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The Effect of Natural Gas Flaring on Air Pollution and its contribution to Climate Change in Basra City

Abdul Haleem Ali Al Muhyi *, **Faez Younis Khalil Aleedani**

Department of Marine Physics, Marine Science Center, University of Basrah, IRAQ

Abstract

The effects of climate change differ from one region to another, as its effects are not the same in all regions of the world. The consequences differ from one region to another, according to its geographical location, or according to the ability of the region and its social and environmental systems to adapt to climate change or mitigate its effects. One of the most important factors of climate change is global warming. There are two major sources of global warming: natural and human. The human resource contributes by adding heat and greenhouse gases to the atmosphere because of the global use of fossil fuels, nuclear energy, burning of natural gas, coal, timber, and others. Natural gas flaring is one of the most important challenges facing energy sources and the environment globally and locally. In this study, light was shed on the flaring of natural gas in Basra Governorate and its impact on the environment and climate change. The results showed that burning natural gas in Basra contributes to changing the local climate by adding heat and greenhouse gases to the atmosphere, which led to an increase in the air temperature in the region. In recent years, it has reached (52 degrees Celsius), and it also affects air pollution by increasing concentrations of toxic gases in the

* Corresponding Author: Abdul Haleem Ali Al Muhyi

atmosphere, and it is one reason for the increase in the number of cancer patients in Basra Governorate. And there was a strong positive correlation between increased gas burning and an increase in cancer cases.

Keywords: gas flaring, fossil, methane, decades, oxidation.

تأثير حرق الغاز الطبيعي على تلوث الهواء ومساهمته في تغير المناخ في مدينة البصرة

عبد الحليم على المحي، فائز يونس العيداني

قسم الفيزياء البحرية، مركز علوم البحار، جامعة البصرة، العراق

الخلاصة:

تختلف اثار التغير المناخي من منطقه الى أخرى، وإن آثاره ليست متشابه في جميع انحاء العالم. بل تختلف من منطقة إلى أخرى، حسب الموقع الجغرافي لكل منطقه، أو حسب طبيعة المنطقة وأنظمتها البيئية على التكيف مع التغير المناخي أو التقليل من آثاره. أحد اهم عوامل التغير المناخي هو الاحتباس الحراري.

هناك مصدران رئيسيان للاحتباس الحراري: طبيعي وبشري. يساهم المصدر البشري من خلال إضافة حرارة وغازات دفيئة الى الغلاف الجوي نتيجة للاستخدام العالمي للوقود الاحفوري والطاقة النووية وحرق الغاز الطبيعي، والفحم، والاخشاب، وغيرها. يعد حرق الغاز الطبيعي أحد أكثر التحديات التي تواجه مصادر الطاقة والبيئة عالميا ومحليا. في هذه الدراسة تم تسليط الضوء على حرق الغاز الطبيعي في محافظة البصرة وتأثيره على البيئة وتغير المناخ وأظهرت النتائج أن حرق الغاز الطبيعي في محافظة البصرة يساهم في تغير المناخ المحلي من خلال إضافة حرارة وغازات الاحتباس الحراري إلى الغلاف الجوي مما أدى إلى ارتفاع درجة حرارة الهواء في المنطقة بالسنوات الأخيرة لتصل الى (52 درجة مئوية)، كما انه يؤثر على تلوث الهواء من خلال زيادة تراكيز الغازات السامة في الغلاف الجوي، ويعتبر أحد أسباب زيادة عدد مرضى السرطان في محافظة البصرة. ووجدت هناك علاقة طرديه قوية بين زيادة حرق الغاز وزيادة حالات السرطان.

ولتجنب هذا الهدر الهائل في الثروة الوطنية المتمثلة في حرق الغاز الطبيعي نوصي باستثماره بدلا من حرقه وبالتالي تجنب التأثير الضار للبيئة والمناخ الناتج عن حرقه.

الكلمات المفتاحية: حرق الغاز، الأحفوري، الميثان، العقود، الأكسدة.

