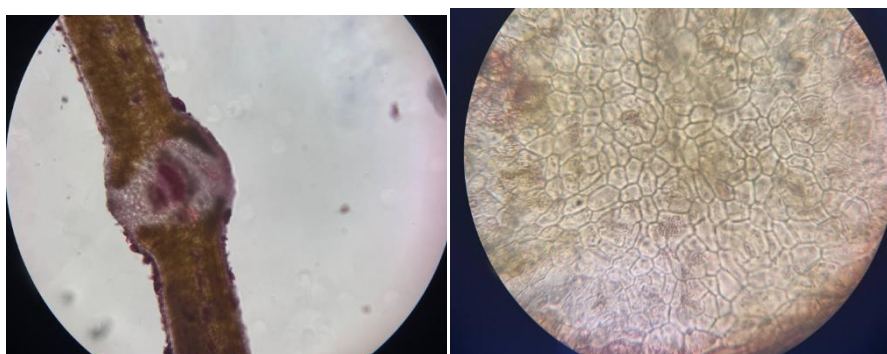


Figure (7): normal La Niña leaf.

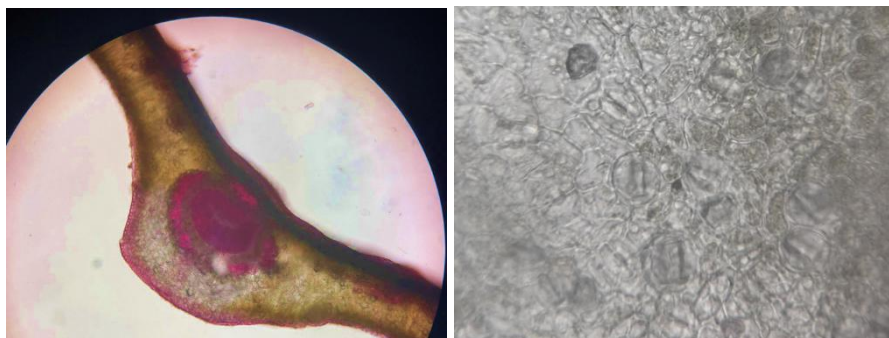


Figure (8): normal *Citrus aurantium* leaf.

Some of the species under study exhibited notable differences in leaf thickness between contaminated and non-polluted areas. For example, the thickness of eucalyptus was 350 mm in the unpolluted area and 680 mm² in the polluted area. In contrast to 320mm in the non-polluted site, La Niña displayed the smallest leaf area of 300mm in the polluted site. This is in line with Shi et al. [19] and [20], who found that air pollution caused changes in leaf venation and vein characteristics, as well as alterations in leaf thickness and shape in addition to stomatal features. According to leaf micromorphological studies, the epidermis and vascular cylinder in particular are adaptive traits for environmental stressors [21]. These morphological changes are explained as one of the ways that plant leaves resist air pollutants and preserve the water balance of their tissues by thickening their leaves; the more stressed a plant is, the less water it loses, and the more resilient it is [22].

Table (3) shows the distribution of pores on the leaves of the plants under study according to the polluted and unpolluted areas. It is noted that in the La Niña leaves collected from polluted soil, the number of pores was 12, while it was 15 in the La Niña leaves collected from healthy soil. Likewise, for eucalyptus, the number of pores in the leaves of polluted soil was 22, while it was 50 in the leaves collected from healthy soil. In the mulberry leaves collected from polluted soil, the number of pores was 20, while it was 40 in the leaves collected from healthy soil. In the *Citrus aurantium* leaves collected from polluted soil, the number of pores was 20, while it was 32 in the leaves collected from healthy soil.

Table (3) Distribution of stomata on the leaves of the plants under study according to polluted and unpolluted areas

| Measures | Polluted area | unpolluted area |
|-------------------------|---------------|-----------------|
| La Niña | 12 | 15 |
| Eucalyptus | 22 | 50 |
| Mulberry | 20 | 40 |
| <i>Citrus aurantium</i> | 20 | 32 |

According to the current study's findings, most plant leaves have more epidermal cells when compared to areas that are less contaminated. In contrast, the majority of plant leaves' stomatal index values decreased in polluted areas as compared to less contaminated areas. This discrepancy in outcomes could be caused by the degree to which plants react to air pollution as well as the variations among the species under study. One possible explanation for the decline in stomata and epidermal cells in plant leaves is a decrease in leaf area [23]. These modifications clarified how environmental factors impact the morphological and anatomical traits of plant leaves. Because of its small leaf area, tiny stomata, low transpiration rate, low plant gas exchange rate, and consequently lower rate of polluting gas penetration into the leaf, it is also thought to be a plant that can withstand drought or air pollutants [24]. One of the better anatomical responses that plants have to air pollution is the stomatal index [25]. Because fewer stomata result in less absorption of air pollutants, a low stomata number has been interpreted as an indication of plant tolerance to air pollution [26].

Conclusions

Based on the results of the current study, it appears that soil pollution, especially with phytochemical derivatives, led to changes in the anatomical characteristics of the leaves of the study plants in terms of the thickness of the cortex and epidermis of the leaves and even the vascular cylinder. Pollution also directly affected the distribution and number of stomata in the leaves compared to leaves collected from plants growing in healthy soil. This demonstrates the extent of the direct impact of pollution on the structural characteristics of plants.

