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Research Article

The use of the inflorescence of Sprangletop (*Leptochloa fusca* L.) as a potential bioindicator of air pollution

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This research was carried out to evaluate the use of the inflorescence of *Leptochloa fusca* as a potential bio-indicator of air pollution. The presence and concentrations of heavy metals, specifically Barium (Ba), Cadmium (Cd), copper (Cu), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), Uranium (U) and Zinc (Zn) in the inflorescence of *Leptochloa fusca* collected from two locations (high and low traffic) were determined using Atomic Absorption Spectrometry (AAS). From the analysis, the concentration of heavy metals in the samples collected from high traffic roadside in their decreasing order are Zn(10.72), >Ni(6.19)> Cu (4.62), Mn (2.72)>Ba (2.02)> Cd(0.14)> Cr (0.12)>Pb (0.08)>Hg (0.03), U (0.02). The concentration of heavy metals in the samples collected from low traffic roadsides in their descending order are Zn (6.32), Mn (1.23)>Ni (1.19)> Cu (1.13),>Ba (0.19)>Cd (0.02)>Pb (0.01))> Hg (0.00)> Cr (0.00)> U (0.00). The concentration of the heavy metals in the inflorescence of *L. fusca* collected from high traffic locations was significantly higher than the samples collected from low traffic locations. From the study, it was concluded that high traffic roadsides are more prone to air pollution by vehicle exhaust and that the inflorescence of *L. fusca* is a potential bioindicator of air pollution. It is therefore recommended that proper monitoring and assessment of heavy metal pollutants should be carried out regularly to provide a better idea of the levels of pollution exposure at the roadside which can be absorbed by plants, humans, and other living organisms.

Keywords: *Leptochloa fusca, bio-indicator, heavy metals, automobile exhaust, air pollution*

Introduction

Due to their detrimental impacts on ecosystems and ability to contaminate air, water, and soil, heavy metals from vehicle emissions can pose serious risks to both individuals and the environment (Adamiec et al., 2016). Pollutants, including heavy metals delivered directly into the environmental compartments (air, soil, water, and biota), models that depict the dispersion of pollutants, and bio-indicators can all be used to measure and monitor environmental quality (Markert et al., 2003). Living things are called bio-indicators, and they are used to track the health of the ecosystem (Puttick et al., 2018). The primary benefit of bio-indicators is their capacity to identify environmental changes and pollution from a variety of sources early on (Begu, 2011). One of the main causes of air pollution is automobile exhaust, which is made up of entirely oxidized components like carbon dioxide and water that are regarded as safe. Although heavily industrialized locations are typically linked to heavy metal pollution, one of the main causes of heavy metal emissions has been shown to be high traffic (Brugge et al., 2007). The term "air pollution" refers to the prolonged and substantial presence of contaminants in the atmosphere. It is the existence of compounds that are detrimental to the environment, materials, or human and other living things' health (WHO, 2020). Hazardous materials are released by motor vehicles, including some hydrocarbons and heavy metals like mercury (Hg), cadmium (Cd), nickel (Ni), lead (Pb), copper (Cu), and chromium (Cr), which contaminate the air and endanger human health (Altaf R et al, 2021). The naturally occurring elements known as "heavy metals" include lead, mercury, and cadmium as well as nonessential metals including copper, iron, nickel, and zinc. Heavy metals are widely dispersed throughout ecosystems due to human activities including industrial mining and agricultural practices, but they also pose a risk to human and ecological health (Luis, 2018). These trace elements are necessary for the body in very small amounts, but prolonged exposure to them or exceeding specific thresholds might make them poisonous (Anhwange et al., 2013). As a result, there is a link between the environmental degradation caused by these metals and the growing ecological and worldwide public health issues. Heavy metals in the environment come from geogenic, mining, chemical, household waste, and agricultural sources (He et al.,2005). Because of their continuous exposure and affordable sampling, plants offer an alternative method of monitoring the quality of the air in metropolitan areas (Molnár VÉ et al., 2020). The perennial weed known as sprangletop, *Leptochloa fusca*, is found across the world. Since it is frequently observed by roadside vegetation, it could be regarded as a sign of air pollution brought on by vehicle emissions. Because of its capacity to fix nitrogen and its tolerance for both salty and alkaline soils, this aggressive species exhibits a competitive advantage in a variety of environments (Peterson et al., 2012); Snow et al., 2018). According to Peterson et al., (2012), the habitat and distribution extend from open mesic habitats, brackish marshes along the eastern US seaboard, agricultural fields, rural sites, along roadways, and salt flats to Massachusetts (USA) and Southern Ontario (Canada). The air is contaminated when certain heavy metal concentrations are too high. They make breathing difficult and damage the lungs. When they are absorbed by plants and consumed by humans or by direct inhalation, they can trigger asthma, burns to the skin and organs, and may lead to the death of living organisms. Extended exposure to heavy metals via eating tainted food crops may cause several biological processes in the human body to malfunction, endangering the health of the entire food chain (Chaudhery, 2020). Toxic compounds from exhaust, particularly heavy metals, can have detrimental effects on humans. Therefore, it is important to determine the concentration of these elements in the various regions where humans may encounter them. To enact policies that consider the users of plant produce along regions exposed to exhaust and the direct inhalation of the air from such environments that is polluted by heavy metals from exhaust, this research will also provide empirical and reliable data to the government and road management agencies.

