Scientific Review – Engineering and Environmental Sciences (2021), 30 (3), 379–387
Sci. Rev. Eng. Env. Sci. (2021), 30 (3)
Przegląd Naukowy – Inżynieria i Kształtowanie Środowiska (2021), 30 (3), 379–387
Prz. Nauk. Inż. Kszt. Środ. (2021), 30 (3)
http://iks.pn.sggw.pl
DOI 10.22630/PNIKS.2021.30.3.32

Ahmed S. HASSAN, Hasan M. AZEEZ

Mustansiriyah University, College of Science

Relation between CO_2 emissions and crude oil combustion in Iraq

Key words: CO_2 emission, crude oil, CO_2 concentration, Iraq

Introduction

The main issue of climate changes that the rapidly increasing of carbon dioxide emissions. Human activities results in emissions for four main greenhouse gases (GHGs): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs). These gases accumulate in atmosphere, then affecting the Earth's energy balance (Shahzad, 2015). The main part of these emissions came from combustion fossil fuel to use in transportation, electricity production, building heating and cooling, manufacture of cement and other goods. Annual average of NO_2 over Iraq increased as linear growth rate 9.8 per year, because the anthropogenic emissions, topography and weather conditions (Rajab, Hassan, Kadhum, Al-Salihi & San Lim, 2020). Carbon dioxide emission from fossil fuel combustion and processes contributed about 78% of the total GHGs emission increase from 1970 to 2010 (Blanco et al., 2014). Global warming began from increased CO_2 concentration is widely considered as main risk for Earth life. The role of CO_2 emission in relationship with increased global surface temperature, that pointed out to debate on accuracy of temperature reconstructions as well as on the exact impact that CO_2 has on global warming (Florides & Christodoulides, 2009).

Carbon dioxide emissions are the main results of burning fossil fuels, and given the important role it plays in climate change, that need to understand the uncertain spatial estimates of these emissions by relying on network data. This data has been studied in the United States, where a total estimate of emissions is made in the states, based on large volume sources and locations of the size of the large points of that network as well

as the distribution and size of the non--point sources, as there are other sources of greenhouse CO_2 gases. In order to determine spatial emissions, they are measured by fossil fuels and industrial processes observed by Boden, Andres and Marland (2017). Energy data statistics can also estimate the time series of CO_2 emissions produced by the initial flow of fossil fuels, as the flow of CO_2 increased in an unimaginable way during the World War I, however were represented by time series for the period from 1751 to 1950, represented by the total emission of CO_2, even during the Industrial Revolution (Andres et al., 2012). The rate growth of total cumulative CO_2 emissions continues to grow during present times, generating debate on the probability of enhanced greenhouse warming. China is largest energy consuming and CO_2 emitter, developed methods for constructing CO_2 emissions for Chinese cities based on energy balance table. This construction, according to the regional emissions report of the Intergovernmental Panel on Climate Change (IPCC), as emissions in social and economic sectors reached 47, 17 fossil fuels, and 9 primary industrial products, and examined uncertainties inventories basis for many climate polices (Shan et al., 2017). The consequence of environmental changing, not only on climate but also on the ecosystems, it is urgent needed to improve the predictive skills of the models used for instance in the prediction models organized by the IPCC. Where total carbon emission was 9 Gt in 2016 as result of fossil fuel combustions. The comparisons between the different methods used to estimate the spatial and temporal air – sea interactions of carbon substantial discrepancies both regional and temporal, this lead to understand the role played by these interactions in the functioning of the ecosystems (Aumont, 2016). Many publications about the carbon emission research domain, which has been more visible especially during 2016–2018. The most significant contribution to the domain was reported from China, United States, and England. While most prolific authors and institutions of the domain were from China, reported the best connection links. It was revealed that evaluating greenhouse gas emissions and estimating the carbon footprint was well known among the researchers. Moreover, climate change and environmental effects of carbon emissions were also significant points of concern in carbon emission research (Udara Willhelm Abeydeera, Wadu Mesthrige & Samarasinghalage, 2019). The carbon monoxide (CO) affecting air quality and climate and acts as a serious indirect GHGs. The vertical distribution of CO over Iraq found that seasonal difference, where winter recorded higher value of CO than summer and autumn. The satellite measurement are able to determine the increased of atmospheric CO concentration over varied region (Abdulfattah, Rajab, Al-Salihi, Suliman & Lim, 2020).

