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MONITORING THE LEVEL OF HEAVY METALS POLLUTION IN AUTOMOBILE MECHANIC WORKSHOPS USING TREE BARKS

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ABSTRACT

The level of heavy metals at automobile mechanic workshops were monitored by examining tree barks of different species and influence of sampling heights on the metals level. This was with the aim of determining the suitability of using tree barks in monitoring the level of air pollution. Tree bark samples were collected at 2 and 4 m heights from different automobile mechanic workshops around Ile-Ife metropolis and at control sites. The samples were transported to the laboratory, oven-dried at 60 °C to a constant weight; ground and analyzed for Pb, Cu, Cd, Fe and Zn using Atomic Absorption Spectrophotometer. Results showed that the concentration of Fe, Cu and Pb at the mechanic sites were significantly ($p < 0.001$) higher at 2 m than 4 m height in all the species. The concentration of Zn was significantly ($p < 0.001$) higher at the 2 m height in all the sites except for *Gliricidia sepium*. The concentration of Cd was however, significantly ($p < 0.05$) higher at the control site at the two heights for the species except for *Gliricidia sepium* and *Terminalia catappa*, that showed no significant difference ($p > 0.05$) between the sites. The correlation value of 0.94 was observed between Zn and Cd; 0.76 between Pb and Cd, and 0.50 between Zn and Pb. This study showed that different species have different affinities for air pollutants and that soil particles also acted as a source of heavy metals in our environment.

Keywords: Atmospheric, Automobile, Pollutants, Soil particle, Trace metals, Tree barks

INTRODUCTION

Environmental pollution is one of the biggest problems facing the world; it is a big global issue that is affecting man and our environment today. Rapid urbanization, industrialization, and phenomenal increasing population are major factors causing environmental pollution in the world. These activities have led to corresponding increases in atmospheric concentration of primary and secondary pollutants (Mage *et al.*, 1996). The different parts of biosphere are impacted upon negatively by different inorganic and organic contaminations because of man-made activities and this modify the normal biogeochemical nutrients cycling (Mahanta and Bhattacharyya, 2011; Montoneri *et al.*, 2014). Heavy metals are characteristic parts of the earth, they are released into the atmosphere in various ways, i.e. transportation, industry, petroleum products, agriculture, and other man-made activities (Butkus and Baltrenaite, 2007; Cayir *et al.*, 2008). Automobiles constitute one of the major modes of transportation for conveying people and goods in many nations of the world; the usefulness of this mode of transportation is not without its negative impact. Pollutants from the exhaust of motor vehicles represent 60-70% of the contamination found in urban area (Tripathi and Gautam, 2007).

The discharge of pollutants at varying concentrations into environments (air, soil and water) needs to be monitored and controlled regularly. Biomonitoring method has been extensively used as a tool for assessing environmental pollution (Olowoyo *et al.*, 2010; Odiwe *et al.*, 2014). In biomonitoring, living species are used to monitor toxic metal pollution in the environment. Plant species, like moss, lichen, pine barks and pine needles have been extensively used for monitoring atmospheric pollution. This is because they are very easy to handle, readily available and more convenient (Olowoyo *et al.*, 2010). Generally, there is no consensus on the unique species that is suitable as biomonitors of trace metal pollutants all over the world, though trees with rough barks have been found to be more effective (Santamaria and Martín, 1997; El-Hasan *et al.*, 2002). For this reason, different species have been used and still being used as bio-monitors in different parts of the world. Among these bio-monitors, tree bark is known to absorb and accumulate airborne contaminants and has therefore been used for monitoring of atmospheric pollution (Odukoya *et al.,* 2000; Olowoyo *et al.*, 2010). It has been reported that airborne pollutants are mostly accumulated in the outer bark of trees (Harju *et al.*, 2002).

