The impact of Diesel quality on the Particulate Matter content in the exhaust gases of Diesel cars – Case study: Diesel cars of Korça District, Albania

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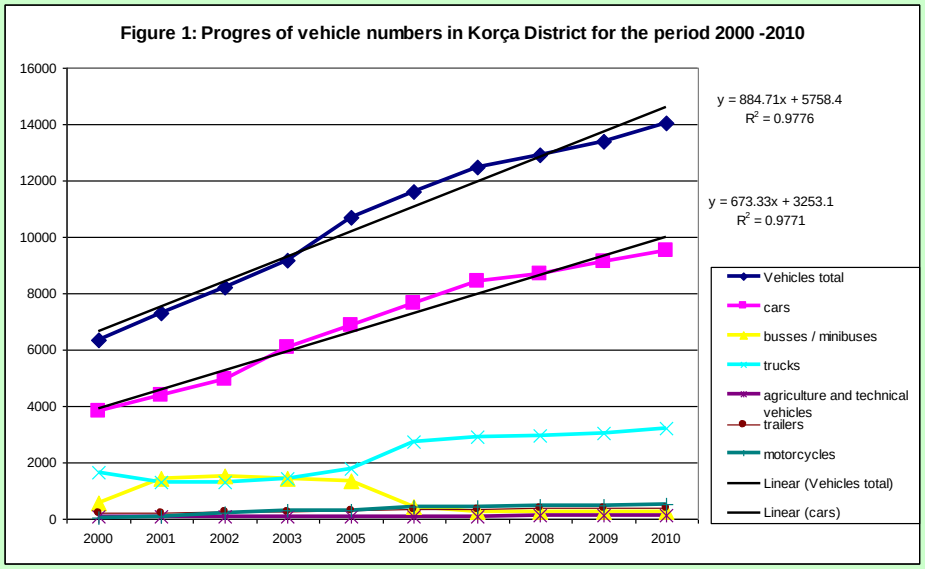
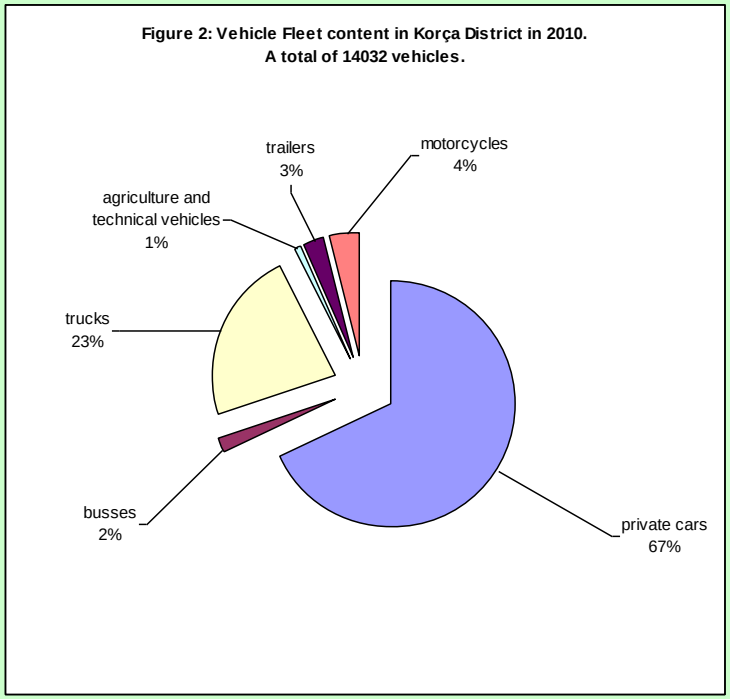
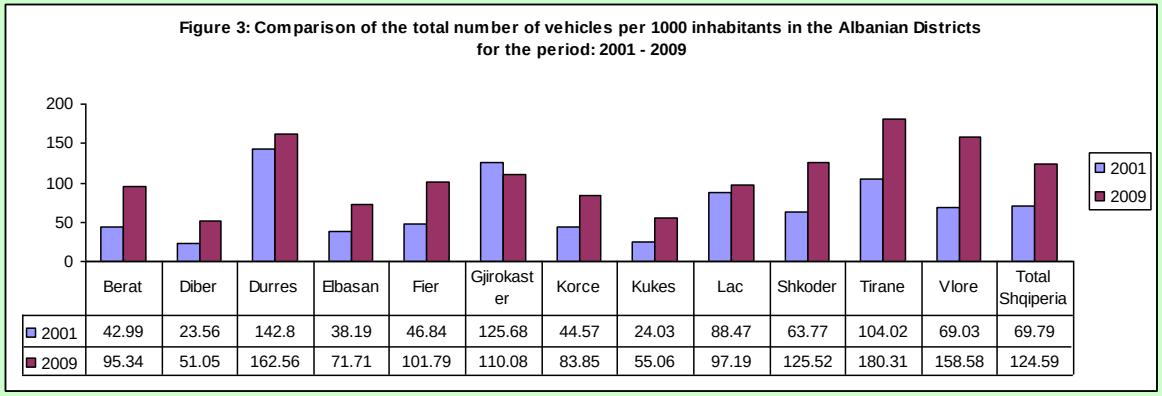
Vehicle Fleet in Korça:





