Ecological Effects Of Particulate Matter On The Histochemical Content Of Alchonea Cordifolia, Musa Paradisiaca, And Manihot Esculenta

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Abstract: A comparative study was carried out to show the effect of particulate matter generated from asphalt on the phytochemical content of plant species in the environment. Asphalt is a sticky, black and highly viscous liquid or semi-solid form of petroleum. It is primarily used in road construction and also for bituminous waterproofing products. Samples from the following species: Manihot esculentus Crantz (Cassava),family Euphorbiaceae, Musa paradisiaca L. (Plantain), family Musaceae, and Alchornea cordifolia (Schum. & Thonn.) Mull. Arg. (Christmas bush), family Euphorbiaceae, were collected from asphalt polluted and unpolluted environment. For localization of calcium oxalate crystals and silicon, fresh stems, leaves and petioles of plant specimens were fixed in FAA (formalin, acetic acid and absolute ethanol) solution in the ratio 1:1:18 respectively. Specimens were rinsed in several changes of water and hand-sectioning method was used. For calcium oxalate crystals, sections were stained with an equal mixture of 5% silver nitrate and 30% hydrogen peroxide under an intense light which was supplied with a 60-watt electric bulb kept at a distance of about 20cm from the slides. The staining took place for about 30 minutes at 10 minutes interval. For Silicon localization, sections were covered with methylene blue and sufficient heat was provided, and then cleared with clove oil and mounted in glycerin. Tannin localization was carried out using the fixative stain method. Specimens were placed in a fixative stain containing a solution of 20ml of 10% ferrous sulphate with 100ml of 4% formaldehyde. They were rinsed in several changes of distilled water and free-hand sectioning method was used. A reduction in the content of tannin, calcium oxalate crystal, and silicon in the highly polluted site as compared to the unpolluted site was recorded. Growth of plants in the polluted site was found to be affected by asphalt particulate matter, which might be due to the presence of different toxic pollutants in asphalt dust. The plants are exposed to both biotic and abiotic stresses which are detrimental to plant health and metabolism.

Key words: Ashpalt plant, Calcium oxalate, Particulate matter, plant, Silicon

1 INTRODUCTION

Vegetation reacts with air pollutants over a wide range of pollutant concentrations and environment. Air pollutants enter the plant system through direct and indirect path ways. The outer surfaces of a leaf are covered by a layer of epidermal cells which help in moisture retention. Between the epidermal cells layers are the mesophyll cells which comprises the spongy and palisade parenchyma. The leaf has a vascular bundle which carries water, minerals and carbohydrate through the plant. Stomata of leaves are controlled by guard cells which can open and close and hence change air spaces in the interior of leaves [1]. Particulate matter enters into leaves through stomata by diffusing into and out of leaves. The indirect pathway occurs through the root system. The deposition of air pollutants on soil and surface water can cause alteration of the nutrients content of the soil in the vicinity of the plant. This changes the soil conditions and hence leads to an indirect effect on air pollutants on vegetation and plants. Atmospheric particulate matter is a mixture element. Deposition of particulate matter to vegetation surface depends on the size distribution of these particles and, to a lesser extent on the chemistry. Effects of particulate matter on vegetation may be associated with the reduction in light required for photosynthesis and an increase in leaf temperature due to changed surface optical properties [2].