References

1. Anbalagan K., Karan S. SOIL POLLUTION: SOURCES, EFFECTS AND REMEDIATION. CHAPTER: 12. 2024, p: 219.
2. Shakor I. F., Ali M. N. In Vitro Propagation of Lemon Citrus Lemon Local. IOP Conf. Series: Earth and Environmental Science. 2024; 1371: 1-8.
3. Münzel T., Omar H., Andreas D., Philip J L. Soil and water pollution and human health: what should cardiologists worry about? Cardiovasc Res. 2022; 119(2):440–449.
4. Khurshid, C.A.; Mahdi, K.;Ahmed, O.I.; Osman, R.; Rahman, M.;Ritsema, C. Assessment of PotentiallyToxic Elements in the Urban Soil andPlants of Kirkuk City in Iraq.Sustainability 2022, 14, 5655.
5. Maaruf N. S., Ali H. R. The effect of phosphorus fertilizer types and varieties on growth and yield of Sorghum [Sorghum bicolor (L.) Moench]. Kirkuk University Journal for Agricultural Sciences, 2024; 15(4:) 237-250.
6. Bone, J., Head, M., Barraclough, D., Archer, M., Scheib, C., Flight,D. and Voulvoulis, N., 2010. Soil quality assessment under emerging regulatory requirements. Environment International, 36(6), pp.609-622.
7. Jamal Q J. Air Pollution: Concepts and Effects. Journal of Scientific Prospects. 2019; 11: 300-305.
8. AL-Bassaw Z M., Abd-Al-Aziz H.M., DhUha M.A. Evaluation of performance of the workers in the agricultural division of the University of Mosul for agricultural work and its relationship to some variables RESEARCHERS. Kirkuk University Journal for Agricultural Sciences, 2021; 1(12): 1-8.
9. Al-Taai S. H. Soil Pollution - Causes and Effects. IOP Conf. Series: Earth and Environmental Science. 2021; 790: 1-9.
10. Sidor C. G., Radu V., Ionel P., Anca S., Ecaterina A., Ovidiu B. Impact of Industrial Pollution on Radial Growth of Conifers in a Former Mining Area in the Eastern Carpathians (Northern Romania). Forests 2021, 12(5), 640.
11. Abida B., Harikrishna S. Evaluation of Some Tree Species to Absorb Air Pollutants in Three Industrial Locations of South Bengaluru, India. E-Journal of Chemistry. 2010; 7(s1): 1-8.
12. Jonczak J., Urszula J., Marek Kondras M., Magdalena S. The influence of birch trees (Betula spp.) on soil environment – A review. Forest Ecology and Management. 2020; 477(4):118486.
13. Karimi A., Habib K., Mozhgan S., Mirhassan R. Arbuscular mycorrhizal fungi and heavy metal contaminated soils. African Journal of Microbiology Research. 2011; 5(13): 1-6.
14. O'Brien F.J., Almaraz M., Foster M.A., Hill A.F., Huber D.P., King E.K., Leopold M. Soil Salinity and pH Drive Soil Bacterial Community Composition and Diversity Along a Lateritic Slope in the Avon River Critical Zone Observatory, Western Australia. Front. Microbiol., 2019; 10: 1-5.

15. Dixit M., Debabrata G., Amrit L., Ghasal P.C., Ashutosh K., Jairam C., Debashis D. Changes in soil microbial diversity under present land degradation scenario Total Environment Advances. 2024; 10: 1-6.
16. Dietterich Cedric L., Gonneau Cedric G., Brenda B C. Arbuscular mycorrhizal colonization has little consequence for plant heavy metal uptake in contaminated field soils. Ecological Applications. 2017; 27(6): 1-7.
17. Krauss JE, Arduin M. 1997. Manual basico de mtetodos em Morfologia Vegetal. Seropedica: Edur.
18. Johansen DA. 1940. Plant microtechnique. New York: McGraw-Hill Book.
19. Shi P., Jiao Y., Diggle P.J., Turner R., Wang R. and Niinemets Ü. (2021) Spatial distribution characteristics of stomata at the areole level in *Michelia cavaleriei* var. *platypetala* (Magnoliaceae). *Annals of Botany* 128(7): 875– 885.
20. Shi P., Miao Q., Niinemets Ü., Liu M., Li Y., Yu K. and Niklas K.J. (2022) Scaling relationships of leaf vein and areole traits versus leaf size for nine magnoliaceae species differing in venation density. *American Journal of Botany* 109(6): 899–909.
21. Perez-Estrada L.B., Cano-Santana Z. and Oyama K. (2000) Variation in leaf trichomes of *Wigandia urens*: environmental factors and physiological consequences. *Tree Physiol* 20: 629–632.
22. Seyyednejad S. M., Niknejad M., Yusefi M. The Effect of Air Pollution on Some Morphology and Biochemical Factors of *Callistemon citrinus* in Petrochemical Zone in South of Iran. *Asian J.Pl.Sci.*,2009; 7(1): 1-4.
23. Abdulmoniem M.A.S. Effects of Auto-exhaustPollution on the Micro-Morphology and Leaf EpidermalFeatures of Ornamental Plants in Khartoum, Sudan,” *J.App. Sci. Res.*, Vol.7, NO.3, PP. 270-273, 2011.
24. Pourkhabbaz A., Rastin N. Influence ofEnvironmental Pollution on Leaf Properties of Urban PlaneTrees, *Platanus orientalis* L.,” *Bull. Environ. Cont. Toxic.*,Vol. 85, pp.251-255, 2010
25. Ogunkunle C. O., Abdulrahaman A.A., Fatoba P.O. Influence of cement dust pollution on leafepidermal features of *Pennisetum purpureum* and *Sidaacuta*,” *Environ. Exp. Bio.*, Vol.11, pp. 73-79, 2013.
26. Verma R.B., Mahmood U., Siddiqui T.O., Iqbal M. Foliar response of *Ipomea pes-tigridis* L. to coal-smoke pollution,” *Tur. J. Bot.*, Vol. 30, pp.413-417.