- 80 % of it there are Diesel cars which are mostly second hand vehicles imported from neighbor countries after the 90s.
- As Figure 1 shows, in Korça District, there is noticed an annual increase with about 885 vehicles, out of which there are 673 private cars (passenger cars with 4+1 seats).
- Vehicle fleet composition shows that private cars and trucks account for 90 % of the total vehicles registered till the year 2010 in Korça District (Figure 2).

Vehicle Fleet in Korça:

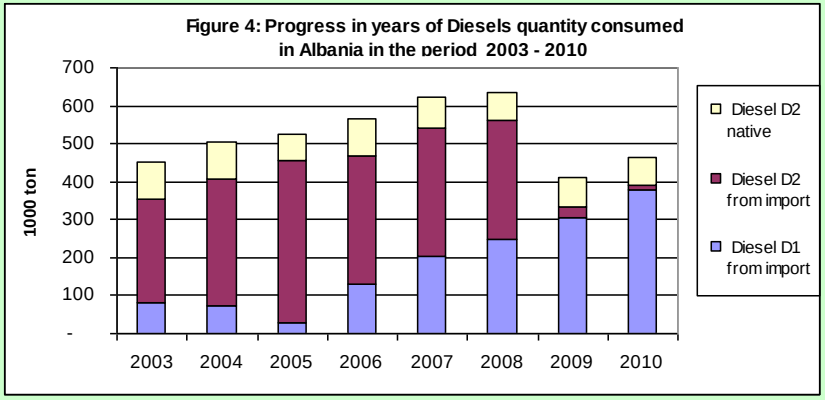


	Berat	Diber	Durres	Elbasan	Fier	Gjirokaster	Korce	Kukes	Lac	Shkoder	Tirane	Vlore	Total Shqiperia
2001	42.99	23.56	142.8	38.19	46.84	125.68	44.57	24.03	88.47	63.77	104.02	69.03	69.79
2009	95.34	51.05	162.56	71.71	101.79	110.08	83.85	55.06	97.19	125.52	180.31	158.58	124.59

- The vehicle density for Korça District has been under the average of Albania, if the number of vehicles per 1000 inhabitants was to be compared. Nevertheless, from 2001 to 2009 this parameter has increased with 88%, as Figure 3 shows, ranking Korça District the ninth out of twelve Districts in 2009.

- From another research by the corresponding author of this article, the percentage of Albanian families that owned a car in 2009 was 36.10 %. For Korça District this percentage was lower, only 23.28 % of families owned a car.

