Chemistry Research Journal, 2021, 6(6):154-159

Available online www.chemrj.org

Research Article

ISSN: 2455-8990
CODEN(USA): CRJHA5

Assessment of Some Selected Heavy Metals from Generators Soot in Lafia Metropolis, Nasarawa State, Nigeria

Nasirudeen, M.B.*, Onwukwe, F., Binin, M.E.

Department of Chemistry, Federal University of Lafia, P.M.B 146, Lafia Nasarawa State -Nigeria
*Corresponding author: nasirudeenbaba@gmail.com

Abstract In recent times, the use of Industrial Power Generating Plants (PGP) and Small Generators (SG) have increased considerably in Lafia Metropolis due to the epileptic power supply. Many houseolds, businesses and industries depend on these generators for their day to day activities. As a result of the continuous use over time soot from these generators accumulate and are emitted into the environment. More so, the road side engineers do repair work on these generators when they breakdown, scoop the soot and dispose them indiscriminately into the environment. In this study, the soot from the PGPs and SG were investigated for heavy metals such as Pb, Cd, Cr, Al and Fe using Atomic Absorption Spectrometry (AAS). The concentration obtained for Pb ranges from 0.775±0.008 ppm to 0.002±0.000 ppm in the PGPs and 0.837±0.000 ppm to 0.027±0.000 ppm in the SGs. The concentrations of Cd and Cr in PGPs were below the detection limits of the Atomic Absorption Spectrometry, whereas, the SGs showed concentrations in the range of 0.243±0.000 ppm to 0.019±0.000 ppm for Cd and 0.287±0.000 ppm to 0.019±0.000 ppm for Cr. More so, Al concentration ranges from 0.170±0.000 ppm to 0.097±0.000 ppm for PGPs and 1.348±0.000 ppm to 0.518±0.000 ppm for SGs, whereas Fe mean concentrations ranges from 62.663±0.004 ppm to 11.422±0.019 ppm for the PGPs and 129.433±0.008 ppm to 9.129±0.002 for the SGs. The study revealed that the investigated heavy metals were higher in concentrations in the SGs. Hence, the results showed that the SGs cause more heavy metal pollutions compared to the PGPs. The results obtained for Pb and Al in PGPs were above the WHO permissible limits for emissions into air and water while all the results obtained for the SGs are above the permissible limits.

Keywords Heavy Metal, Soot, Generator, Pollution

1. Introduction

Heavy metal refers to any metal and metalloid element that has a relatively high density ranging from 3.5 -7.9 gcm^{-3} and is toxic or poisonous at low concentration [1] .They are elements with atomic number 21 or higher, for example, scandium and above [2]. Heavy metals are naturally occurring elements that have a relatively high density compared to water [3]. As result of several human activities like agriculture, power generation, automobile emission, discharge from industries, seepage of municipal landfills, septic tank effluents, and large scale use of agrochemicals, these metals are emitted into the environment in the form of air, water, or soil contaminants [3-4].

In Nigeria, automobiles and generators are the largest industrial and domestic sources of air pollution [5].Vehicular and generator emissions as one of the sources of heavy metal pollution is a threat to the humans and the environment due to their effects on the environment leading to the contamination of air, water and soil [6].

In gasoline exhaust emission, the pollutants of concern are carbon monoxide, hydrocarbon, carbon dioxide and polycyclic aromatic hydrocarbons (PAHs); in diesel exhaust emission, the pollutants of concern are nitrogen oxides and particulate matter [7]. These pollutants differs between various internal combustion engines and depend on variables like air/fuel ratio, ignition timing, load and speed [8].

Soot is defined as an unwanted byproducts resulting from incomplete combustion of carbon containing materials [9]. Soot formation is the conversion of a hydrocarbon fuel molecule containing few carbon atoms into carbonaceous agglomerate. The process is gaseous-solid phase transition where the solid phase exhibits no unique chemical and physical structure [10-12]. Lafia Metropolis depends on generators for both households and commercial power supply. Lead is used as anti-knock additive in conventional gasoline fuels. Leaded gasoline exhaust not only infects the air we breathe, but also responsible for adding Pb to the environment [7]. It is observed that Lafia Metropolis is hot, and the roofs of houses within the metropolis are corroded and rusty due to soot effects. This study is aimed at determining concentrations of selected heavy and trace elements such as Pb, Cd, Cr, Al and Fe in the soot of generators used within the metropolis by the populace.

