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Automobile Emissions in Tulsa, Oklahoma

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Introduction

A study of automobile emissions was conducted in Tulsa, Oklahoma over a two week period in July of 1994 by the Remote Sensing Institute at the University of Denver. Although Tulsa is in attainment of federal ground-level ozone standards, the City had two "ozone alert" days in June and is taking actions to ensure it remains in attainment. The purpose of this study was to characterize the active automobile fleet in Tulsa and to identify any gross emitting vehicles which may be contributing to the high ozone levels in that City. Owners of vehicles with excessively high carbon monoxide (CO) and hydrocarbon (HC) emissions were to be notified by mail, and given a voucher for a 15% discount on the parts and labor cost of having their vehicle repaired.

A total of 15 measurement sites were selected in the Tulsa area. Seven of these sites were designated as off-road sites, in which employees of a number of local industries, and the general public, were encouraged to voluntarily drive through. The remaining 8 sites were single lane freeway interchanges and on-ramps at which a large number of vehicles could be measured. The on-road sites were chosen throughout the Tulsa area so that all segments of the City could be represented, while still enabling a large number of vehicles to be measured. In addition, all sites chosen were flat or slightly uphill, so that vehicles would be in a steady state or accelerating slightly under load. It has previously been shown that decelerating vehicles may temporarily emit high levels of HC, or may not show an exhaust plume significant enough to be measured.[1]

The University of Denver has developed a remote sensor capable of measuring the CO, HC, and CO_2 content of automobile emissions. The instrument is essentially a 4 channel non-dispersive infra-red absorption spectrometer that measures the CO/CO_2 and HC/CO_2 ratios of motor vehicle exhaust. The IR absorption bands caused by CO, HC and CO_2 in automobile exhaust are isolated by bandpass filters at 4.6, 3.4, and 4.3 μm, respectively, and are ratioed to the reference band at 3.9 μm. The instrument is coupled to freeze-

frame video system that records an image of the rear of the vehicle being measured, so that the license plate can be read and the owner identified. The system is capable of recording an image of every vehicle that is measured, but for the purposes of this study, the system was configured such that only gross emitting vehicles were taped. The instrument was calibrated at each site with a certified gas cylinder containing known amounts of CO, HC, CO_2, and N_2, and the measurements have been validated by single and double blind intercomparisons.[2] A detailed description of the instrument used in this study can be found elsewhere.[3]

Results and Discussion

The 15 sites where measurements were taken, the dates for those sites, and the number of valid CO and HC measurements are shown in Table 1. Off-road sites are designated with an OR in parentheses. It can be seen that, in contrast to the on-road sites, voluntary participation at the off-road sites can be described as light. This is owing to the fact that, despite assurances no action would be taken against them, vehicles owners were hesitant to have their automobile tested for fear that it may fail.

Three typical measurement sites in the Tulsa area were selected for further analysis; the Citgo parking lot, I44 E. to US64 E., and Peoria Ave. to US75 S. These sites were chosen to give an accurate representation of the vehicle fleet in Tulsa. Citgo was a typical off-road site with voluntary driver participation, meaning the majority of vehicles tested were relatively new, well maintained commuter vehicles. The interchange between I44 E. and US64 E. was a high volume on-road site near the centre of Tulsa with both private and commercial vehicles well represented. The third site, Peoria Ave. to US 75 S., was chosen because the anticipated lower socio-economic status of the area would result in an older fleet.

An inspection of the statistical data for these three sites in Tables 2 and 3 shows the variation in vehicle emissions was much as anticipated. The median

Table 1. Measurement sites and valid reading counts.

