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AIR POLLUTION FROM DIESEL CARS IN TIRANA

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SUMMARY

Tirana's vehicles are dominated by diesel cars, with more than ¾ of them older than 10 years. They are considered to be the greatest contributors to the particulate matter (PM) air pollution in Albania's capital. Opacity of exhaust gases released during combustion of diesel at idle conditions was measured from 1505 cars produced before 1988, 919 cars produced during 1989–1998 and 567 cars produced after 1998. It resulted that 16.3%, 11.2% and 4.4% of cars had opacity of their exhaust fumes greater than the approved norm of the absorption coefficient (K) for their category, determined by their year of production. The minimal norm is set for diesel cars produced after 1998 is K = 2.5 m^{-1}. The existence of a tolerating standard for old cars, combined with the lack of proper maintenance, or/and usage of low-quality diesel fuel is the reason of high PM levels in Tirana's heavy-traffic sections.

Key words: Diesel cars; opacity; absorption coefficient; particulate matter; air pollution.

PËRMBLEDHJE

Parku i automjeteve të Tiranës dominohet nga makinat me motor Diesel, më shumë se ¾ e të cilave janë me moshë mbi 10 vjeçare dhe janë kontribuesi kryesor në ndotjen e ajrit nga PM (Lënda e Grimcuar). Opaciteti i gazeve që çlirohen nga djegia e dieselit kur makina është e ndalur në vend, u mat për 1505 makina të prodhuara para vitit 1988, 919 makina të prodhuara gjatë viteve 1989–1998 dhe 567 makina të prodhuara pas vitit 1998. Rezultoi se 16.3 %, 11.2 % dhe 4.4 % e makinave kishin opacitet më të lartë nga sa e lejon norma e miratuar për Koefiçientin e opacitetit për kategorinë e tyre, që përcaktohet nga viti i prodhimit. Norma minimale e K është vendosur për makinat diesel të prodhuara pas vitit 1998: K=2.5 m^{-1}. Ekzistenca e standardit tolerant për makinat e vjetra, kombinuar me mosmirëmbajtjen e duhur dhe/ose përdorimi i dieselit me cilësi të ulët, është arsyeja e niveleve të larta të PM në rrugët me trafik të rënduar në Tiranë.

INTRODUCTION

About 1/3 of Albanian vehicles are registered in Tirana. The total number of registered vehicles in 2008 was 135799. An additional 30000 vehicles from other districts circulate every day in the Albanian capital. Out of the total number, 76 % of the vehicles are private cars, and more than 85 % of them use diesel fuel [1]. Tirana's vehicle fleet increases with over 10 thousand vehicles per year, out of which 8600 are cars. The number of other types of vehicles has shown little increase in the last decade [Figure 1].

Since the main factories in Albania were shut down after 1991, it was expected that the air quality in urban areas would improve. Instead it deteriorated, especially regarding the total suspended particulate [TSP] and the PM_{10} [particulate matter less than 10 micron] components. The stationary sources of air pollutants were increasingly replaced by the impact of mobile sources (i.e. road traffic).

Factors that contribute to the particulate matter (PM) air pollution in Tirana are; vehicles' age, fuel quality, and maintenance. The vehicle fleet in Albania is relatively old, with the majority of cars being older than 10 years. In Tirana there are more newer cars in comparison to other parts of Albania, however, until 2007, the cars produced during the period 2000 – 2007 comprised only 37 % of the total vehicle fleet of Tirana, with the rest of cars being produced before the year 2000 [1].

The state run vehicle inspection service in Albania requires the monitoring of the opacity of exhaust gases [2]. This is done through the use of opacimeter that measures the absorption coefficient K (in unit m^{-1}) for all vehicle categories, based on their year of production and whether the engine is with natural induction or with turbo compression. The actual norms are presented in Table 1.