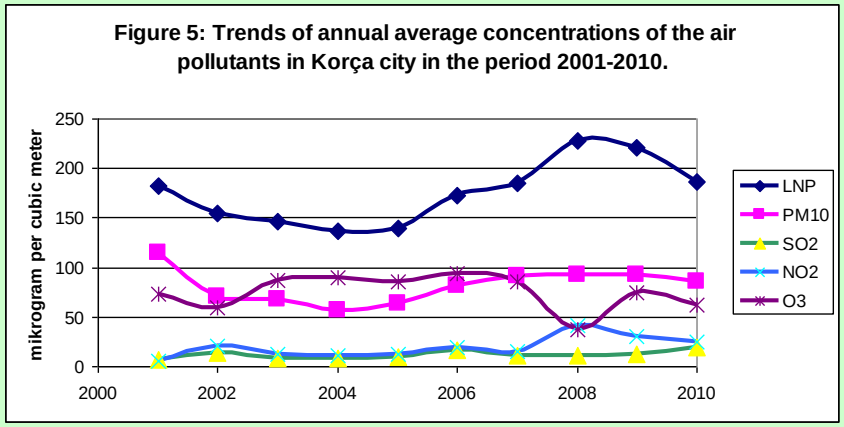
Diesels consumed in Albania

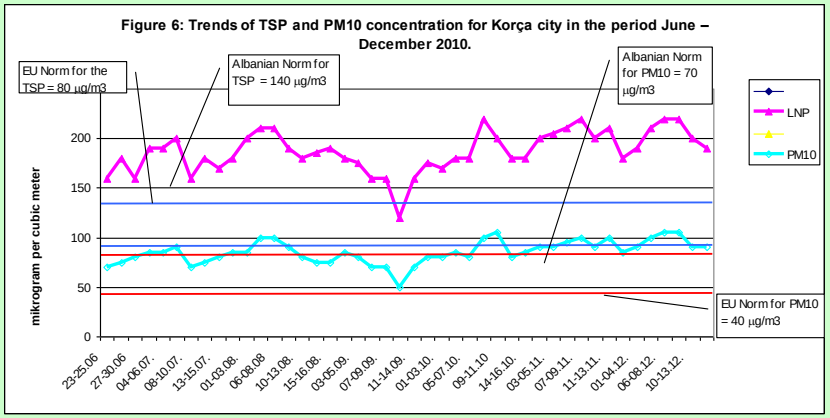


At present it is impossible to define the exact Diesel quantity consumed only in Korça District. It is observed that the main fuel providing companies in Albania have their branches in Korça District and their fuel stations are present along each road and highway in this District. Due to vicinity with Greece, there are several fuel providers that import Diesel from Greek refineries.

- In Albania up to 2009, the Diesel vehicles used
  - Diesel D2 which contained sulfur in the range of 0.05 – 0.2 % in mass and
  - Diesel D1, otherwise named “Eurodiesel”, which contained less than 0.05 % (in mass) sulfur in it, according to the customs’ classification.
- The quantity of diesels consumed by the Albanian market has annually increased in the last decade, as the Figure 4 shows.
- However, there was an exception of this trend in the year 2009, due to the banning of the import of the Diesel D2 type by the Government.
- The effect of financial crisis worldwide was felt even in Albania and a reflection of this is the reduction of the Diesel quantity consumed from. Yet from the graph in Figure 1 it can be seen that the effect of the global crisis was not felt in the vehicle fleet growth.
- It can be said that Albanians would prefer to buy a car and drive less than in previous years now that the fuel prices have very much noticeably increased.