Site (OR)=off road	Date	CO readings	HC readings
I44 E. to US64 E.	7-18-94	5319	5410
Fairgrounds (OR)	7-19-94	127	129
21st St. to US169 S.	7-19-94	1353	1352
West Tulsa Park (OR)	7-20-94	276	278
25th Ave. to US64 E.	7-20-94	1148	1153
SH51 W. to US169 N.	7-21-94	2660	2842
UCAT (OR)	7-22-94	405	405
HomeBase (OR)	7-23-94	522	522
71st St. to US169 N.	7-25-94	3486	3527
American Airlines (OR)	7-26-94	103	103
Oral Roberts U. (OR)	7-27-94	98	101
Peoria Ave. to US75 S.	7-27-94	1713	1725
Citgo (OR)	7-28-94	276	278
SH51 E. to US169 S.	7-28-94	4225	4232
US412 E. to US169 S.	7-29-94	4049	4063
total		25760	26120

CO values, which are the best representation of a typical car at that site, shows that the voluntary fleet at Citgo was the cleanest. Two factors are at work in this instance. Drivers who suspect that their vehicle may fail the test might not

Table 2. Mean and Median CO and HC readings for 3 sites (all values in %).

Site	Total Cars	Valid Readings	Mean CO	Median CO	Mean HC	Median HC
Citgo	288	276	0.62	0.13	0.030	0.017
I44 to US64	6015	5319	0.78	0.27	0.088	0.058
Peoria to US75	1745	1713	1.16	0.30	0.061	0.037

Table 3. Emission distribution among the 3 fleets (all values in %).

	Citgo		I44 to US64		Peoria to US75	
	CO	HC	CO	HC	CO	HC
Dirtiest 10% of fleet	63	49	56	39	50	46
Second dirtiest 10% of fleet	18	14	18	16	24	14
Third dirtiest 10% of fleet	8	10	9	12	11	10
Cleanest 70% of fleet	11	28	17	33	14	31

participate, and it has already been shown elsewhere that vehicles which commute to a regular place of work are generally newer and better maintained than the average fleet.[4] By contrast, the dirtiest fleet among the three sites was at the Peoria Ave. to US75 S. on-ramp, owing mostly to the high number of older, ill-maintained vehicles.

Table 3 shows the contribution of the total emissions, as distributed among the individual fleets. As for most North American cities[5], the majority of the gross CO emissions are caused by a relatively small percentage of the cars, with most cars contributing very little to the overall total tailpipe emissions. This is also illustrated in Figures 1-6, which show the CO and HC emissions relative to the number of emitting vehicles for the three sites.

The CO and HC data have also been illustrated as decile plots in Figures 7 and 8, showing the average CO and HC emissions of each decile. It can clearly be seen that only a small percentage of active vehicles are high emitting, and that, in the case of CO, the older, less-maintained fleet from the Peoria to US75 site is a higher emitting fleet, and that the voluntary fleet from Citgo is the cleanest fleet. The HC decile plot displays a slight anomaly, as the I44 to US64 site shows the highest average HC concentration per decile. This can be attributed to the fact that the I44 to US64 site is a flat, curving interchange, while teh Peoria to US75 site is slightly uphill. There is evidence[1] that at flat sites some drivers would have their foot off the accelerator, allowing a slight misfire in some vehicles, and thereby raising the HC emissions.

Conclusions

From the data presented here, it appears that the active vehicle fleet in Tulsa, Oklahoma is similar to that in most North American cities. The vast majority of automobile emissions in this metropolitan area are caused by a relatively small percentage of the vehicles. Not only should finding and fixing this small percentage of high emitting vehicles reduce the tailpipe emissions in this City by a significant extent, but in most cases, the cost of vehicle repair should be recovered by the owner in the form of improved fuel economy within one year.[6]