Introduction:

The dependence on the oil and gas industry in Iraqis increasing as economies and infrastructure continue to depend entirely on petroleum-based products.

1. Natural gas

Natural gas (NG) is one of the fossil energies sources that was formed deep beneath the earth's surface. It is found in oil wells, in the form either dissolved in crude oil or exists separately in a form of a cap on top of the oil. Unless it is used for commercial purposes, the gas either is burned off upon reaching an oil well surface or directly vented into the atmosphere without burning. The composition of natural gas is different depending on the location. Each well has a different gas composition and different amounts of each component.[1] Iraq's proven reserves of the conventional natural gas amount to **(3.5 trillion cubic meters (tcm))**[2], placing Iraq 11th among global reserve-holders. Most of it is concentrated in the southern part of Iraq (Basra Province) **figure (1)**, mostly as the large associated gas reserves in the super-giant fields of Zubair, Rumaila, Nahr Umr, Majnoon, and West Qurna. [3] Gas production creates three major Climate Problems. **First:** Produces CO_2 when burned. **Second:** Methane, CH_4, purposefully vented and leaked during 1-drilling 2- initial frac fluid flow-back period. 3- liquid unloading 4-gas processing 5- transmission, storage, and distribution. 6- Continuously at the pad site via leaking wells and equipment. **Third:** Produces black carbon BC, (soot) during flaring and processing.

2. Natural gas flaring

The process of NG flaring has existed since the beginning of the production of crude oil. Realizing that NG has great value as a source of energy, companies began to reduce its flaring to the minimum. The impact of NG flaring is of local and global concern, it is one of the most challenging energy and environmental problems facing the world today whether regionally or globally [4] NG flaring is one of the upstream oil and gas industry processes to dispose undesirable NG through high-temperature oxidation at the tip of a stack [5] often with devastating effects on the local environment through visual pollution[6], noise, light, heat stress[7], acid rain[8], flaring emits volatile organic compounds (VOC), black carbon (BC), methane (CH_4), and carbon dioxide CO_2, the last three are powerful climate forcers, BC and VOCs are dangerous air pollutants. [9] [10]

3. Influence of Black carbon (BC) to atmosphere

Black carbon (BC) which is regarded as an important component of atmospheric aerosols is produced from the incomplete combustion of hydrocarbon-containing materials [8] There are two main emission sources of BC aerosols: first natural emission source, which includes

volcanic eruptions and forest fires, and second the anthropogenic emission sources which comprise the combustion of fossil fuels, oil, coal, and other fossil fuels like NG, burning of biomass, and car exhaust emissions.[11] The BC concentration in the atmosphere has increased rapidly because of human activities [12] one of these activities is gas flaring. Annually, the contribution of gas flaring to global BC concentration is estimated to be 260 Gg [13, 14] BC emission measurements from gas flaring compared to the traditional emission sectors relatively little studied. Black Carbon (BC) regards as atmospheric aerosol, which affects the climate directly and indirectly, via its mechanism, absorb solar radiation in the infrared and visible bands, heat the atmosphere and then change the characteristic of the climate and air quality. Intergovernmental Panel on Climate Change (IPCC) report indicates that the average direct radiative forcing of global BC aerosols is 0.4 Wm^{-2} [15] , therefore play a unique and important role in the climate systems.[11]

4. The effects of Natural gas flaring on the economics

From an economist's point of view, the flaring of this associated gas is a colossal waste to the communities, in terms of the loss of funds and revenue which it could have realized if it had preserved instead of flaring same.[4] Iraq gives a terrible example of such a loss. In this article, we discuss and analyze all these effects on the climate and pollution in Iraq and Basra in particular.