Air Pollutants in Korça



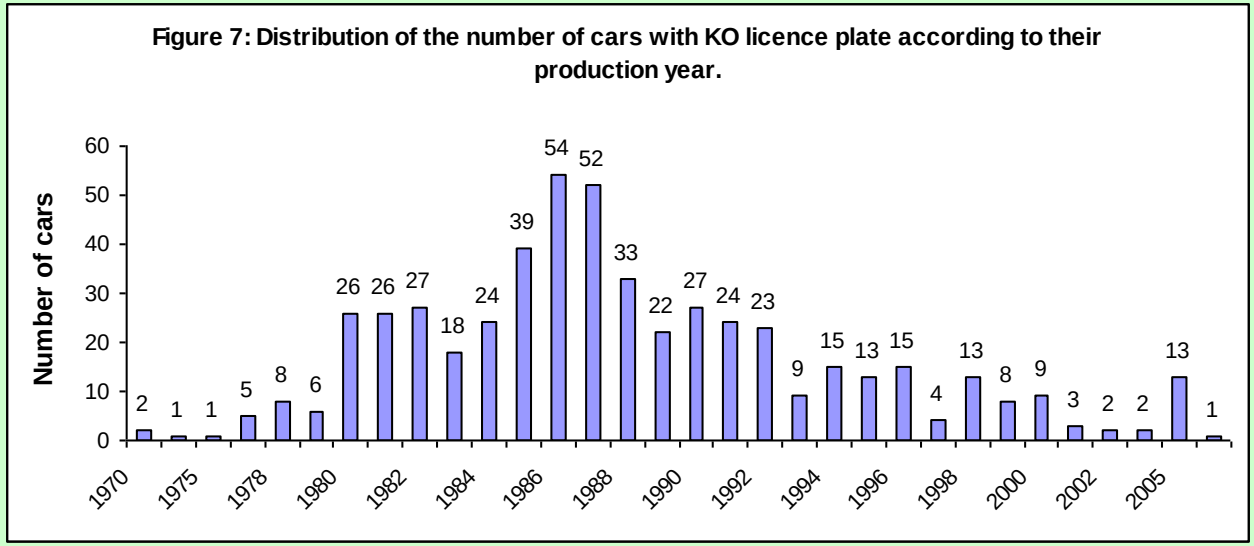


- The air quality in Korça is being monitored by the Institute of Public Health. The air pollutants monitored are: Total Suspended Particulates (TSP), PM_{10} (particulate matter less than 10 microns), SO_2 (sulphur dioxide), NO_2 (nitrogen dioxide), and O_3 (ozone). Figure 5 gives the trend of all these air pollutants' concentrations in the last decade in Korça city.

- While SO_2, NO_2 and O_3 respect the Albanian and the EU norms, in the last decade, the most problematic air pollutants in Korça city there have been TSP and PM_{10}. For these two air pollutants a closer observation is carried out.

- As the graph in Figure 6 shows, the concentrations of TSP have been daily above the Albanian and the EU norm. The concentrations of PM_{10} have been daily above the EU norm and on 86 % of the days they have been above the Albanian norm too.

Material and methods (target group of cars)



- The target group of 525 Diesel cars, with which experiments were performed, was comprised of 41 % of cars registered in the Communes and 59 % registered in the City of Korca. The average age of cars at the moment of purchase was 15.5 years and at the moment of testing it was 21 years. As it can be seen from the graph in Figure 7, the distribution of cars according to their production years shows that the majority of cars are produced in the period 1981–1992.

Material and methods

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.

$$I / Io = e^{-KL} = e^{-a \cdot c \cdot L} \quad , \quad \text{where} \quad K = a \cdot c$$

a is the concentration of the particulate matter,
c indicates the dimensions and the nature of particulates,
Io 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,
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.

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

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.	1989-1998	Diesel	Natural induction With turbocompression	3.5 4.0
3.	After 1998	Diesel	Natural induction With turbocompression	2.5 2.5

Results and Discussion …

The impact of cars' age on the PM emissions

Figure 8: Variation of the average value of K m-1 for diesel cars, divided by their production year and compared with the norms of K in power up to Feb. 2010.

