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Monitoring, Evaluation of Air Pollutants, and Their Relation to Safety and Occupational Health inside the Working Environment of the Construction Sector

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Abstract

Air pollution from dust and equipment exhaust from earth moving equipment, is an issue that the construction sites cannot ignore. The use of different equipment at the construction site either individually or combined types resulted in air pollution of the surrounding environmental area . The results showed that all the investigated SME gave low concentration of Co2 (less than 60%) for the total exhaust sample. It was found that there was no much differences between the emissions of the different SMS in the Co level.

All the investigated soil moving equipment exhausts had a free O2 range from 10.7 to 14% which was higher than the 7% of the standard level . The influence of the power increase on the exhaust emissions was noticed For far most equipment..

In this research investigation we explained that the level of impact is influenced by the materials used and the emissions that are released into the air, but it also increases relative to the scale, duration, and activities of the construction sites. There are also greater health and environmental risks if more than one activity takes place at the same time on the site and/or if there are sensitive populations or natural environments is close proximity to the construction site.

Keywords: air pollution, Environment, Occupational Health, air quality

Introduction

All construction projects have a significant impact on the air quality in the work environment, Air pollution refers to man-made emissions that are released into the atmosphere.

Poor air quality is a global health hazard, responsible for approximately 4.2 million premature deaths in 2016 (**Joseph, J. et. al 2009**). Air pollution is one of the biggest polluters within a construction site and comes in many forms (**EzzatI, M. et aL**,, **2011**) although the three most common pollutants include large amounts of dust, the emission of a number of gases, and the presence of large amounts of smoke. Air pollution is not limited to just the build itself, and can also occur during excavation, land clearing, Demolition, the burning of materials, the operation of vehicles and equipment **(WHO 2000),** and when construction workers are working with toxic materials. Given the nature of the work undertaken on various construction sites, dust is one of the main causes of air pollution from these sites (**Putaud, J.P. et al. 2002 Joseph, J., et al 2009)** Dust is categorized by any particulate matter that is smaller than 10 microns in diameter. First off, the materials that the builders are working with, such as concrete, cement, wood, stone and silica, are prone to releasing dust and can be carried over wide areas **(Rashi B. 2019**).

Additionally, diesel engines, and on-site equipment that uses diesel, releases dust-sized particulate matter in the form of soot, sulphates, and silicates into the air **(Wen, L.L 2011).** There are many reasons why dust is the biggest air pollution issue. Further, air pollution contributes significantly to the warming of the planet, and therefore to climate change.

As construction activities are large contributors to air pollution, organization within the construction sector have responsibility to limit the amount air pollution produces, such as diesel engines and equipment are causes of releasing of toxic gases into the air **(Muleski, G.E. et al 2005).**

The current study aims to determine the effective distances at which dust and particles broadcast around the machine during earth moving and exciting operations; determine the deposited and suspended dust particles which polluting the air at different positions in from the to the earth moving matching; Identify sizes and types of particles which polluting the air during the earth moving operation and Identify of adverse effects on the worker health that operate the earth moving machines. This study is a real case study for one of the construction projects in DP World project in Ain El Sokhna- El Sues- Egypt.

1. Materials And Methods

Air pollution as resultrd in the operation of different types of earth moving machines was determined. Data collected during oparation at Dubai Port, Ain Sokhna, Suez Governorate, Egypt. during 2020 –2021.

The main objectives of this study are as follows:

1. Determine the effective distances at which dust and particles broadcast around the machine during earth moving and excating operations.
2. Determine the deposited and suspended dust particles which polluting the air at different positions in from the to the earth moving maching.
3. Identify sizes and types of particles which polluting the air during the earth moving maching operation.

4. Identify of danger effects on the worker health that operate the earth moving maching machines.
5. study the gas emissions from the machine

2-1 Materials

2-1-1 The earth moving machines:

Random samples of earth moving machine were examined through the of years 2020 and 2021 The machine were examined at the local projects was (Wheel Loader, Excavator and Motor Grader) The samples were classified under four main power categories, which are commonly used in Egypt reference to the national statistics; (i) less than 100 hp, (ii) 100-170 hp, (iii) 170 * 265 hp, and (iv) higher than 265 hp. The technical specifications and the description of the investigated machine sample were listed in the Table (1).

Table (1): The technical specifications and the description of the investigated Machine samples.

Power Categories	**Vendor**	**Model**	**Type**	**Engine specifications**		
				Power [Hp]	Rated rpm	Number of cylinders
Less than 100 hp						
100-170 hp						
170-265 hp						
Higher than 265 hp						

In order to link the emissions were the unit of the land area [Kilometer], a sketchy calculation procedure were conducted to calculate the actual field capacity [AFC] of the investigated earth moving machines at the lowest and high load conditions. The used assumptions of the average lowest and highest loads for each power category are illustrated Based on the load assumptions, the actual field capacities were calculated by using Kepner (1978).

