

Toxic Impacts of Emissions from Small 50cc Engine Run under EC47 Driving Cycle: A Comparison between 2-Stroke and 4-Stroke Engines and Lube Oil Quality and Ethanol Additivation

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09/11/2011Jean-Paul MORIN
INSERMDavid PRETERRE and Veronika Keravec
CertamChristelle MONTEIL
University RouenFrederic Dionnet
CERTAM

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ABSTRACT

One 4-stroke scooter and two 2-stroke scooters (50 cc bore) were run on dynamic test benches according to the EC47 driving cycle. Emissions from these scooters were continuously monitored, sampled and hot- diluted prior being driven to continuous flow through chambers containing organotypic cultures of lung tissue under bi-phasic Air/liquid culture conditions for three hours. Lung tissue was evaluated for viability (ATP), anti-oxidant defenses (intracellular GSH, Catalase, superoxide-dismutases, glutathione-S-Transferase, glutathione peroxidase, glutathione-reductase activity levels) and inflammatory reaction through the measurement of TNFalpha secretion in the culture medium.

4-stroke engine emissions had a moderate impact on lung tissue viability but induced a marked GSH depletion concomitant of increased GPx activity.

2-strokes engine emissions had variable impacts according to after-treatment technology and lube oil quality. Lower oxidation catalysis and mineral lube oil were found to be the worse situation inducing a marked lung tissue viability loss

and high intracellular glutathione depletion, a marked decrease in SOD activity both Mn and Cu/Zn iso-enzymes being affected and a decrease in TNF alpha secretion. On the other hand, high oxidation catalysis and semi-synthetic lube oil was found to be the best situation with only minor tissue viability loss, moderate glutathione depletion, moderate elevation of glutathione peroxidase, almost no impact on superoxide dismutase activities and a moderate increase in TNFalpha secretion.

The measurement of regulated emissions (CO, NO, NO2, HC, and particulate matter) showed that under warm engine conditions, 2-stroke engine with high oxidation catalysis and semi-synthetic lube oil was the least emitting situation especially when CO, HC and particulate matter are considered. 4-stroke engine proved to have intermediate emissions levels especially for CO, HC and particulate matter. 2-stroke engine with low oxidation catalysis and mineral oil was found to be the worse situation especially for HC and particulate matter.

In conclusion : emissions from small scooters may have detrimental impacts on lung tissue which may be highly

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reduced by the use of an oxidation catalyst on the exhaust line and by using high quality grade oil like semi-synthetic oil compared to mineral oil. Suitable recently designed after-treatment strategies allow a very efficient reduction of 2-stroke engine emissions and toxic potential leading to an even lesser impact than for the 4stroke commercially available engine emissions.

INTRODUCTION

As a mode of urban transportation, motorized two-wheeler vehicles (motorcycles, mopeds, scooters) encompass a great variety of vehicles and they are used for a wide range of purposes. This mode plays different roles: from marginal for a few travellers in some industrialized Countries, to “unavoidable” in some others, particularly in moderate climates, to dominant in many developing Countries. In Europe, according to the Council Directive 92/61 EC, powered two wheelers of class A correspond to small vehicles not exceeding 50 cc and 45 km/h. This class seems to gain again new interest as a popular urban commuting mode. Recurrent problems are associated with these vehicles as safety issue due to improper knowledge of riders behavior and motivation, lack of comprehensive policies and environmental and health concerns due to potentially very high emissions. According to the WHO report, many factors contributed to open the air pollution drawer. Indeed, just in 1990s, the awareness that, per kilometer, the average two-wheeler can pollute more than the average gas-fuelled car started to become stronger among decision-makers. Air quality levels were rather poor in many urban areas of both industrialized and developing Countries but, notwithstanding such a new consciousness, initially the contribution of PTWs was still not properly taken into account and consequences became severe: for instance in Milan, in 2001, PTWs were still the second contributor, after private cars, to the emissions of CO (13%), NMVOC (22%) and CH₄ (23%), according to data monitored by Milan Municipality (2001). Needless to say, PTWs were (and still are) the second mode per number of registered vehicles in the city. However, such a situation does not differ a lot from what takes place in Asia. Two different technologies are most common for these class A two wheelers which may significantly impact pollutant emissions : 4 strokes and 2 strokes engines. Compared to four stroke engines, two-stroke engines produce a lot of pollution because the fuel-air mixture in them gets contaminated with the engines lubricating oils. Simultaneously the combustion chamber draws in the contaminated mixture as exhaust gases are expelled through an exhaust port. Some of the fuel and oil gets mixed up with the exhaust. Measurements of how much pollution two-wheelers emit are rare, but one study of traffic intersections in Bangkok, Thailand, found that two-wheelers contributed up to 47% of particulates. On the other hand, a highly tuned two-stroke engine produces a tremendous amount of power per cubic centimeter, is usually lighter than a four stroke engine, and might if adequately depolluted with