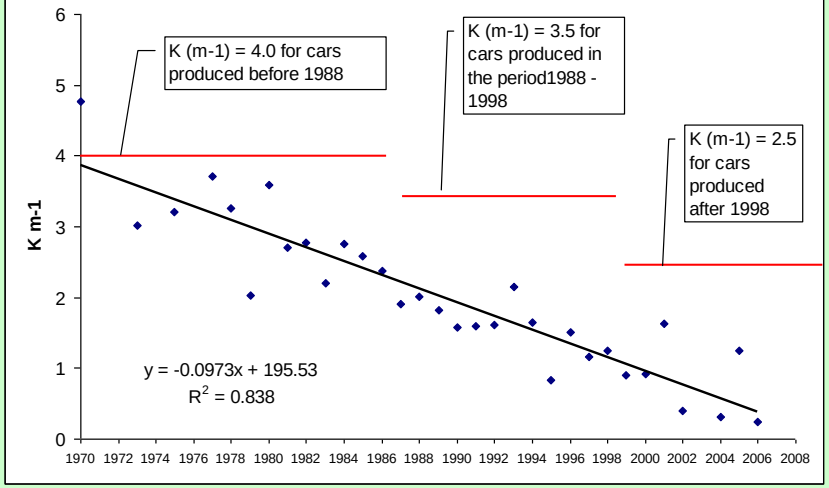
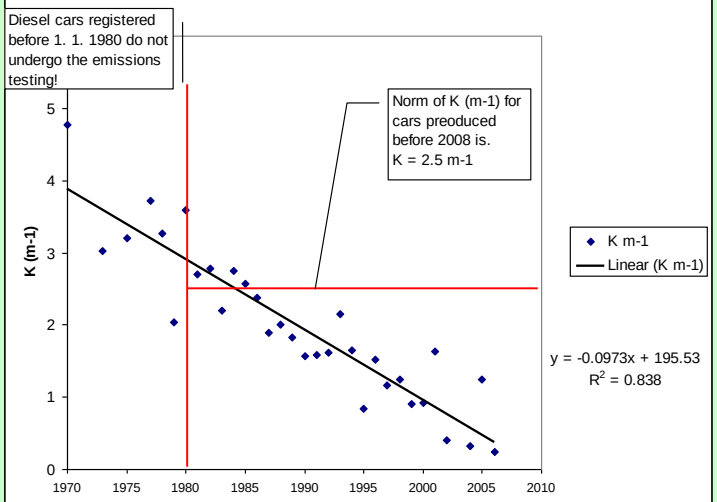


Figure 9: Comparison of average values of K m-1 with the new norms and criteria, according ot the Guideline of the Minister of Transports, No. 2 dt. 11/02/2010



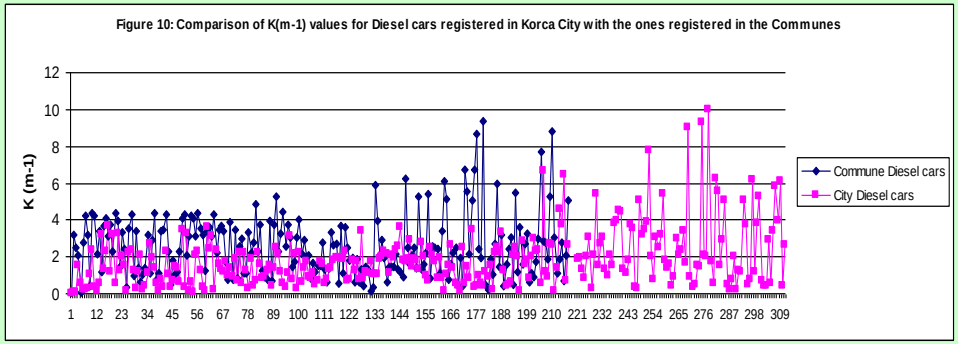
- From the Figure 8, it is obvious that the older the cars, the higher the amount of particulate matter (PM) they emit in their exhaust gases.
- On the Figure 9, the same average values of K (m-1) for the cars of our target group are compared with the new norms, in power from February 2010 (MTTPW, 2010).
- According to this Guideline, for cars produced before 1980 there is not required an emissions testing, but only a visible inspection of the exhaust gases whether they are black in colour or not. Also the norm of K (m-1) for cars produced in the period 1980-2008 is set at 2.5 m-1, which still is high. Moreover, it used to be the norm only for the cars produced after 1998, but now it applies to the cars produced in a very wide age range: 28 years apart from one another.