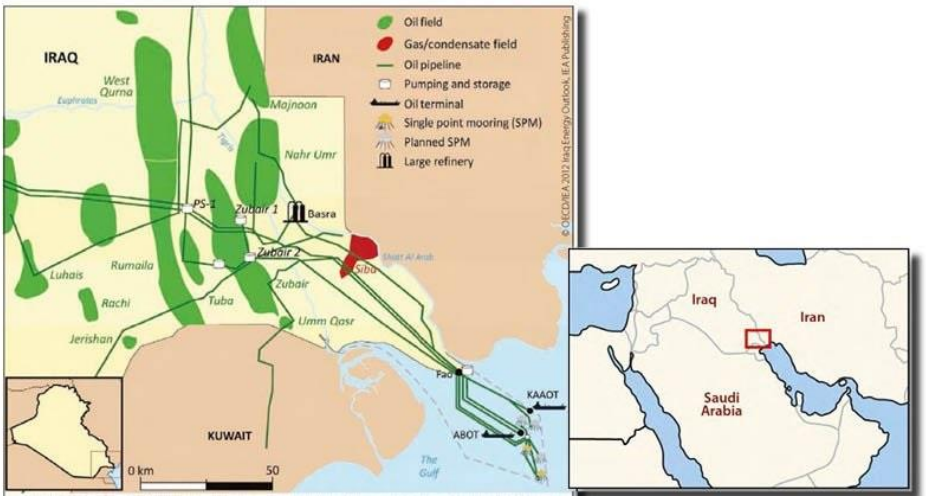

Figure (1) Study area[16]

Data and method:

The time series of annual mean temperature of Hui Al Hussain station in Basra for the period (1960-2019), annual total number of cancer cases in Basra for the period (2013-2019) and monthly natural gas flaring in Basra for the period (2018- 2019) sourced from the Iraqi

Meteorological Organization and Seismology, Reports of air pollutants and health indicators [17] and Report of Environment Statistics for Iraq [17, 18] respectively.

The sources of other data are from websites: top 30 countries gas flaring for the period (2014-2019) [19], Global average atmospheric Methane for the period (1984-2020) [20], CO_2 emission in Iraq for the period (1965-2019**)** [21]. We compute the amount of heat release from gas flaring and anomaly of annual CO_2 emission due to gas flaring, the time series have been plotted by using MS Excel, determine Pearson correlation coefficients between gas flaring and cancer in Basra city.

Results and discussion:

1. Gas flaring adding heat to the atmosphere.

The greenhouse effect still needs an explanation, and we agree with the interpretation that considers the warming results from heat emissions from the global consumption of non-renewable energy [22]. Global warming means that heat has been accumulating in air, ground, and water since 1880. The Heat was released into the atmosphere by heat dissipation from the global use of fossil fuel and nuclear power.[23] According to the World Bank, Iraq is currently flaring over 16 Bcm of associated gas each year; [14] **Figure (2)** shows the top 30-country gas flaring in the world.

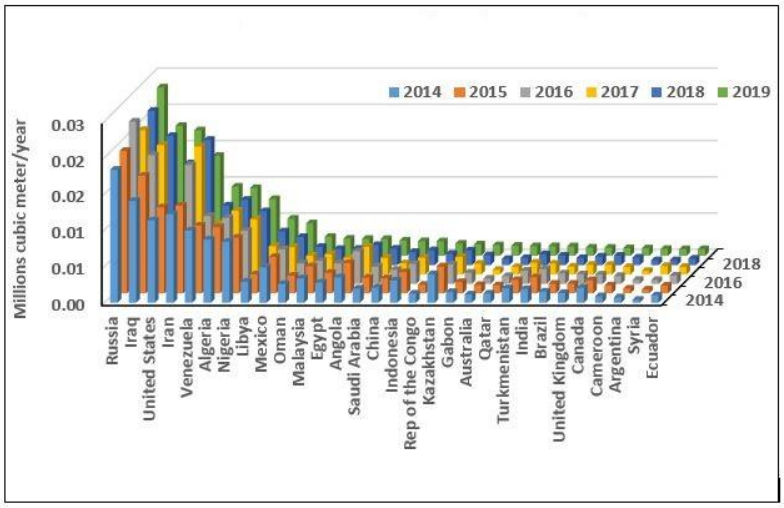

Fig. (2) Top 30 countries gas flaring for the period (2014-2019)

