A REVIEW ON CONTAMINATION OF HEAVY METAL IN ROAD DUST COLLECTED FROM HEAVY TRAFFIC AREAS

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ABSTRACT:

Road traffic is one of the main sources of emission of heavy metals into the environment. Road traffic involves various potential sources of metals through combustion products from fuel and oil, wear products from tyres, brake linings, bearings and clutches, corrosion products of vehicle components and road construction material. The number of vehicles in operation increasing year by year and lengthening of trips have resulted in the emissions of larger amount of metals originating from brake, tyre, and road wear. Zn is the most abundant heavy metal from tire wear. Metal containing aerosols released from vehicular exhaust and non-exhaust emissions may lead high accumulation of heavy metals such as Pd, Cd, Ni, Cu and Zn and mixed with road dust. Vehicle brakes release a significant amount of heavy metals in the form of wear particles. One of the most dangerous elements contained in brake pads is copper. Zn is the most abundant heavy metal from tire wear. Its high concentration resulted from the addition of ZnS to the tire during vulcanisation. The greatest Zn emission from tire occurs through abrasion in the form of tire dust during acceleration, braking, and concerning. Asphalt and sand paper like effects are significant sources of Ni in road dust. Concentration of Ni and Zn in road bitumen were higher than in raw bitumen therefore the heavy metal concentrations in road dust are significantly affected by vehicle operation and road abrasion.

Key words - vehicle, copper, zinc, heavy metals.

I. INTRODUCTION

Road traffic is one of the main sources of emission of heavy metals into the environment. Road traffic involves numerous potential sources of metals through combustion products from fuel and oil, wear products from tyres, brake linings, bearings and clutches, corrosion products of vehicle components and road construction material. The major sources of non-exhaust vehicular emissions that leads to heavy metal pollution in road dust are tire wear, brake, road surface wear, and other heavy vehicles that leads road component abrasion. This review is an attempt to determine heavy metals in road dusts collected from heavy traffic areas. The finest fractions of urban and motorway dusts were significantly contaminated with all of the investigated metals, especially with Ti, Cu, and Cr, which are well-recognized key tracers of non-exhaust brake wear [1]. That is the reason why brake lining and tire wear majorly contributed to the heavy metal contamination of road dust. Heavy metals coming out from vehicular exhaust and non-exhaust emissions can be a serious threat to humans and the environment because they have hazardous effects on ecosystems inducing contamination of water and air. Road dust produced during the running of vehicles is obtained from a number of sources, such as from breaking wear, tire wear and clutch plates abrasion as well as from erosion engine particles. Diesel engines are a major source of nitrogen oxides and particulate, which mainly consist of soot and metals. The composition varies depending on engine type, operating conditions, fuel and lubricating oil composition and whether an emission control system is present [2]. Budai and Clement have determined that highway wear emission is responsible for 57% of copper and 65% of zinc vehicle traffic emissions [3]. Landa et al. calculated that 285,000 Mg of Zn was released from tire wear in the U.S. between 1936 and 1999 and that about 10,000 Mg of Zn was released in 1999 [4]. The composition varies depending on engine type, operating conditions, fuel and lubricating oil composition and whether an emission control system is present. Recent studies have focused on the composition and toxicity of diesel exhaust (DE) and diesel particulate matter [5].

II. Materials and Methods

Sampling

The Road dust samples (ca. 20 g) were collected by means of a vacuum cleaner from the acoustic barriers on two surfaces: the 0.0-0.6 m×20 m bottom section, and the 1.8-2.4 m×20 m upper section (road dust samples are denoted as RD-(b) and RD-(u), respectively) [6]. All the road dust samples were allowed to dry in air under laboratory conditions and then sieved through a nylon 1 mm screen and kept in tightly closed plastic containers before analysis.

