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RESEARCH ARTICLE

EVOLUTION OF POLLUTANTS EMISSIONIN RELATION TOROAD TRAFFIC IN THE CITY OF LOMÉ (TOGO) FROM 2010 TO 2019

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Abstract

The automobile fleet in Togo has increased in the last decades with a patchwork of vehicles that are in majority older than ten (10) years. Until 2019, the car fleet in Togo was almost dependent upon petroleum products, and was consequentlya source of air pollutants emission. Lomé is the capital city of Togo with the characteristic of having the highest road traffic volume that significantly impacts air quality. In accordance with the EMEP/EEA air pollutant emission inventory guide and the COPERT method, emissions of carbone monoxide (CO), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs) and particulate matter (PM) are respectively estimated to: 2621.674 tCO ; 82.444 $tNO_{x;}$ 558.778 tNMVOC and 7.241 tPM. In the time series 2010-2019, emissions of CO, NMVOCs and NOx fell overall with average yearly rates by respectively 83,0234 ; 66,4888 ; and 0,8073 t/year whereas the PM emission rose(0,8208 t/year).

Introduction:-

Air pollution results from the direct discharge of gas compounds and of particles emitted due to human activities. It is the cause of some respiratory diseases such as respiratory and cardiovascular disorders, eye inconveniences, and acid rain. Air pollution is noticed on several rating scales according to various criteria that are in connection with the nature of pollutants, weather conditions and the intensity of emission sources (Koffi, 2002, Roussel, 2006, Sportisse, 2008, Elichegaray, 2010).Neighbourhood pollution is the combination of a background pollution and the local impact of road traffic in urban areas (Roussel, 2006). It is indeed possible to notice on an urban scale that when road traffic is more intense, a pollution that is directly induced by traffic is superimposed onto urban background pollution (Fenger, 1999, Oxley et al, 2009). This study examines afineterritorial scale (Elichegaray, 2010) by taking into consideration neighbourhood pollution in accordance with the principle of subsidiarity(Roussel, 2006)in terms of space through regional, urban and local pollution, and in terms oftimebyanalysing various time steps.Given that in Togo the air pollution inducedby road transport constitutes a real public health issue, the present study has made an assessment of the situation in relation to transport in Lomé so as to estimate the chemical pollutants from 2010-2019, with 2019 taken as a year of reference in order to point towards some solutions for a decrease.

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Methodology:-

Data Collection Method

The collected data are related to weather parameters and to parameters that are characteristic ofof road transport in Lomé: minimum temperatures; maximum temperatures; humidity; average traffic flow; proportion of heavy goods vehicles; speed profiles of every vehicle; yearly vehicle fleets and other parameters (Aumont, 2012).

Weather Parameters

The weather parameters that were used are minimum temperatures, maximum temperatures and humidity of the city of Lomé. These parameters were provided by the Meteorological Service of Lomé[1] (Lomé Station).

Parameters characteristic of road transport in Lomé

The quantitative data related to fuel consumption and their annual properties on national scale were provided by the General Office of Transport in Lomé. Hypotheses were formulated to derive consumption shares of vehicles and motorcycles going throughGreater Lomé. These data have been converted into consumption energy to calculate emissions of pollutants thanks to the COPERT V software used for estimation. All categories of vehiclesand motorcycles circulating through the city of Lomé have been taken into consideration to evaluate the emissions. The vehicles include cars, vans, coaches, lorries, semitrailers and road tractors. These vehicles are classified into four (04) groups, namely privatevehicles (PV), light-dutyvehicles (LDV), heavy weights (HW) and buses. As for the motorcycles, they are two-wheel machines of 50 cm^3 to 125 $cm^3$and of more than 125 cm^3. The statistic data were provided by the INSEED (National Institute of Statistics and Economic Studies[2]). The transport data collected from the INSEED and the General Office of transport are national. The ones of Lomé were calculated through hypothesesbased upon expert judgements. Therefore, the expert judgementsrate the number of vehicles and motorcycles in Lomé at 70% out of the total number of vehicles on a national scale. This percentage of the number of vehicles and motorcycles is also allocated to the other road traffic parameters in Lomé such as the calculation of the distances covered, the quantity of consumed fuel by vehicles in the city.

