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STUDY OF EMISSION LEVELS DURING FARM OPERATIONS

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ABSTRACT: This study assessed farm environment in relation to air quality and level of pollutant gases from farming operations. The study is cross-sectional as it involved direct onsite observation and monitoring of pollutant gases at the two farm sites; (experimental; a commercial farm and control, a subsistence farm). An observational checklist was used to assess activities that pollute air on the farm. Carbon monoxide (CO), Carbon dioxide (CO_2), Nitrogen dioxide (NO_2), and Sulphur dioxide (SO_2) meter were used to monitor the levels of those gases on the two farms for two months. Gas measurements were taken twice a week at each farm site in the morning (10am – 12pm) and afternoon (2pm – 4pm) at three strategic points (front, back and center) for two months. Descriptive statistics was used to analyze the result for all the gases. Result showed that there were significant differences on the level of those gases at the control and experimental sites (p= 0.000), air pollution-related activities at the control farm were very low compared to that experimental site. Emission of CO recorded at the experimental site is higher than Occupational Health Safety Administration (OSHA) guideline limit of 50ppm and CO_2 level of 4428.24-5695.83ppm is also higher than United State Environmental Protection Agency (USEPA) guideline limit of 1000ppm while NO_2 and SO_2 emission at the experimental site were below the OSHA guideline limit of 5ppm at the end of the 2 months. Emissions from agricultural tractor have detrimental impacts on human health and the environment. The levels of emission recorded at the experimental site are significantly higher than the control site.

Keywords: emission levels, Carbon monoxide (CO), Carbon dioxide (CO_2), Nitrogen dioxide (NO_2), and Sulphur dioxide (SO_2)

1.0 INTRODUCTION

Air pollution is a serious problem in most countries of the world. Diesel engines seem to have larger influence on air pollution because they are used for heavy-duty trucks and emit higher level of pollutants than petrol engines however; diesel fuel has slightly higher energy content than petrol per unit volume. Many studies have been conducted concerning diesel emission analysis and reduction techniques (Felsch *et al.*, 2009). Pollutants from diesel engines are either Nitrogen-oxide (NO) or Nitrogen-dioxide (NO_2). The concentration of NO in diesel exhaust is higher than that of NO_2; however, NO_2 has much higher toxicity than NO does. In addition to these two species, N_2O (Nitrous-oxide) is recently gaining attention because it has 200 times higher impact factor than carbon dioxide on global warming. Although, it can be said that NO, NO_2, and N_2O have different impacts on the environment, most studies of diesel engine exhaust introduce them as the same species, which is named just NO_x.

The second element of diesel exhaust is hydrocarbons and CO. Hydrocarbons consist of thousands of species, such as alkanes, alkenes and aromatic. Although their toxicity, carcinogenicity, and impact of oxidant formation vary from species to species, they are usually treated together as total hydrocarbons (THC). Usually, an analysis of engine exhaust is performed by gas chromatography–mass spectrometry (GC–MS) (Borras *et al.*, 2009). However; achieving quantitative analysis takes a long time thus, real time measurement is desirable for engine exhaust analysis because the exhaust gas composition changes in real time along with changes in engine operating conditions and only few studies have been done on the details of exhaust gas compositions and the effects of engine operating conditions on the compositions (Gullett *et al.*, 2006).

HEI (1995) reported that the composition of diesel exhaust varies considerably depending on engine type, operation conditions, fuel, lubricating oil, and whether an emissions control system is present. An important proportion of the diesel engine emissions causing environmental problems are caused by work machinery such as agricultural tractors and forestry machines (Hansson *et al.*, 2001). Exhaust emissions from agricultural tractors have detrimental impact on human health and the environment. In order to reduce these emissions, standards have been introduced and are continuously being tightened (EU, 2004, 2005; Larson and Hansson, 2011). These standards only concern existing tractor. The latest studies have shown that emission values for agricultural tractor operations cannot be calculated accurately from average emission factors without account being taken of the type of load on the engine in the operation performed. Environmental impact of catalytic converters and particle filters for agricultural tractors determined by life cycle assessment investigated by (Larsson and Hansson 2011), simulated farm fieldwork, energy consumption and related greenhouse gas emissions in Canada, effects of vehicle type and fuel quality on real world toxic emissions from diesel vehicles were investigated (Dyer and Desjardins, 2003).

Farming has always been one of the most hazardous industries because of the number of activities performed like tractor usage. Today's tractors are much safer than they have been at any point in history, but some hazards can never be totally eliminated, especially when safety rules and precautions are not followed (Eastwood *et al.*, 2004). Uptake of excess nitrogen into leaves can cause mineral nutrient imbalances in plants. The exposure of plants to NO_x pollution has been shown to lead to changes in activities of nitrate and nitrite reluctances in leaves. Diesel engines make a significant contribution to air pollution (Lindgren, 2002).