Munn (2019) focus on global fossil CO_2 emissions had increased in last three years consecutively: +1.5% in 2017, +2.1% in 2018, and +0.6% in 2019. Economic indicators and trends in global natural gas and oil use suggest a further rise in emissions in 2020. Global CO_2 emissions from oil increased over the next decade or more. Stronger global commitments and carbon pricing would help implement such policies at scale

and in time. Moreover (Hassan & Zaki, 2018) studied for three states of fossil fuel in Iraq, the analysis of CO_2 emissions and for three types of fossil fuels: gas, liquid, steel, gases emitted from these cases are considered greenhouse gases, which in turn affect the radiation balance of the Earth, where the emission density is the average rate of emission. Therefore, the burning of carbon since the Industrial Revolution increased the concentration of CO_2 in the atmosphere, as results showed that the consumption of gaseous fuel increased by about 10 times, up to 1,045.10 kt, the CO_2 emission presented from the consumption of fossil fuels increased by 10.4 greater than it was, which reached to 86,759 kt. The per capita gross domestic production (GDP) was main determinant of CO_2 emissions in global panel, thereby carried out positive effect on CO_2 (Sharma, 2011). The relationship between total of CO_2 emissions and GDP by using the environment Kuznets curve (EKC) model in Iraq. This relationship takes invert U-shape and CO_2 emissions increased more than five times after 2000 than before, that's refer to increased had damage environmental (Al-rukabie, Hassan & Kadhum, 2020). When looking into global carbon intensity of crude oil production by developed the climate intensity (CI) model identify major drives of these emissions, and estimation emissions for 90 countries in 2015 from 8,966 oil fields represent 98% of global crude oil condensation production with above of average global CI. The link between climate and sustainable development are strong. Poor and developing countries, particularly least developed countries, will be among those most adversely affected and least able to cope with the anticipated shocks to their social, economic and natural systems. The goal of this research is to calculate the annual total CO_2 emissions from crude oil in Iraq, then compare the results with estimation of total CO_2 emissions over Iraq. The ratio between annual total CO_2 emissions for Iraq and world found out. The annual CO_2 concentration investigated over Iraq then calculated the percentage of this concentration to annual CO_2 concentration over world.

Methodology and dataset

Iraq is now the second largest producer and exporter in world, and expected to grow its oil production capacity over the next decade and account for a significant share of additional supply. In spite of all these positives have disadvantages; Iraq has faced environmental degradation over by rising CO_2 emissions. The question that is addressed here is how many tons of CO_2 emissions are generated by the crude oil being burned. So that, it is necessary understanding CO_2 molecules weight and the structure of it, beside more information about crude oil. The crude oil weight about 136 kg (159 l), the crude oil has on carbon ratio maximum and that equal 78%. The carbon ratio in one barrel is approximate to 118 kg. The molecular weight of carbon is 12, where molecular weight of oxygen is 16, it has mass of ≈ 16 u, that's mean molecular weight ratio of CO_2 equal to 44; the density of one barrel of oil is 0.85 g·cm^{-3}. The crude oil has on carbon ratio maximum and that equal 78%

that means the carbon ratio in one barrel is approximate to 118 kg, so that carbon ratio from total molecular weight is 27.27% of carbon in CO_2. Carbon dioxide emission from one barrel equal 433 kg. The calculation for CO_2 emissions that used in this paper is Eq. (1), it is simple equation depend on crude oil production only, as followed.

$$CO_2\ emission = \frac{P_{oil}}{27.27} = P_{oil} \cdot 3.67 \cdot 0.118 \quad (1)$$

where:

$CO_2\ emission$ – carbon dioxide emission from crude oil,

P_{oil} – crude oil prediction.

The sources of datasets consist of three parts: first, dataset for crude oil production in Iraq for period of 1980–2018. These datasets available from Trading Economics Application Programming Interface (TEAPI) provides direct access to annual crude oil production for Iraq. The second source provides data was the Carbon Dioxide Information Analysis Center (CDIAC) annual data used in this study to compare between Iraq and global emissions (Andres et al., 2012; Andres, Boden & Higdon, 2014). The CDIAC' estimates of CO_2 emissions from fossil-fuel consumption for annual total CO_2 emissions data for Iraq and world sourced from CDIAC for long period (1980–2014) to found out the ratio between of them (Andres et al., 2014). Third dataset was annual averaged of CO_2 concentration observed data provide in parts per million (ppm), for Iraq from 2002 to 2016, while for world in 1980–2018 (Friedlingstein et al., 2019).