Estimation Method

The analysis of the evolution of chemical substances emissions in relation to road transport in Lomé was conducted in accordance withorientationsprovided in the EMEP/EEA air pollutant emission inventory guide (EMEP/EEA, 2020) and in accordance with the COPERT method. The necessary input data that were compiled to estimate the emissions were obtained from the national institutions and they cover the time series 2010-2019. They were disaggregatedon the basis of expert judgements to stick to the study area of the city of Lomé. The calculations were made with the V Version of COPERT software, focusing on 2019 as a basic year for results interpretation. The estimations of pollutants emissions are based on the fundamental equation of Tier 1 that combines activity data withemission factors:

$$Ei = \Sigma_j (\Sigma_m (FC_{j,m} \times EF_{i,j,m}))$$

Where:

- Ei = Emission of pollutant i [g],
- FCj,m = fuel consumption of vehiclecategory j using fuel m [kg],
- EFi,j,m = fuel consumption-specificemission factor of pollutant i for vehiclecategory j and fuel m [g/kg].

Results and Discussion:-

Results:-

The pollutants that are considered as sources of bad quality of air are as follows: CO, NOx, NMVOCs and PM. Their estimated values pertaining to the year 2019 and the trends related to the time series 2010-2019 are respectively compiled in the tables (1 and 2).

Table 1:- Pollutants emitted in 2019 by road traffic in the city of Lomé.

Polluant (t)	Fuel	PV	LUV	HV	BUS	Motos	TOTAL
CO	Gasoline	111.28	24.93	-	-	2476.51	2612.73
	Diesel	3.13	1.76	2.34	1.69		8.93
CO_2	Gasoline	44309.72	5884.14	-	-	42766.78	92960.64

[1]Service Météorologique de Lomé (Station Lomé)
[2]Institut National de la Statistique et des Etudes Economiques

	Diesel	8902.21	1192.82	2236.58	1461.92	-	13793.53
NO	Gasoline	9.5	1	-	-	9.4	19.9
	Diesel	15.9	1.9	11.3	7.8	-	36.9
NO_2	Gasoline	0.29	0.029	-	-	0.38	0.712
	Diesel	19.47	2.38	1.84	1.26	-	24.96
NO_X	Gasoline	9.75	0.99	-	-	9.748	20.49
	Diesel	35.4	4.33	13.15	9.07	-	61.94
NMVOCs	Gasoline	3.03	0.18	-		554.78	557.99
	Diesel	0.43	0.14	0.11	0.08	-	0.78
PM	Gasoline	0.32	0.03	-	-	4.84	5.19
	Diesel	1.75	0.18	0.11	0.07	-	2.05

NB : PV = Particularvehicle, LUV = Light Utility Vehicle, HV = Heavy Vehicle

Table 2:- Trends of pollutantsemissionfrom 2010 to 2019.

Polluant (t)	CO	CO_2	NOX	NMVOCs	PM
2010	3451.91	109876.91	90.52	747.33	7.67
2011	3828.45	146435.02	170.84	819.71	11.21
2012	3946.4	147275.03	156.3	847.67	10.57
2013	3788.76	143953.04	129.69	810.5	10.16
2014	4612.99	120446.98	176.41	990.48	12.29
2015	5920.39	214239.2	158.98	1270.41	15.45
2016	4162.95	177356.19	135.98	879.91	11.78
2017	3816.72	175680.04	145.26	800.17	11.26
2018	3996.82	187073.77	155.94	836.84	11.91
2019	2621.67	106754.17	82.44	558.78	7.24

Results Discussion:-

The results analysis shows that the main pollutants emitted by road traffic in the city of Lomé are: carbone monoxide (CO), non-methane volatile organic compounds, nitrogen oxides (NOx), and particulate matter (PM). The 72% of pollutants emissions from road transport in Lomé derive from gasoline-powered vehicles. This is due to the very high number of the latter as compared to the diesel-powered ones.Diesel-powered vehicles emit more nitrogen oxides (61.95 tons/year) whereas gasoline-powered vehicles generate morecarbone monoxide (2612.74 tons/year). This phenomenon can depend upon engine characteristics, fuel type and the nature of combustion. Indeed, in optimal conditions, combustion in an automobile engine creates steam and carbone dioxide. The quantities of pollutants emitted in Lomé in 2019 are as follows:

1. CO: mainly emitted by PV, LDVand motorcycles and estimated at 2612.739 t/year,
2. NMVOCs: emitted in majority by gasoline-powered vehicles and evaluated at 557.997 t/year,
3. Nitrogen oxides (NO_X) : mainly emitted by diesel-powered vehicles estimated at 61.949 t/year, and
4. PM: mainly originating from gasoline-powered vehicles and estimated at 5.191 t/year.

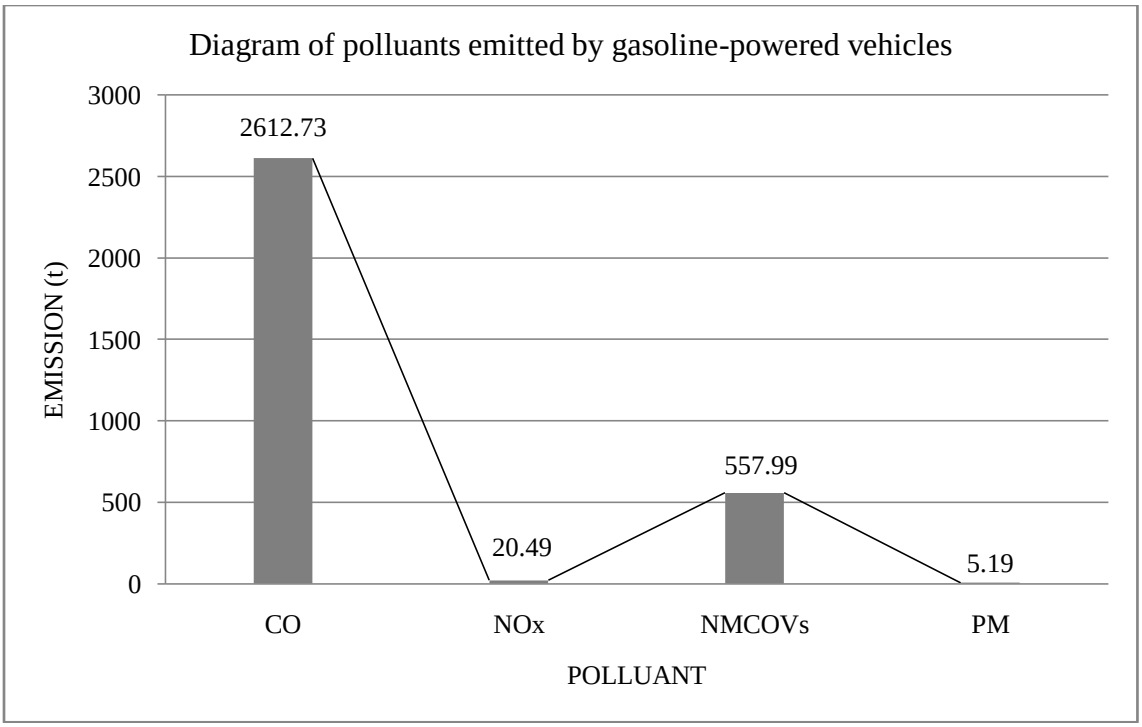

Figure 1:- Diagram of pollutants emitted by gasoline-powered vehicles.

