Platinum and Lead in South African Road Dust

Sebastien Rauch and Olalekan S. Fatoki

Introduction

Automobile traffic is an important source of pollutants into the environment. Elevated Pb concentrations have been attributed to the use of tetraethyllead as an anti-knocking additive in gasoline. The recognition of human health effects, especially in children, has resulted in a progressive worldwide phase out of leaded gasoline [1]. Leaded gasoline was banned in South Africa in 2006. Until the ban, Pb was added to gasoline at a concentration of 0.33 g/l. Combined with a gasoline consumption of 7,000 Mt/year, this equates to a Pb consumption of 2,300 t/year, making South Africa the second largest consumer of Pb gasoline additives in Africa [2]. Lead concentrations are now expected to decrease in the South African environment owing to the ban of leaded gasoline.

Catalytic converters are placed in the exhaust system of cars to reduce the amount of gaseous pollutants (CO, hydrocarbons and NO_x) emitted as by-products of fuel combustion in the engine. Because these catalysts are poisoned by the presence of Pb, the ban of leaded gasoline and the subsequent availability of unleaded gasoline support the introduction of exhaust catalysts in South Africa. Platinum and other Pt group elements are the main active components in catalysts and some Pt is emitted into the environment [3]. As a consequence, Pt concentrations are increasing in the urban and roadside environment [4], and elevated Pt concentrations are now found in airborne particles, road dust, as well as in roadside soil, plants, and biota [5, 6]. Therefore, environmental Pt concentrations are expected to increase in South Africa as a result of automobile emissions. However, South Africa is the

S. Rauch
Department of Civil and Environmental Engineering, Water Environment Technology, Sven Hultins gatan 8, 41296 Göteborg, Sweden
e-mail: Sebastien.Rauch@chalmers.se

O.S. Fatoki
Faculty of Applied Sciences, Cape Peninsula University of Technology, Cape Town, South Africa

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world's largest Pt producer [7] and mining activities might be an additional source of Pt. Mining occurs in the Bushveld Igneous Complex, a 65,000 km^2 mafic intrusion containing approximately 75% of the world's Pt resources [8]. Platinum emissions from the mines has until now not been quantified.

The study presented here aims at determining current Pb and Pt levels in road dust in South Africa and at assessing the relative importance of automobile and mining emissions. Road dust is an attractive medium for urban pollution studies and it is important to determine current Pb and Pt concentrations in road dust, as Pb concentrations are still high and expected to decrease in the near future, and Pt emissions by automobile traffic are still limited.

Methodology

Road dust samples were collected at several locations in Cape Town (2.9 million inhabitants), Pretoria (1.8 million), Port Elizabeth (1.0 million) and Rustenburg (0.4 million) in October–November 2007. Selected cities are shown in Fig. 1. Rustenburg was selected for its vicinity to the Bushveld Igneous Complex where Pt is mined, while other cities are important urban areas with high traffic volumes.

Fig. 1 Map of South Africa with cities selected for road dust sampling

Sampling was performed on asphalt covered roadside. Road dust was collected using a brush and placed in ziplocked PE bags for transport and storage.

Samples were dried overnight at 105°C. Dry samples were then sieved and the <125 μm fraction was retained for analysis. Samples were prepared by microwave-assisted acid digestion using closed Teflon vessels (Mars5, CEM, USA). Approximately 0.5 g of dry dust was placed in microwave digestion vessels. Digestion was performed in closed vessels after addition of 8 ml *Aqua regia* (6 ml HCl + 2 ml HNO_3) using 2-step temperature increase to 185°C and a maximum allowed pressure of 200 psi. It is important to note that the procedure does not provide a full digestion, but a strong leach usually suitable for the study of anthropogenic metals in road dust. The leachate was then slowly taken to dryness on a hot plate and redissolved in 5% HNO_3.

Prepared samples were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS) using a quadrupole system (Elan 6000, Perkin Elmer, USA) and standard operating conditions. Calibration was performed by the analysis of multi-element standard solution, except for Pt for which a single element solution was used. Interferences on Pt analysis were corrected mathematically [9, 10] and reference material BCR-723 was analyzed to assess the accuracy of Pt concentrations.

Results and Discussion

Average Pb and Pt concentrations in road dust in South African cities are presented in Table 1.

Lead Concentrations

Average Pb concentrations were found to range from 345 μg/g in Rustenberg to 775 μg/g in Pretoria (Table 1), with a minimum concentration of 103 μg/g at Joubert Street in Rustenburg and a maximum concentration of 1,928 μg/g at Church Street in Pretoria (Fig. 2). For comparison, urban concentrations in Accra, Ghana were reported to be 365 ± 93 μg/g [11]. The higher concentrations in South Africa are likely the result of the larger consumption of Pb gasoline additives [2].

Large concentration variations were observed in individual cities; Pb concentrations in Pretoria range for instance from 186 μg/g at Schueman Street to 1,928 μg/g at Church Street (Fig. 2). Although automobile traffic is expected to be the main source of Pb, there is no direct correlation between Pb concentrations and traffic density. The absence of correlation may be the result of factors other than Pb emission from automobile traffic and subsequent deposition. Because leaded gasoline is now banned in South Africa, it is possible that removal efficiency play a more important role than Pb deposition.