Results and discussion

Carbon dioxide is continuously emitted into the atmosphere through several processes, such as those from fossil fuel combustion, black oil refining, unstopped engines and even plants. The amount of this gas emitted from these sources varies by location and time. Therefore, the CO_2 emissions from fossil fuel for Iraq was calculated by using the Eq. (1) depend on amount of crude oil production carbon thereby determined the amount of CO_2 emitted from it. The results carried out the heights value of emission was in 2018 that reach to 1.97 Mt, however the last four years begin this rise of emissions from 2012 (1.29 Mt) to end of study period; that represented the highest period of emissions than whole period study as shown in Figure 1. The minimum value of CO_2 emissions was 0.1 Mt in 1991, compatible with the lower crude oil production was in 1992–1996 (0.2 Mt) because that Iraq was under economic embargo of UN and the crude oil production was so limited. The next period witnessed fluctuation in production, and therefore the amount of CO_2 emissions was fluctuating, in contrast to the subsequent period, which found that there was a slowly increase to reach maximum values at the end of the study period with oil production more than 4 million barrels per day, then the emission activity returned and remained to this day without providing any clarifications or treatments.

The main common between CO_2 emissions for Iraq and world that have same behavior, rapidly increased, especially in last decade of this study as shown in Figure 2. There was a clear increased in the quantities of emissions gradually

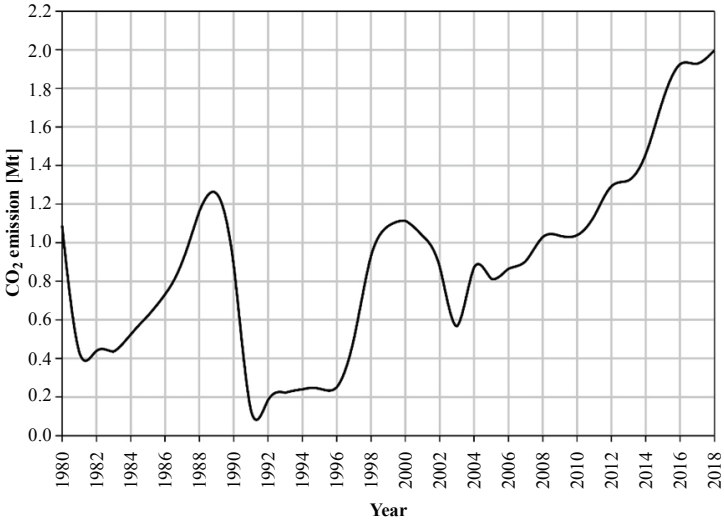

FIGURE 1. Time series for calculated of total CO_2 emissions from crude oil for period of 1980–2018 of Iraq

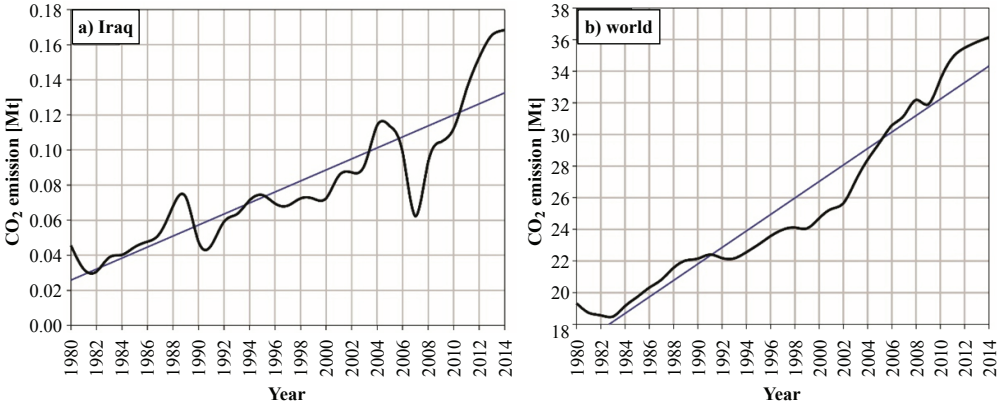

FIGURE 2. Time series of annual CO_2 emissions from fossil fuel production in 1980–2014 for Iraq (a) and the world (b)

and represented from 1980 to 2014 for both Iraq and the world, but there was a different slope of the average line, that was 0.5 for the world and 0.003 for Iraq. This means that the average global CO_2 emissions are 166.6 times higher than that of Iraq. The behavior of two curves were similar in Figure 2 except for the middle of the study period (1990–2008), where Iraqi emissions recorded a decline in 1991 and 2007 (0.042 and 0.061 Mt, respectively), while the world was emissions during the same the period was below the average slope line. Both world and Iraqi CO_2 emissions were increased as exponential function from 2008 to end of study period (2014) to reach 36 and 0.17 Mt, respectively.