Acknowledgements

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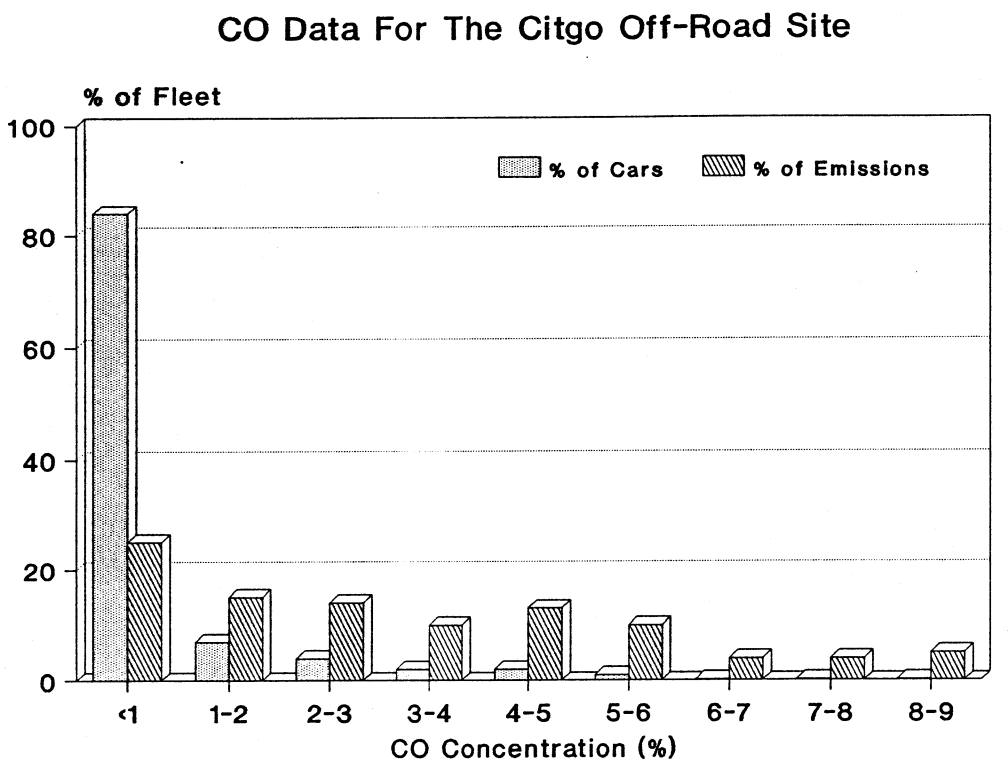

Figure 1. Percentage of vehicles found in each % CO category for the Citgo site.

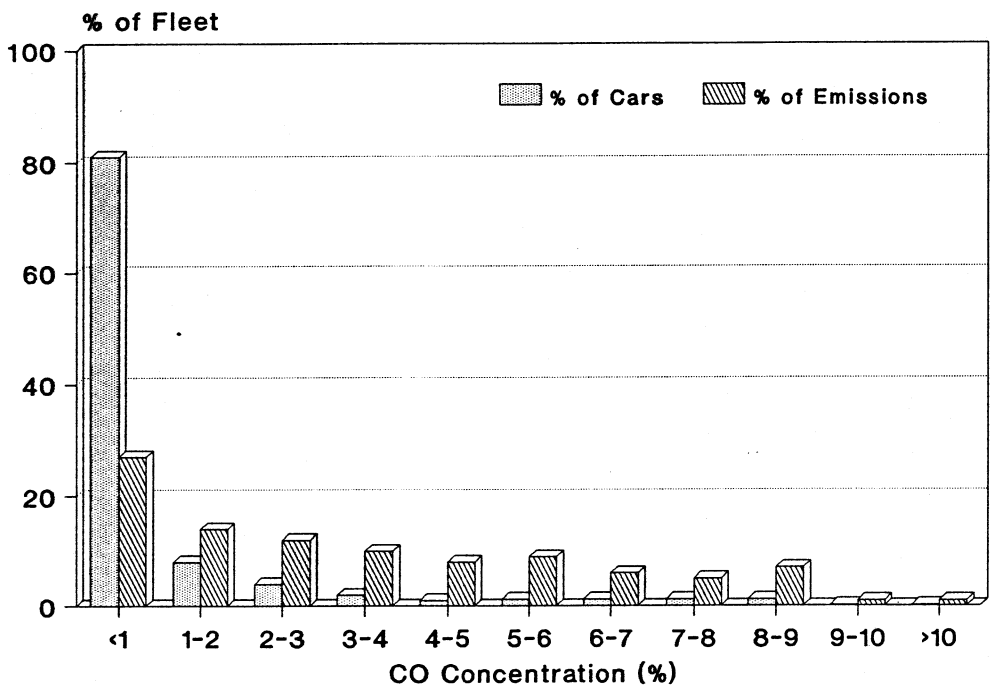

Figure 2. Percentage of vehicles found in each % CO category for the I44 to US64 site.

