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DEVELOPMENT OF VEHICLE EMISSION REDUCTION UNIT (VERU) FOR USE IN PETROL ENGINES

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SUMMARY: Vehicle emissions constitute the main source of atmospheric pollution in modern cities. The increasing number of passenger cars, especially during the last decade, has resulted in composite traffic problems with serious consequences on emissions and fuel consumption. The main focus is on the development of a unit to reduce the constituents of vehicle emissions before they get into the atmosphere.

The Vehicle Emissions Reduction Unit (VERU) was used to absorb certain percentages of carbon dioxide (CO_2), carbon monoxide (CO), and hydrocarbons (HC) which would have been emitted into the atmosphere.

The VERU consists of a canister and specimen prepared by mixing clay with soda lime and water and rolled into balls which were then sun dried. The sun dried specimen were placed in the canister and applied at the tail end of exhaust pipes of vehicles.

The results of the tests carried out using VERU showed that CO_2 was reduced by 60%, CO by 73%, HC by 80%, while O2 was increased by 150%. It was concluded that the use of VERU could reduce vehicle emissions and is therefore recommended for use.

Key words: *vehicle emissions, VERU, catalytic converter, carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC)*

INTRODUCTION

The personal automobile has been recognized as the single greatest producer of harmful vehicle exhaust emissions *(John, 1998; Milton, 1995)*. Road transport activities still contribute significantly to environmental problems at different geographical levels and the issues of paramount interest include exposure to air pollutants in areas with heavy traffic, photochemical smog formation, national emission levels of primary air pollutants and global warming *(Smit et al., 2007)*.

In fact, the Intergovernmental Panel on Climate Change *(2007)* noted that the effect of greenhouse gas emissions from the transportation sector on the atmosphere is of increasing concern, as this sector contributes about 14% of the global anthropogenic greenhouse emissions. O' Mahony et al. *(2006)* observed that the main source of air pollution was automobile traffic, as 60% of all volatile organic compounds have road traffic as their source. Similarly, Taylor and Fergusson *(1997)* noted that these pollutants include the carcinogenic pollutant benzene in petrol engines and particulate matter that is emitted from diesel engines. In cities, pedestrians going to and coming from work are highly exposed to harmful environmental pollutants *(King et al., 2009)*. Vehicle emissions include volatile organic com-

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pounds, nitrogen oxides, lead and carbon monoxide that have adverse effects on natural environment, human health, agricultural productivity and natural ecosystems, as noted by Bolaji and Adejuyigbe *(2006)*. Similarly, Dewaram *(2002)* stated that hydrocarbons present in the exhaust, particularly in vehicles with poor combustion, cause respiratory problems. Once these fumes are emitted into the atmosphere *(Zannetti, 1992)*, the pollutants undergo mixing or diffusion to a degree that depends on topographic, climatic and meteorological conditions.

Due to their harmful effects on humans and plants, the quantity of these pollutants should be reduced as much as possible. Vehicle emissions are controlled in three ways. One is to promote more complete combustion with fewer by-products. The second is to reintroduce excessive hydrocarbons back into the engine for combustion, and the third is to provide an additional area for oxidation or combustion to occur. This additional area is called a catalytic converter. The catalytic converter resembles a muffler in appearance. It is located in the exhaust system, before the muffler. Inside the converter are pellets or a honeycomb made of platinum or palladium. The platinum or palladium is used as a catalyst (a catalyst is a substance used to speed up a chemical process). As hydrocarbons or carbon monoxide in the exhaust pass through the catalyst, they are chemically oxidized or converted to carbon dioxide and water *(Kummer, 1981)*. The most common cause of catalytic converter failure is contamination due to rich air/fuel mixtures, leaded fuels and engine coolant that has leaked into the exhaust.