In order to reduce these emissions, standards have been introduced and are continuously being tightened (Larson and Hansson, 2011). These standards only concern existing vehicles. However, vehicles older than 10 years are responsible for 25-40% of all exhaust emissions from off-road machines (Lindgren, 2002). The latest studies (Hansson *et al.*, 1999) have shown that emission values for agricultural tractor operation cannot be estimated without knowing the type of load on the engine in the operation performed. Often the objective of the farmer, especially when performing heavy operations such as plowing or harrowing, is to obtain the maximum work-rate, not to minimize emissions. Amount of emissions that arise from a specific operation depend on engine load characteristics. The engine load can be influenced by alternative driving techniques, by the design of the drive train and by the use of implements with different work capacities (Danfors, 1988). The main objective of this study is to assess the farm environment in relation to air quality and determine the level of pollutant gases from the control and experimental sites.

2.0 METHODOLOGY

This study is a cross-sectional study which involved direct onsite observation and monitoring of pollutant gases at two farm sites (experimental and control farm).

Direct onsite observation: An observational checklist was used to assess activities that pollute air on the farm environment such as: Open air burning, animal dung, oil spillage, animal fats, bush burning, and emission release by the tractor (during the farm operations), decomposition of farm waste, such as animal feaces and dung's etc.

Gas monitoring: Carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) meters were used to monitor the levels of those gases on the two farms twice a week (in the morning; 10am - 12pm and afternoon; 2pm- 4pm at three strategic points; front, back, and centre) for a period of two months for two months.

Carbon monoxide (CO) monitoring: This was achieved using Extech CO10 meter [0-1000 ppm, resolution: 1 ppm, accuracy: ±5% or ±10 ppm, sensor type: stabilized electrochemical gas-specific (CO), sensor life (typical): 3 years, warm-up period: <2 seconds, power supply: 9V battery (NEDA 1604 or IEC6F22), battery life: approx. 50 hours with alkaline battery, operating temperature 0 to 50^{o}C (32 to 122^{o}F), storage temperature: -30 to 60^{o}C (-22 to 140^{o}F), operating humidity: 0 to 99% RH (non-condensing), dimensions: 160 x 56 x 40mm (6.3 x 2.2 x 1.57"), weight 180g (6.35^{o}z)] as presented in Plate 1

Carbon dioxide (CO_2) monitoring: This was achieved using Telaire 7001 CO_2 and Temperature monitor [measurement range 0-10,000 ppm display, 0-4,000 ppm voltage output, display resolution: ± 1 ppm, accuracy: ±50 ppm or ±5% of reading up to 5,000 PPM (above 5,000 ppm not specified), repeatability: ±20 ppm, temperature dependence: ±0.1% of reading per °C or ±2 ppm per °C, pressure dependence: 0.13% of reading per mm Hg (corrected via user input for elevation), response time: <60 seconds for 90% of step change, warm-up time: <60 seconds at 22°C] as presented in Plate 2.

Nitrogen dioxide (NO_2) monitoring: This was assessed using NO_2 Meter Z-1400 [Environmental Sensors Co's, range: 0- 20 ppm and resolution 0.1 ppm] as presented in Plate 3

Sulphur dioxide (SO_2) monitoring: This was assessed using SO_2 meter Z-1300 [Environmental Sensors Co.'s, range: 0-20 ppm, resolution: 0.1 ppm] as shown in Plate 4.

Statistical analysis: Data was entered and analyzed using SPSS statistical package (version 20). Descriptive and inferential statistical was used in the study to summarize data using mean, standard deviation and range for the levels of CO, CO_2, SO_2, and NO_2 of the two sampling sites.

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T-test was used to compares the level of the gases in the two farms (i.e. Experimental and Control site).

Plate 1: Extech CO10 meter for Carbon monoxide monitoring

Plate 3: NO_2 meter Z – 1400 for Nitrogen dioxide monitoring

Plate 2: Telaire 7001 CO_2 and Temperature monitor

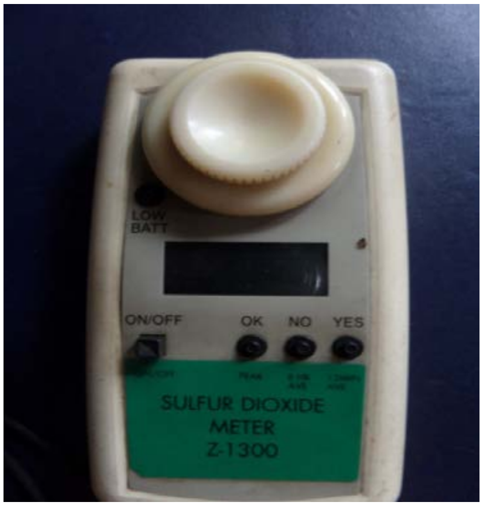

Plate 4: SO_2 meter Z – 1300 for Sulphur dioxide monitoring

3.0 RESULT AND DISCUSSION

Table 4.1 shows the onsite observation of various air pollution-related activities in the two farms. The result of the onsite observation showed that activities that can impair the quality of air were taking place in the farms in varying degrees depending on farm worker(s).

On the average, there were about 8 Tractors at the Experimental farm thus, air pollution-related activities aside emissions includes open air burning, smoking, charcoal and wood burning, use of gasoline-powered generators, vulcanizing, decompositions of farm waste, emission from tractor etc. Moreover, there was no tractor working at the control site and air pollution-related activities seems lower when compared to Experimental site Other activities at the Control site include: local charcoal burning, generator smoke, smoking etc.