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Exposure to a given mass concentration of air born particulate matter may lead to widely differing phytoxic responses, depending on the particular mixture of deposited particles. Particulate deposition and effects on vegetation unavoidably include (1) nitrate and sulfate and their association in the form of acidic and acidifying deposition and (2) trace elements and heavy metals, include lead. While size is related to mode and magnitude of deposition and may be a useful substitute for chemical composition [3]. Mineral dusts in general are less soluble and less reactive than the anthropogenic acid-forming sulfate and nitrate particles [4], [5]. The qualitative importance of dry particulate deposition depends upon the chemical species, topography precipitation regime and surface characteristic, including vegetation properties [5]. Dust with P^H values of > 9, may cause direct injury to leaf tissues on which they are deposited [6], or indirectly through alteration of P^H [7]. Dust accumulation on leaf surfaces may interfere with gas diffusion between the leaf and air, sedimentation of course particles affects the upper surfaces of leaves more [8], [9], while finer particles affects lower surfaces [10]. In dusty environment species having stomata in grooves covering of wax on stomata might be affected less than species in which the stomata are located at the outer surfaces of the leaf. There has been reduction in growth of the dominant trees owing to crust formation on leaves which reduces photosynthesis and bringing premature leaf fall and distribution of leaf tissues [11]. Cement dust on hydration liberates calcium hydroxide which can raise leaf surface alkalinity in some cases to P^H 12. This level of alkalinity can hydrolyze lipid and wax components, penetrate the cuticle and denature proteins finally plasmolyzing the leaf. Limestone dust coating of lichen thallus damaged to photosynthesis apparatus [12]. This leads to change in community and function. This study is therefore designed to determine the ecological effects of particulate matter from an asphalt plant on the histochemical content of some plant.

2 MATERIALS AND METHODS

This investigation deals with comparative study of plants growing in asphalt plant polluted area with those growing in unpolluted area. For this purpose, stems, leaves, and petioles samples of Manihot esculentus (Cassava), Musa paradisiacal (Plantain), and Alchornea cordifolia (Christmas bush) (Table 1), were collected during field trips from asphalt plant highly polluted and unpolluted areas.

2.1 Study Area and Sample Collection

Three sites were selected for polluted area as well as for unpolluted area. For polluted area, samples were collected from different points surrounding an Asphalt plant owned by H x H Engineering in Mbiama, along the East West Road, Ahoada-West Local Government Area, Rivers State, Nigeria. For unpolluted area, the main campus of Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Rivers State, Nigeria, was selected.

2.2 Determination of Calcium oxalate crystals, Silicon and Tannin Content in Plant Materials

For localization of calcium oxalate crystals, fresh stems, leaves and petioles of plant specimens were fixed in FAA (formalin, acetic acid and absolute ethanol) solution in the ratio 1:1:18 respectively. Specimens were rinsed in several changes of water and hand-sectioning method was used. Sections were placed on clean slides and stained with an equal mixture of 5% silver nitrate and 30% hydrogen peroxide under an intense light which was supplied with a 60-watt electric bulb kept at a distance of about 20cm from the slides. The staining took place for about 30 minutes at 10 minutes interval. Sections were further stained with 0.5% safranin to make them clearer and mounted in glycerin. Cover slips were placed on slides and observed using the light microscope. For Silicon localization, Sections were placed on slides after fixing in FAA and covered with methylene blue and sufficient heat was provided. Sections were cleared with clove oil and mounted in glycerin. Tannin localization was carried out using the fixative stain method. Specimens were placed in a fixative stain containing a solution of 20ml of 10% ferrous sulphate with 100ml of 4% formaldehyde. They were rinsed in several changes of distilled water and free-hand sectioning method was used. The sections were placed on slides and mounted in glycerin. A swift MB 500D microscope was used for viewing. Photographs of sections were taken with a photo micrograph unit.

Table 1. Sources of plant materials used for the study

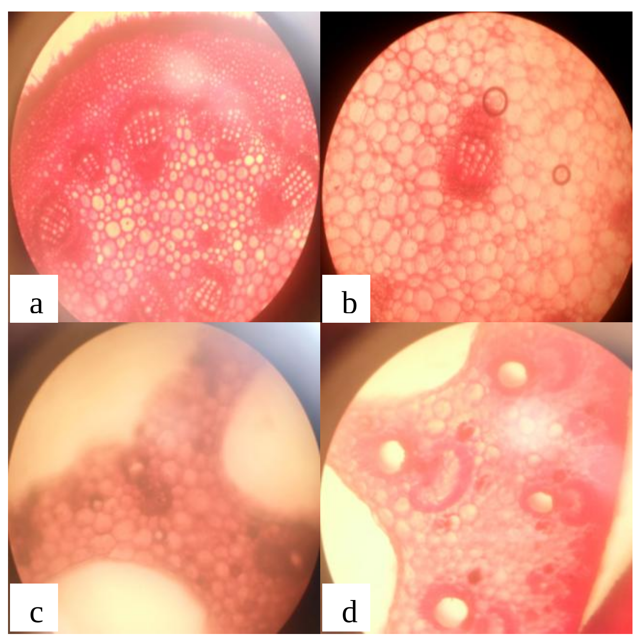
Taxa	Accession No.	Collector & Collection Date	Locality
Alchornea cordifolia	Friday 001	09/02/2014	Asphalt plant in Mbiama, along the East-West Road, in Ahoada-West Local Government Area, Rivers State, Nigeria
	Ajuru 113	15/02/2014	Main campus, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Rivers State, Nigeria
Musa paradisiaca	Friday 002	09/02/2014	Same location as above
	Ajuru 116	21/02/2014	Same location as above
Manihot esculentum	Friday 003	09/02/2014	Same location as above
	Ajuru 118	23/02/2014	Same location as above