Discussing the amount of NG flaring**,** **Figure (3)** presents the monthly amount of gas flaring in Basra for the years 2018 and 2019. The largest amount of gas flaring appears during September 2018 and August 2019, this means that the Governorate of Basra contributes to adding heat to the atmosphere. Its amount was calculated per month for the years 2018 and

2019, as shown in **Figure (4)**, where the largest amount of heat added to the atmosphere was in September 2018, reaching (5256795567 Btu) and in August 2019 when it reached (46153121504 Btu) and the lowest amount was in February of the years 2018 (39426756496 Btu) and 2019 (37175013587 Btu). The neighboring countries of Basra Governorate in Iraq (Iran, Saudi Arabia, and Kuwait) are also oil and gas producing countries and they are among the top 30 countries gas flaring in the world, which are also contributed by adding heat and greenhouse gases to the atmosphere regionally and globally, This means that the region adding heat to the atmosphere and take part in accumulating heat to the atmosphere, and this is one reason for the high temperature in recent years in Basra Governorate and the region which reached its highest levels. Record of temperature highs in recent years show that five Arab countries, including Iraq (Basra, 52 °C) were affected, and the temperature is expected to reach new highs.**[24]**

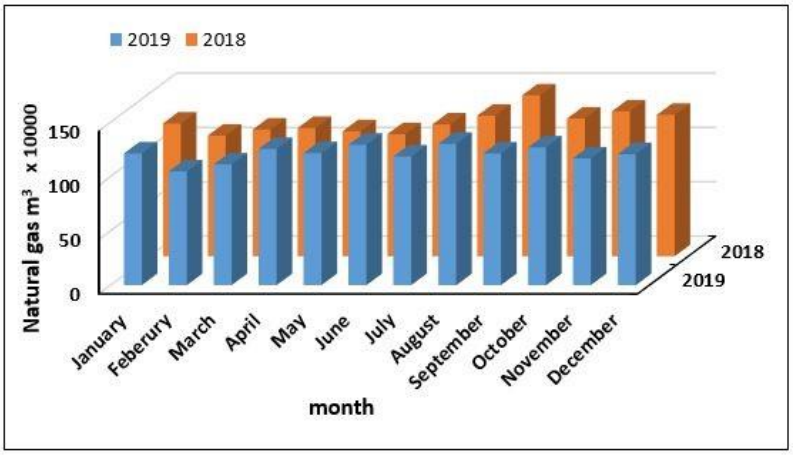

Fig. (3) Monthly Natural gas flaring in Basra for the year 2018 and 2019

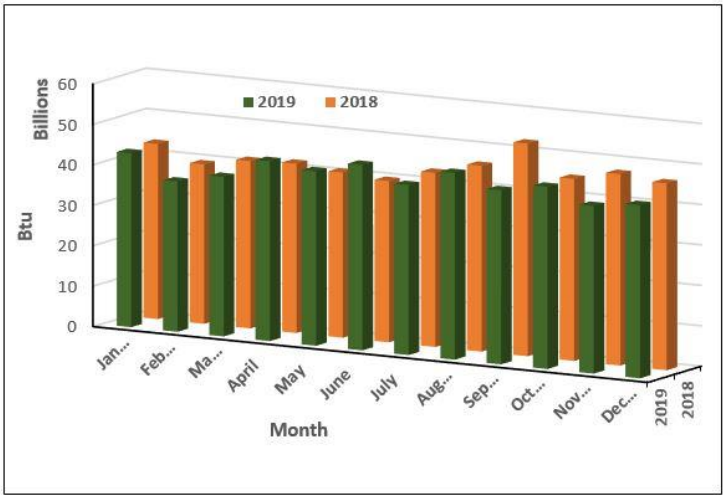

Fig. (4) Monthly amount of heat adding to the atmosphere by Natural gas flaring in Basra for the year 2018 and 2019

Figure (5) shows the annual average of temperatures and the monthly average for July and January, which represent the summer and winter seasons respectively, the temperature and its trend are gradually increasing.