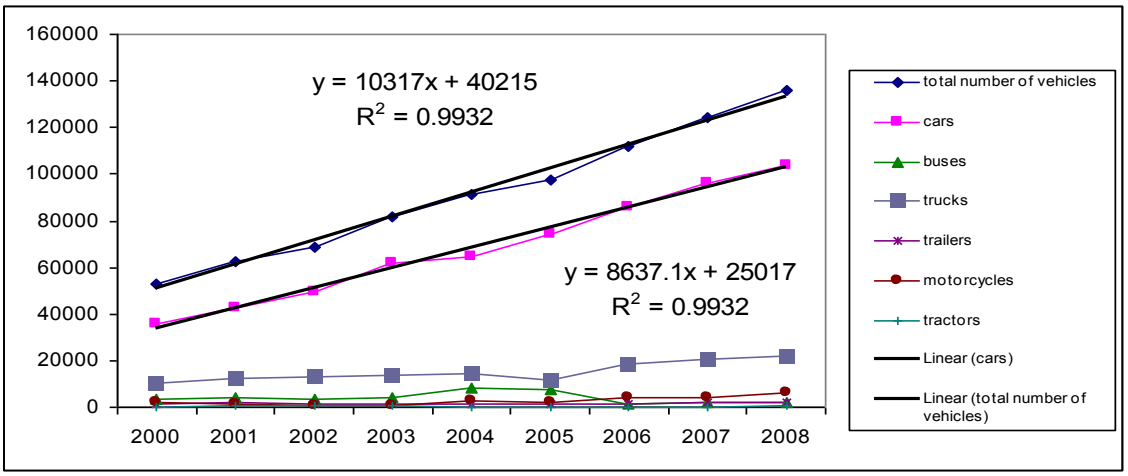

Figure 1: Progress in years of the number of vehicles according to their kinds.

No.	Year of production	Type of fuel	Diesel Engine	Absorption Coefficient K (m^{-1})
1.	Before 1988	Diesel	Natural induction with turbocompression	4.0 4.5
2.	1988-1998	Diesel	Natural induction with turbocompression	3.5 4.0
3.	After 1998	Diesel	Natural induction with turbocompression	2.5 2.5

Table 1: The norms for the pollutants (opacity) that are released with the exhaust gases from the diesel vehicles

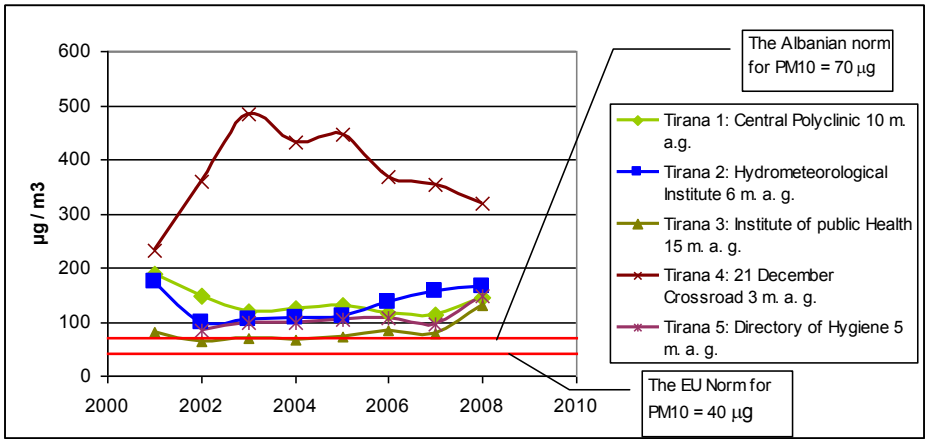

Figure 2: Average annual concentrations of PM10 in Tirana for the period: 2001-2008.

The diesel fuel quality plays a great part in the PM air pollution. Diesel used in Albania is of diverse quality, ranging from 2000 ppm S for the native diesel, to the less than 10 ppm S in the Euro 5 type of diesel that is traded in small quantity in the fuel stations. It is also well known that the higher the sulfur contents in diesel, the higher the PM concentrations in the atmosphere [3].

In 2008, the Albanian diesel (diesel D2: 500 ppm < S content < 2000 ppm) met about 10 % of the needs of

the country [4]. Diesel D2 from import met more than 50 % of the needs, whereas diesel D1 (with less than 500 ppm S) met about 39 % of the needs. In the former years the percentage of diesel D1 has been much less than that [5], while the contribution of the Ballshi Refinery in the Albanian fuel market has been around 10 % in the last decade [4].

The focus of this study was on diesel car's performance measured on the opacimeter. The incentive to perform such a study is the indication of very high PM levels in almost all monitoring points in Tirana. These levels have always been above the National and EU norms for the PM air concentrations [6, 7, 8, 9], as presented in Figure 2. This is particularly evident in the areas near the streets with high traffic intensity in Tirana [10], such as the monitoring station No 4, as presented in Figure 3.