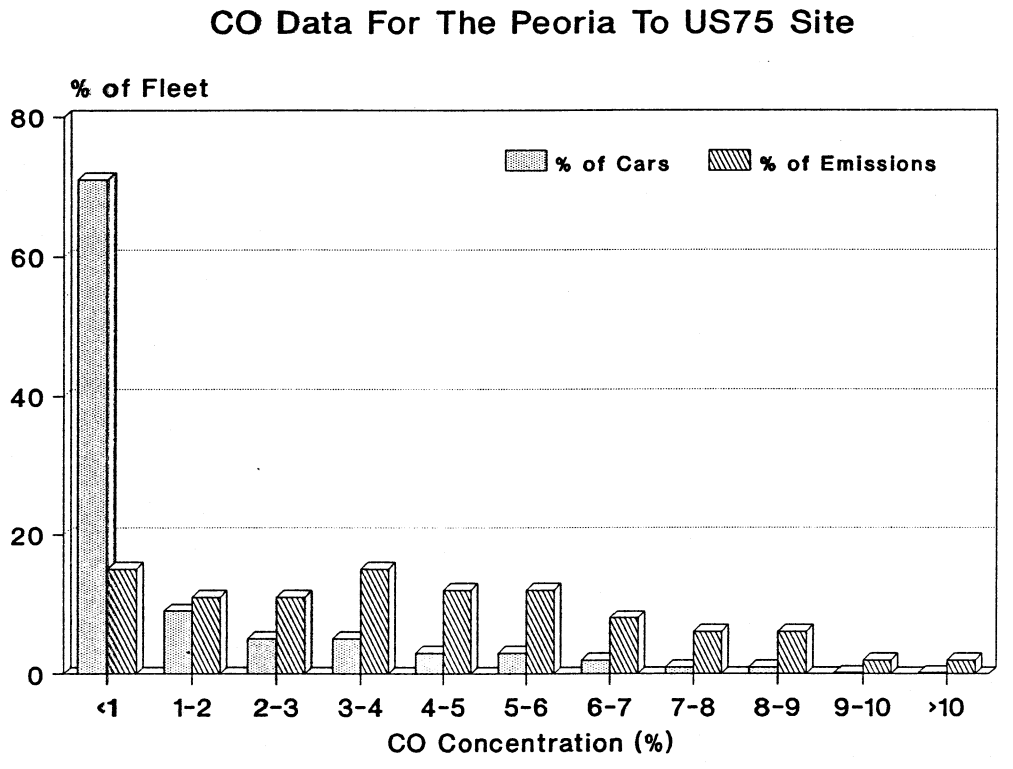

Figure 3. Percentage of vehicles found in each % CO category for the Peoria to US75 site.