2. Study Area

Lafia town is the capital city of Nasarawa State. It lies within latitude $8^{0}29ˈ30"$N and longitude $8^{0}31ˈ00"$E. It is a home to both Federal and State Higher institutions of learning. There are so many agricultural and mining, business and educational activities going on in the city and its environs which involve the use of generators.

3. Sampling Protocol

Soot samples were collected in Lafia Metropolis from three locations; Bukan Sidi, College of Agric and Mararaba Akunza. Sampling location was based on the population density, areas of industrial activities, and anthropogenic events. Soot samples from exhaust of Power Generating Plants (PGP) and Small Generators (SG) were randomly collected. Plastic containers and spatula were used to collect the soot samples for digestion and metal analysis. The containers for the sample collection were thoroughly washed with detergent and dried to eliminate adsorption as described by [5, 13-14]. Analysis of heavy metals in soot samples was done using Atomic Absorption Spectrophotometer (MRC Instruments, Model PG 990 and AA500).

4. Statistical Treatment of Data

The data obtained were subjected to ANOVA test for assessing the significance of differences in heavy metal concentrations in soot derived from the Generators. All the statistical tests were performed using SPSS software (SPSS Ins., version 12) [15].

5. Results and Discussion

Table 1: Mean Concentration of Heavy Metals in Soot Samples from PGPs

Sample			**Element (ppm)**		
Code	**Pb**	**Cd**	**Cr**	**Al**	**Fe**
PGP1	0.002±0.0009	BDL	BDL	0.114±0.0002	42.539±0.0054
PGP2	0.191±0.0004	BDL	BDL	0.142±0.0003	11.422±0.0187
PGP3	0.352±0.0008	BDL	BDL	0.170±0.0006	62.663±0.0041
PGP4	0.775±0.0014	BDL	BDL	0.114±0.0002	43.650±0.0052
PGP5	BDL	BDL	BDL	0.097±0.0000	42.189±0.0152
PGP6	0.187±0.0009	BDL	BDL	0.134±0.0003	42.316±0.0105
PGP7	0.074±0.0003	BDL	BDL	0.118±0.0009	44.221±0.0061
PGP8	0.065±0.0006	BDL	BDL	0.114±0.0002	59.458±0.0040
PGP9	BDL	BDL	BDL	0.106±0.0007	31.264±0.0533
RANGE	0.775-0.002	BDL	BDL	0.170-0.097	62.663-11.422
WHO	0.010	0.003	0.050	0.020	0.300

Key: PGP = Power Generating Plant. WHO = World Health Organization Standard. Below Detection Limit

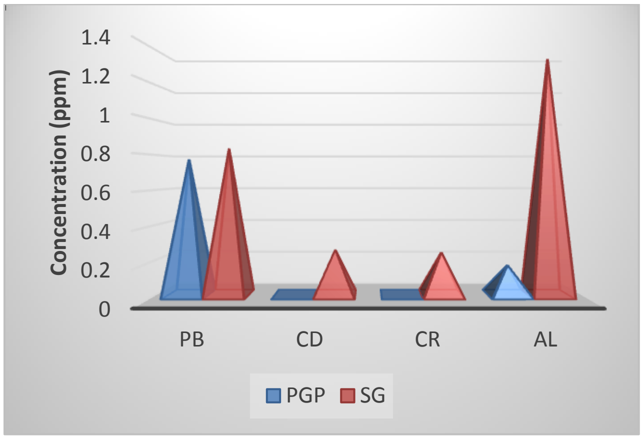

Figure 1: Concentration of Pb, Cd, Cr and Al

Table 2: Mean Concentration of Heavy Metals in Soot Samples from SGs

Sample			**Element (ppm)**		
Code	**Pb**	**Cd**	**Cr**	**Al**	**Fe**
SG1	0.485±0.0004	0.180±0.0006	0.019±0.0002	0.696±0.0013	56.887±0.0147
SG2	0.427±0.0005	0.108±0.0005	0.226±0.0001	0.603±0.0002	39.949±0.0024
SG3	0.352±0.0008	0.258±0.0001	0.218±0.0002	0.719±0.0005	20.138±0.0026
SG4	0.837±0.0003	0.214±0.0004	BDL	0.886±0.0014	14.349±0.0024
SG5	0.717±0.0003	0.204±0.0009	0.234±0.0003	0.518±0.0007	29.867±0.0033
SG6	0.324±0.0001	0.134±0.0009	0.107±0.0004	1.334±0.0008	82.191±0.0086
SG7	0.587±0.0004	0.079±0.0009	0.097±0.0006	1.272±0.0019	129.433±0.0084
SG8	0.027±0.0002	0.063±0.0007	0.046±0.0002	0.761±0.0008	27.937±0.0037
SG9	0.768±0.0004	0.054±0.000	0.086±0.0003	1.348±0.0000	9.129±0.0021
RANGE	0.837-0.027	0.258-0.054	0.287-0.019	1.348-0.518	129.433-9.129
WHO	0.010	0.003	0.050	0.020	0.300