Schelle *et al.* (2006) pointed out that it is possible to use tree barks from different species in similar environmental bio-monitoring studies. Conti and Cecchelti (2001) has reported that there are different mechanisms of accumulation of elements from the environment (atmosphere) which include particulate trapping, ion exchange, extracellular electrolyte sorption, hydrolysis, and intracellular uptake. In Nigeria, the general practice is that automobiles are taken to roadside mechanics by the users for either repair or general maintenance work. Most of these auto mechanic workshops are usually located in areas where trees such as *Spondias mombin* (Anacardiaceae), *Terminalia catappa* (Combretaceae), *Gliricidia sepium* (Fabaceae) and *Senna siamea* (Fabaceae) can provide shade. From previous literature, it has been established that tree barks of different plant species found at the workshops may accumulate the pollutants that are released into the atmosphere (Ojekunle *et al.*, 2015; Agboola *et al.*, 2016).

Generally, studies on air pollution caused by automobile workshops are available (Wong and Lau 1985; Iwegbue, 2007; Ipeaiyeda and Dawodu 2008), but there is a need for continuous research with the use of tree bark for biomonitoring, not just because of the negative effect on the bark but also the indirect effect on humans that rely on these barks for medicinal purposes. Studies using the above-mentioned trees have not been carried out to determine their suitability in assessment of trace metals in the environment (atmosphere). Therefore, this study was carried out to assess the suitability of the back of different tree species that were not previously reported as biomonitors of toxic trace metals found at the mechanic workshops in Ile-Ife, Osun State, Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out in eight different mechanic workshops situated in Ile-Ife metropolis ($7^0$29'42.3"N latitude and $4^0$28′30″E longitude) in Osun State, southwestern Nigeria. The study sites were chosen based on the presence of these trees, the various activities at the workshop and the distance to the main road. The geographical locations (geo-reference) of the study sites were obtained using a Global Positioning System (GPS).

The description of the climate, soil and the vegetation of Ile-Ife have been given in details in our earlier published work (Odiwe *et al.*, 2012). Most of the original lowland rainforests have been destroyed leaving remainder of secondary forest scattered around. The actual age of the trees cannot be ascertained but most of the trees were not less than 10 years based on the information gathered from the operators/owners of the mechanic workshops, the mean yearly temperature of the study site is 25.5 °C with an average yearly precipitation value of 1302 $mmyr^{-1}$ (OAU APRG, 2015). The description and details of the sites are given in table 1.

Table 1: Location, Elevation and Coordinates of the Different Study Sites in Ile-Ife, Nigeria.

Site	Description	Elevation	Latitude	Longitude
1.	Located around Lagere road in Ile-Ife and has been in use for over 15 years. Spraying, rewiring and welding are common activities at the site. *Gliricidia sepium* is present	296 m	N07^{0}29.369'	E04^{0}33.707'
2.	Located along the same area and similar activities as in site 1 are performed at this site. *Gliricidia sepium* also present	301 m	N07^{0}29.396'	E04^{0}33.676'
3.	The site is located very close to site 1 and 2, around Lagere area, Spraying, rewiring and welding are common activities and the tree species found at the site is *Senna siamea*.	289 m	N07^{0}29.501'	E04^{0}33.549'
4.	Located along Lagere road in a busy city center of the town and extensively used. The shade tree species found in this site is *Spondias mombin*.	263 m	N07^{0}29.330'	E04^{0}32.242'
5.	Located at Olurin Street, Ondo road round about. The site has been in existence for over 12 years and the activities at this site are auto -mobile repair, welding, spraying of parts, panel beating, vulcanizing. The tree species found in this site is *Senna siamea*	313 m	N07^{0}27.633'	E04^{0}33.242
6.	Along Ondo road, heavy vehicle/trailer/ trucks are repaired here. Soil at this site is highly polluted going by the very dark soil colour. The tree species found in this site is *Terminalia catappa*.	303 m	N07^{0}27.654'	E04^{0}33.159'
7.	Located along Ondo road, it shares the same major road as site 6 but located about the tail end of the road. Activities noticed in this site are panel beating, engine repairs, servicing and spraying. Tree species found at this site is *Terminalia catappa*. It is about 2 km to site 6	264 m	N07^{0}29.064'	E04^{0}32.139'
8.	The site is along Ondo road. Activities at this site are automobile engine repairs, panel beating, vulcanizing, spraying. Refuse burningis also common. *Spondias mombin* is present here.	264 m	N07^{0}29.063'	E04^{0}32.137'

Sample Collection and Analyses

The trees used in this study were planted as shade plants around the workshops; with nothing less than six stands of the same species at the workshops. Six to eight trees of approximately the same girth size from each of the workshops were used in the study. Tree bark samples were collected from the tree species present in each of the automobile mechanic workshops (Table 1). For the control site, samples of tree barks of the same species found in the mechanic sites were collected at the Obafemi Awolowo University (OAU) Botanical Garden, Ile-Ife which is reasonably free from automobile pollution activities (about 4 km to the closest site where experimental samples were taken).