Concentration of heavy metals

Digestion process of road dust should be done by aqua regia digestion method [7]. 3 g samples of dried road dust were digested using a mixture of 14.4 mL aqua regia solution ($HNO3:HCl$ ¼ 1:3 (v/v)) and 15.6 mL deionized water [8] in Erlenmeyer flask and left overnight. Then the digested samples were ultrasonificated for 1 h at 70 degrees Celsius and then heated for 1 h in a water bath maintained at 70 degrees Celsius under a fume hood operation. The extracted solutions were filtered using quantitative filter paper. Deionized water was added to the filtered solutions to make 30 mL of the analysis solutions. The concentrations of the heavy metals, including Cd, Cu, Pb, Zn and Ni, which are commonly released from vehicles and found in urban dust and plants at the vicinity of the highway [9], were analysed using atomic absorption spectrometry.

Contamination factor and degree of contamination

A modification of the contamination factor and degree of contamination determined by Hakanson (1980) was applied in order to evaluate the contamination of road dust by the determination heavy metals. The degree of contamination (Cd) is the sum of contamination factors for all of the elements. The degree of contamination by the five heavy metals in the road dust from the study areas was determined as follows [10]. In this study, four categories of Cd were used to evaluate metal contamination levels as follows: low ($Cd < 5$), moderate ($5 < Cd < 10$), considerable ($10 \leq Cd < 20$), and very high ($20 \leq Cd$) degree of contamination. If Cd values exceeded 20, then it was necessary to take immediate countermeasures to reduce heavy metal contamination in the road dust.

III Discussion

The high vehicle speeds on road can cause increased energy consumption and increased tire abrasion. The elevated energy consumption and abrasion can cause more heavy metals concentration on road dust as compared to those circulation roads where vehicles run with comparative low speeds. Among the samples from the circulation roads, the concentrations of the heavy metals in the road dust from the road with vehicle speed limits of 80 to 90 km/h were higher than those from the two other circulation roads with vehicle speed limits of 70 to 80 km/h. The correlation between the concentrations of heavy metals and the vehicle speeds was very high ($R > 0.94$). In addition, the total concentrations of the heavy metals in the road dust from the industrial circulation road [11] which was adjacent to automobile manufacturing plants and had a higher volume of vehicles, were higher than those in the sample from the city circulation road located far away from the industrial areas. Therefore, it had been seen that the higher concentrations of heavy metals were found in the in the road dust at the circulation roads resulted from the increased vehicle speeds and traffic volumes.

The road made from asphalt contains a high concentration of hydrocarbons and a much smaller quantity of heavy metals [12]. Gadd and Kennedy [13] reported that the concentrations of Ni and Zn contained in road bitumen samples were higher than those in raw bitumen samples. Tire abrasion occur more on concrete highway as compared to asphalt highway. Therefore, the increased energy consumption of vehicles driving on a rough concrete highway When compared to asphalt highway could result in increased heavy metal concentrations in the road dust from the concrete highway. The road dust samples determine an averaged pattern of exhaust emissions, brake wear, tire wear, road abrasion, and corrosion of road structure and automotive parts. The concentration of heavy metals in the samples also relates the density of the road traffic and driving conditions that is averaged for a relatively long time.

IV Conclusion

In the city area there is much more braking involved due to continuous traffic load which causes additional contamination of road dust with brake pads wear. The highest concentrations of heavy metals in the road dust were identified in the samples from the heavy traffic areas. The concentrations of heavy metals in the road dust from the circulation roads were dependent upon their traffic volume as well as on vehicle speeds. The major sources of Ni were determined to be diesel exhaust emissions, brake abrasion and the corrosion of vehicles. Cu was mainly derived from brake pads and the exhaust emissions from fuel consumption of vehicle engines. The concentration of Zn is usually occurring due to tire wearing. Traffic volumes and exhaust and non-exhaust emissions, vehicle speeds and the road environment were important parameters in determining the contamination levels of heavy metals in the road dust.