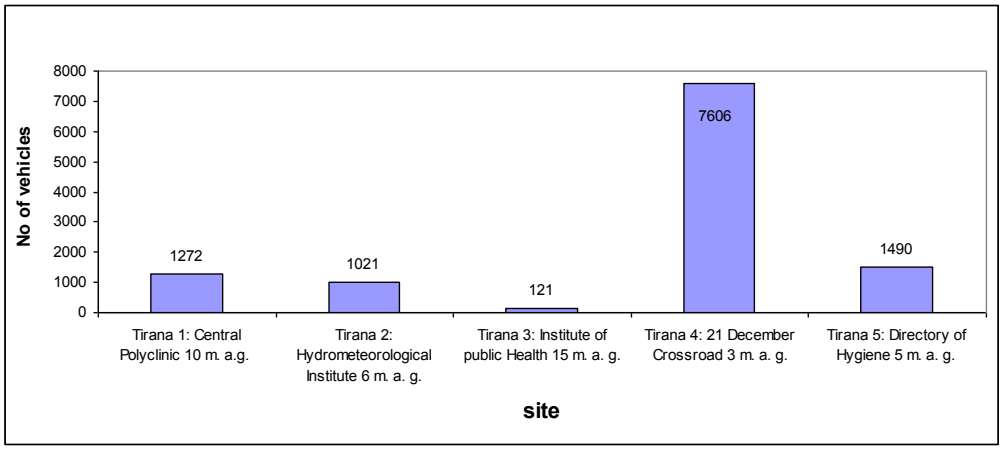

Figure 3: Total number of vehicles passing by the monitoring sites in Tirana, in the morning peak hour, in 2007.

Licence Plate No	Time of purchase	Number of cars	Taken from the range of Licence plate numbers:	Average age in the moment of purchase of the car (years)	Average age in the moment of testing (years)
A	1996-1997	452	TR 0000A–9999 A	11.95	22.98
B	1997-1998	422	TR 0000B–9999 B	12.74	23.9
E	1999-2000	485	TR 0000E–9999 E	13.33	21.82
F	2002-2003	496	TR 0000F–9999 F	13.77	19.14
N	June– Sep. 2007	500	TR 8000 N–9999N	10.59	11.6
P	Oct.– Dec. 2007	640	TR 0000P–1999P	9.98	10.97
Total		2995		11.95 ~ 12	17.82 ~ 18

Table 2: Description of the target group of the diesel cars.

MATERIAL AND METHODS

We collaborated with several government institutions to retrieve the most up-to-date information and used it with their permission. Table 2 gives a description of the target group of the diesel cars tested during this research. Since the Albanian law divides the cars into three categories, according to the year production, also the above mentioned target group was divided into the same categories as given in Table 3.

Cars produced	before 1988	1989–1998	after 1998
Number of cars in the target group	1505	919	657
Average age in the moment of testing (years)	24.07	14.3	6.89

Table 3: Detailed description of the target group according to the year of production

The experiments were performed at the Center for Technical Inspection of Vehicles in Tirana by using the equipment STARGAS 898 Global Diagnostic System [11]. Car testing was done in idle conditions with the engine running at 2500 – 3000 rpm [revolutions per minute].

The PM concentration in the exhaust gases was measured from the light weakening after it passes through the mixture of exhaust gases in the tailpipe, by using the Lambert – Beer equation [12, 13]. Coefficient of opacity K (m^{-1}) summons the concentration of PM inside the exhaust gases from the diesel combustion in the engine as well as the dimensions and the nature of these particulates.

$\frac{I}{I_0} = e^{-KL} = e^{-a \cdot c \cdot L}$, where, K = a·c ,a is the concentration of the particulate matter, c indicates the dimensions and the nature of particulates, I_o is the light intensity when there is no smoke [PM] at all in the exhaust gases , I is the light intensity when there is smoke [PM] in the exhaust gases, and L is the length of the tube where the measurement of the light intensity is taking place (in meters).

The absorption Coefficient, K (m^{-1}), and not the real PM concentration in the exhaust gases was measured with this equipment. The higher the K values, the higher the PM concentration in the exhaust gases of cars.