Materials and Methods

Sample collection

To understand and determine the presence and the concentration of heavy metals in the inflorescence of *Leptochloa fusca*. *Leptochloa fusca* grasses were obtained from high traffic roadsides and areas with low traffic/control. The samples were selected considering the volume and nature of exposure of the grasses to exhaust from vehicles because of high traffic and their age. The experimental design was a randomized complete block design with three (3) replicates each for each pollutant (heavy metal) tested. This experimental design not only enhances the reliability of the result but also allows for a comprehensive exploration of the potential impacts of different pollutants on the sampled grasses. The two (2) samples of sprangletop (*Leptochloa fusca)* inflorescence collected from the various roadsides were placed in transparent containers with labels and were taken to the biochemical laboratory, where a test was carried out on each sample in duplicates to ascertain the presence of ten different toxic heavy metals which are Barium, Cadmium, Copper, Chromium, Lead, Manganese, Mercury, Nickel, Uranium and Zinc and the result obtained was taken for further analysis.

To comprehend and quantify the heavy metal content and presence in the *Leptochloa fusca* inflorescence, the *Leptochloa fusca* grasses were collected from regions with little traffic and from roadsides with a lot of activity. Because of the heavy traffic and the age of the grasses, the samples were chosen with consideration for the extent and kind of exposure to vehicle emissions. Three (3) replicates of each pollutant (heavy metal) assessed were included in the randomized complete block design of the experiment. This experimental setup enables a thorough investigation of the possible effects of various contaminants on the grasses that were tested, which improves the result's dependability. Two (2) inflorescence samples of sprangletop (*Leptochloa fusca*) that were gathered from different roadside locations were placed in transparent containers with labels and transported to the biochemical laboratory. There, duplicate tests were performed on each sample to determine the presence of ten distinct toxic heavy metals: barium, cadmium, copper, chromium, lead, manganese, mercury, nickel, uranium, and zinc. The results were then taken for additional analysis.

Sample preparation

The samples were pulverized and allowed to air dry. Each sample was taken in separate Pyrex flasks weighing around 2.0g. For breaking down organic materials, 2 milliliters of an acid and oxidant mixture (65% HNO_3 and 30% H_2O_2) were added to the flask contents in a 1:1, v/v ratio. For two to three hours, the contents of the flasks were heated to 80 degrees Celsius on electric hotplates until a clear solution was achieved. Atomic Absorption Spectrometry (AAS) was used to determine the levels of Barium, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Nickel, Uranium, and Zinc in the final solutions, which were made up to 25 milliliters with 0.2M HNO_3 (Radwan, 2005). The resulting solutions were then passed through the evaporation process to semi-dry mass.

Analysis of metal Ions using AAS

The sample is vaporized, and the target element is atomized at high temperatures in Atomic Absorption Spectrometry (AAS). Using AAS, the amounts of Zinc, Uranium, Lead, Manganese, Mercury, Nickel, Cadmium, Chromium, Copper, and Manganese were measured. The idea is to evaporate a sample solution by nebulizing it into an air-acetylene flame. Atomization of elements produces atoms that then absorb certain wavelength radiation from a hollow cathode lamp. The amount of analyte in the sample is proportionate to the observed absorbance.