The average operation times per each operation were collected from the working field sheets records of DP World Project in Ain El Sokhna – Sues City. The emission values in kg/h were divided on the AFC of Earth moving machines [Km/h], in order to calculate the approximate range of the emissions (in kg) attributed to the unit of the land area.

The modle of earth moving machines were selected to study the effect of earth moving machine operation on enviromental pollution. All earth moving are prevailed so far in the Egyptian machinery markets.

The selected earth moving machines were:

1. Caterpillar 906H2 Wheel Loader
2. KAWASAKI 95ZV WHEEL LOADER
3. JCB 409ZX Wheel Loader
4. JCB 407ZX Wheel Loader
5. DOOSAN DL400 WHEEL LOADER

6. CATERPILLAR 966C WHEEL LOADER
7. Caterpillar 966H WHEEL LOADER

The impact of the Earth moving machines on air quality was measured by two main indicators; (i)exhaust emissions, and (ii) dust as an important component of atmospheric particulate matter [PM].All the measurements were done at regular recommended field conditions of earth moving, soil moisture content levels, wind speed, temperature and soil moisture content.

The concentrations of the exhaust emissions were measured by using "AUTOCHEK 974/5"gas and smoke analyzer (SPTC.Ltd.).This portable gas analyzer indicated monitor the composition of the exhaust air from CO_2[%],CO[%],O_2[%],HC [ppm].

Also, the analyzer indicates some of the diesel engine ignition indicators, such as air-fuel ration (AFR, is the ratio between the mass of air and the mass of fuel in the fuel–air mix at any given moment), and Lambda (Air–fuel equivalence ratio, is the ratio of actual AFR to stoichiometry for a given mixture).

Exhaust emissions were measured for the multi-purpose Earth moving machines at three cases of operating conditions. First at the steady condition [ST], then the forward speed without load [FS], and finally under the conditions of forward speed with crop load [FSL].
Whereas, the exhaust emissions were measured steady and full load conditions. Table shows the average forward speeds of the investigated case studies at the moving and full load conditions.

The average forward speeds (km/h) for the investigated case studies of the Earth moving machines, at forward speed with load (FSL) and the moving without-load conditions.
The concentration of the NOx, as basic exhaust emissions from diesel engines, could not be measured directly by the gas analyzer. Therefore, the concentration of NOx [ppm] was calculated as a function in CO2concentration, CO concentration, HC concentration, AFR, Lambda, and the molecule composition of the fuel. The full methodology of NOx calculation and the standards of the exhaust emissions from diesel engines are reported at the EPA Code of Federal Regulations(CRF 86) of control emissions from diesel engines (EPA, 2010).
In order to link the measured exhaust emissions with the investigated combines operating hours, as a kg of the emission per hour, the measured emission concentrations were multiplied by the average exhaust flow rate
(m3/h) and the density of the gas (Table 2). The average exhaust flow rate (m3/h) values were collected from Donaldson Co. guidelines, based on the engine model and horse power of the combines.

Table(2) : The density [kg/m3] of the measured gases:

	CO2	CO	O2	Air
Density [kg/m3]	1.977	1.145	1.4290	1.293

The exhaust emissions were linked to the unit of the land area [Kilometer], by dividing the emission values by kg/h on the actual field capacity of each combine [Km/h]. The actual field capacities were calculated by using Kepner (1978).

2. Results and discussions

The data collected for the two seasons 2020 /2021 were collected and presented either in the forms of tables or figures. All data were statistically analayezed following the new methods of analysis , the data divided at the new trend followed in writing up the materials & methods, then it was discussed as following.

3.1. Loader Exhaust Emissions:

Most of the soil moving equipment (S.M.E) are equipped with diesel engines, with different levels of power, which is among the largest contributors to environmental pollution problems worldwide. Diesel emissions contribute to the development sever health effects; pollution of air, water, and soil; soiling are causes global climate change.

The exhaust emission gases are composed of the three major components of water vapor, CO_2 and N_2. However, the exhaust gas also contains several combustion by-products such as CO, NO_x, particulate matter, free O_2 and unburned HC.

Fig.1 the minimum and the maximum concentrations of the main exhaust gases from the investigated soil moving equipment such as Wheel loader CAT 966H, CAT 972K Komatsu WA70-5 Loader and CAT 950E gave a direct indication of combustion efficiency and the maintenance level of the engine, and concentrations of CO_2 and free O_2 in the exhaust samples, and how well the fuel is burned in the engine.

The results showed that all the investigated S.M.E (Wheel loader CAT 966H, CAT 972K Komatsu WA70-5 Loader and CAT 950E) gave a CO concentration below the maximum standard level (less than 60 % for the total exhaust sample), and all recorded concentration were below than 60% of CO standared levels.

There were no large observed differences between the different types of the S.M.E in the maximum levels of CO emissions. Whereas there were noticeable differences between the minimum levels of CO in the exhaust emissions of the investigated Soil moving equipment.

