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1	An Investigation on the Variation of Vehicular Emissions with
2	Ambient Temperature and Humidity in the Tropics
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5	Received: 14 December 2011 Accepted: 3 January 2012 Published: 15 January 2012

#### 7 Abstract

<sup>8</sup> In this study, we proposed an approach for investigating whether vehicular emissions vary

<sup>9</sup> with Ambient Temperature and Humidity of the day. The proposal includes mathematical

<sup>10</sup> models that can be used to predict the amount of pollutants dispersed into the atmosphere at

<sup>11</sup> a particular time of the day. The pollutants include; NOx, CO, CxHy. These pollutants were

<sup>12</sup> measured and analyzed during the morning and afternoon periods, using the Exhaust Gas

<sup>13</sup> Analyzer and the Digital Thermometer/Hygrometer. The measured and estimated values of

<sup>14</sup> these pollutants compared favorably using MATLAB simulations.

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Index terms— Ambient Temperature, Humidity, Exhaust Gas Analyzer, Digital Hygrometer, Vehicular
 Emissions.

### 18 1 INTRODUCTION

esearch work had been carried out in the past to investigate the influence of ambient temperature on exhaust emissions ??1 -14]. It was reported that exhaust emissions could be increased tremendously at cold ambient conditions. For instance, the hydrocarbon emissions could increased by 650% at -20 o C and carbon monoxide emissions could increased by 800% at -20 o C, compared to standard certification values at +25 o C [8,9]. However, the influence of cold temperatures on NOx was much lower and more complex as cold temperatures increase engine heat losses and cool the flame, thus reducing NOx emissions from the engine. This partially offset the slower catalyst light off.

The low ambient temperature can reduce lubricating oil pumpability and increase viscosity of lubricating oil 26 and thus results in higher mechanical losses for engine's cold start. The performance of the battery would be 27 affected by low ambient temperature. The air and fuel mixture can be affected due to poor volatility of fuel 28 at low ambient temperature and therefore cause deterioration of combustion quality. The lower the ambient 29 temperature, the richer the air fuel mixture required for a start up. Incomplete combustion with excess fuel 30 results in increased carbon monoxide and hydrocarbon emissions. The low ambient temperature can also delay 31 32 the light-off of the catalyst, which is one of the most important reasons accounting for high emissions at cold 33 start.

The literature above reveals the influence of ambient temperature on vehicular emissions at 'cold start' period only. However not much work has been done to investigate the variation of vehicular emissions with ambient temperature and humidity at both the morning and afternoon periods, which entails the cold start and warm-up period of the engine.

With a unique approach, this study investigates the variation of vehicular emissions with ambient temperature and humidity in the tropics by considering both the morning and afternoon period for exhaust emission

40 measurements and analysis.

#### 41 **2** II.

### 42 3 METHOD OF INVESTIGATION

43 Certain exhaust samples were collected from a number of vehicle engines (that use Motor Premium Spirit) and 44 analyzed using the Exhaust Gas Analyzer with Model number "Testo 350 XL". These samples were collected 45 during the morning (low temperature and high humidity) and afternoon (high temperature and low humidity) 46 periods. A temperature and humidity sensing device (Digital Thermometer/Hygrometer with Model number IT 47 202) was used to measure both temperature and humidity during those periods. The investigation was carried 48 out in some parts of Edo State of Nigeria and thereafter mathematical models and graphical representation of 49 the investigations were obtained using MATLAB. (See table 1)

# 50 4 **RESULTS AND DISCUSSION**

51 Using linear and quadratic fitting of the MATLAB code, the following mathematical and graphical models for CO,

52 CxHy, and NOx emissions were obtained; b) NOx Emissions Figure 3 above shows the Nitrogen Oxides emissions 53 as a function of the temperature. The result of figure 3 above shows that the "engine out NOx emissions" are

reduced in the morning period when the ambient temperature is very low, but increased during the afternoon

<sup>55</sup> period when the ambient temperature was high. This implies that the increase of NOx emission is directly

<sup>56</sup> proportional to the ambient temperature. The reason for this is that NOx is a temperature dependent pollutant

57 as it is formed in the combustion chamber when the combustion temperature increases to 2000 o C [3]. This

58 means that, as the temperatures decreases, the engine heat loss increases thereby cooling the flame temperature

<sup>59</sup> and therefore reducing the amount of NOx released from the engine exhaust.

The mathematical model and graphical representations of the pollutants against the humidity (H) are shown below;

## $_{62}$ 5 Figures of 4 & 5 show

63 Carbon Monoxide and Hydrocarbon emissions as functions of humidity. It is observed that when the humidity is 64 very high, the concentration of the pollutants (CO & CxHy) will also be high and when the amount of humidity 65 present in the atmosphere is very low, the concentration will automatically be low. The reason for this is that high 66 amount of humidity in the atmosphere can cause poor mixing of fuel and air in the combustion chamber, thereby 67 hereby

resulting in incomplete combustion which will in turn results in excessive release of CO and CxHy pollutants [5].

The case is the reverse for NOx emissions of figure 6 above as high humidity will result in the reduction of NOx

69 pollutants released from the engine exhaust. The reason for these has been explain in the previous paragraph of

70 this study.

# 71 6 CONCLUSION

72 Investigations carried out in this study tend to show that vehicular emissions vary with ambient temperature 73 and humidity at different times of the day. There seem to be much increase in emission rates when the ambient

temperature falls below the standard temperature of 75 o F, this might be due to "cold start problem of the

vehicle engine". It could also be that it takes a long time for the emission control system (catalytic converter) to

76 warm up, indicating that more fuel is required in the combustion chamber for smooth combustion (rich fuel/air 77 mixture).

The findings from this study have shown high concentration of CO and CxHy pollutants during the early morning periods when the engine is just warming up, and high concentration of NOx emissions during the afternoon period when the engine is fully warmed up. These pollutants are capable of causing harm to the environment by contributing to the formation of smog, ground level ozone and global warming.<sup>1</sup>

 $<sup>^1 \</sup>odot$  2012 Global Journals Inc. (US)

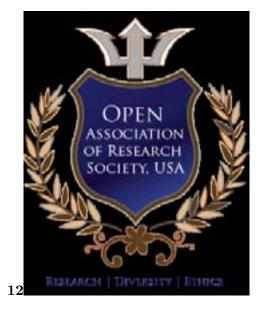


Figure 1: Fig 1 : Fig 2 : F

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and humidity	
Temperature ( o C)	Humidity (%)
26.9	70
28.5	64
29.2	61
31.8	54
33.4	49
III.	

Figure 2: Table 1 :

#### 6 CONCLUSION

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