a suitable after-treatment strategy keep an interest for light two wheelers.

Our interest in this paper was to characterize emissions from three different commercially available two wheelers (1 four-strokes and two two-strokes) representative of today's French market driven according to the EC47 cycle and characterize their potential health impacts by the use of organotypic cultures of lung tissue exposed to a continuous flow of diluted emissions continuously drawn and sampled from two wheeler tailpipes.

METHODS

Scooter and emission sampling and pollutant analysis

3 different scooters were used throughout the study A 2-stroke-Piaggio ZIP50, A 2-stroke Peugeot Ludix, both equipped with an oxidation catalyst and a fresh air injection device into the exhaust pipe upstream from the catalyst, and a 4-stroke Peugeot VClic. Fuel was market SP95. Two lube oil qualities were used : Ful Synthetic oil Castrol, and a semi-synthetic oil.

These scooters were purchased new from the commonly public available market and considered as representative of the recent on road French scooter fleet.

Scooters were placed on a dynamic roller bench (MotoscanII bench driven by the Kronos interface software - Rotronics France) allowing to control and perform the EC47 dynamic cycle ([fig 1](#)) consisting in a succession of individual 120 second bricks including idling, 50km/hour and 20 km/hour steps.

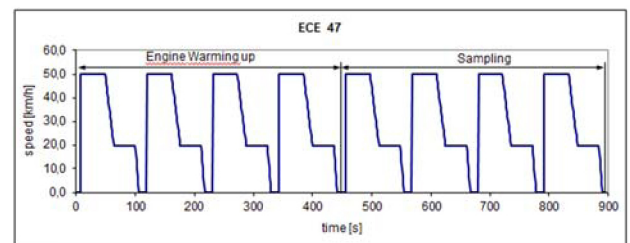


Figure 1. Description of EC47 driving cycle: Bricks consist in 3 sequential speed plateau levels 50 km/hour, 20 km/hour and idling, full cycle consist in 8 consecutive bricks from cold start, first four bricks are allowed from engine warming up, bricks 5-8 are used for emission characterization.

Continuous emission sampling was achieved by the use of a fine particle sampler (FPS Dekati - Finland) allowing to control and monitor precisely the temperature and dilution ratio of the exhaust. FPS allows to hot-dilute exhaust gas in order to avoid condensation phenomenon and maintain the