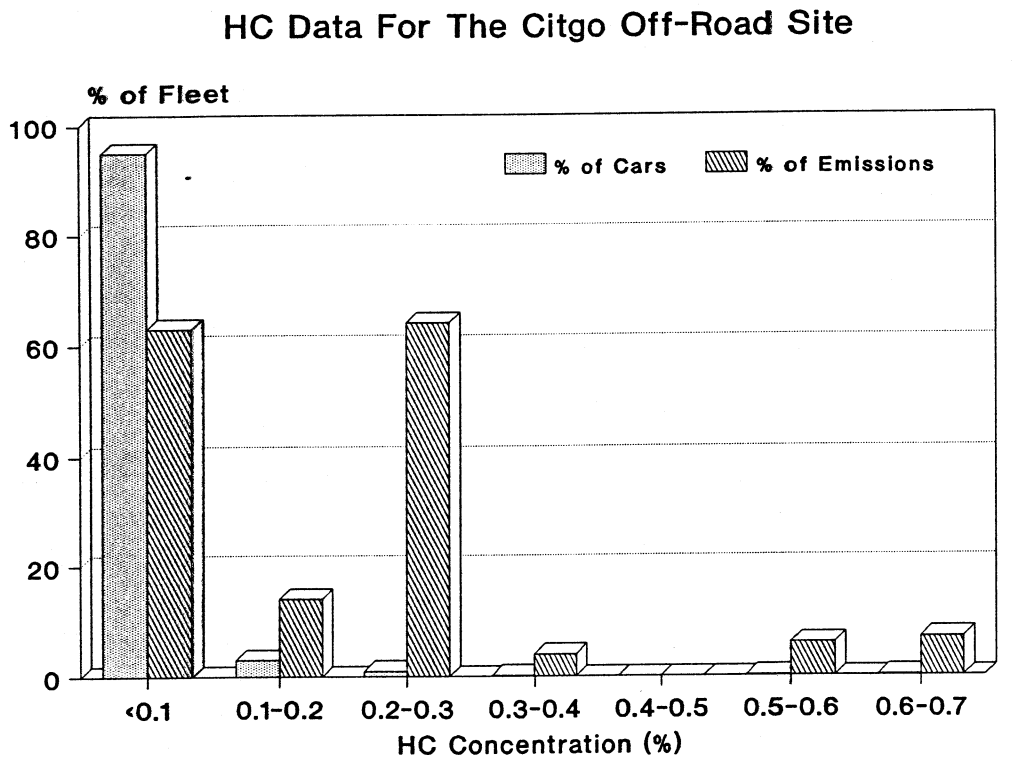

Figure 4. Percentage of vehicles found in each % HC category for the Citgo site.

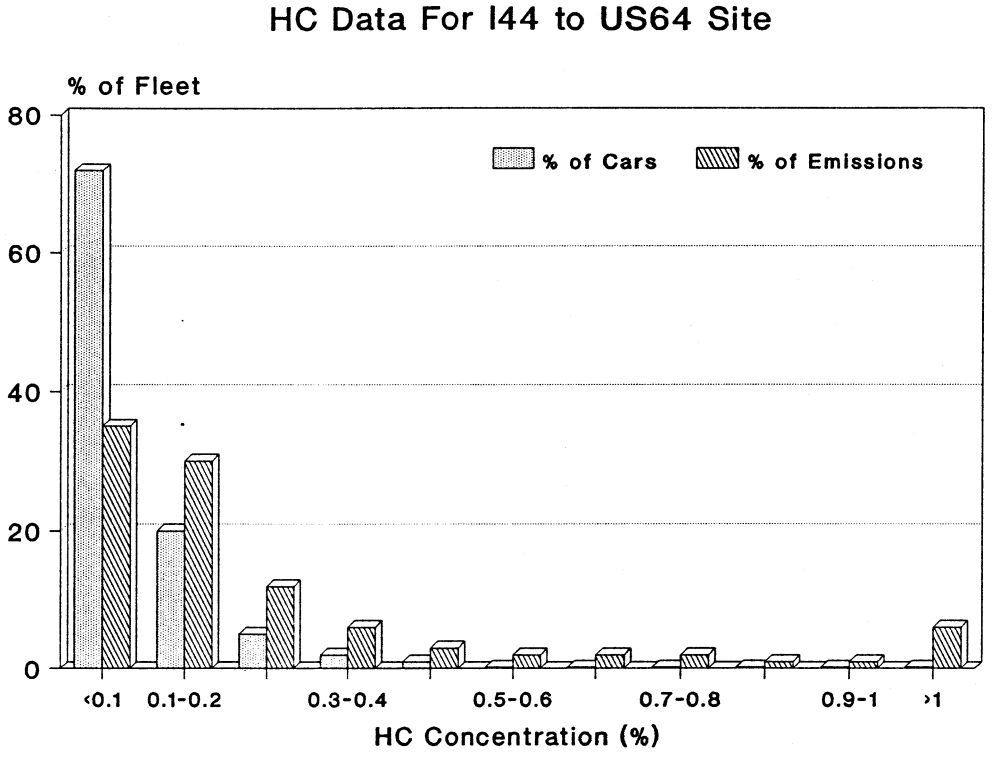

Figure 5. Percentage of vehicles found in each % HC category for the I44 to US64 site.