Results and Discussion …

The impact of the type of road on PM emissions

Table 2: Description of the target group of Diesel cars of Korça District according to their place of registration		
Registered in	Communes	City
Number of cars tested	217	308
Cars' age at the moment of purchase	16.08	15.07
Cars' age at the day of testing	21.59	20.53
Average value of K (m-1)	2.572	1.83

From the Table 2 it is noticed that cars registered in the Communes are slightly older than the ones registered in the City but the average value of K (m-1) for Commune cars resulted much higher than the one for City cars.



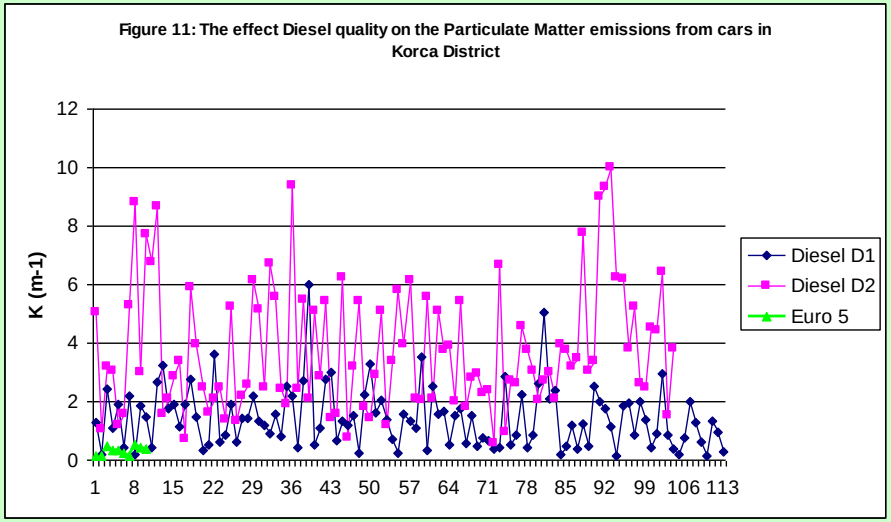
The graphical information given on Figure 10 confirms that, with rare exceptions, the Commune cars pollute the air much more than the City cars.

Results and Discussion

The impact of Diesel quality on PM emissions

Table 3: Description of the target group of Diesel cars of Korça District according to the type of Diesel they use.

Type of Diesel	Diesel D1	Diesel D2
Number of cars tested	113	104
Registered in the City	69	59
Registered in Communes	44	45
Cars' age at the moment of purchase	12.79	17.13
Cars' age at the day of testing	17.21	22.02
Average value of K (m-1)	1.436	3.788



- About 220 cars from the target group were divided in two major sub-groups based on the type of fuel they use: Diesel D1 (with less than 500 ppm sulphur in it) and Diesel D2 (with less than 2000 ppm and more than 500 ppm sulphur in it).