3 RESULT

Observations of the phytochemical content of the plant species studied are presented in Figures 1-3.

3.1Calcium oxalate crystals:

Calcium oxalate crystals in form of druses were present in the ground parenchyma tissues in minute quantities in A. cordifolia and M. paradisiaca but completely absent in M. esculentum collected from the asphalt polluted site, compared to the plant materials collected from the main campus of Ignatius Ajuru University of Education. The quantity of druses is a bit high and are present in the parenchyma tissues. In addition, druses were also located in the vascular bundles of M. paradisiaca, as shown in Figure 1.



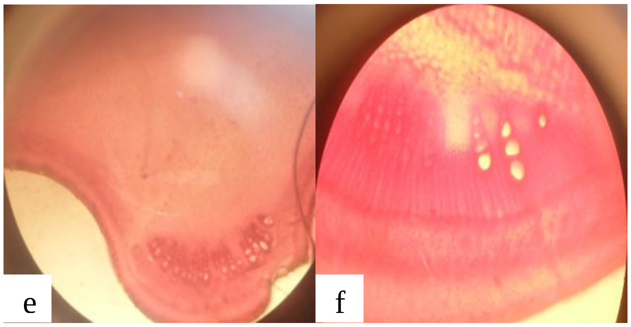
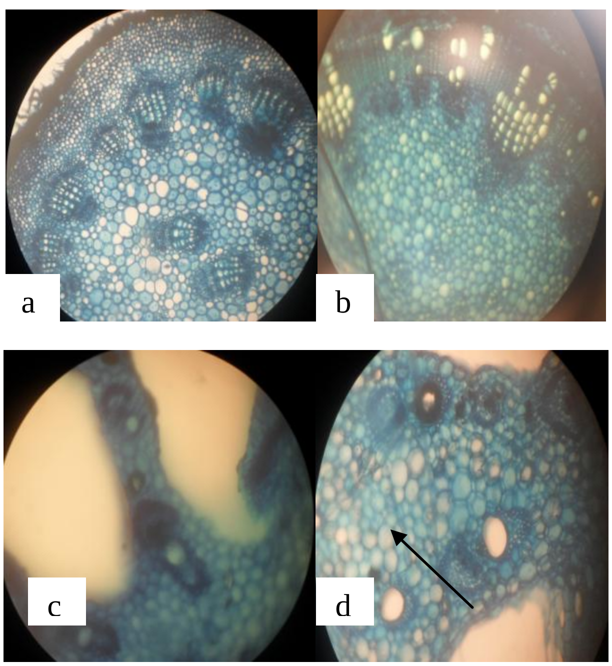


Figure 1. *Calcium oxalate crystals in form of druses in the plant species studied; a- stem of A. cordifolia from polluted site; b- stem of A. cordifolia from unpolluted site; c- leaf of M. paradisiaca from polluted site; d- leaf of M. paradisiaca from unpolluted site; e- stem of M. esculentum from polluted site; f- stem of M. esculentum from unpolluted site (x100)*

3.2 Silicon:

A comparative study of the silicon content in plant materials collected in the asphalt polluted and unpolluted areas show differences in its composition. Materials from the asphalt polluted area contain very little quantity of silicon in the ground parenchyma cells, close to the vascular bundles, while materials from the non-polluted area contain high quantity of silicon. Silicon was found in large quantity in the parenchyma and vascular tissues of M. paradisiaca and A. cordifolia, while in M. esculentum, it was located only in the parenchyma tissues, as shown in Figure 2.