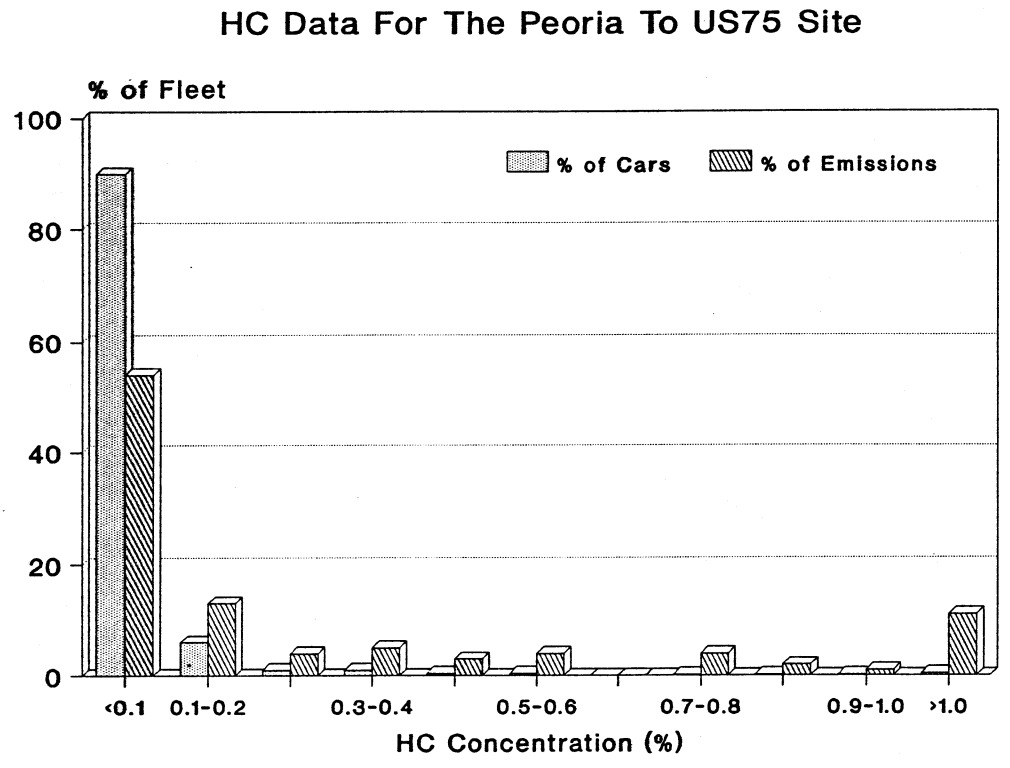

Figure 6. Percentage of vehicles found in each % CO category for the Peoria to US75 site.