Tree bark samples were collected at approximately 2 m (Barnes *et al.*, 1976) (to assess effect of soil particles) and 4 m above the soil (to assess the pollutants). The tree bark samples were obtained by utilizing a properly washed stainless steel knife and washed after each collection with 10% HNO_3 to avoid contamination. The collection was done during dry season and they were replicated six times. The samples were collected around the whole diameter of the trees. The bark samples were parked in a plain white paper, put in a polythene bag and taken to the laboratory. The samples collected were oven-dried at 60 °C to a constant weight, ground into powdery form and analyzed for the presence of the following heavy metals: Cu, Pb, Zn, Fe and Cd using the method described by Tel and Rao (1982).

Statistical Analysis

Two-way ANOVA was used to compare the level of heavy metals in the polluted sites (automobile mechanic workshop) and unpolluted site (control site), and at the two heights (2 m and 4 m) in each of the species. The significant means are separated using a post hoc analysis (LSD). The statistical analysis was done using SAS 9.3 model.

RESULTS

Concentration of Iron

The concentration of Fe in the polluted sites (mechanic workshops) was significantly ($p < 0.001$) higher at 2 m compared with the 4 m height in all the species (Figure 1). From the 2 m height, the concentration ranged from 92.83 ± 4.30 to 110.49 ± 3.21 ppm; and 84.84 ± 2.21 to 111.22 ± 6.19 ppm at the 4 m height.

Concentration of Copper

The concentration of Cu followed similar trend like that of Fe, where the concentration in all the species was significantly ($p < 0.001$) higher in the polluted sites (mechanic workshops) at 2 m height compared with the 4 m height (Figure 2). From the 2 m height, the concentration ranged from 4.26 ± 0.08 to 5.72 ± 0.18 ppm; and 3.73 ± 1.13 to 5.29 ± 1.21 ppm at 4 m height.

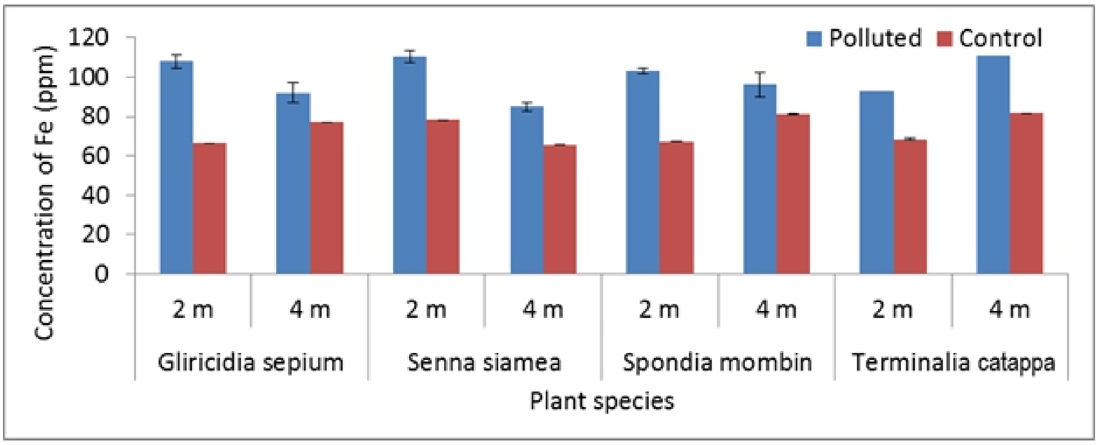

Figure 1: Mean Concentration of Fe in the Control and Polluted Sites across the Species and between the Heights. Bars on the column represent the standard error of the mean, n = 6.