One of the most effective ways to reduce emissions of nitrogen oxides is by introducing exhaust gas recirculation (EGR) and using two-stage combustion *(Vestilind et al., 1993)*. The purpose of the exhaust gas recirculation (EGR) valve is to meter a small amount of exhaust gas into the intake system. This dilutes the air/fuel mixture so as to lower the combustion chamber temperature. Excessive combustion chamber temperature creates oxides of nitrogen, which is a major pollutant. While the EGR valve is the most effective method of controlling oxides of nitrogen, in its very design it adversely affects engine performance *(Moneib et al., 2009)*. The engine was not designed to run on exhaust gas. For this reason the amount of exhaust entering the intake system has to be carefully monitored and controlled. This is accomplished through a series of electrical and vacuum switches and the vehicle computer. Since EGR action reduces performance by diluting the air /fuel mixture, the system does not allow EGR action when the engine is cold or when the engine needs full power. Another method is the 'use of water in combustion chamber or admitting inert gases inside the combustion chamber of the engine' *(Moneib et al., 2009)*. The removal of some exhaust gases is based on physical and physical-chemical processes, such as adsorption or mechanical filtering *(Tesar, 2005)*. Tesar *(2005)* however, identified the problems of previous intervention strategies and proposed the use of fluidic valves but admitted that they are difficult to design. Despite the use of some of the emissions control items, vehicles still emit pollutants that can be further reduced. The need to further reduce the vehicular emissions necessitated the development of the vehicle emission reduction unit (VERU) which is the focus of this paper.

MATERIALS AND METHODS

Barash et al. *(2005)* stated that soda lime is a mixture of chemicals (about 75% calcium hydroxide, about 20% water, about 3% sodium hydroxide, and about 1% potassium hydroxide). It is used in granular form in closed breathing environments, such as general anesthesia, submarines, rebreathers and recompression chambers, to remove carbon dioxide from breathing gases so as to prevent CO_2 retention and carbon dioxide poisoning.

Sun dried clay was ground and then sieved to make very fine particles to enhance proper and thorough mixing with the mentioned compounds that make up soda lime in powdery form as shown in Table 1.

Table 1. Constituents of materials for VERU

Tablica 1. Sastojci materijala za VERU napravu

Materials	Proportion (Teaspoonful)	Constituents Weight +Nylon weight (g)	Constituents Weight -Nylons' weight (g)	% in soda lime	% in specimen
$Ca(OH)_2$	5	39.9528	39.6528	75.63	65.95
H_2O	3	11.2332	10.9332	20.85	18.18
NaOH	1/5	2.0436	1.8436	3.52	3.07
Clay	1	7.9928	7.6928		12.80

The resultant product was rolled into balls and dried. The clay balls had a diameter of 10 mm and 40 of such clay balls were used.

The clay balls were put inside a canister which was made of stainless pipe of 45 mm outer diameter and 43 mm inner diameter (1 mm thickness). The pipe length was 150 mm. The canister was attached to the end of the exhaust pipe for the emission to pass through the specimen before it passes into the atmosphere. The testing of VERU (figure 1) was done on twenty two (22) vehicles (available during the test) using gas analyzer (figure 2). It was conducted in conjunction with Pescasen Nigeria Limited, established under the Ogun State Emission Control Scheme by Ogun State Environmental Agency, to identify vehicles that are producing more air pollution than expected. The various types of vehicles tested were Toyota Carina E, Nissan Maxima, Toyota Camry Le, Honda Accord, Mitsubishi Galant, Benz 190, Volkswagen Golf, Mazda 626, Nissan Sunny, Honda Conderto, Audi 80, Nissan Primera and Nissan Maxima. The method of testing adopted was the Steady State Loaded/ Idle which gives results in percent or parts per million (ppm).

Figure 1. Testing of VERU
Slika 1. Ispitivanje VERU naprave

The requirements before and after the test:

1. Vehicle should be in good working condition and maintained according to the recommended maintenance schedule. The tires and brakes need to be in good condition.
2. Vehicle needs to be driven enough miles to warm up the engine and ensure that the vehicle is at normal operating temperature.
3. While waiting for the test, the engine should be left to run in neutral or park.
4. No smoking or mobile phone calls are allowed during testing.

The company was granted the authority to implement vehicle and generator emissions testing in Ogun State on behalf of the Ogun State government. There were set values that served as boundary between pass and fail for vehicles, according to the company's standards (Table 2).

