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Research paper

Employing spider webs for environmental investigation of suspended trace metals in residential and industrial areas

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A R T I C l E I N F O

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A B S T R A C T

Spider webs were gathered from residential and industrial areas to found the order of heavy suspended metals in the air. The treatment of spider webs were done with nitric acid and digested by atomic absorption spectrophotometer before analysis (AAS). The average value of several heavy metals concentration were observed to be meaningfully great at $p < 0.05$ in suspended ingredients in industrial zones including, Cadmium (Cd) 0.15 ± 0.05 and Lead (Pb) 0.53 ± 0.09 µgg-1, respectively. The average values of concentration of Copper (Cu), Nickel (Ni) and Zinc (Zn) were not meaningfully changed from residential, industrial and control zones. It was observed that, the heavy metals concentration reduces when the web specimens were collected more away from the road.

Introduction

Controlling trace metals of street dust has prepared an instrument for approximating the contamination degree, habitat and source of industrial and residential commercial zones (Smith and Aust 1997, Trevarthen, Aitken et al. 2006). Emissions of motor vehicle and industrial street dust are airborne ingredients sources in urban zones. The emitted motor vehicles particles contain or carry heavy metals that might be toxic of existing more than natural background orders. The toxic features of this airborne ingredient might be owing to the metals biochemical activity devoted to them. The particles existing in domestic airborne aerosol has an important role in toxicological impacts (Yassoglou, Kosmas et al. 1987, Wilczek, Babczynska et al. 2003, Żmudzki and Laskowski 2012). Being suitably insoluble and small, these may get sufficient time to enter the deepest lungs zone causing asthma attacks and intensify suffering. Species of spider webs, Stiphidion facetum, were frequently observed in both built and natural structures on rocks, trees, under bridges, fallen logs and caves wall. This spider web is a tightly woven sheet of cribellate silk that hangs such as a hammock, pasted to the substrate via supporting threads in some areas around perimeter (Kowalczyk, Gordon et al. 1982, Babczyńska, Wilczek et al. 2006, Butt and Aziz 2016). The spiders repeatedly repair the webs but if severely removed or damaged, they construct another one; therefore, renewable webs might be suitable for evaluating temporal change. Zmudzki and Laskowski (2012) investigated the structure and biodiversity of communities of spider beside a metal pollution particles and found that community of spiders might be influenced by heavy metals by indirect and directly pollutants' impact. The heavy metals order in spider webs could be employed for obtaining environmental pollution or contamination and quality control. Spider webs have been revealed as suitable heavy metals index related to emission of particles (Hose, James et al. 2002). In several developing countries, controlling pollution might be very expensive owing to the economic condition. If the monitoring tool is accessible, maintenance and handling might pose an issue since the maker might not regard the country weather condition. So, there is necessary to search for economical way for controlling trace metals in environment. The goal of the current study is to evaluate the air quality in residential and industrial environment by spider webs as an index.

Sampling area

Ota city of Ogun State is the centers of industrial nerve, lying among longitude 3° 13′ 47″ E and latitude 6° 42′ 0″ N. 3 industrial zones were Lagos-Abeokuta express way, Idiroko road and Ijoko road. The residential zones involve Sango, Ota and Ijoko, though the control zones involves Federal Polytechnic Ilaro farmlands, beside Oja Odan road without settlements of human and industrial activities happen with the exclusion of limited passage on the road with vehicular. Ilaro is situated on longitude 3° 13′ and 47″ E latitude 6° 42′ 0″ N.

Sample collection

Spider webs were gathered from residential and industrial zones of Southwest, Ota Ogun State, Nigeria. These spider webs were gathered in January/February. To make sure comparable and uniform webs age at each zone, the webs were recognized and gathered after 7 days.

Specimen treatment

The gathered webs were alcohol washed to eliminate air-dried, greasy matter, digested by treating 1 gram of each web using intense acid nitric and then boiled, re-dissolved and boiled during 6 hours. Specimens were re-suspended in acid nitric and 2.0 milligram of 30 percent hydrogen peroxide. The remain was repetitively re-suspended in acid nitric and heated at 120°C to complete digestion.

Specimen analysis

Trace metals determination was quantitatively done via Atomic Absorption Spectrophotometer (Bulk Scientific Model).

Statistical analysis

Information were analyzed via 1 way ANOVA.