RESULTS AND DISCUSSIONS

The results of the performance on the opacimeter of the diesel cars tested are shown in the Tables 4, 5, 6 respectively for each category. Since it is not known whether the car is on turbo-compression or on natural induction, we referred only to the norms of the smaller cars with natural induction.

	1972	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
No of cars with K > 4.0 m^{-1}	0	1	2	5	22	11	17	28	16	19	36	36	37	15
No of cars with K > 2.5 m^{-1}	1	6	4	18	66	39	68	101	74	58	113	120	100	57
No of cars per production year	1	7	8	34	99	64	118	168	127	119	210	212	199	139

Table 4: The number of cars that resulted with K (m-1) above the norm of their category set by the year of production, and with K (m-1) above the minimal existing norm.

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
No of cars with K > 3.5 m^{-1}	26	13	10	7	12	11	4	8	8	4
No of cars with K > 2.5 m^{-1}	54	33	26	25	25	20	20	18	15	9
No of cars per production year	127	89	73	74	69	71	73	91	115	137

Table 5: The number of cars that resulted with K (m-1) above the norm of their category set by the year of production, and with K (m-1) above the minimal existing norm.

	1999	2000	2001	2002	2003	2004	2005	2006	2007
No of cars with K > 2.5 m-1	11	2	4	5	2	0	0	1	0
Total No of cars	165	112	78	72	52	45	26	12	5

Table 6: Number of cars with K (m^{-1}) above the norm set for their category for vehicles produced after the year 1999

Based on the measurements of K, it resulted that 16.3 % of the cars produced before 1988, 11.2 % of the cars produced during the period 1989 – 1998 and 4.85 % of the cars produced after 1999 passed the norm for their category, respectively; 4.0 m^{-1}, 3.5 m^{-1}, and 2.5 m^{-1}. Because of the existence of a tolerating standard, this research showed that 25 cars produced after 1998, with a resulting K>2.5 m^{-1}, were not permitted to circulate, whereas 580 other cars produced before 1988 and 142 cars produced during 1989-1998 were permitted to circulate, even though their K>2.5 m^{-1}., The average value of K (m^{-1}) for the entire target group was calculated for all the cars with the same year of production and the results are shown in Figure 4.

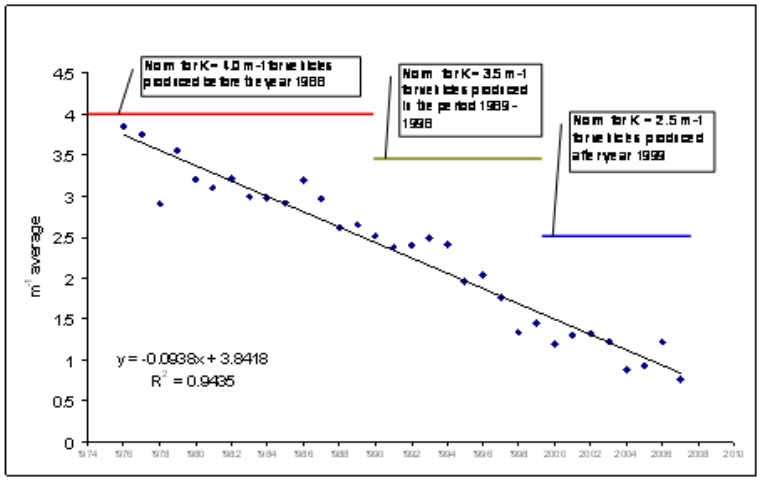

Figure 4: The dependence of average values of K (m^{-1}) from the year of production for Diesel cars.

The air quality standards are set on one fixed value whereas the K (m^{-1}) values differ depending on the year of car production. As it was seen in the Figures and Tables above, old cars that meet the norm of their category are allowed to circulate and pollute the air of Tirana. Therefore, there has to be only one standard regarding the air pollutants emitted by cars, and that standard has to be set in gram of pollutant / km driven. We recommend the government to review the norm of K, at the moment, and in the short term the Center for Inspection of Vehicles to be equipped with modern equipments which measure a wider range of air pollutants. It is necessary to have only one standard for all cars, regardless of their age. This would motivate even the drivers that own old cars to render frequent services to their cars and also to use good quality fuel to meet the standard.

In conclusion, the vehicle fleet in Tirana does contribute greatly to the PM air pollution. Usage of high quality fuel and renewing the fleet would improve the quality of air.

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