Table 2. Standard values prescribed by Pescasen Nigeria Limited

Tablica 2. Standardne vrijednosti propisane od Pescasen Nigeria Limited-a

	CO (%)	CO_2 (%)	O_2 (%)	HC(ppm)	Lambda
Petrol Engine	3.5			700	
Diesel Engine	4.5				
2 & 3 Wheel Vehicles	4.5			9000	

Figure 2. Gas analyzer for vehicle emissions
Slika 2. Analizator ispušnih plinova vozila

The dried clay, after the addition of the constituents, as well as before use and after use, was analyzed to identify other materials that were likely to be contained in it using standard colorimetric techniques *(Brown, 1988)*, Flame Atomic Absorption Spectrophotometry (FAAS) and Loss On Ignition (LOI). The emissions before the application of VERU and during its use were analyzed using SPSS 16.0 statistical package for differences.

RESULTS AND DISCUSSION

The values of carbon monoxide (CO%) before and after the application of VERU is shown in figure 3, indicating that there was a reduction in the values of CO emitted into the atmosphere due to the application of VERU. Figure 4 shows the comparison of CO_2 values before and after the application of VERU. Just as for CO, there was also a reduction in CO_2 due to the application of VERU. On the other hand, there was an increase in the O_2 emitted, as shown in figure 5, while there was a reduction in hydrocarbon (HC) due to the application of VERU.

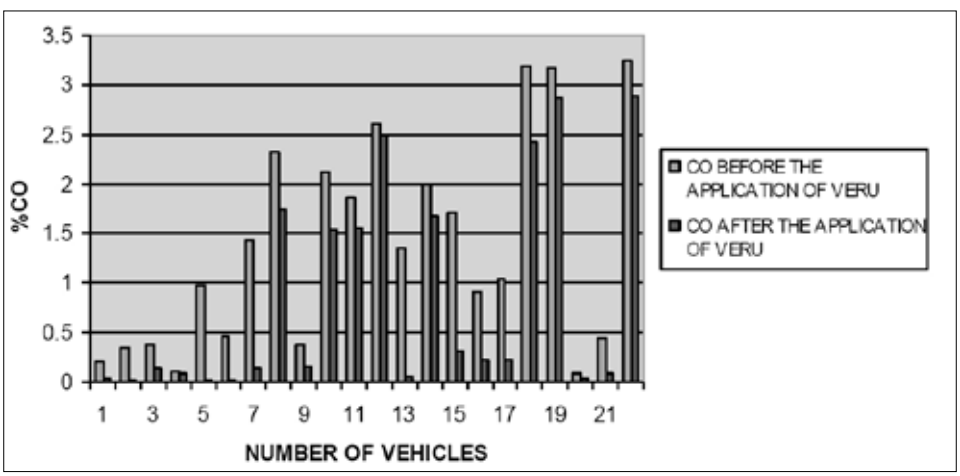

Figure 3. Values of CO before and after application of VERU
Slika 3. Vrijednosti CO prije uporabe i poslije uporabe VERU naprave

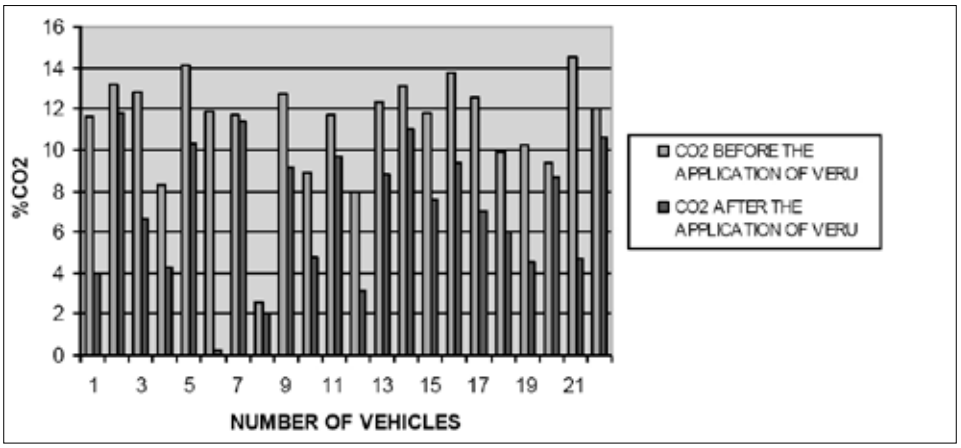

Figure 4. Values of CO_2 before and after application of VERU
Slika 4. Vrijednosti CO_2 prije uporabe i poslije uporabe VERU naprave