Discussion and Results

Table 1 presented results in detail attained from various zones. The maximum average concentration values of Lead (Pb) equal to 0.44, 0.62, and 0.53 µgg^{-1} was documented respectively in industrial zones A, B and C. The average Pb values of 0.06, 0.05, and 0.01 µgg^{-1} was documented respectively from residential zones D, E and F, though 0.02 µgg^{-1} was documented respectively for control zones G, H and I. Also, the average concentration values of Cadmium (Cd) equal to 0.11, 0.14, and 0.20 µgg^{-1} was documented for industrial zones, though 0.04, 0.04, and 0.03 µgg^{-1} was documented from residential zones and 0.01 µgg^{-1} was documented from the control zones. The average concentration values of Zinc (Zn) from industrial zones respectively are 0.35, 0.18, and 0.18 µgg^{-1}, though those from residential zones respectively are 0.27, 0.18, and 0.18 µgg^{-1}. The average concentration values of Zn equal to 0.01 µgg^{-1} was documented from the control zones. The average concentration values of Nickel (Ni) from industrial zones respectively are 0.0.04, 0.02, and 0.01 µgg^{-1}, though those from residential zones respectively are 0.01, 0.01, and 0. 03 µgg^{-1}. The average concentration values of Ni equal to 0.01 µgg^{-1} was documented from the control zones. The average values of Copper (Cu) documented from residential, industrial and control zones are nearly similar to the average value of 0.01 µgg^{-1} documented from all zones (Table 1). Table 2 presented the statistical analysis of metal specimens results gathered from residential, industrial and control zones. There was an important variance in Pb and Cd concentration from residential and industrial zones, while there was no important variance in Ni, Zn and Cu concentration from residential, industrial and control zones. Also, Figs. 1, 2 and 3 displayed the metal concentrations differences from different intervals of high way. The maximum Pb, Cd, Zn, Cu and Ni concentration respectively are 0.98, 0.42, 0.52, 0.03 and 0.05µgg^{-1}, as documented from zones A, C, A, A, and B that are entire industrial zones (Table 1). This reality was more validated by the statistical analysis results that displayed that the Pb concentrations was meaningfully upper in spider web specimens gathered from industrial zones with the average value of 0.53 ± 0.09 µgg^{-1}, though there was no important variance in the average values of Pb documented from control and residential zones (Table 2). Also, concentration of Cd was meaningfully upper at $P < 0.5$ in industrial zones with the average value of 0.15 ± 0.05 µgg^{-1}, while no important variance in average values was documented from control and residential zones.

Table 1. Detailed outcomes of elements concentration (μgg^{-1}) obtained in spider webs gathered from various residential (D, E, F), industrial (A, B, C), and control zones (G, H, I) (N = 27).

Element	A	B	C	D	E	F	G	H	I
Pb	0.44	0.62	0.53	0.06	0.05	0.01	0.02	0.02	0.02
Cd	0.11	0.14	0.20	0.04	0.03	0.03	0.01	0.01	0.01
Zn	0.5	0.18	0.18	0.27	0.18	0.08	0.01	0.0	0.01
Ni	0.04	0.02	0.01	0.01	0.01	0.03	0.01	0.01	0.01
Cu	0.01	0.01	0.01	0.01	0.003	0.01	0.01	0.01	0.01

