Tractor engine and gas emissions

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Abstract: - The following experiment is based on the gas emissions (CO, HC, NOx) of a farm tractor with diesel engine. It has been used a laboratory investigation in order to loud the tractor engine and measure the emissions by using Diesel fuel. Then the tractor was used for ploughing a field and the exhaust emissions were measured. According to measurements an estimation of the total emissions produced during field works were made for winter wheat and maize for silage crops under Greek conditions. The results showed that considerable emissions are produced contributing to environmental pollution. CO emissions are much higher than HC and NOx.

Key words: Diesel engine, Emissions, Farm tractor, Field works

1 Introduction

The human contributes to the emission of gas pollutants activities. The atmospheric pollution does not only affect the air, but also by an indirect way pollutants are transported to the ground via atmospheric precipitations (rain, snow), to the water and then to the flora and fauna, and finally to humans. The atmospheric pollution differs from one country to another. Due to the fact that in each country there a different number of vehicles. Another factor that effects the atmosphere pollution is the industrial development of each country, the fuels that are being used and other factors. The impact of the pollutants has consequences not only during the production but also for a longer time period. In addition it affects not only the place of production but other as well [1,2,3]. Gas emissions cause many human diseases and some pollutants are considered as carcinogenic. Agriculture is generally considered as an activity with low energy consumption. In most developed countries consumes about 2-3% of the total energy consumed. In Greece this consumption is about 7% of the total energy spent[4,5,6]. Additionally engine emissions are released in the open air where the effects to the environment are considered of lower importance than the emissions in the Cities. But emissions even in open air can contribute to air pollution and it is worth estimating them. Tractors need a significant amount of energy in order to produce power. Nowadays, tractors have diesel engines and they use petroleum-based fuels. Petroleum-based fuels are not renewable; sometime in the future they will be depleted. Diesel engines can also use biomass as source of energy. Tractors could use fuels produced from biomass. However, this can not be happened at the moment, due to the fact that the use of renewable sources of energy is still in an early stage [2,6,7,8]. As a consequence this will continue for many years in the future.

The basic exhaust emissions from engines contain combinations of NO and NO_2 that is indicated as NOx by emission analysts, free carbon and unburned hydrocarbons [9,10]. The effect of nitrogenous pollutants on plants is somehow complicated because all plants for their growth process require nitrogen. Uptake of excess N into leaves can cause mineral nutrient imbalances in plants. The exposure of plants to NOx pollution has been shown to lead to changes in activities of nitrate and nitrite reluctances in leaves [3,11,12]. High concentration of NO_2 to the atmosphere can also cause many health problems such as breathing. NOx can also contribute to the acid rain formation. Carbon monoxide can be a problem for people in high concentrations. CO reacts with hemoglobin causing a reduction of oxygen capacity of the blood. Hydrocarbons are related with atmospheric pollution because of the direct toxicity of some compounds and their role as precursors of photochemical ozone [3,13,14]. The quality of fuel affects diesel engine emissions (HC, CO, NOx and particulate emissions) very strongly. The fuel that is used in diesel engines is a mixture of hydrocarbons and its boiling temperature is approximately 170 to 360^{o}C[4]. Diesel fuel emissions composition and characteristics depend on mixture formation and combustion. In order to compare the quality of fuels the following criteria are tested: ketene rating, density, viscosity, boiling characteristics, aromatics content and sylph content. For environmental compatibility, the fuel must have low density, low content of aromatic compounds, low sylph content and high ketene rating [5,16]. This paper examines how the tractor's gas emissions affect the environment during fieldwork, by using diesel as fuel. Furthermore, the time that the same tractor needs for working under real conditions is measured for grain and maize tillage.

2 Material and Methods

The experimental measurements were conducted using a model John Deere tractor engine. This is a four-cylinder engine with an approximate 44,1 kW output at 2800 rpm. Initially a PTO output test was performed in the laboratory to assess the engine characteristics.

Then the tractor was used to plough fields in the area of Orestiada, North – Eastern Greece. The fields were prepared for winter wheat and maize for silage crops. During the tests the composition of exhaust gas (CO, HC, NOx) was monitored. For this purpose, the HP 3497A Data Acquisition Unit was used. The data acquisition unit was interfaced with a IBM-486 AT via the HP-IB 82990A Command Library IEEE-488 interface card. This particular measuring system and software completed a scanning cycle per channel every 0.1 s approximately. This measuring speed was considered adequate for the purpose of the experiment and the sampling capabilities of the chemical sensors. For the exhaust gas measurements a type gas analyzer was used. The unit has ±2% accuracy and ±2% repeatability. These delays are not caused only by the actual sensors, but also by the time required for the exhaust gas to reach the sensing area via the connecting tubes and filters.