For every element to be examined, the AAS machine (Alpha 4 Model) was configured in compliance with the manufacturer's instructions. These include choosing the right burner type, slit-width settings, fuel (acetylene) and oxidant (air). Parts per million (ppm) concentrations of the standards, blanks, and samples were automatically recorded once they were sucked into the flame (Radwan, 2005).

Statistical analysis

Statistical package for Social Science (SPSS) by International Business Machine version 20.0 was used for data analysis. Significant differences between the concentration of the different heavy metals considered in the two different locations (high and low traffic) were determined using the Student's T-test. All tests were considered significant at $P<0.05$ at 95 degree of confidence level. Values were recorded as Mean±S.E.M (standard error of the mean).

Results

Concentrations of heavy metals in the inflorescence of *Leptochloa fusca* found along roadsides

The heavy metal concentration of the *Leptochloa fusca* inflorescence that was obtained from two separate roadsides with differing levels of traffic intensity is displayed in Table 1 below. The concentration of heavy metals in the inflorescence of *Leptochloa fusca* collected from high-traffic roadsides was found to be significantly higher ($P < 0.05$) than the concentration of heavy metals found in the control samples, which were the inflorescence of *Lippochloa fusca* collected from low-traffic roadsides. Zinc had the highest concentration of all the heavy metals in both high- and low-traffic congested roads (10.72 ± 0.005) and low-traffic congested roads (6.32±0.015), while uranium had the lowest concentration in both high- and low-traffic roads (0.02±0.000) and low-traffic roads (0.00±0.000).

Table 1. The Concentrations of heavy metals in the inflorescence of *Leptochloa fusca* collected from high and low traffic roadsides

	Locations		
Heavy metals	**Low traffic**	**High traffic**	**P value**
Pb	0.01±0.000	0.08 ± 0.005	0.00*
Cu	1.13 ±0.010	4.62 ±0.015	0.000*
Zn	6.32±0.015	10.72 ± 0.005	0.000*
Hg	0.00±0.000	0.03 ± 0.005	0.038*
Cd	0.02±0.005	0.14 ± 0.010	0.008*
Ni	1.19±0.010	6.19± 0.010	0.000*
Cr	0.00±0.000	0.12±0.010	0.007*
Ba	0.19±0.005	2.02±0.015	0.000*
Mn	1.23±0.025	2.72±0.015	0.000*
U	0.00±0.000	0.02±0.000	

Mean ± S.E.M; *= Significance at p<0.05

Figure 1 shows that, although lead and silver concentrations in the chosen area are relatively low when compared to other heavy metal concentrations, Lead (Pb) and Mercury (Hg) concentrations in the high traffic region are 833.3% and 850.0% higher, respectively, than in the low traffic area. According to the findings, Copper (Cu) and Zinc (Zn) are significantly present in both high- and low-traffic locations. When comparing the high-traffic area to the low-traffic area, the concentration of Zn increases by 70.7% and the concentration of Cu increases by 129.4%. Consequently, it can be concluded that the analysis of elevated metal concentrations in the selected area has provided insightful information on the alterations in the environment associated with traffic effects. The elevated levels of Lead (Pb), Copper (Cu), Zinc (Zn), and Mercury (Hg) that have been reported in the heavily traveled area highlight the potential impact of vehicular activities on air and environmental conditions.