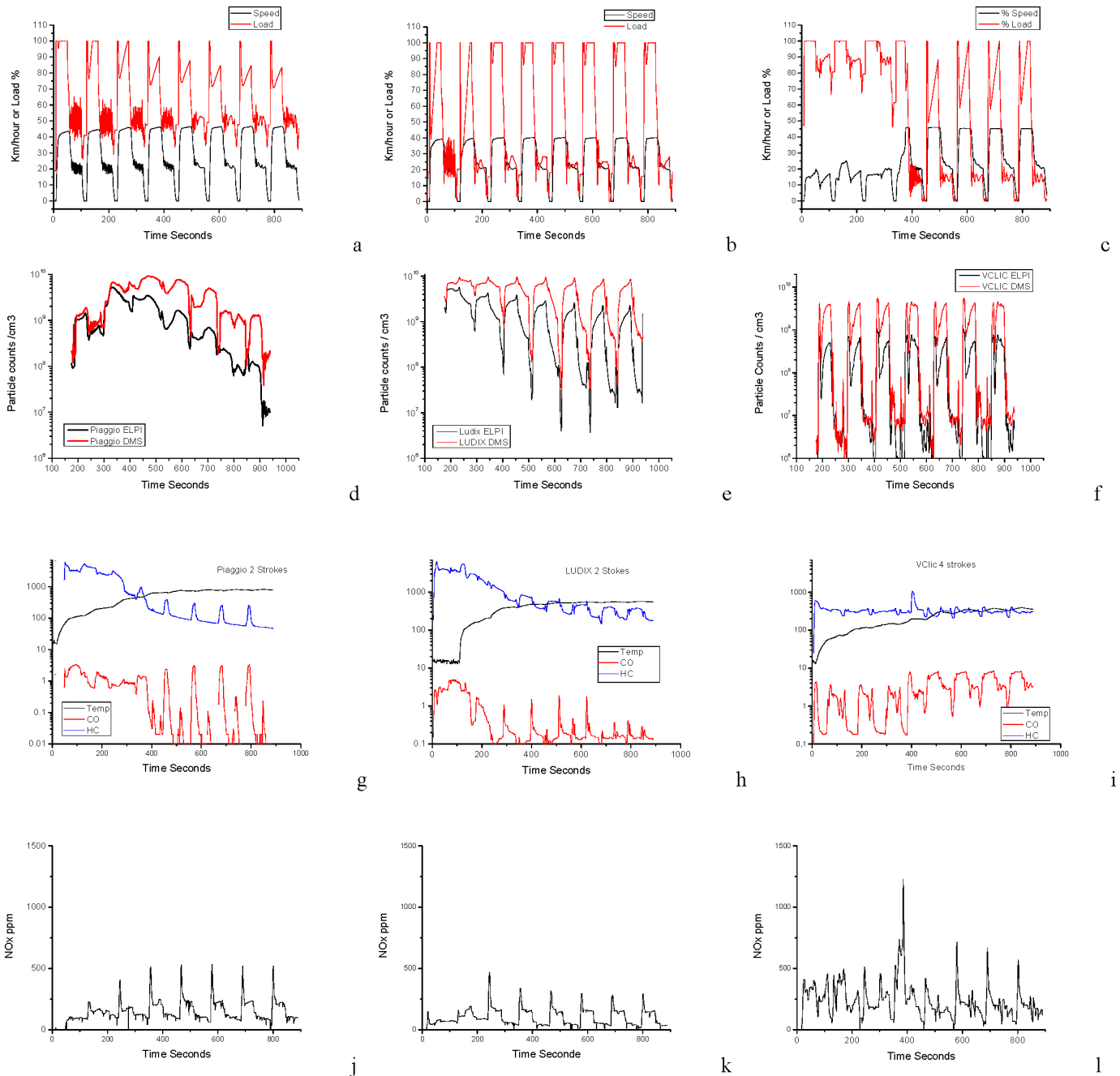


Figure 2. Continuous monitoring of two wheeler behavior and emissions on full EC47 driving cycle. Upper panel (a,b,c) show actual speed and loads to reach cycle conditions, intermediate high panels(d,e,f) show particulate emissions using both ELPI and DMS50 dynamic measurements, intermediate low (g,h,i) panels show temperature, carbon monoxide and non methane hydrocarbons, lower panel (jkl) show NOx emissions. Left panels (a,d,g,j) for Piaggio Zip50 2 strokes, central panels (b,e,h,k) for Peugeot Ludix 2 strokes and right panel (c,f,i,l) for Peugeot VLCic 4 strokes.