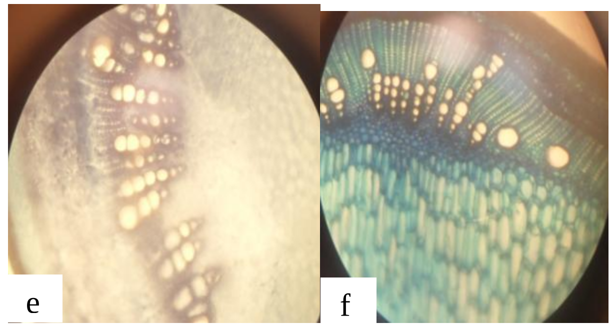
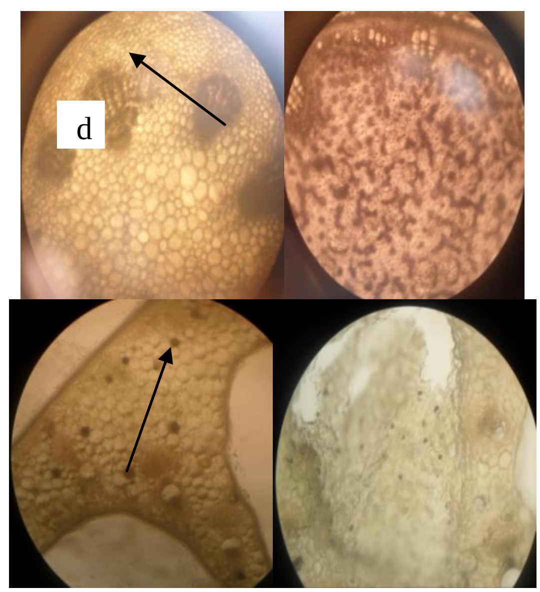


Figure 2. *Silicon localization in the plant species studied; a- stem of A. cordifolia from polluted site; b- stem of A. cordifolia from unpolluted site; c- leaf of M. paradisiaca from polluted site; d- leaf of M. paradisiaca from unpolluted site; e- stem of M. esculentum from polluted site; f- stem of M. esculentum from unpolluted site (x100). Arrow points to the present of silicon in the plant species*

3.3Tannin:

A. cordifolia species, collected from the asphalt polluted area contained tannins in little quantity in the parenchyma, sclerenchyma, and vascular tissues; while M. paradisiaca contained tannins in little quantity in parenchyma and vascular tissues, and M. esculentum had no tannin in its tissues. But the materials from the non-polluted area all contain tannin in varying quantities. In A. cordifolia, the ground parenchyma tissues were almost completely filled with tannins and the vascular tissues also contain a lot of tannins. M. paradisiaca also contain large quantity of tannin in both the parenchyma and vascular tissues, higher than in the same species collected from the asphalt polluted area. M. esculentum contain little quantity of tannin in the parenchyma and collenchyma tissues. So tannin was present here unlike in the same species collected from the asphalt polluted area, as shown in Figure 3.



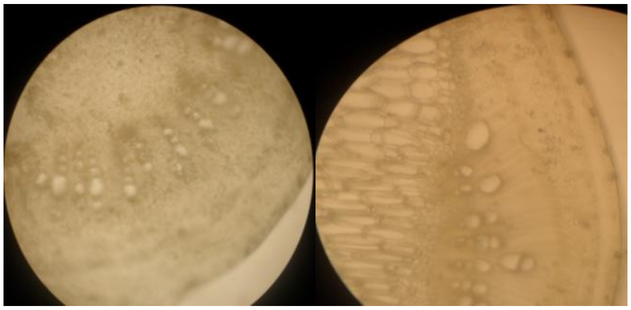


***Figure 3**. Tannin localization in the plant species studied; a- stem of A. cordifolia from polluted site; b- stem of A. cordifolia from unpolluted site; c- leaf of M. paradisiaca from polluted site; d- leaf of M. paradisiaca from unpolluted site; e- stem of M. esculentum from polluted site; f- stem of M. esculentum from unpolluted site (x100). Arrow points to tannin present in the plant species*