However, for Zn, Cu and Ni, there was no important variance. The values documented for Pb might be because of industrial activities in zone however the reality that considerable values are documented in the control and residential zones easily specifies that Pb in suspended ingredients are presenting how unsafe the air were in which we breadth. Gathering of metals by spiders particularly Pb in these zones is probable to happen. Laskowski and Kammenga (2000), stated spider equally one of the territorial invertebrates that gather the maximum concentrations of several trace metals. While intoxicated by metals they display robust physiological reactions because of the intoxication, for instance, with raised orders of detoxifying enzymes that might cause changes in their budgets of energy. Xiaoli et al. (2006) presented the Pb average concentration of 4.5 times higher from various zones and meaningfully great value in spider webs at $P < 0.05$. Though, motor vehicle particle emissions are a likely source (de Miguel, Llamas et al. 1997, Sternbeck, Sjödin et al. 2002). By elimination of Pb from petrol in the world, fuels combustion is now an unimportant emissions source of Pb, however might participate Cd and Zn (Sternbeck et al., 2002). The Pb source in Nigerian oil is probably because of illegal refineries emergency that used illicit approaches [for instance, tetra ethyl lead (TEL)] in the crude oil refining and their products smuggling into the market of Nigerian. Brake linings are nowadays the most public Pb source in roadside environments, though Pb contaminated dusts re-suspension stay a matter (De Miguel et al., 1997). Brake linings wearing is the major Cu sources, and the motor oils and tyres wear are regarded the key Zn sources (Sternbeck et al., 2002). Regarding the specimens zones' interval to the major road that activities of vehicles regularly happen; Figs. 1, 2, and 3 displayed difference of elements during consideration and their different concentrations. At all the intervals from the major road, the level of concentration was Pb > Zn > Cd > Ni > Cu (Figs. 1, 2, and 3). The Pb concentration at 100, 200, and 300 m respectively were, 0.34, 0.18, and 0.09 μgg^{-1}, presenting that vicinity of the specimen zone to the high busy road is a major parameter. The webs were gathered by Hose et al. (2002) from reference zones which were further than 30 kilometer from the closest main road. Xiaoli et al. (2006) stated webs which included 30 μg/g of Pb and 100 μg/g of Zn that are fewer than the concentration documented in urban reference zones. These results for Pb, Cd, and Zn are in agreement with prior investigations which have revealed a reduction in concentrations of metal with increasing interval from the road. This might be clarified by the study of Smith (1997) who presented that around 40 percent of emissions of particle have diameters more than 9 μm that owing to their great gravitational settling velocity, settle rapidly and are placed in around 10 meter from the road. Around 20 percent of the ingredients have diameter among 1 and 9 μm and are placed around 40 meter from the road. The residual 40 percent of the ingredients have diameters fewer than 1 μm and stay suspended for a long time in the atmosphere and might be transferred far away from the road. Utmost Cu is related to ingredients with size of 1 to 10 μm and an average size of 6 μm.

The concentration variance between the zones easily shows variances in the webs' ages from each zone. Research was done to sample the matured spiders' webs to make age and size limits of webs from each zone as similar as possible. The importance of finding the age of web as implemented in the current investigation is that it prepares a particular web age as webs gather heavy metal loads during a period of time, that gives webs a separate benefit over strategies of straight air sampling (like dynamometric experiments) which just prepare a view of conditions.

Table 2. Concentration distribution ±SD ($\mu g g^{-1}$) of elements obtained in spider webs gathered from various residential, industrial and control zones (N = 27).

Location	Pb	Cd	Zn	Ni	Cu
Industrial	0.53	0.15	0.24	0.02	0.01
Residential	0.04	0.03	0.18	0.02	0.01
Control	0.02	0.01	0.01	0.01	0.01

Superscripts with the similar letters below the column are not meaningfully various based on Duncan Multiple Range Test (P < 0.05)

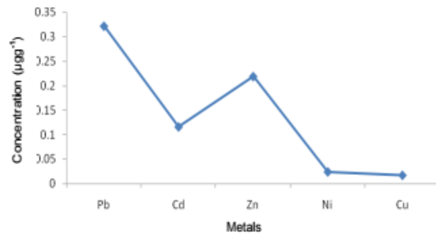

Fig. 1. Metal concentrations difference at a distance of 100 meter from road.

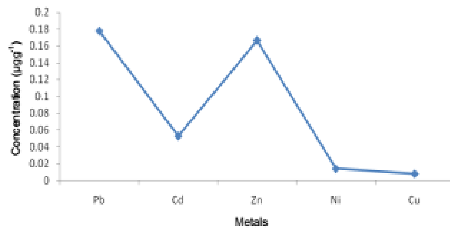

Fig. 2. Metal concentrations difference at 200 meter from road.

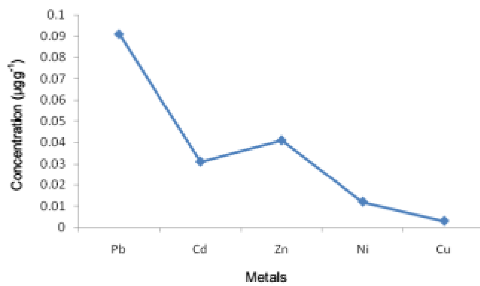

Fig. 3. Metal concentrations difference at 300 meter from road.

Conclusion

In this paper, we study metals' concentration in suspended ingredients in spider webs from residential and industrial zones. The metals' concentration in spider webs from the investigation zone is not just affected by industrial activities but then vehicular movement largely participated to the values documented. Investigations must be increased to control vehicular emission on a ordered basis to guarantee safe environment.

Conflict of interest

The authors declare that they have no conflict of interest.

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