3 Experimental Results

The power output variation vs tractor engine speed during the PTO test is presented in the Table 1 and in Figure 1:

rpm	*Power (kW)*
1000	**18,4**
1700	**30,9**
1900	**34,6**
2300	**41,2**
2800	**44,1**
3000	**41,9**

Table 1. The power output variation during PTO test

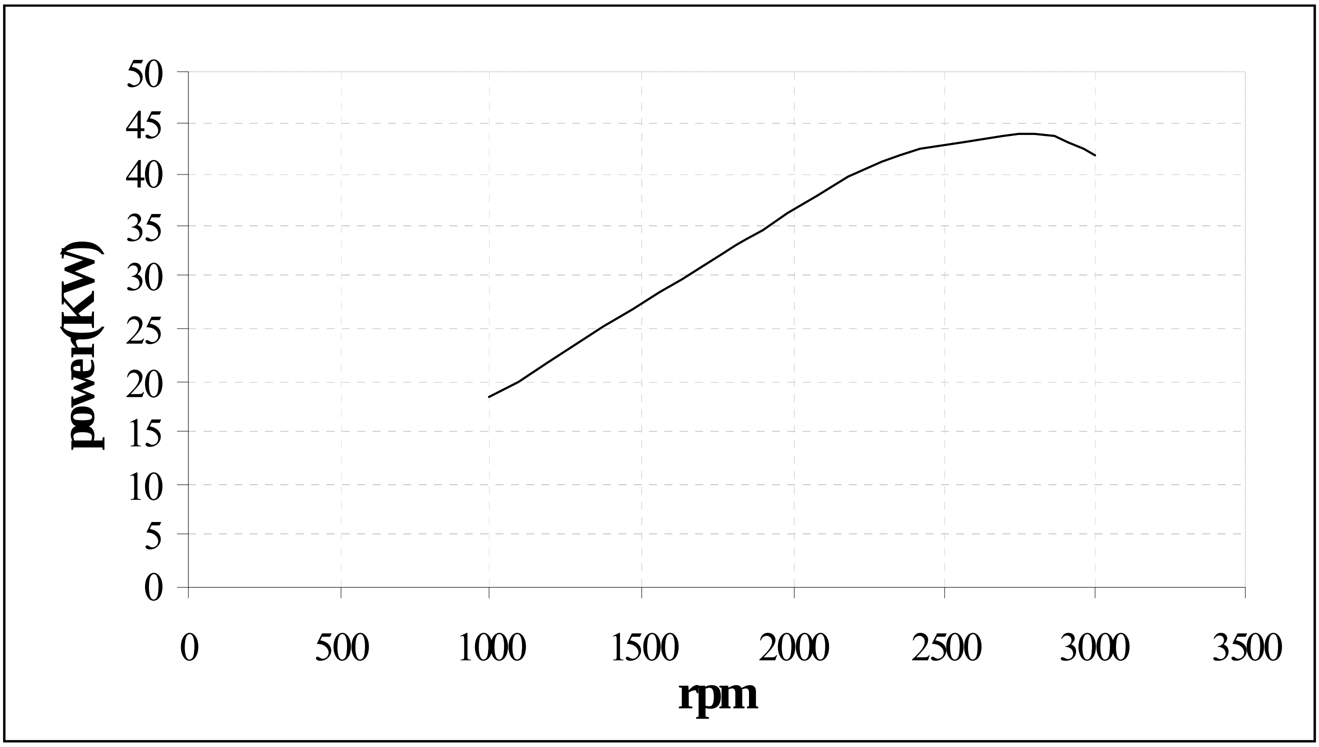

Figure 1. The power output variation vs engine speed during the PTO test

Figure 1 shows that the maximum engine power it is produced at 2800rpm. It is also observed that the maximum engine power does not correspond with the maximum rpm.
Fuel quality affects diesel engine emissions even more strongly than emissions of spark-ignition engines. HC, CO and particulate emissions are the main pollutants affected by the fuel quality. The effect on nitrogen oxides is negligible. Similar to gasoline for spark-ignition engines, diesel engine fuel is a mixture of hydrocarbons, although its boiling temperature is approximate 170 ^{o}C to 360^{o}C. Depending on diesel fuel composition and characteristics, the major differences on mixture formation and combustion and, hence, exhausts emissions. Major quality criteria are ketene rating, density, viscosity, boiling characteristics, aromatics content and sulphur content. With regard to environmental compatibility, the following requirements have to be met: low density, low content of aromatic compounds, low sulphur content, high ketene rating. To a certain degree, the above requirements contrast with the demands for engine power and fuel economy. This becomes evident when the relationship between parameters such as density, content of aromatic substances and ignition quality (readiness to ignite) is considered: "High density = high content of aromatic substances = low ignition quality". All of the petroleum-based fuels are fossil fuels that have been stored in the earth for many centuries. They are non-renewable and will be depleted at some future date. Production of crude oil in United States is already declining, and it is expected that world petroleum reserves will be depleted in the twenty-first century. Other sources of fuel energy for engines are being sought. Solar energy is the most inexhaustible energy source, and it may be used directly or may be stored for later use. Petroleum is an extreme example of stored solar energy. Plants growing thousands of years ago trapped the energy, and, these plants were eventually transformed into petroleum. In direct use, solar energy is used as soon as it is collected [17,18,]. Direct use of solar energy to supply power to a farm tractor is impractical for two reasons. The energy is not concentrated enough to supply a tractor with a reasonably sized collector, and it is unavailable at night or on cloudy days[19]. Coal, oil shale, and tar sands are fossil fuels that are available in much larger reserves than is petroleum. If these fossil fuels could be extracted from the earth and converted to petroleum-like liquids, the duration of the fossil-fuel era could be greatly extended. The extraction and conversion processes have been demonstrated on a pilot scale. The enormous capital costs of full-scale plants have delayed their

construction in the United States, but South Africa produces large quantities of liquid fuel from coal. Engines can be operated on liquid fuels produced from biomass. Alcohol fermented from farm crops has been used as a fuel for spark-ignition engines. Soybean, sunflower, and other vegetable oils have been used as fuel for diesel engines. Such fuels might become available in sufficient quantities to supply the fuel needs of farm tractors, but not ugh would be available to fulfil the needs of transportation, manufacturing, and other industries.

The tests they were realised using as fuel diesel, the comparison however it can become independent from kind of fuel.

All emission measurements

were carried under real conditions when the tractor was used for ploughing the fields. Figures 2, 3, 4 present the gas emissions for working time 2000s:

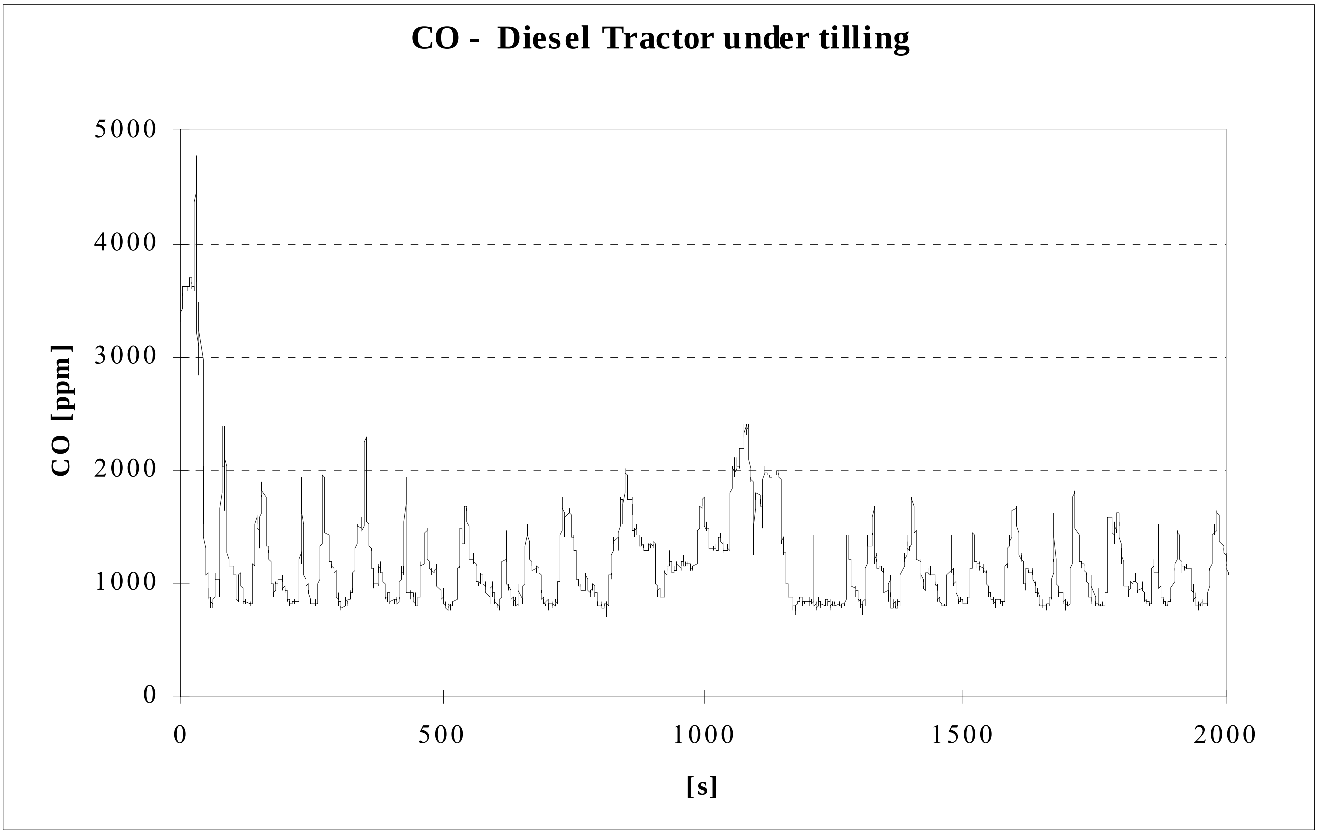

Figure 2. CO emissions of the tractor engine during ploughing the field

The average value of CO, HC, and NOx emissions from the above figures 2,3,4 respectively is:

CO = 1188,65 ppm/s, HC = 68,78 ppm/s and NOx = 139,28 ppm/s.

Typical time tables for field work for winter wheat and maize for silage are presented in Tables 2 and 3. The times that the tractor needs for every type of work in the case of winter wheat, per month per hectare(104 m2) are shown in Table 2:

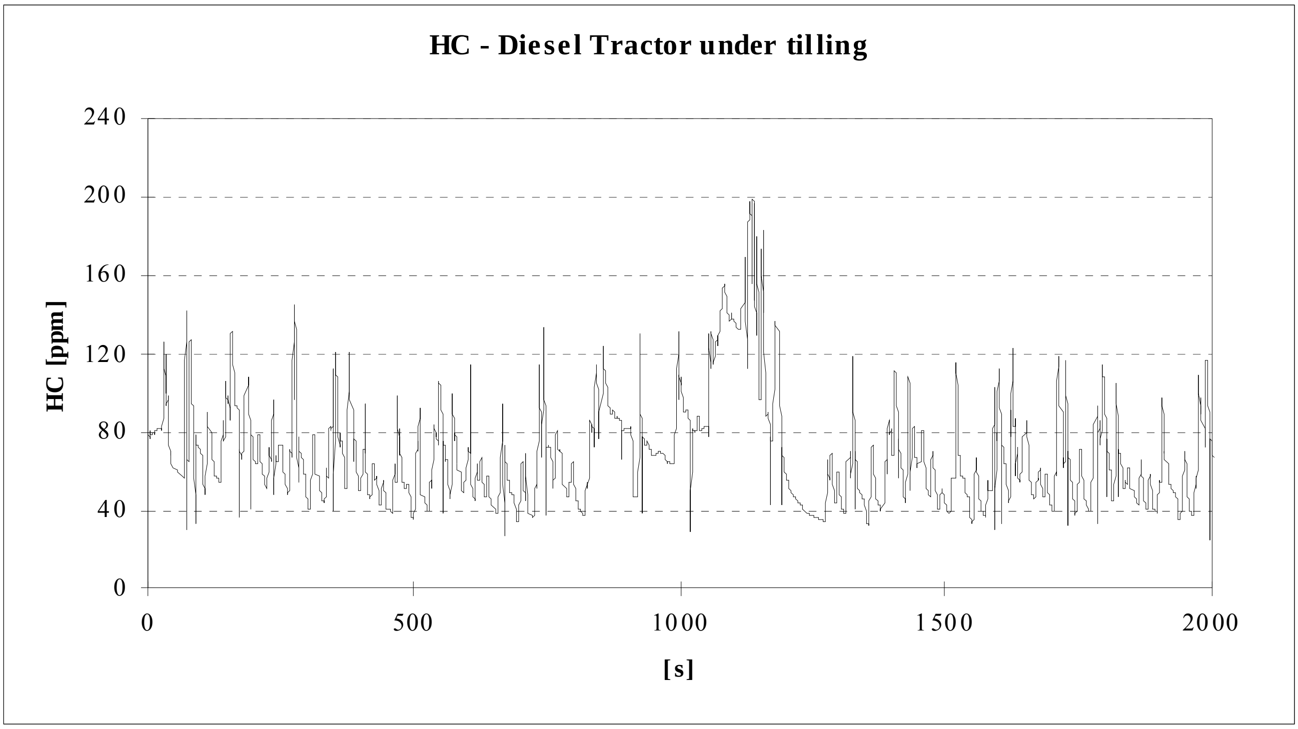

Figure 3. HC emissions of the tractor engine during ploughing the field

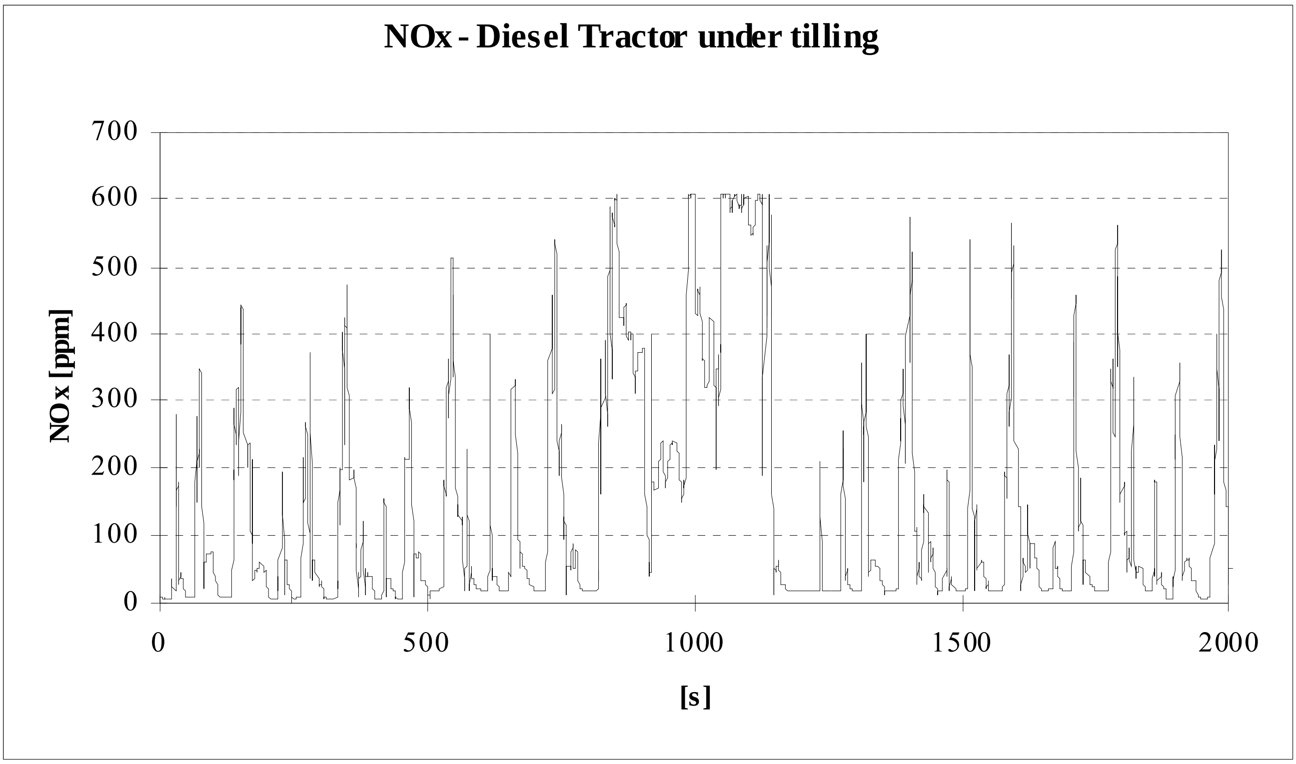

Figure 4. NOx emissions of the tractor engine during ploughing the field

Type of work	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total (hours)*
Ploughing													2,5
HarrowingX 2													1,4
Sowing													1,4
Fertilization													0,55
Product transp													2,1
Spraying													1,1
Packaging													0,84
Straw transp													2,1
TOTAL (hours)		0,55	1,1			2,1	2,94				5,3		11,99