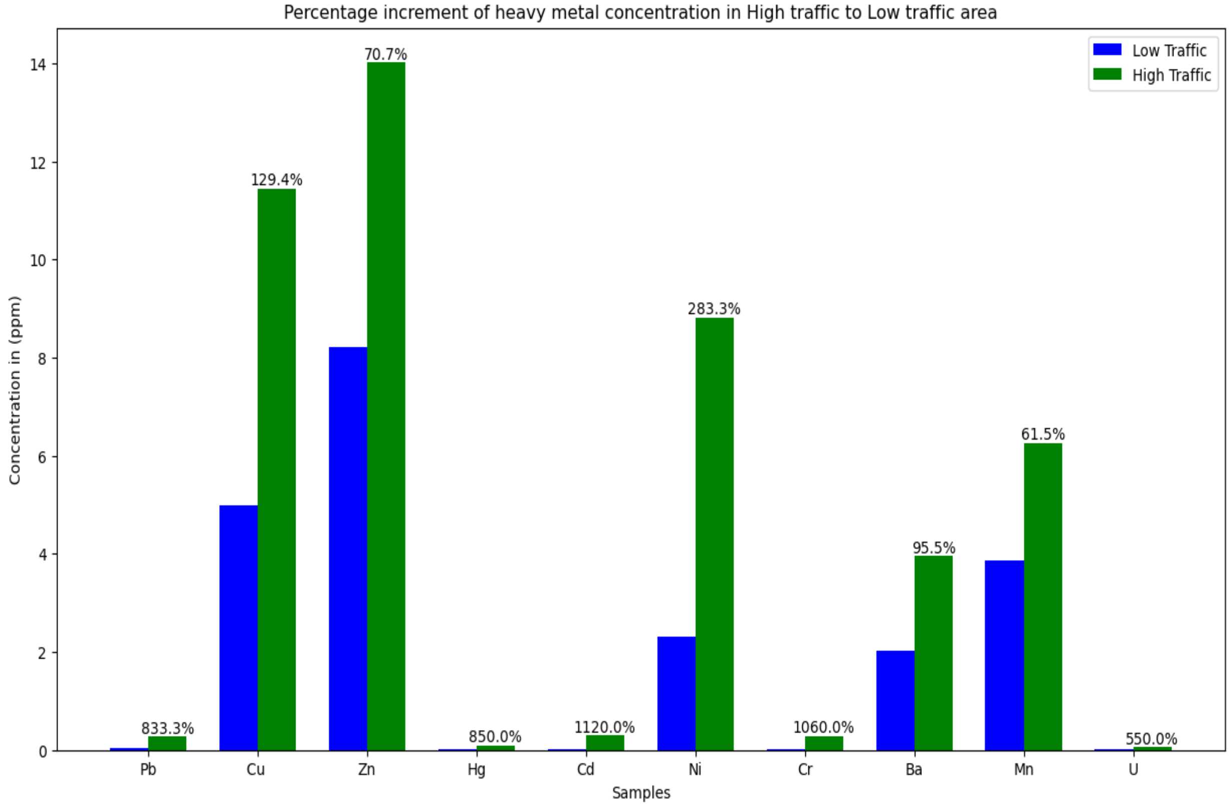

Figure 1. Percentage increase of heavy metal concentration in high traffic to low traffic

Discussion

According to Table 1, the heavy metal concentrations in the inflorescence of *Leptochloa fusca* taken from high-traffic locations were substantially greater ($P < 0.05$) than those in the inflorescence of the same species collected from low-traffic roadsides. Given that heavy traffic has been shown to be one of the main causes of heavy metal emissions, this is consistent with the findings of related research conducted by (Popescu, 2011) , which show a link between highly industrialized areas and heavy metal concentrations. Lead (Pb), Copper (Cu), Zinc (Zn), Mercury (Hg), Cadmium (Cd), Nickel (Ni), Chromium (Cr), Barium (Ba), Manganese (Mn), and Uranium (Cu) concentrations in the inflorescence of *Leptochloa fusca* collected from high traffic roadsides were 0.08 mg/kg, 619 mg/kg, 10.77 mg/kg, 0.03 mg/kg, 0.14 mg/kg, 6.19 mg/kg, 0.12 mg/kg, 2.07 mg/kg, 2.72 mg/kg, and 0.02 mg/kg, respectively, and significantly higher than those of *Leptochloa fusca* collected from low traffic roadside (biological science garden), which were 0.01 mg/kg, 1.13 mg/kg, 6.32 mg/kg, 0.00 mg/kg, 0.02 mg/kg, 1.19 mg/kg, 0.00 mg/kg, 1.19 mg/kg, 1.23 mg/kg, and 0.00 mg/kg. This finding is consistent with a study conducted (Sharma & Dubey, 2005) which demonstrated that the lead cycle induced by human activity is longer than the natural lead cycle, making lead contamination a global problem. It was discovered that car emissions have been linked to trace metal contamination in soils (Krailertrattanachai et al., 2019). For the common trace metals cadmium, cobalt, chromium, copper, nickel, lead, vanadium, and zinc in roadside agricultural soils with varying traffic densities, the degree of contamination, the impact of traffic density, and the distance from highways on the concentration of trace metals in the environment were investigated. This is consistent with recent research that has demonstrated that traffic densities vary the distribution of these heavy metals. Table 4.1 illustrates this, demonstrating that vehicle exhaust emissions are a major source of pollution to the environment as the concentrations of heavy metals significantly decrease in low traffic conditions.