Table 1 Pb and Pt concentrations in road dust in selected South Africa cities. Concentrations are presented as average ± standard deviation (standard deviation is presented in brackets when it exceeds average concentration)

City	Pb (µg/g)	Pt (µg/g)
Cape Town	706 ± 271	4 ± 2
Port Elizabeth	434 ± 228	6 ± 1
Pretoria	775 (999)	23 ± 13
Rustenberg	345 ± 172	223 ± 116

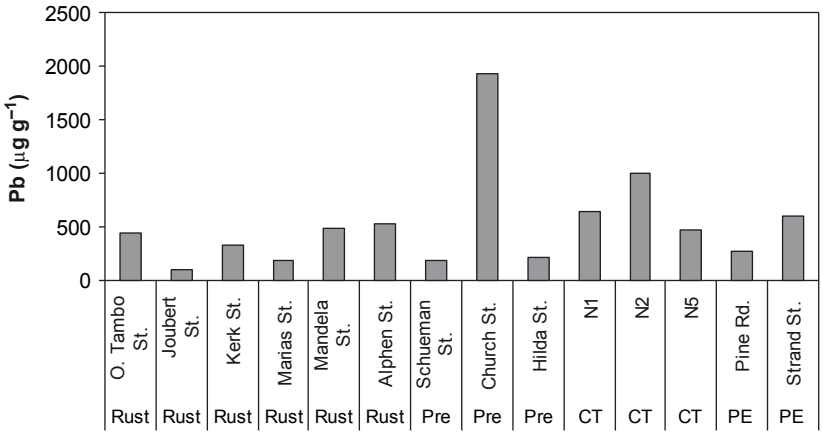

Fig. 2 Lead concentrations in road dust in Rustenburg (Rust), Pretoria (Pre), Cape Town (CT) and Port Elizabeth (PE)

Platinum Concentrations

Average Pt concentrations range from 4 ng/g in Cape Town to 223 ng/g in Rustenburg (Table 1) with a minimum concentration of 2 ng/g along highway N2 in Cape Town and a maximum concentration of 391 ng/g at Mandela Street in Rustenburg (Fig. 3). For comparison, average Pt concentrations in Ghana ranged from 1.5 ng/g at a background site to 55 ng/g near a heavy traffic road [11].

Concentrations in Rustenburg and Pretoria range from 108 to 391 ng/g and from 13 to 37 ng/g, respectively, and are clearly higher than in other South African cities where concentrations range from 2 to 7 ng/g. The relatively low concentrations in Cape Town and Port Elizabeth indicate that automobile traffic is a minor source of Pt in South Africa, possibly due to the currently limited number of vehicles equipped with exhaust catalysts. Therefore, the relatively high Pt concentrations found in Rustenburg and Pretoria are attributed to non-automobile sources. Since Rustenburg is located on the edge of the Bushveld Igneous Complex, near major Pt mines, mining activities are a likely source of Pt in road dust in Rustenburg.

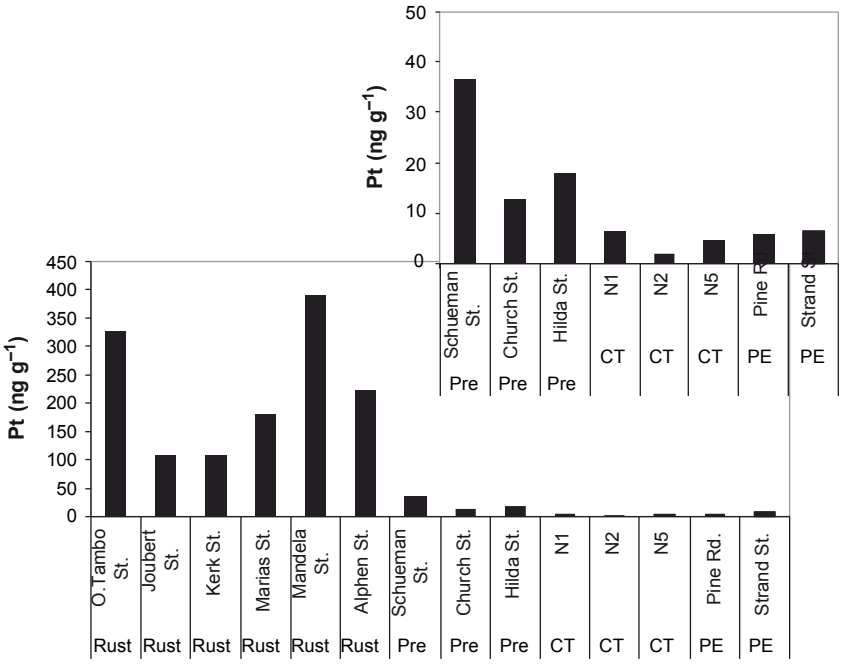

Fig. 3 Platinum concentrations in road dust in Rustenburg (Rust), Pretoria (Pre), Cape Town (CT) and Port Elizabeth (PE)

Pretoria is located approximately 150 km from Rustenburg and elevated Pt concentrations in Pretoria are attributed to atmospheric transport of Pt emitted from the mines.

Conclusions

Elevated Pb and Pt concentrations were found in South African road dust. The occurrence of Pb is attributed to automobile traffic owing to the use of leaded gasoline. Leaded gasoline has recently been banned in South Africa and environmental Pb concentrations are expected to decrease in the near future. In contrast, automobile emissions are a minor source of Pt due to the limited number of vehicles currently equipped with an exhaust catalyst. South Africa is the world's leading Pt producer and elevated Pt concentrations were found in road dust collected near Pt mines in Rustenburg.

Atmospheric dispersion of emitted Pt also results in contamination further from the mines and elevated Pt concentrations were also found in Pretoria. Further studies are needed to characterize emissions from Pt mines and associated risks of should be assessed. Automobile traffic may become an additional source of Pt in South Africa owing to the introduction of automobile exhaust catalysts.

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