Key: SG = Small Generators. WHO = World Health Organization Standard

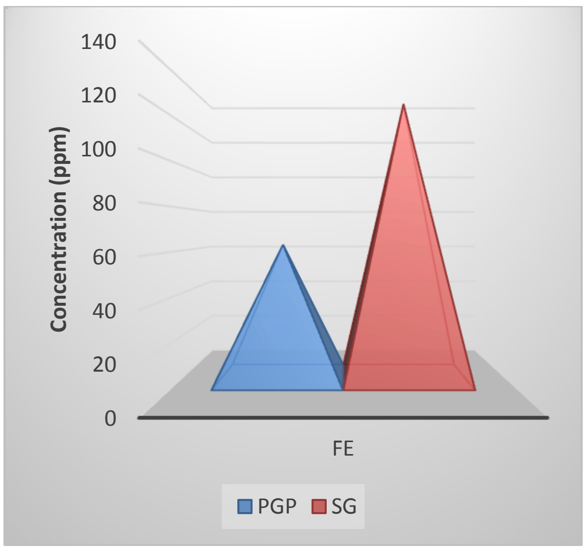

Figure 2: Concentration of Fe

From the results as presented in Tables 1 and 2, Lead concentration values in the studied Soot Samples of PGPs varies in range from PGP4>PGP3>PGP2>PGP6>PGP7>PGP8>PGP2 with values above the [16] permissible limits for emissions into air and water,. The highest concentration value for the PGPs is 0.775±0.0014 ppm, and the lowest concentration is 0.002±0.000 ppm.

Soot of SGs in the study revealed concentration values of Pb in the range of SG4>SG9>SG5>SG7>SG1>SG2>SG3>SG6>SG8. The highest concentration is 0.837±0.003 ppm and the lowest is 0.027±0.002 ppm. Values obtained for the SGs are above the [16] permissible limits for emissions into air and water. A similar research in Ghana by [14] revealed the value obtained for Pb to range from 0.09 to 0.16mg/kg; and it compares well with this study. According to [17] in their study, there is a correlation in concentration of lead in bus terminals and volume of vehicular counts. A related study [18]revealed an average concentration value for Pb in gasoline engine as 14.097±0.644 mg/kg, (1mg/kg = 1ppm), and 11.278±0.028 mg/kg for diesel engine with the gasoline engine having the highest value. The values are higher when compared with this study. In this study, the highest peak for Pb as shown in Figure 1 above was observed in SG.

As presented in the Tables 1 and 2 above, Cadmium was below the [16] permissible limit in all PGPs soot samples. Hence highest concentration value for SGs is 0.258±0.000 ppm while the lowest is 0.054±0.000 ppm.

Results of Chromium showed PGPs have concentration values below detection limit of the Atomic Absorption Spectrometry used in the study and below the [16] permissible limits for emissions into air and water. More so, SGs have values above WHO limits with the exception of SG4. The highest concentration value is 0.243±0.000 ppm and the lowest is 0.019±0.000 ppm. Figure 1 above showed that the SGs have the highest mean concentration of Chromium compared to the PGPs. In a related study by [19] chromium mean concentration was reported as 0.115±0.016µg/m^3, and it agrees with the values obtained for SGs in this study. Chromium was found to be below the detection limit of the Spectrophotometer in a similar study by [14] this compares well with the values obtained for all PGPs.

Aluminum concentrations obtained in this study revealed that PGPs have the highest concentration of 0.170±0.001 ppm and the lowest concentration is recorded at 0.097±0.000 ppm. More so, Aluminium concentrations obtained for SGs ranges from 1.348±0.000 ppm as the highest to 0.518±0.000 ppm as the lowest. Figure 1 above showed that the SGs have the highest Aluminium concentration compared to the PGPs. The values obtained in both PGPs and SGs are above the [16] permissible limits. The work by [20] reported the values of Aluminium for different blends of diesel engine exhausts as W20 = 20.6±2.3µgN^{-3}, B30 = 19.1±23µgN^{-3}, and A3 = 18.0±4.4µgN^{-3}. Aluminium was reported as one of the dominant metals among the 21 metals analyzed in the PM emissions. Thus, their findings agreed with this study.