Considering that the converging behavior between CO_2 emissions for Iraq and the world leads to divide the Iraqi CO_2 emissions to total CO_2 global emissions, to achieve this goal calculating the ratio from fossil fuel between them as shown in the table from period 1980 to 2008. This ratio explain that two different periods have different variance; first period (1981–1997) that change approximately 0.0001 each year, while second period (1998–2008) change 0.0001 each two–three years, and the high ratio found in 2008 (0.0034). These ratios for both periods were very small to refer CO_2 emission for Iraq was very low compared to world's emissions.

The atmosphere contains a range of greenhouse gases and the most important of these gases is CO_2 emitted to the atmosphere through several processes and several ways where this emission can have concentrations vary from place to place because of GCM as the movement of the wind cycle in the atmosphere important in reducing or increasing CO_2 concentrations over the duration of history. Where the results showed that the concentrations of CO_2 gas, which existed since industrial revolution in increasing till today as non-liner functions.

Carbon dioxide concentration for Iraq as represented in Figure 3, show the growth rate of 1.875 ppm per year, with continuity increased from 375.93 ppm in 2002 to reach highest value of 403 ppm was in 2016. Statistics indicated that Iraq is one of the countries in dealing with CO_2 emissions according to international agreements, in spite of despite that; it is consistent with the concentrations when compared to the world concentrations.

The global CO_2 concentrations shown slowly increased with slop the average line equal to 1.75 ppm per year, from minimum value of 338.6 ppm was in 1980, while maximum value of 407.05 ppm was in 2018, that means three of the four highest annual increases have occurred in the past four years. It's no coincidence that the last four years also had the highest CO_2 emissions on record. Undoubtedly, there is no decrease in CO_2 concentrations unless emissions are addressed. Compared to Iraq's CO_2 concentrations, there is also an increase in concentrations due to emissions, concentrations increased approximately two times through study period.

TABLE. The ratio between CO_2 emissions from fossil fuel for Iraq to world in 1981–2008

Year	Ratio	Year	Ratio	Year	Ratio	Year	Ratio
1981	0.002049	1988	0.002576	1995	0.002938	2002	0.003243
1982	0.002142	1989	0.002643	1996	0.00299	2003	0.003284
1983	0.002230	1990	0.002675	1997	0.00304	2004	0.003303
1984	0.002314	1991	0.002738	1998	0.003088	2005	0.003342
1985	0.002354	1992	0.002798	1999	0.003112	2006	0.003379
1986	0.002431	1993	0.002856	2000	0.003157	2007	0.003415
1987	0.002505	1994	0.002854	2001	0.003201	2008	0.003433

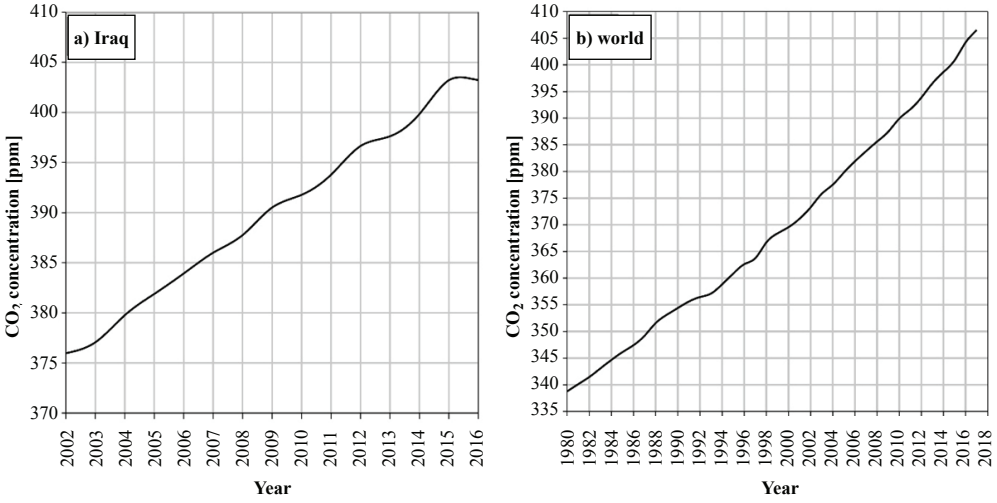

FIGURE 3. Time series of annual CO_2 concentration for Iraq (a) and the world (b) in the 2002–2018