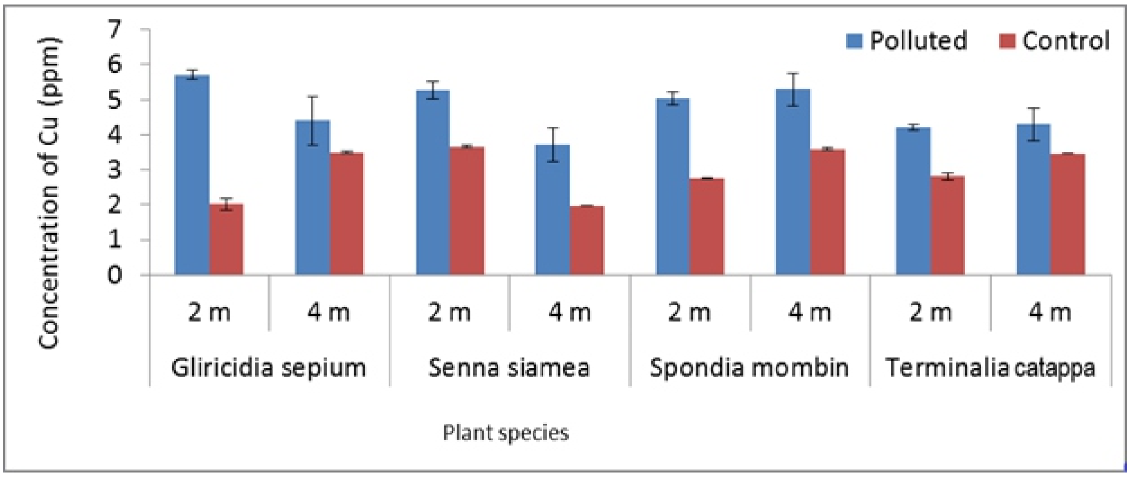

Figure 2: Mean Concentration of Cu both in Control and Polluted Site across the Species and between the Heights. Bars on the column represent the standard error of the mean, n = 6.

Concentration of Zinc

The concentration of Zn in the analyzed tree barks in all the species (Figure 3) revealed that the polluted sites was significantly ($p < 0.001$) higher compared with control site at the 2 m height in all the species except for *Gliricidia sepium* species, where control was higher at 4 m height; and in *Terminalia catappa* where there was no significant ($p > 0.05$) difference between the control and polluted sites. From the 2 m height, the concentration of Cd ranged from 55.52 ± 3.82 to 59.55 ± 0.26 ppm; and 27.43 ± 2.14 to 55.07 ± 2.49 ppm at the 4 m height.

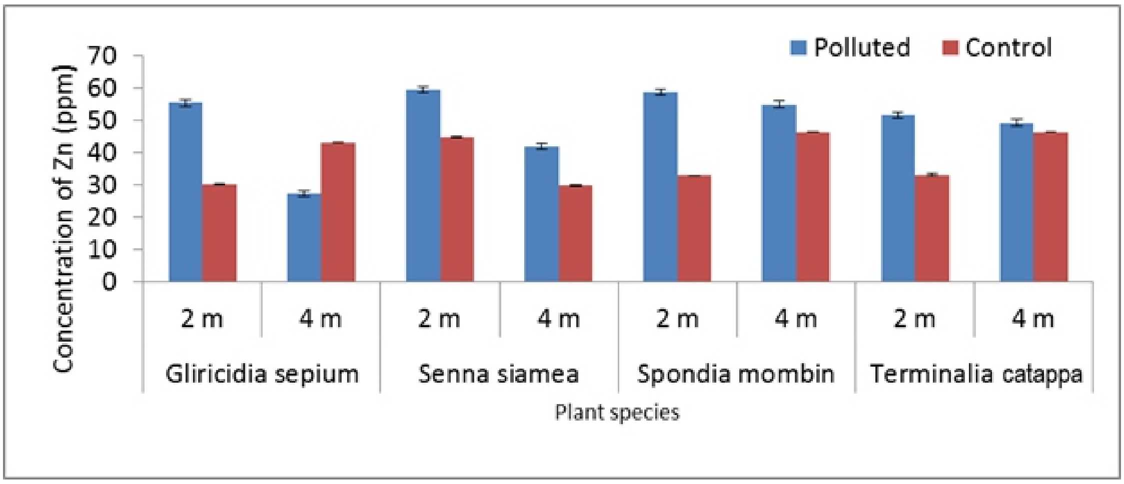

Figure 3: Mean Concentration of Zn both in Control and Polluted Site across the Species and between the Heights. Bars on the column represent the standard error of the mean, n = 6.