Iron concentration obtained for PGPs has 62.663±0.004 ppm as the highest concentration value while 11.422 ±0.019 ppm is the lowest. The SGs have concentrations values of 129.433 ±0.008 ppm and 9.129 ±0.002 ppm as the highest and lowest iron concentrations. Both the PGPs and SGs have concentration values above the [16] permissible limits. Figure 2 above showed that the SG has the highest concentration of iron compared to the PGP. A study by [14] reported iron mean concentration of 9.20mg/kg which agreed with this study. In a related study, [21] reported iron concentrations of 12.90mg/L, 1.93mg/L, 10.01mg/L, 19.70mg/L and 16.00mg/L, and this agreed with this study.

Using a multivariate test, the Levene’s test was calculated for all the heavy metal. The post hoc test was used to compare the effect of direction to one another.For Lead, Mararaba Akunza has no statistically significance difference from Bukan Sidi with a 45.5%. More so, Lead obtained from Mararaba has a statistically significance difference from College of Agric with 0.1%. College of Agric has no statistically significance difference of 2.9% with Bukan Sidi.

For Chromium, Mararaba Akunza has no statistically significance difference from College of Agric and Bukan Sidi with a 95.2 and 97.7% respectively. College of Agric has a statistically significance difference of 87.2% with Bukan Sidi.

For Cadmium, Mararaba Akunza has a statistically significance difference from College of Agric with a 2.7% significance and is not statistically significantly difference from Bukan Sidi with a 26.4% significance. College of Agric has no statistically significance difference of 47.3% with Bukan Sidi.

For Aluminium, Mararaba Akunza has a statistically significance difference from College of Agric with a 0.1% significance and is not statistically significantly different from Bukan Sidi with a 90.5% significance. College of Agric is statistically significantly difference from Bukan Sidi with a 0.1% significance value.

For Iron, Mararaba Akunza has a statistically significance difference from Bukan Sidi and College of Agric with 0.1 and 0.1% respectively. College of Agric is statistically significantly difference from Bukan Sidi with a 51.0% significance value.

Conclusion

The results obtained from this study revealed that the investigated heavy metals were more significant in the Small Generators; hence, the SGs cause more heavy metal pollutions compared to the PGPs. The results obtained for Pb and Al in PGPs are above the WHO permissible limits for emissions into air whereas the Cd and Cr are below the detection limit of the Atomic Absorption Spectrometry. More so, all results obtained for the SGs are above the permissible limits. The high values obtained for the iron and aluminum are as a result of the materials used in making the tailpipes. The results of this study have showed that soot from generators are sources of heavy metal pollutions in Lafia Metropolis, and government need to put up urgent measures to regulate the soot emissions as they possess health challenge to the populace due to heavy metal related ailments. Soot emissions from generators and other sources contribute to the hotness of Lafia Metropolis.

References

[1]. Gautam, R.K., Sharma, S.K., Mahiya, S., and Chattopadhyaya, M. C. (2014). *Contamination of Heavy Metals in Aquatic Media: Transport, Toxicity and Technologies for Remediation*, Published by the Royal Society of Chemistry. www.rsc.org

[2]. Augustine, A.U., Onwuka, J.C., and Albert, C.Q. (2016). Determination of Heavy Metal Concentration in Neem (Azadirachta indica) Leaves, Bark and Soil along Some Major Roads in Lafia, Nasarawa State Nigeria. *Journal of Environmental Chemistry and Ecotoicology,* 8(5), 38-43.

[3]. Tchounwou, P. B., Clement, G.Y., Anita, K.P., and Dwayne, J.S. (2012). Heavy Metals Toxicity and the Environment. *National Institutes of Health*. *Author Manuscript, 101, 133-164.*

[4]. Ibeto, C.N., Okoye, C.O.B., Ofoefule, A., and Uzodinma, E. (2012). *Analysis of Environmental Pollutants by Atomic Absorption Spectrophotometry, Macro To Nano Spectroscopy, Dr Jamal Uddin (Ed.). ISBN: 978-953-51-0064-7, 25-50.*

[5]. Okorie, E., Olorunfemi, C., and Sule, H. (2010). Assessment of Some Selected Heavy Metals in Soot from the Exhaust of Heavy Duty Trucks and Power Generating Plants in Nigeria by Flame Atomic Absorption Spectrophotometer. *International Journal of Biological and Chemical Sciences*, 4(4), 1146-1152.