Table 2. Timetable of field works, and working time per ha, for tractor in the case a winter cereal crop (autumn sown)

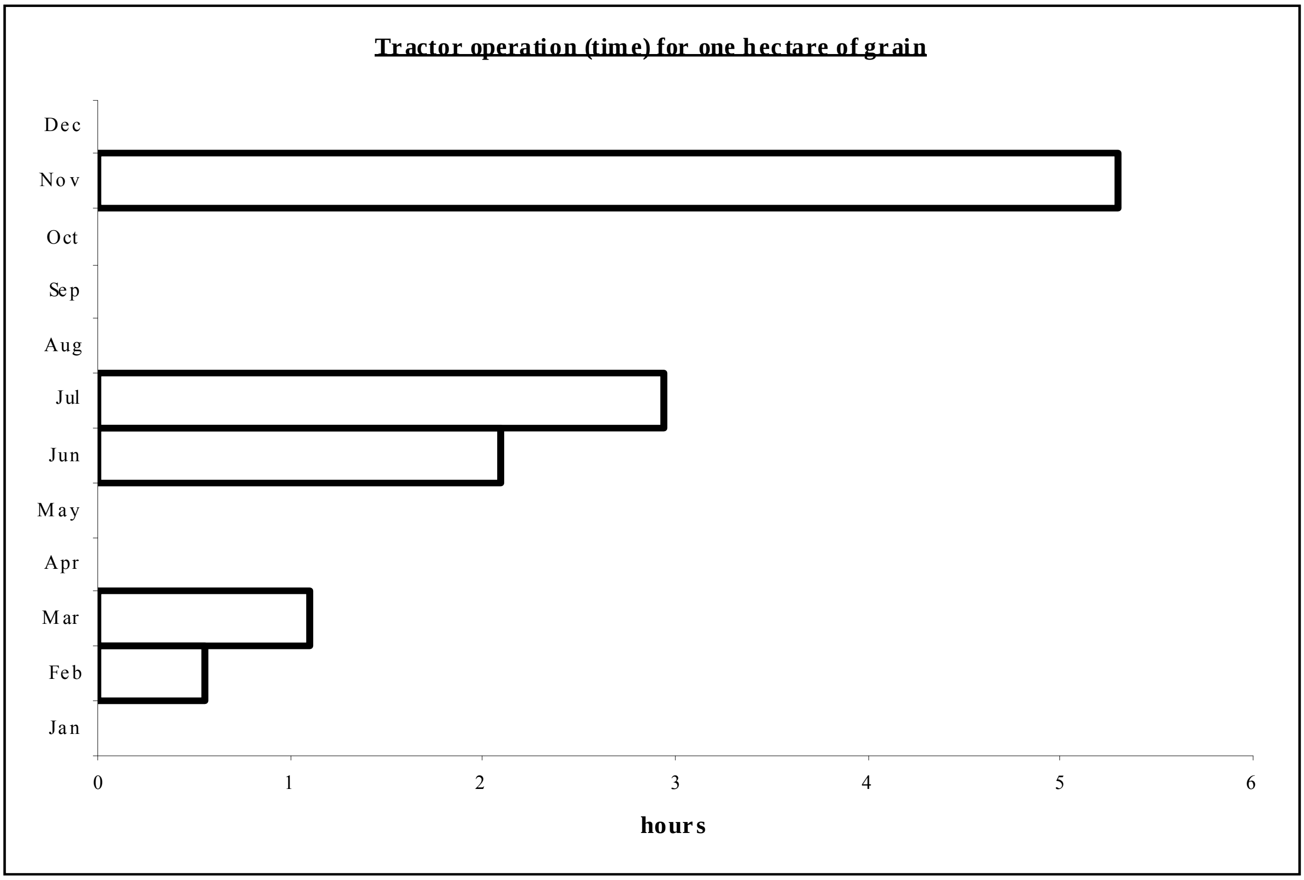

Figure 5. Tractor work time per month for one hectare of grain

The time that the tractor needs for every type of work in the case of maize for silage, per month per hectare are shown in Table 3:

Table 3. Timetable of field works and working time per ha, for a tractor in the case a mays for silage crop (spring sown).