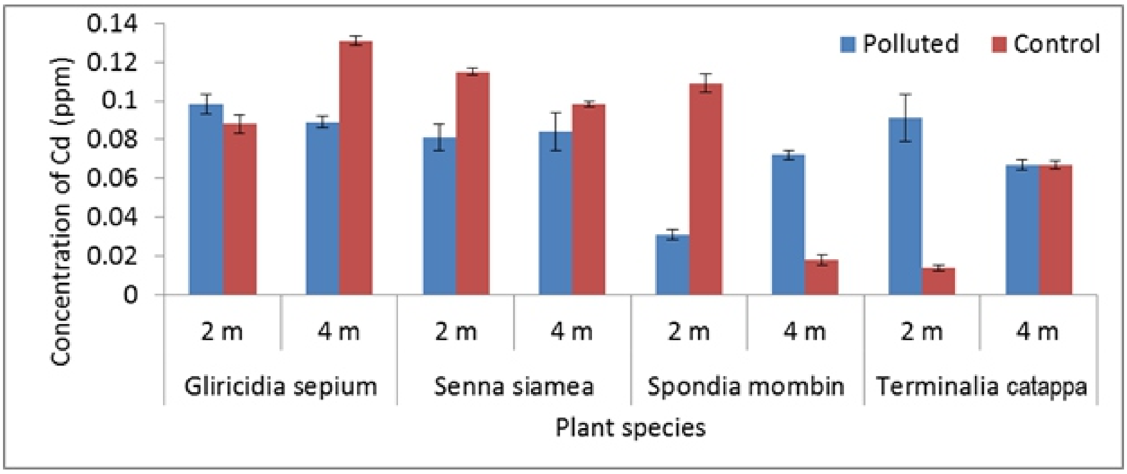

Figure 4: Concentration of Cd both in Control and Polluted Site across the Species and between the Heights. Bars on the column represent the standard error of the mean, n = 6.

Concentration of Cadmium

The concentration of Cd was significantly ($p < 0.05$) higher at the control site compared to the polluted sites in all the species at the two heights except for *G. sepium* and *T. catapa*, where there was no significant difference ($p > 0.05$) between the polluted and the control at 2 m and 4 m heights respectively (Figure 4). It should however be noted that, the concentration of Cd in the polluted sites was significantly ($p < 0.05$) higher in *Spondias mombin* at 4 m height and in *T. catappa* at 2 m height. From the 2 m height, the concentration of Cd ranged from 0.03 ± 0.01 to 0.11 ± 0.01 ppm; and 0.07 ± 0.01 to 0.09 ± 0.01 ppm at the 4 m height.

Concentration of Lead

The concentration of Pb in all the species was significantly higher in the polluted sites compared with the control at the two heights except for *Terminalia catappa* where there was no significant difference between the control and the polluted ($p < 0.05$) at the 2 m height (Figure 5). From the 2 m height, the concentration of Pb ranged from 0.07 ± 0.01 to 0.26 ± 0.02 ppm; and 0.06 ± 0.02 to 0.18 ± 0.03 ppm at the 4 m height.