Conclusions

1. Carbon dioxide emissions calculated from crude oil for Iraq was increased from 2012 (1.29 Mt) without any decline to reach end of study period in 2018 (1.97 Mt), while the minimum value was in 1991 (0.1 Mt).
2. Total observed CO_2 emissions increased with different slop of average line that was 0.5 for world, 0.003 for Iraq. The behavior of two carve were similar except decline in 1991 and 2007 in middle period study. The world and Iraq CO_2 emissions were increased exponential function from 2008 to 2014 to reach 36 and 0.17 Mt, respectively.
3. The ratio of Iraqi CO_2 emissions to world CO_2 emission divided into two periods: first period (1980–1997) was 0.0001 each year, while second period (1998–2008) was 0.0001 each two–three years. These results shown that Iraqi CO_2 emissions very small compared with CO_2 emissions.
4. The global CO_2 concentrations slowly increased with slop the average line equal to 1.75 ppm per year, from minimum value was 338.6 ppm in 1980, while maximum value was 407.05 ppm in 2018, that means three of the four highest annual increases have occurred in the past four years. Iraqi CO_2 concentrations was increased two times than before, where highest value of 403 ppm was in 2016. That's mean no decreased in CO_2 concentration unless emissions addressed.

References

Abdulfattah, I.S., Rajab, J.M., Al-Salihi, A.M., Suliman, A. & Lim, H.S. (2020). Observed vertical distribution of tropospheric carbon monoxide during 2012 over Iraq. *Scientific Review – Engineering and Environmental Sciences*, *29*(2), 184-195.

Al-rukabie, J.S.A., Hassan, A.S. & Kadhum, J.H. (2020). Empirical analysis of CO_2 emission using EKC model in Iraq. *International Journal of Advanced Science and Technology*, *29*(3), 557-564.

Andres, R.J., Boden, T.A. & Higdon, D. (2014). A new evaluation of the uncertainty associated with CDIAC estimates of fossil fuel carbon dioxide emission. *Tellus B: Chemical and Physical Meteorology*, *66*(1), 23616. https://doi.org/10.3402/tellusb.v66.23616

Andres, R.J., Boden, T.A., Bréon, F.M., Ciais, P., Davis, S., Erickson, D., Gregg, J.S., Jacobson, A., Marland, G., Miller, J., Oda, T., Olivier, J.G.J., Raupach, M.R. & Treanton, K. (2012). A synthesis of carbon dioxide emissions from fossil-fuel combustion. *Biogeosciences*, *9*(5), 1845-1871.

Aumont, O. (2016). *Étude des cycles biogéochimiques marins au moyen de la modélisation* [*Study on marine geochemical cycles using modelling*]. Paris: Sorbonne University.

Blanco, G., Gerlagh, R., Suh, S., Barrett, J., Coninck, H.C. de, Morejon, C.F.D., Mathur, R., Nakicenovic, N., Ahenkorah, A.O., Pan, J., Pathak, H., Rice, J., Richels, R., Smith, S.J., Stern, D.I., Toth, F.L. & Zhou, P. (2014). Drivers, trends and mitigation. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 351-411). Cambridge: Cambridge University Press.

Boden, T., Andres, R. & Marland, G. (2017). *Global, Regional, and National Fossil-Fuel CO2 Emissions (1751–2014) (V. 2017)*. https://doi.org/10.3334/CDIAC/00001_V2017

Florides, G.A. & Christodoulides, P. (2009). Global warming and carbon dioxide through sciences. *Environment International*, *35*(2), 390-401.