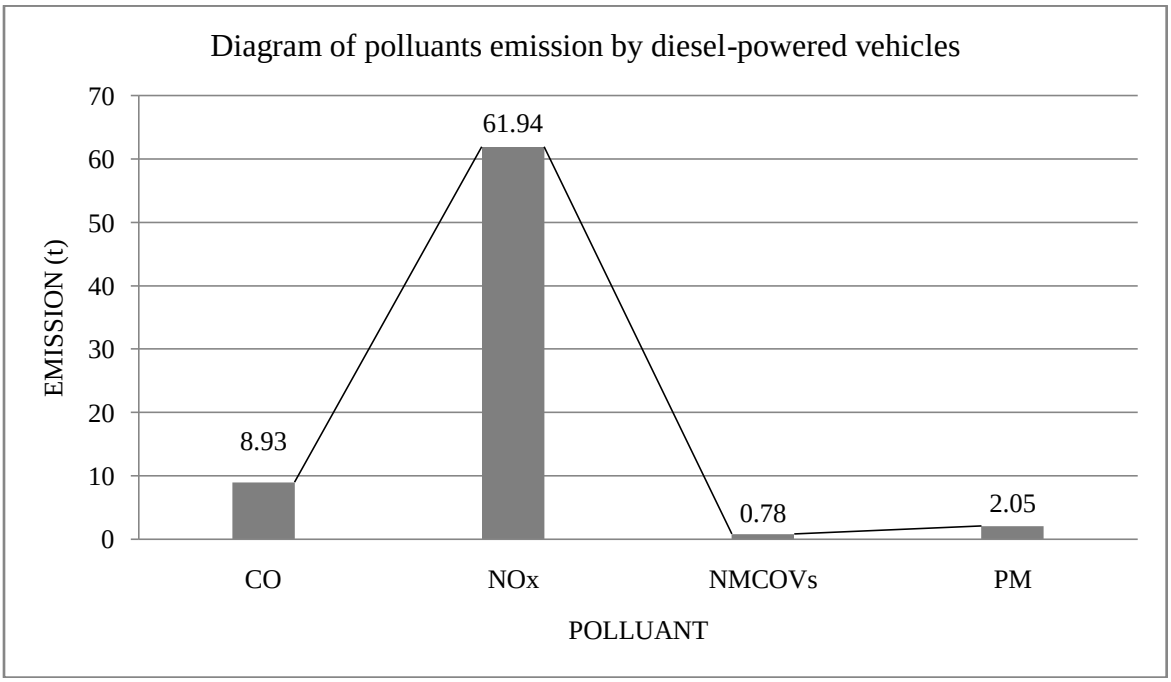

Figure 2:- Diagramof pollutants emission by diesel-powered vehicles.

The trends show, on the one hand, falls in the emissions of CO, NMVOCs, NOx and on the other hand, a rise in the emissions of CO_2 and PM. The emissions of the year 2015 dominate the trends (Figure3). The number of old vehicles was higher than other years' numbers. As for the quantity of emissions of the four selected chemical pollutants, the CO is the one that is more emitted during the time seriesunder study, followed by NMVOCs,NOx and PM. The CO emissions varied in two series with an evolution from 2010 to 2015 prior to the regression from 2016 to 2019. The variation is dominated by the regression, then the emissions decreased by 83.0234t/year. The variation in the emissions of NMVOCs shows characteristics that are similar to those of CO with a regression by

66.4888t/year. Emissions of Nitrogen oxides seesawed with a regression of 0.8073t/year. In contrary to the preceding pollutants, the variation in the emissions of PM shows a progression with an increase by 0.8208t/year. The trends in emissions of chemical pollutants related to road transport in the city of Lomé from 2010 to 2019 is shown in Figure 5. Overall, the emissions skyrocketed in 2015 with a relative decrease until 2019. This decrease can be explained by the change in the mode of transport. One can say that the very obsolete automobile fleet is getting improved through the rebuilding of roads and the implementation of measures and laws that regulate the state of vehicles in Togo, particularly in Lomé. It is almost difficult to justify the fluctuations in emissions of pollutants in Lomé with regard to the objectives set by the present study.

D'autresétudes plus approfondiespermettront par la suite d'apporterd'éléments de réponse.