References

1. Adamiec et al. (2016). Heavy metals from non-exhaust vehicle emissions in urban and motorway road dusts. Environ monit assess. https://dx.doi.org/10.1007/s10661-016-5377-1.
2. Dwivedi et al. (2006) Particulate emission characterization of a biodiesel vs diesel-fuelled compression ignition transport engine: A comparative study. doi: 10.1016/j.atmosenv.2006.05.005
3. Budai P., Clement A. Refinement of national-scale heavy metal load estimations in road runoff based on field measurements. Transport Res D-TR E 16, 244, 2011.
4. Councell T.B., Duckenfield K.U., Landa E.R., Callender E. Tire-Wear Particles as a Source of Zinc to the Environment. Environ. Sci. Technol. 38, 4206, 2004.
5. Sharma, M., Agarwal, A.K., Bharathi, K.V.L., 2005. Characterization of exhaust particulate from diesel engine. Atmospheric Environment 39, 3023–3028.
6. Swietlik et al. (2013). Evaluation of Traffic-Related Heavy Metals Emissions Using Noise Barrier Road Dust Analysis. Pol. J. Environ. Stud. Vol. 22, No. 2 (2013), 561-567.
7. Fadigas, F.S., Amaral Sobrinho, N.M.B., Anjos, L.H.C.Mazur, N., 2010. Background levels of some trace elements in weathered soils from the Brazilian Northern region. Sci. Agric. 67. doi:10.1590/S0103-90162010000100008 Piracicaba Jan./Feb.
8. Al-Khashman, O.A., 2004. Heavy metal distribution in dust, street dust and soils from the work place in Karak Industrial Estate, Jordan. Atmos. Environ. 38, 6803e6812.
9. Faiz, Y., Tufail, M., Javed, M.T., Chaudhry, M.M., Siddique, Naila, 2009. Road dust pollution of Cd, Cu, Ni, Pb and Zn along Islamabad Expressway, Pakistan. Microchem. J. 92, 186e192.
10. Hakanson, L., 1980. An ecological risk index for aquatic pollution control. A sedimentalogical approach. Water Res. 14, 975e1001.
11. Manno, E., Varrica, D., Dongarrà, G., 2006. Metal distribution in road dust samples collected in an urban area close to a petrochemical plant at Gela, Sicily. Atmos. Environ. 40, 5929e5941.
12. Herrington, P.R., 1993. Safiniya bitumen e verification of chemical properties. Transit New Zealand research report no. 22.
13. Gadd, J., Kennedy, P., 2000. Preliminary examination of organic compounds presents in tyres, brake pads and road bitumen in New Zealand. Report prepared by Kingett Mitchell Ltd for Ministry of Transport.
14. Shobokshy, M.S.E., 1984. A preliminary analysis of the inhalable particulate lead in the ambient atmosphere of the city of Riyadh, Saudi Arabia. Atmospheric Environment 18 (10), 2125–2130.
15. Adachi, K., Tainosho, Y., 2004. Characterization of heavy metal particles embedded in tire dust. Environ. Int. 30, 1009e1017.

16. Legret, M., Pagotto, C., 2006. Heavy metal deposition and soil pollution along two major rural highways. Environ. Technol. 27, 247e254.
17. Li, X., Poon, C.S., Liu, P.S., 2001. Heavy metal contamination of urban soils and street dusts in Hong Kong. Appl. Geochem. 16, 1361e1368.
18. Kabadayi, F., & Cesur, H. (2010). Determination of Cu, Pb, Zn, Ni, Co, Cd, and Mn in road dust of Samsun City. Environmental Monitoring and Assessment, 168, 241–253.
19. Maricq, M. M. (2007). Chemical characterization of particulate emissions from diesel engines: a review. Journal of Aerosol Science, 38, 1079–1118.
20. Chen, J., Wang, W., Liu, H., & Ren, L. (2012). Determination of road dust loadings and chemical characteristics using resuspension. Environmental Monitoring and Assessment, 184, 1693–1709.