Friedlingstein, P., Jones, M.W., O'Sullivan, M., Andrew, R.M., Hauck, J., Peters, G.P., Peters, W., Pongratz, J., Sitch, S., Le Quéré, C., Bakker, D.C.E., Canadell, J.G., Ciais, P., Jackson, R.B., Anthoni, P., Barbero, L., Bastos, A., Bastrikov, V., Becker, M., Bopp, L., Buitenhuis, E., Chandra, N., Chevallier, F., Chini, L.P., Currie, K.I., Feely, R.A., Gehlen, M., Gilfillan, D., Gkritzalis, T., Goll, D.S., Gruber, N., Gutekunst, S., Harris, I., Haverd, V., Houghton, R. A., Hurtt, G., Ilyina, T., Jain, A.K., Joetzjer, E., Kaplan, J.O., Kato, E., Klein Goldewijk, K., Korsbakken, J.I., Landschützer, P., Lauvset, S. K., Lefčvre, N., Lenton, A., Lienert, S., Lombardozzi, D., Marland, G., McGuire, P.C., Melton, J.R., Metzl, N., Munro, D. R., Nabel, J.E.M.S., Nakaoka, S.-I., Neill, C., Omar, A.M., Ono, T., Peregon, A., Pierrot, D., Poulter, B., Rehder, G., Resplandy, L., Robertson, E., Rödenbeck, C., Séférian, R., Schwinger, J., Smith, N., Tans, P.P., Tian, H., Tilbrook, B., Tubiello, F.N., Werf, G.R. van der, Wiltshire, A.J. & Zaehle, S. (2019). Global carbon budget 2019. *Earth System Science Data*, *11*(4), 1783-1838.

Hassan, A.S. & Zaki, K.N. (2018). Decadal Analysis of Carbon Dioxide Emissions from Different State of Fossil Fuels in Iraq. *Indian Journal of Public Health Research & Development*, *9*(12), 865-868.

Munn, C.B. (2019). *Marine microbiology: ecology & applications*. Boca Raton: CRC Press.

Rajab, J.M., Hassan, A.S., Kadhum, J.H., Al-Salihi, A.M. & San Lim, H. (2020). Analysis of tropospheric NO_2 over Iraq using OMI satellite measurements. *Scientific Review – Engineering and Environmental Sciences*, *29*(1), 3-16.

Shahzad, U. (2015). Global warming: Causes, effects and solutions. *Durreesamin Journal*, *1*(4), 1-7.

Shan, Y., Guan, D., Liu, J., Mi, Z., Liu, Z., Liu, J., Schroeder, H., Cai, B., Chen, Y. & Shao, S. (2017). Methodology and applications of city level CO_2 emission accounts in China. *Journal of Cleaner Production*, *161*, 1215-1225.

Sharma, S.S. (2011). Determinants of carbon dioxide emissions: empirical evidence from 69 countries. *Applied Energy*, *88*(1), 376-382.

Udara Willhelm Abeydeera, L.H., Wadu Mesthrige, J. & Samarasinghalage, T.I. (2019). Global research on carbon emissions: a scientometric review. *Sustainability*, *11*(14), 3972. https://doi.org/10.3390/su11143972

Summary

Relation between CO_2 emissions and crude oil combustion in Iraq. Fossil fuel is the main source for CO_2 emissions that causes global warming. This fact is the starting point for this paper, that consider on three different sources of data: crude oil used to calculate CO_2 emissions for Iraq for the period from 1980 to 2018; annual data of total CO_2 emissions available from the Carbon Dioxide Information Analysis Center (CDIAC) for Iraq and the world for the period from 1980 to 2014; and CO_2 concentrations for Iraq for the period from 2002 to 2006 and for the world for the period from 1980 to 2018. The result is a multifaceted according to the dataset sources. Carbon dioxide emissions calculated from Iraqi crude oil was increased from 1.29 Mt in 2012 to 1.97 Mt in 2018. The world and Iraq CO_2 emissions with different slop of average line that was 0.5 for world, 0.003 for Iraq, while increased exponential function from 2008 to 2014 to reach 36 and 0.17 Mt, respectively. The highest value of Iraqi CO_2 concentration was 403 ppm in 2016, while the global CO_2 concentrations slowly increased with slop line equal to 1.75 ppm per year, from minimum value of 338.6 ppm was in 1980, while maximum value of 407.05 ppm was in 2018, that's mean no decreased in CO_2 concentration unless emissions addressed.

Authors' address:
Ahmed S. Hassan – corresponding author
(https://orcid.org/0000-0001-5029-5642)
Mustansiriyah University
College of Sciences
Atmospheric Sciences Department
Palestine Street, postal code 46131, Baghdad
Iraq
e-mail: ahmed.s.atmsc@uomustansiriyah.edu.iq

Hasan M. Azeez
Mustansiriyah University
College of Sciences
Atmospheric Sciences Department
Palestine Street, postal code 46131, Baghdad
Iraq
e-mail: hassan.m.a7878@uomustansiriyah.edu.iq