The heavy metal levels (Pb, Cu, Zn, Hg, Cd, Ni, Cr, Ba, Mn, and U) in the inflorescence of *Leptochloa fusca* from the busy roadside of Anyigba Market Road, which was selected due to its traffic volume, age, and environment, have been assessed with the aid of this study. This study, which took into account the effects of traffic volume, road age, and urbanization level, also coincides with research conducted by Bernadino et al. (2019) on metal buildup in roadside soils of Rio de Janeiro, Brazil. Cadmium, Cobalt, Chromium, Copper, Iron, Manganese, Nickel, Lead, Strontium, Vanadium, and Zinc were evaluated in the study on samples that were taken at various separations from the road (1, 3, 5, 10, and 15 m). Their study's findings demonstrated how each highway's soil metal levels are greatly influenced by variables like traffic volume, proximity to the road, and additional human-caused pollution sources. It was evident that the high roads with heavier traffic had the highest quantities of soil metals. The findings of the current study support this finding: samples of *Leptochloa fusca* inflorescence collected from heavily trafficked areas had higher concentrations of heavy metals than samples collected from less trafficked areas, which had lower concentrations of heavy metals than samples collected from heavily trafficked areas. This study determined that in the inflorescence of *L. fusca* gathered from high-traffic roadways coupled with some car fuel, zinc (Zn) had the greatest content (10.72 mg/kg). Pulles et al. (2012) state that heavy metals are a significant class of persistent hazardous contaminants that are present in other media including ambient air. The burning of transportation fuels in cars is one of the likely sources of this metal in the environment. There is a great deal of variation in the heavy metal concentrations found in gasoline and diesel fuel between various samples. The inflorescence of *Leptochloa fusca* obtained from both high- and low-traffic locations showed the lowest concentration of uranium heavy metal, with amounts of 0.02 mg/kg and 0.00 mg/kg, respectively. This might be because the research area uses very little fuel. Melo et al. (2011). In addition to vehicle emissions, other local elements that can impact the concentrations of heavy metals in the environment include the use of pesticides and fertilizers in agriculture, the climate, and human activity. Understanding the homology of pollution sources would be aided by the correlation analysis of the common soil heavy metals linked to traffic activities (Zhang et al., 2019). There was a relationship between the concentration of lead and the volume of traffic, which suggests that the lead originated from vehicle exhaust (Aslam, 2013). According to this study, *Leptochloa fusca* inflorescence has the potential to be a valuable bio-indicator of air pollution.

Conclusion

The result showed the concentration of heavy metals in the inflorescence of *Leptochloa fusca* collected from high traffic roadsides was significantly higher ($P<0.05$) compared to the concentration of heavy metals found in the inflorescence of *Leptochloa fusca* collected from low traffic roadsides and the elevated levels of Lead (Pb), Copper (Cu), Zinc (Zn), and Mercury (Hg) that have been reported in the high-traffic road highlight the potential impact of vehicular activities on air and environmental conditions. Considering that living things are exposed to pollutants from vehicle exhaust, more should be done to discourage people from living by the side of the road. To determine the amounts of pollution that plants and other animals can absorb and inhale, roadside locations must undergo routine monitoring and assessment of contaminants. More research is necessary to determine whether *Leptochloa fusca* inflorescence is a reliable bio-indicator of environmental pollution and how to use it to assess various pollutants. Simultaneously, it is advisable to monitor vehicle fuel levels to ensure that they do not contribute to pollution. This will support a bigger effort to reduce vehicle pollution and the hazards that life on the road poses to people and the environment.

Author contributions

Edogbanya Paul Ramallan Ocholi conceived the research idea, Bello Christiana Ojochogwu carried out the laboratory experiments and prepared the manuscript, Victor Ugbede Okpanachi proofread the manuscript.

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Conflict of interest

The author declares no conflict of interest. The manuscript has not been submitted for publication in other journal.

Ethics approval

Not applicable

AI usage statement

No AI and related tools are not used to write the manuscript.

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