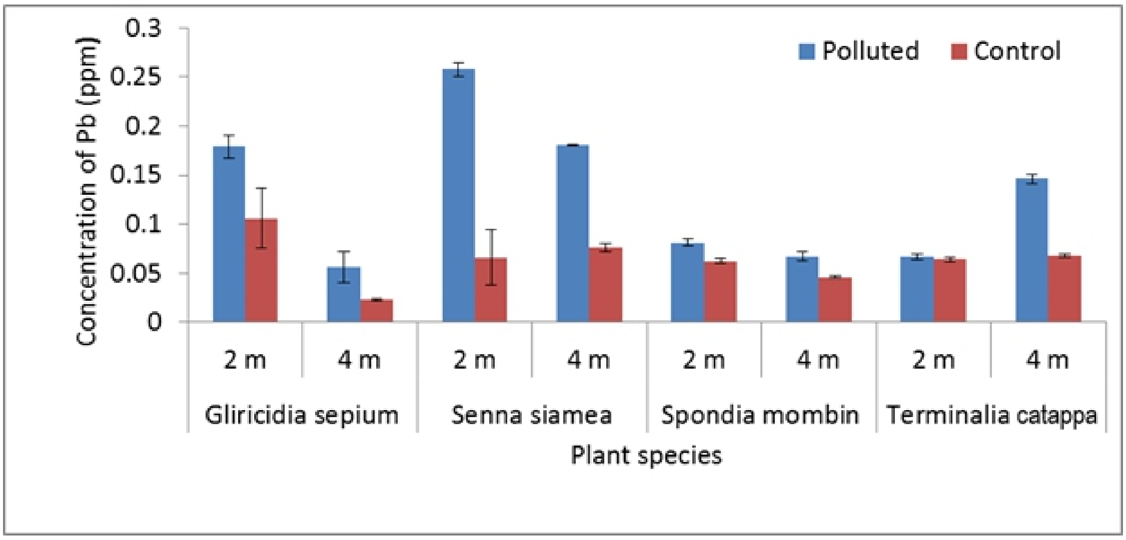

Figure 5: Concentration of Pb both in Control and Polluted Site across the Species and between the Heights. Bars on the column represent the standard error of the mean, n = 6.

Relationship between heavy metals at both heights and across the sites

Pearson correlation coefficient was used to establish if there was any relationship between level of heavy metals in the samples from the sites at both 2 m and 4 m height (Table 2). It was obvious from the matrix that there was a positive and strong correlation among elements that are associated with vehicular emission. The positive high correlation values of 0.94, 0.76, and 0.50 were observed between Zn and Cd; Pb and Cd; and Zn and Pb respectively (Table 2).

Table 2: Correlation values showing the relationship between the trace metals across the study sites

Heavy metals	Fe	Zn	Cu	Cd	Pb
Fe	1				
Zn	0.30	1			
Cu	-0.21	-0.99	1		
Cd	-0.05	**0.94**	-0.97	1	
Pb	-0.68	**0.50**	-0.58	**0.76**	1

DISCUSSION

Concentration of Iron

The higher level of Fe obtained at the automobile workshops compared to control site in this study showed that Fe is linked to activities like repair, burning and maintenance services at the workshops. This finding is consistent with results of Ademoroti (1990); Olowoyo *et al.* (2010): Mbong *et al.* (2014) and Odiwe *et al.* (2014) where higher Fe concentration at the polluted sites compared with unpolluted area was reported. The higher values recorded at the lower height (2 m) close to the ground surface compared to higher height (4 m) across the sites give an indication that soil/dust particles also serve as a source of heavy metals in our environment. This observation is in agreement with the findings of Frati *et al.* (2005) and Ho and Tai (1998) who reported that the occurrence and distribution of Fe as pollutants in the environment originate mainly from soil particles.

Concentration of Copper

The pattern of increased concentration of Cu observed at both heights for the polluted sites compared with the control sites in this study might be associated to some extent with automobile repair activities at the sites. The source of Cu may be due to corrosion of metallic parts of cars derived from engine wear, thrust burning, brushing and bearing metals, scrap batteries and other parts at the mechanic workshops (Odiwe *et al*., 2014). Olowoyo *et al.* (2010) in their study have also reported that the sources of Cu were related to corrosion of metallic parts of cars derived from engine wear, thrust burning and other activities around the polluted sites.

Concentration of Zinc

The higher concentration of Zn just like Pb and Cu recorded at the automobile mechanic sites compared with the control site at both heights might be linked with repair and maintenance activities at the sites. The accumulation of lead recorded in this study might be as a result of numerous activities involving lead and its products that are carried out by the automobile technicians. These activities include spray painting, panel beating, metal cutting, radiator repair, battery charging, and welding as well as repair works by mechanic. This observation is consistent with the findings from other studies (Nyle and Ray, 1999; Elik, 2003; Khan *et al*., 2011). The average concentration of Zn from the two sites (at both heights) (27.42-55.51 ppm) is very low compared to the acceptable value of 300 mg/kg (Faiz *et al*., 2009); and the values of 410 µg/g and 715 µg/g reported for Zn from studies conducted in Jordan and China respectively.