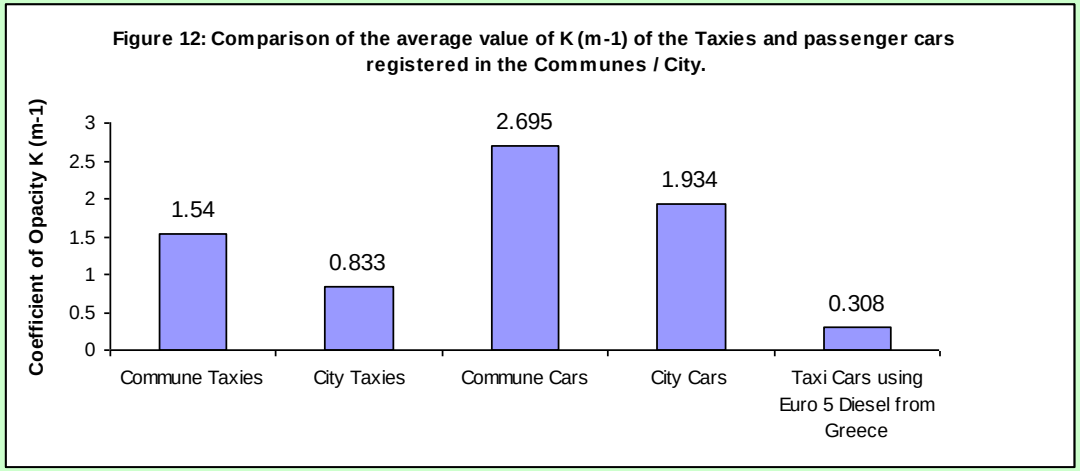
- The average value of K (m-1) for cars that use Eur 5 Diesel is 4.67 times less than the average K (m-1) which resulted for cars that use Diesel D1 type and 12.3 times less than the average K (m-1) for cars that use Diesel D2 type. The individual results of cars testing based on the type of fuel used in them are presented in Figure 11. It is obvious that the presence of PM in the exhaust gases of all cars that use Euro 5 type of Diesel is the lowest.

Results and Discussion

The impact of maintenance on PM emissions

Table 4: Comparison of the K (m^{-1}) of cars with the K (m^{-1}) of the Taxies respectively for Commune and City registered vehicles.

Cars division after:	Taxi cars using Euro 5 Diesel from Greece	Commune Taxies	City Taxies	Commune cars	City cars
Number of cars tested	10	23	29	194	279
Cars' age at the moment of purchase	12.7	12.96	14.38	15.99	15.46
Cars' age at the day of testing	16	18.04	19.86	21.72	20.7
Average value of K (m-1)	0.308	1.54	0.833	2.695	1.934



- As information summarised in Table 4 and Figure 12 reveals, the PM emissions for taxies have resulted much lower than the PM emissions for private cars.
- Within the "taxies" category, the PM emissions have resulted lower for city taxies than for commune taxies, and the lowest of all were the PM emissions for Taxies running on Euro 5 Diesel bought in Greece. These taxies use the Greek maintenance services as well.

CONCLUSIONS

- In conclusion, the Diesel quality plays a crucial role on the PM tailpipe emissions of cars.
- The highest quality of Diesel is being used in relatively newer cars which are driven on paved roads; and also it is being used more in taxies compared to other cars. The Diesel D2 using cars emit much more PM in their tailpipe emissions than Diesel D1 using cars. The cars that use Euro 5 type of Diesel pollute the air much less than the former two car categories using respectively Diesel D2 and Diesel D1.
- New cars emit much less PM in the air than old cars; cars that are driven on unpaved roads pollute the air with much more PM than cars which are driven on asphalted roads in the city; taxi cars that are well (and often) maintained emit much less PM in the air than other cars.
- Korca City does have an air quality monitoring station which measures the TSP, PM_{10}, SO_2, NO_2, and O_3. In the last decade the TSP and PM10 have been continuously above the National and EU norms whereas the other air pollutants have complied with these norms.

RECOMMENDATIONS

- **- fuel stations to provide the Albanian drivers with Euro 5 type of Diesel which meets all EU criteria for this fuel category.**
- **- vehicle fleet renewal.** Promotion of purchase of brand new cars should be an ongoing effort by the government, by finding the right economic and fiscal mechanisms in order to increase the preference of Albanians to purchase newer cars than at present.
- **- road paving especially in communes.** Road maintenance in the cities (which already have asphalted roads) and paving roads in the communes is a must in order to reduce PM emissions, not just by avoiding the dust in the air when the cars travel on these types of roads, but mainly by lowering the PM tailpipe emissions by these cars.
- **- improving the Inspection and Maintenance control** of vehicles by making all registered cars undergo the emissions testing at least once a year.
- **- introduce in Albania the testing procedure that measures the pollutants emitted by cars in the unit “gram of pollutant / km driven” regardless their production year.**

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THANK YOU VERY MUCH FOR YOUR ATTENTION!

Any Questions?