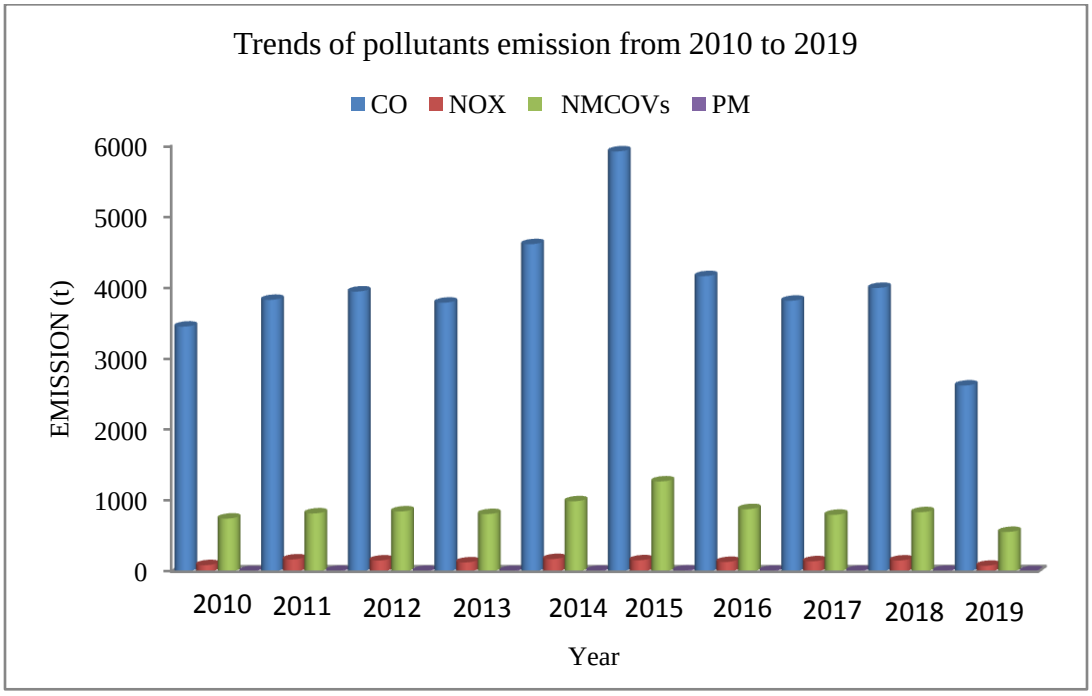

Figure 3:- Trends of pollutants emission from 2010 to 2019.

To better characterise road traffic pollution in Lomé, a comparative research about emissions was conducted using the Euro4 norm (table 3) in line with the preceding works' approach (Inchaouh, 2016).

The results shown in table 3 indicate that the emission ofprivate vehicles are belowthe Euro4 normthreshold. However, the emissions of particulate matter by vehicles exceed their threshold. This results from their obsolete state and their high average activity. These emissions have atmospheric chemical impacts that affect man and the environment. The pollutants emitted in the city of Lomé can generate other pollutants called secondary pollutants such as ozone andperoxyacetonitratesthat more dangerous through the photochemical phenomenon. Physicochemical reactions between chemical compounds (primary pollutants and other air components) are governed by meteorological conditions.

Table 3:- Comparison of the main pollutants emissions to the Euro 4 norm.

	Polluants	CO		NO_X		NMVOCs		PM	
	Emission thresholds and Results	Norm	Results	Norm	Results	Norm	Results	Norm	Results
Gasoline	PV (g/km)	1.000	0.439	0.080	0.038	0.1000	0.0129	-	0.0013
Diesel		0.500	0.049	0.250	0.550	-	0.0017	0.0250	0.0276
	HV (g/KWh)	1.500	0.015	3.500	0.083	0.4600	0.0007	0.0200	0.0007

NB: PV = Particularvehicle, HV = Heavy Vehicle

Conclusion:-

The present study showsthat road traffic in Lomé contributes to air pollution through emissions of pollutants such as carbone oxides, nitrogen oxides, non-methane volatile organic compounds and particulate matter by automobile vehicles circulating through this city. In 2019, the quantities of pollutants emitted were 2621.674 CO; 82.444 $NO_{X;}$ 558.778 NMVOCs; 7.241 PM. The trends in the emissions relatively indicate a fall from 2010 to 2019 in CO (83.0234 t/year), in NMVOCs (66.4888 /year), in NOx (0.8073t/year) and a rise in PM (0.8208 t/year). Although air pollution caused by road transport in Lomé is below norms, measures should be taken so as to avoid health and environment issues. To better grasp the contribution of road transport to emissions of air pollutants, further studies ought to analyse the physicochemical characteristics of the fuel types used and of the exhausting gases directly emitted by vehicles during circulation and determination of the actual number emitted, by category, as well as the characteristics of automobile fleet.

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