Concentration of Cadmium

The higher concentration of Cd in the control site compared with the polluted site in this study contradicts the general belief that Cd release is associated with combustion products in the carburetors of motor vehicles (Divrikli *et al*., 2006). However, the present result did not show that the level of this trace element in all the sites is associated with automobile related activities. Though, metal production and refining are additionally known to be a source of cadmium discharge into the atmosphere as well as during manufacture of batteries (Al-Khashman and Shawabkeh, 2009). However, the higher level obtained at the control sites indicates the level of the metal in the soil. Cadmium is also known to be an inevitable by-product of zinc, lead and copper and it is also found in manures and pesticides which may be the case for samples collected from the botanical garden. The level of Cd from this study (0.02 -0.13 ppm was lower than the values reported by Olowoyo *et al.* (2010) in Pretoria (0.12-1.34) and Odiwe *et al.* (2014) in Ile-Ife.

Concentration of Lead

The higher concentration of Pb recorded at the polluted sites compared with the control at both heights might be related to the volume of vehicles that come for repair and maintenance activities. This might suggest anthropogenic source for the metal. Sources of Pb in the environment have been pointed out to include soil and dust from combustion of gasoline that contains tetraethyl lead as anti-knock agent (Tuzen, 2003). Burning of fossil fuels and traffic has also been reported to contribute to the high level of Pb (Al-Khashman, 2007). Olowoyo *et al.* (2010) in their study also reported that high level of Pb was obtained from sites with high traffic. Report from other researchers suggested a long history of metal contamination in urban environment due to re-suspension which may in turn account for the presence of Pb in the environment (Li *et al*., 2001). The results obtained in this study are comparable to heavy metal concentrations obtained by Ho and Tai (1998), who found that concentration of various heavy metals in urban city of Hong Kong are high. They correlated high Pb level with higher traffic density and the extent of aerial deposition volume of heavy metals. The level of Pb recorded at the mechanic workshops in this study is consistent with the findings of Lukashev *et al.* (1994); Lippo *et al.* (1995) and Poikolainen, (1997) in Europe, where Pb concentration of the barks have been reported to be in the range of < 5 ppm and even in some places, < 1 ppm).

Relationship between the heavy metals across the sites at the two heights

The strong correlation coefficient for some of these metals may imply that these elements might have originated from the same source which in this case could be linked to vehicular emission and automobile repair activities at the various sites in this study area. The correlation coefficient recorded for these metals in this study is in agreement with the results of Faiz *et al.* (2009), who also reported a positive correlation for the metals in their study. The poor correlation values for some of the other metals (Fe and Cu; Fe and Cd and Fe and Zn) might indicate that the metals are not from the same source (automobile pollution) but rather from some other sources (Table 2). Generally, the higher concentration of the pollutants at the lower height (2 m) compared with the upper height (4 m) simply indicates that soil particles played a major role in the levels of the pollutants recorded in this study. This observation is consistent with the findings of Huhn *et al.* (1995) and Schulz *et al.* (1999) who reported that concentration of heavy metals in tree barks is generally found to be a function of heavy metals deposition.

CONCLUSION

The heavy metals concentration in the tree barks gave a clear indication that trees found in automobile mechanic workshop might have been bio accumulating some metal pollutants. The tree barks were found to be a good bio-indicator of trace metals like Fe, Pb, Zn, and Cu; which are the most pronounced elements detected in the tree barks at the automobile workshops. The variation in the concentration of heavy metals between the sites studied and across the tree species might be due to volume of automobile repair and maintenance activities at the sites. This study has also shown that dust samples may be a potential source of the heavy metals in our environment in addition to vehicular activities. It is therefore recommended that planting of trees should be encouraged in automobile workshops so as to help in the reduction of the pollutants through absorption thereby making the air quality of these premises better. Automobile workshops should also be cited in places that are not close to public or residential area.

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