[6]. Ewa, A., Elzbieta, J.K., and Robert, W. (2016). Heavy Metals from Non-exhaust Vehicle Emissions in Urban and Motorway Road Dusts. *Journal of Environmental Monitoring Assessment*, 188, 369.

[7]. Lu, J. (2011). *Environmental Effects of Vehicle Exhausts, Global and Local Effects-A Comparison between Gasoline and Diesel. Master Thesis of Applied Environmental Science. School of Business and Engineering, 11. Halmstad University.*

[8]. Ogur, E.O., and Kariuki, S.M. (2014). Effect of Car Emissions on Human Health and the Environment. *International Journal of Applied Engineering Research*, 9(21), 11121-11128.

[9]. Niranjan, R., and Thakur, A.K. (2017). The Toxicological Mechanisms of Environmental Soot (Black Carbon) and Carbon Black: Focus on Oxidative Stress and Inflammatory Pathways. *Frontiers in Immunology, 8, 763.*

[10]. Xi, J., and Zhong, B.J. (2006). Soot in Diesel Combustion Systems. *Chemical Engineering & Technology, 29(6), 665-673.*

[11]. Omidvarborna, H., Kumar, A., and Kim, D.S. (2014)[a]. Characterization of Particulate Matter Emitted from Transit Buses Fueled with B20 in idle Modes. *Journal of Environmental Chemical Engineering*, 2(4), 2335-2342.

[12]. Omidvarborna, H., Kumar, A., and Kim, D.S. (2015). Recent studies on soot modeling for Diesel Combustion. *Renewable and Sustainable Energy Reviews*, 48, 635-647.

[13]. Atiku, F.A., Ikeh, P.O., Faruk, U.Z., Itodo, A.U., Abdulhamid, A., andRikoto, I.I. (2011). Comparative Test Analysis of Petroleum (Diesel and Gasoline) Soots as Potential Sources of Toxic Metals from Exhausts of Power Plants. *Archives of Applied Science Research, 2011, 3(4), 147-156.*

[14]. Doamekpor, L.K., Abusa, Y., Acheampong, C., Klarke, R.K., Nartey, V.K., and Aoamekpor, M.M.E.A. (2019). Assessment of Some Heavy Metals and Polycyclic Aromatic Hydrocarbons in soot from the Exhaust of Standby Generators. *International Journal of Applied and Natural Sciences, 8(3), 81-94.*

[15]. Watson, A.Y., and Valberg, P. A. (2001). Carbon Black and Soot: Two Different Substances. *American Industrial Hygiene Association*, 62(2), *218-228*.

[16]. Weli, V.E., and Iwowari, F.A. (2014). Impact of Automobile Exhaust Fumes on concentration levels of lead on Bread in Port Harcourt City, Nigeria. *International Journal of Environmental and Pollution Research*, 2(3), 51-72.

[17]. Nwaedozie, G., and Nyan, S.E. (2018). Determination of Heavy Metals in Soots from Petroleum Vehicles Exhaust Tailpipes. *International Journal of Environment, Agriculture and Biotechnology,* 3(6), 2233-2242.

[18]. WHO. (2000). World health organization global water supply and sanitation assessment report. Geneva, Switzerland: WHO Press.

[19]. Safo-Adu, G., Ofosu, F.G., Carboo, D., and Armah, Y.S. (2014). Heavy Metals and Black Carbon Assessment of PM_{10} Particulates along Accra-Tema Highway in Ghana. *International Journal of Science and Technology, 3(8), 467-474.*

[20]. Jen-Hsiung, T., Sheng-Lun, L., Shui-Jen, C., Ciao-Jhen, G., Kuo-Lin, H., Jia-Twu, L. Kuei-Jyum, C.Y., Juei-Yu, C., and Chih-Chung, L. (2018). *Aerosol and Air Quality Research, 18, 1246-1254.*

[21]. Verma, P.C. (2015). Determination of Concentration of Some Heavy Metals in Roadside Dust in Damaturu Metropolis Which Causes Environmental Pollution. *International Journal of Advances in Science Engineering and Technology, ISSN:* 2321-9009, 3, 87-92.