Type of work	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total (hours)*
Ploughing											■		2,5
HarrowingX2			■										1,4
Sowing			■										1,4
Fertilization			■		■								1.1
Platform loading								■					1,2
Product transp								■					10
Spraying			■										1,1
TOTAL (hours)			4,45		0,55			11,2			2,5		18,7

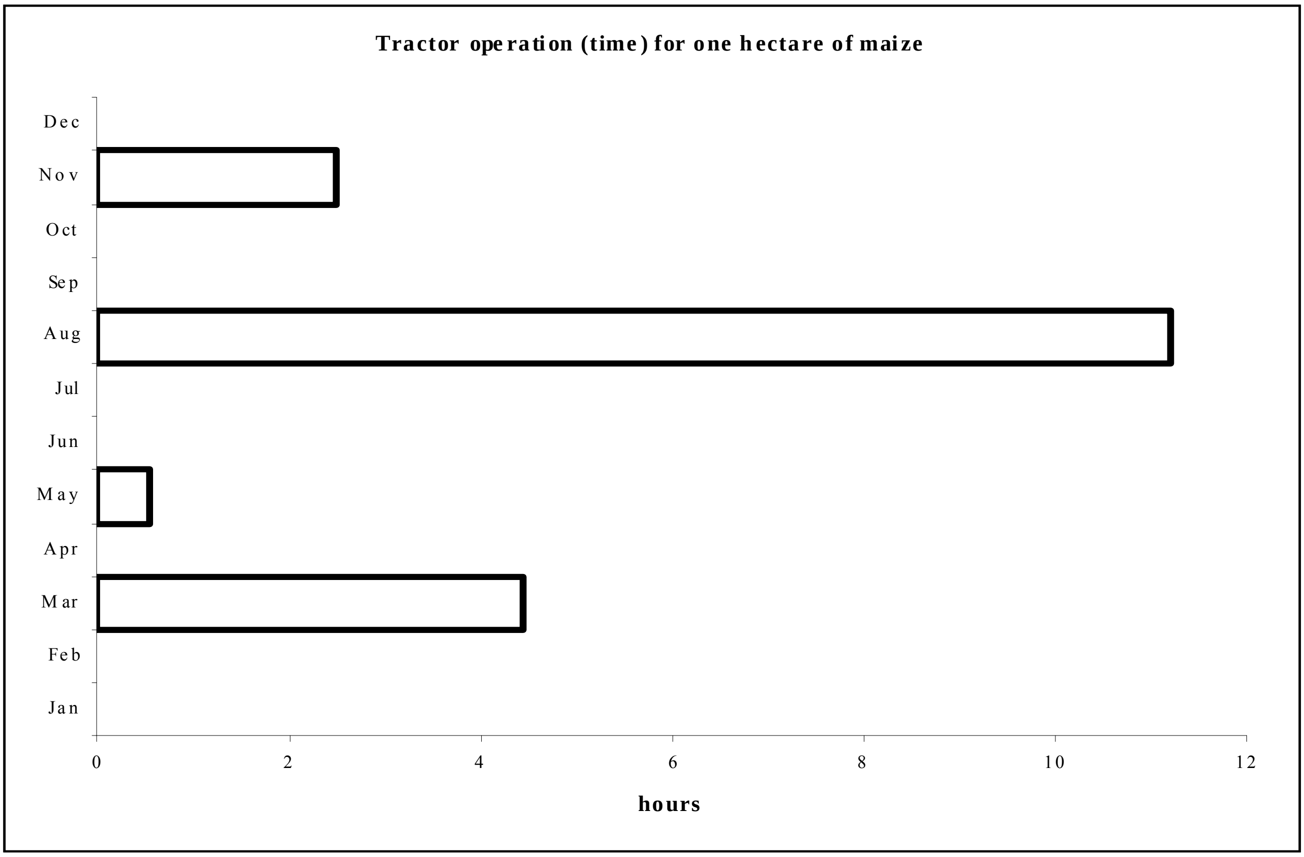

Figure 6. Tractor work time per month for one hectare of maize

The total emissions (CO, HC, NOx) for winter wheat and maize tillage per hectare are presented in Table 4 and the Figure 7.