Table 4.1: Assessment of Air Pollution related Activities on the Farms.

Indicator	Experimental site	Control site
Generator smoke	++	+
Open burning	+++	++
Experimental Tobacco Smoke (ETS)	++	++
Vulcanizing	++	++
Local charcoal burner	++	++
Decomposition of farm waste	+++	+

KEY: **+++** Highly present, **++** Moderately present, **+** Present, **-** Absent.

Table 4.2 shows the comparison of mean concentrations of CO,CO_2, NO_2, and SO_2 at the three sampling point in each farms, and the result of **ANOVA** shows that there were differences in the levels of CO, CO_2, NO_2 and SO_2 in the sampling point statistically significant at $p<0.05$.

Table 4.2: Levels of CO, CO_2, NO_2, and SO_2 at different sampling points of each farm site

Location	Experimental site	Control site	p-value
CO	69.91±37.91	5.62±1.37	0.000
	5.00-268.00	2.00-8.00	
CO_2	4428.24±5695.83	146.07±99.53	0.000
	200.00-74287.00	42.00-1766.00	
NO_2	3.89±1.88	0.0129±0.0158	0.000
	0.35-10.02	0.00-0.10	
SO_2	0.0230±0.0512	0.0030±0.0088	0.000

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	0.00-0.31	0.00-0.04

Gas [CO, CO_2, NO_2 and SO_2] at the Two Farms

Table 4.3 shows the overall mean and range for CO, CO_2, NO_2 and SO_2 at the farms. The overall mean CO concentration (ppm) for experimental and control farm site was 66.88±46.15 and 74.44±19.75 respectively (p=0.133) while the range was 5.00-268.00 and 35.00-119.00 respectively. CO (ppm) concentration was 85% and 95% higher than Occupational Health Safety Administration (OSHA) guideline limit of 50ppm for 8hour monitoring respectively.

Mean CO_2 concentration (ppm) for the farms was 3117.43±2032.70 and 6394.46±8308.41 (p=0.000) while range was 200-6700 and 2014-74287 for the experimental and control farm respectively. The CO_2 concentration mean are lower than USEPA guideline of 1000ppm.

Mean NO_2 concentration (ppm) for the farms was 3.51±1.65 and 4.4574±2.065 (p=0.001) while the range was 0.35-09.01 and 0.45-10.02 for the experimental and control farm respectively. These NO_2 mean concentrations are lower than United State Environmental Protection Agency (USEPA) guideline limit of 5ppm.

Mean SO_2 concentration (ppm) for the farms was 0.0275±0.0633 and 0.0163±0.02146 (p=0.001) while the range was 0.00-0.31 and 0.00-0.12 for the experimental and control farm respectively. These SO_2 mean concentration are lower than OSHA guideline limit of 5ppm.

Table 4.3: CO, CO_2, NO_2, and SO_2 mean±SD of the Sampling Points for the farm site

Location		Morning	Afternoon	p-value
Experimental site	**CO**	66.88±46.15	74.44±19.75	0.133
		5.00-268.00	35.00-119.00	
	CO_2	3117.43±2032.70	6394.46±8308.41	0.000
		200.00-6700.00	2014.00-74287.00	
	NO_2	3.51±1.65	4.4574±2.065	0.001
		0.35-09.01	0.45-10.02	
	SO_2	0.0275±0.0633	0.0163±0.02146	0.090
		0.00-0.31	0.00-0.12	
Control site	**CO**	5.52±1.34	5.7130±1.405	0.151
		2.00-8.00	3.00-8.00	
	CO_2	135.20±49.78	156.84±130.96	0.025

	42.00-342.00	50.00-1766.00	
NO_2	0.0134±0.0159 0.00-0.10	0.0125±0.01573 0.00-0.09	0.543
SO_2	0.0046±0.0103 0.00-0.04	0.0013±0.0064 0.00-0.04	0.000

Discussions: The result of onsite observation revealed that air pollution related activities were higher at the experimental site than the control site. All emissions recorded at the experimental site were higher than the concentration from the control site and the different is statistically significant ($p = 0.000$). Carbon monoxide (CO) emission recorded at the experimental site was higher than Occupational Health Safety Administration (OSHA) guideline limit of 50ppm, while CO_2 emission recorded at the experimental site (4428.24$\pm$5695.83ppm) was also higher than United State Environmental Protection Agency (USEPA) guideline of 1000ppm. Also, NO_2 and SO_2 emission recorded at the experimental site were below the Occupational Health Safety Administration (OSHA) guideline limit of 5ppm.

4.0 CONCLUSION

Emissions from agricultural tractor have detrimental impacts on human health and the environment. The levels of emission recorded at the experimental site are significantly higher than the control site; levels of Carbon monoxide (CO) and Carbon dioxide ($CO_{2)}$ at the experimental site were higher than Occupational Health Safety Administration (OSHA) guideline limit, this could be attributable to usage of heavy machineries like tractors at the experimental farm

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