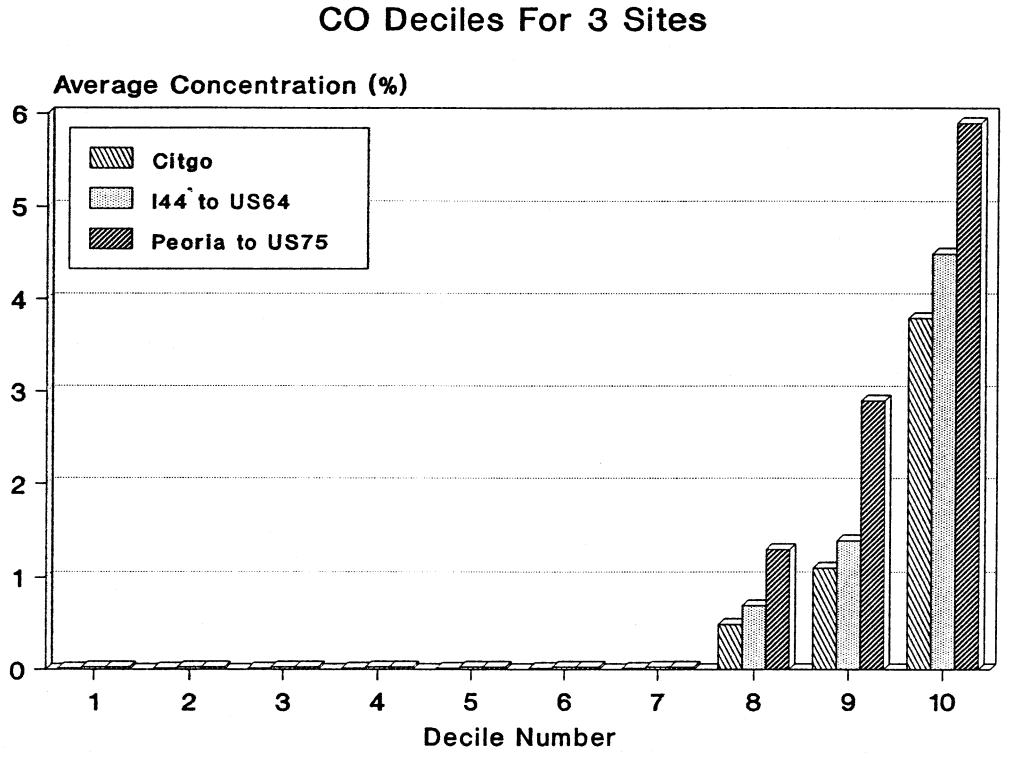

Figure 7. A histogram illustrating the average % CO emissions for each decile of the fleet at each site. Note that 70% of the vehicles at all sites have negligible emissions.

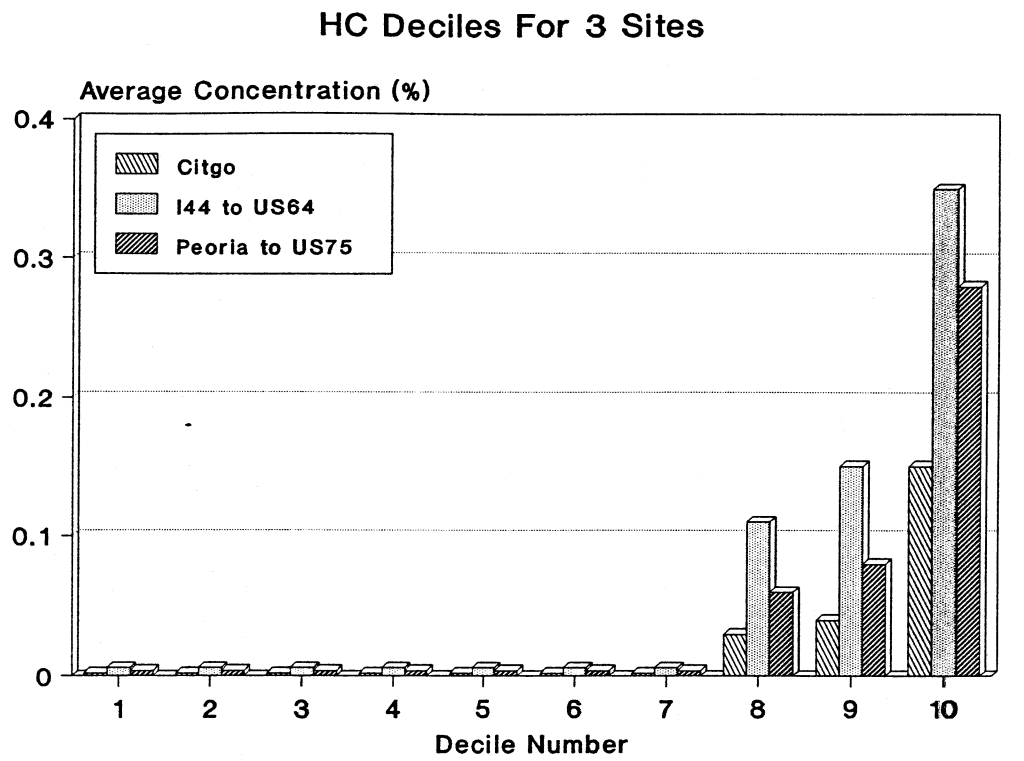

Figure 8. A histogram illustrating the average % HC emissions for each decile of the fleet at each site. Note that 70% of the vehicles at all sites have negligible emissions.