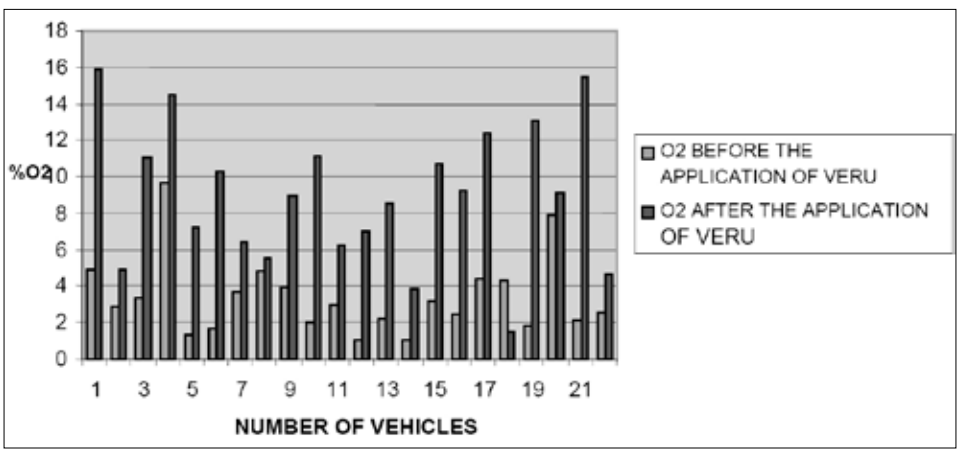

Figure 5. Values of O_2 before and after application of VERU
Slika 5. Vrijednosti O_2 prije uporabe i poslije uporabe VERU naprave

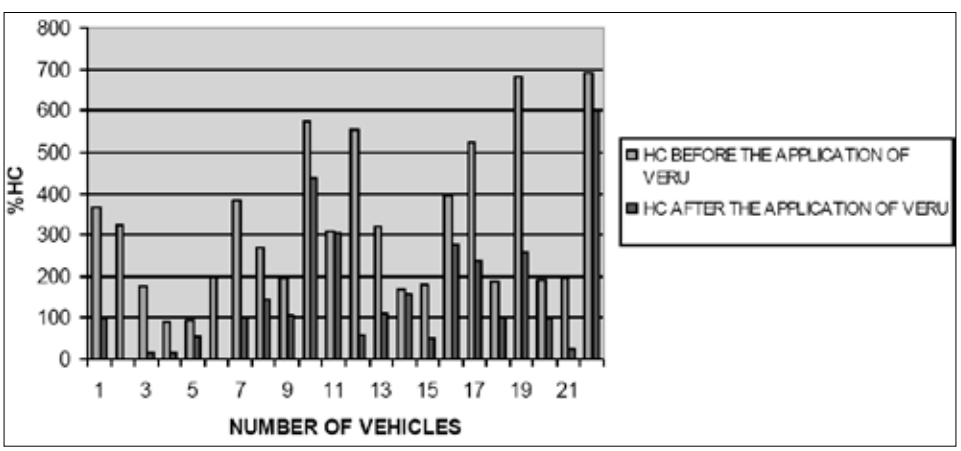

Figure 6. Values of HC before and after application of VERU
Slika 6. Vrijednosti HC prije uporabe i poslije uporabe VERU naprave

Positive effects of the application of VERU were found on all the results for CO, CO_2, O_2, and HC. The results of the tests carried out using VERU showed that CO_2 was reduced by 60%, CO by 73%, HC by 80%, while O_2 was increased by 150%. The greatest benefit of using VERU is not only in the reduction of the greenhouse gas but also in the increase of the available O_2. The differences in emissions characteristics before and during the use of VERU showed that there were significant differences between CO (t=6.083, p=0.000, standard deviation=0.40901, standard error of mean=0.08720), CO_2 (t=6.763, p=0.000, standard deviation=2.88126, standard error of mean=0.61429), O_2 (t=-6.703, p=0.000, standard deviation=3.91497, standard error of mean=0.83468), and HC (t=6.356, p=0.000, standard deviation=128.13406, standard error of mean=27.31827). Thus, the catalytic converter is one of the most effective emission control devices available. It processes exhaust to remove pollutants, achieving considerably lower emissions than is possible with in-cylinder techniques. However, with greater mileages emissions catalyst conversion efficiency and durability would decrease. It was observed that the decrease in emissions was lower in some vehicles when compared to others. This may be as a result of presence and functional catalytic converter.