	GRAIN TILLAGE			***MAIZE TILLAGE***		
Total time ***(hours)***	11,99			18,7		
Emissions	CO	***HC***	***NOx***	***CO***	***HC***	***NOx***
(10^6ppm)	51,31	2,97	6,01	80,02	4,63	9,38

Table 4. Total emissions of the tractor engine for field works

The results from Table 4 are presented in the Figure 7 below:

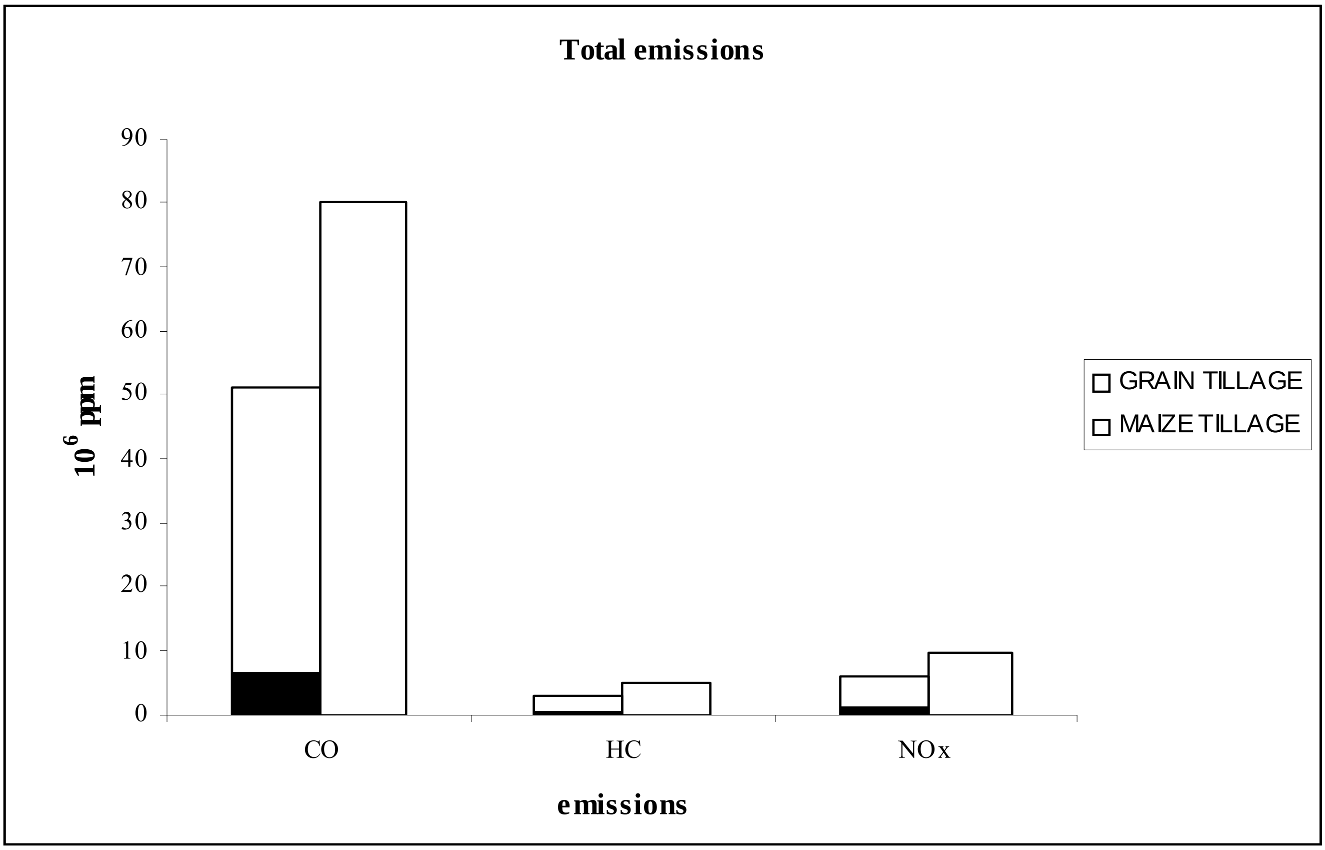

Figure 7. Total emissions

Figure 7 shows that the CO contribution to the environment during tillage is grater than the other gas emissions (HC, NOx). The CO emissions have effect on the environment and also on the plants. Thoughts for future extension of this paper are the investigation of the effects of gas emissions (CO, HC, NOx) on the plants.

4 Conclusion

The present paper investigates the contribution of the tractor in the environmental pollution. The working times for the grain and maize tillage were studied. Furthermore, the tractor emissions were studied under real conditions. It was found that from the CO, HC, NOx gas emissions, the CO emissions have the higher percentage, which means that the CO emissions have the greater effect on the environment.

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