4 DISCUSSION

Air pollutants, fly ash, and dust emissions have a profound impact on the concentration of tannin, silicon, and calcium oxalate crystals in plants. The results of this research indicate the plant species are under stress and are deficient due to pollution. Analysis of the calcium oxalate crystals in plant materials collected from the asphalt polluted site indicated minute quantities of druses in A. cordifolia and M. paradiasiaca and complete absent of the crystal in M. esculentum; but the same plant species collected from the unpolluted site showed the presence of this crystals in large quantities in all the species. This result is in support of the findings by Fodor [13] and [14], that toxic metals may cause deficiency of elements essential for plants. Calcium oxalate crystals are essential for the general metabolism of plants. These crystals in plants participate in calcium homeostasis, storage of calcium, removal of excess oxalate [15], which might have a toxic effect when accumulated in excess quantities [16]. Also, calcium oxalate crystals provide support to tissues, protect plants against herbivores by their association with irritating chemicals [17].Therefore, the plant materials found in the polluted sites will not thrive well due to little or complete lack of these crystals which helps protect the plants against herbivores, and accumulation of excess oxalate, among others. In addition, presence of calcium oxalate crystals have been reported in leaves and stems of plants [18], [19], [20], [21], [22], [23]. From the results, it can be seen that the composition of silicon in materials from the two sites is different. Plant species located at the asphalt polluted area contain minute quantity of silicon, only in the ground parenchyma tissues, while the species from unpolluted site contain high quantity of silicon, in the parenchyma and vascular tissues in M. paradisiaca and A. cordifolia, and only in parenchyma tissue in M. esculentum. This showed the effect of asphalt particulate matter on silicon in the plant species. Silicon has been identified as a bioactive and beneficial element in some plant species. The favourable effects of silicon include increased growth and production, improvement in some morphological features such as plant height, root penetration into the soil, protection of leaves from ultraviolet radiation damage, etc. Also, it alleviates both biotic and abiotic stresses including disease, pest lodging, drought, and nutrients imbalance, reduced manganese and iron toxicity, and increased growth in some plants. Therefore, the plant species growing in this polluted site are under stress because the plants are not protected from attack by fungi and other organisms, lack sufficient nutrients, etc. In general, the plant species in this site will not thrive well compared to their counterparts in the unpolluted areas. Tannin analysis showed deficiency of the phytochemical in plant species collected from the polluted site, compared to the plant materials from unpolluted site which contain tannin in high quantity. A. cordifolia and M. paradisiaca from the polluted site contain tannin in the cortex but in little quantity, compared to the high quantity of the chemical in materials collected from the unpolluted site. Tannin was found both in the parenchyma and vascular tissues of these plants. M. esculentum, collected from the polluted site had no tannin in the tissues, compared to the same plant species collected from the unpolluted site which contains tannin in the cortex. This showed the effect of the particulate matter of asphalt on these materials. Tannin compounds are widely distributed in many species of plants, where they play a role in protection from predation, and in plant growth regulation [24].

4 CONCLUSSION

On the basis of this study, it could be concluded that growth of plants in the polluted site was found to be affected by asphalt particulate matter, which might be due to the presence of different toxic pollutants in asphalt dust. The plant materials from this site were deficient in phytochemicals that are normally present in them, exposing the plants to both biotic and abiotic stresses which are detrimental to plant health and metabolism. Measures should be taken to control the level of pollution in this area in order not to destroy the plant life in this area which will adversely affect animals and humans living in the environment. Also, toxic substances which may be present in the plants will be absorbed by animals and humans during consumption of these plants. Moreover, morphological, anatomical, palynological, cytological, and embryological studies should be carried out on plants growing in this area to ascertain the level of effect of asphalt pollution on them.

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