The results of the soil analysis conducted on variants of clay are shown in Table 3.

Table 3. Soil analysis for clay in VERU

Tablica 3. Analiza gline u VERU napravi

Material	Fe (g)	Ca (g)	Mn *10 (g)	Zn (g)	Cu (g)	Cd (g)	Al (g)
Clay with constituents	0.668	0.481	0.887	0.116	0.072	0.114	0.021
Clay as used in VERU	0.712	0.508	0.813	0.172	0.092	0.108	0.018

It was observed that there was an increase in the quantity of iron (Fe) from 0.668 g to 0.712 g, calcium (Ca) from 0.481 g to 0.508 g, zinc (Zn) from 0.116 g to 0.172 g, and copper (Cu) from 0.072 g to 0.092 g after use in VERU. However, there was a reduction in the quantity of manganese (Mn) from 0.0887 g to 0.813 g, cadmium (Cd) from 0.114 g to 0.108 g, and aluminum (Al) from 0.021 g to 0.018 g. These increases and decreases may be as a result of other unnoticed reactions that took place between the constituents of VERU and the vehicle emissions resulting in the increase of essential O_2 and decrease of unwanted CO, CO_2 and HC. It should, however, be noted that the suitability of using VERU on vehicles travelling long distances is yet to be tested. VERU is expected to endure 15,000 km of vehicle travel.

CONCLUSION

The living environment is a cornerstone of good health and every appropriate investment in the environment should bring about improvement to peoples' health. The major problem that people in cities are facing nowadays is environmental pollution due to gaseous emissions from automobile engines. The automobile exhaust gases contain oxides of nitrogen, carbon monoxide, carbon dioxide, unburned and partially burned hydrocarbons and particulates. Increased global concerns about the state of the environment in recent decades have been accompanied and partly prompted by an ever-growing body of evidence on the extent to which pollution has caused severe environmental degradation. Thermal air pollution, greenhouse effect, ozone layer depletion and other types of disturbances of the natural environment are the major effects of emissions. Using VERU will go a long way in reducing the amount of emissions of CO_2, CO, HC and increasing O_2 emitted into the atmosphere by vehicles on our roads, minimizing the problems of air pollution, greenhouse effect, ozone depletion and other health hazards.

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RAZVOJ VERU NAPRAVE ZA SMANJENJE EMISIJA PLINOVA IZ VOZILA

SAŽETAK: Emisije plinova iz vozila glavni su uzrok zagađenosti zraka u modernim gradovima. Sve veći broj osobnih automobila, posebno u zadnjem desetljeću, doveo je do složenih prometnih teškoća i ozbiljnog povećanja potrošnje goriva i emisija plinova. Cilj je razviti napravu koja će smanjiti štetne sastojke u ispušnim pliovima iz vozila prije njihova ispuštanja u atmosferu.
VERU (Vehicle Emissions Reduction Unit = naprava za smanjenje emisija) je upotrebljavan za upijanje određenih količina ugljičnog dioksida, ugljičnog monoksida i ugljikovodika koji bi inače završili u atmosferi.
VERU se sastoji od metalne cijevi i smjese načinjene od gline, soda vapna i vode, oblikovane u kuglice koje se zatim suše na suncu. Suhe kuglice namjeste se u cijev koja se pričvrsti na kraj ispušne cijevi vozila.
Rezultati ispitivanja VERU naprave pokazuju smanjenje ugljičnog dioksida za 60 %, ugljičnog monoksida za 73 % i ugljikovodika za 80 %, dok je količina kisika veća 150 %. Stoga je zaključeno da bi VERU mogao smanjiti emisije plinova iz vozila i iz tog se razloga preporuča njegova uporaba.

Ključne riječi: *emisije iz vozila, VERU, katalizatorski pretvarač, ugljični dioksid, ugljični monoksid, ugljikovodici*

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