All the investigated Soil moving equipment exhausts had a free O_2 ranged from 10.7 to 14 % of the total exhaust sample, which is higher than the 7 % of the standard level. As it was observed for CO no large differences were recoded.

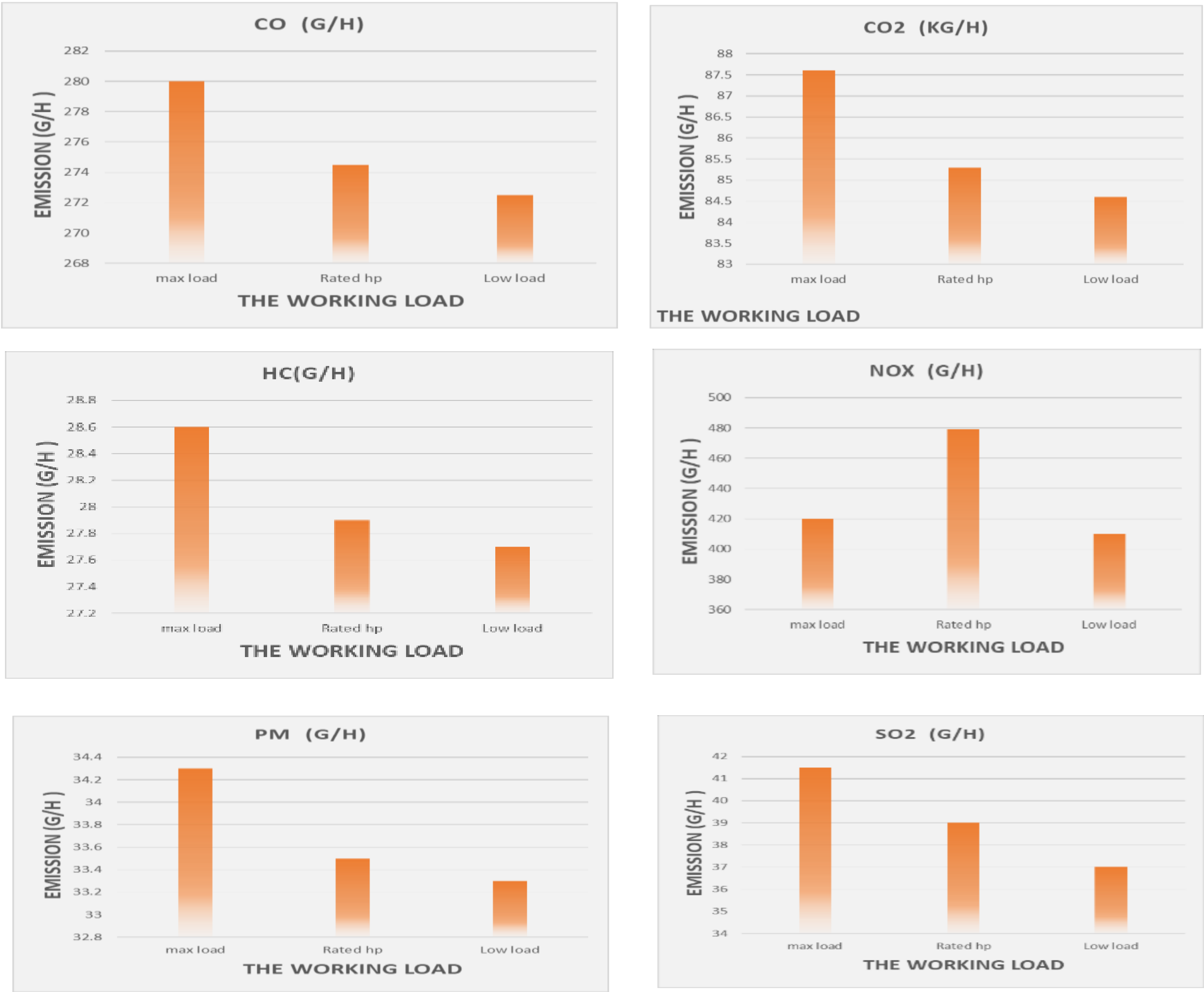

Fig. (1): The concentration of the exhaust gases under minimum and maximum operating loads under the investigated S.M.E.

Conclusion

The results of this assessment should be considered as a start step to produce Oa national emission factors and guidelines, in order to describe the impact of soil moving equipment over air-quality under Egyptian conditions. The outputs of the study gave a primary emission factor for the main power categories of the used for soil moving equipment in Egypt. These emission factors are based on direct field measurements of exhaust emissions, and sketchy calculations using operational records in order to calculate the actual field capacities of the studied soil moving equipment and a range of operating loads. Much more studies should be conducted to improve the emission factors and the other air quality guidelines resulted from this work. These studies should consider some of the important factors such as the actual fuels consumption rates, the quality of the fuels, the actual efficiencies of the engines, the actual influence of the operating loads, and any other factors that affect the combustion process.

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