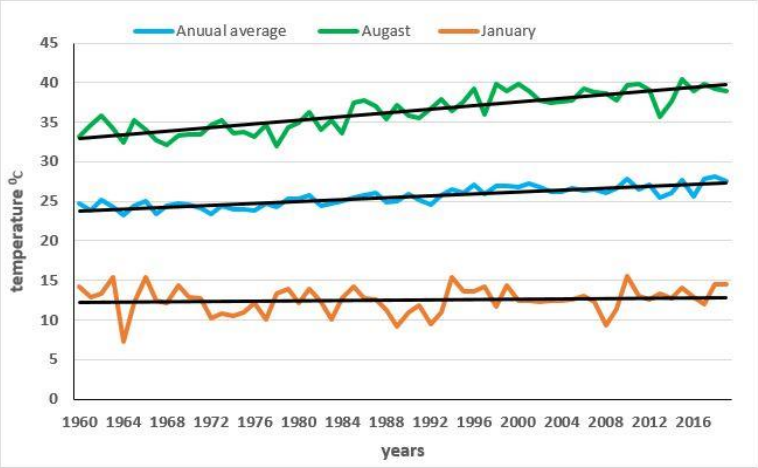

Fig. (5) Annual temperature variation and for the months of January and August in Basra

2. Gas flaring adding greenhouse gases (GHG) to the atmosphere

Another factor that the gas flaring process contributes to climate change is emitting greenhouse gases into the atmosphere and it plays a major role in increasing the temperature of the atmosphere. However, gas flaring results in less global warming impact than if it was venting into the atmosphere. This is because methane gas, one of the primary components of NG has a higher GWP than CO_2. Iraq annually adds CO_2 because of the combustion of NG as presented in **Figure (6)** which shows annually CO_2 emission by NG flaring in Iraq, and Governorate of Basra contributes 70% of the quantity. **[19]** This increase has been continuing since 1965, as we note the trend line increasing annually, also we note minimum value during the period 1991 to 2003 because Iraq through this period was under sanction.

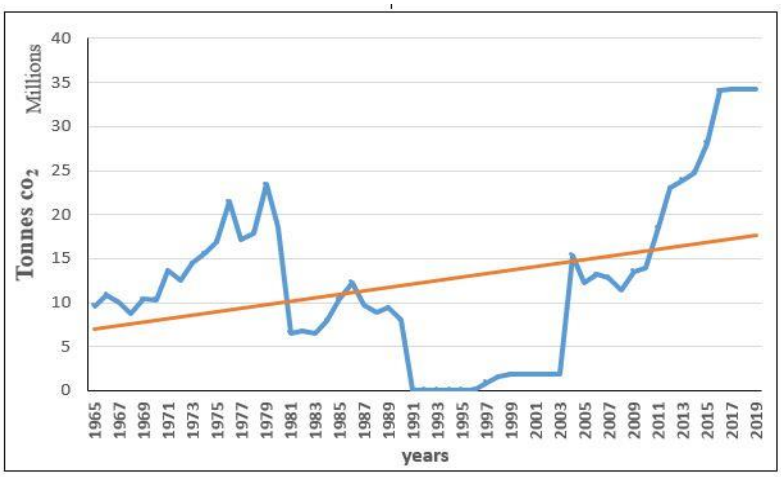

Fig. (6) Annually co_2 emission because of natural gas flaring in Iraq

Figure (7) shows the anomaly of annual CO_2 emitted. We can see four periods in the Time series, two negative and other two positives. This means that the first period from (1965 to 1970) and the third period from (1981 to 2003) are negative sign and they emitted CO_2 below the average, while the second period from (1971 to 1980) and the fourth period from (2004 to 2019) is a positive sign, they emit over annual average, and in the fourth period is very high compared to the length of the series. Among other greenhouse gases that are added to the atmosphere by natural gas, methane resulting from the venting process and released to the atmosphere, which affects greater than 25 times the effect of carbon dioxide**[14]**. Although the life of carbon dioxide lasts for hundreds of years, the time life of methane gas is short and estimated at tens of years.

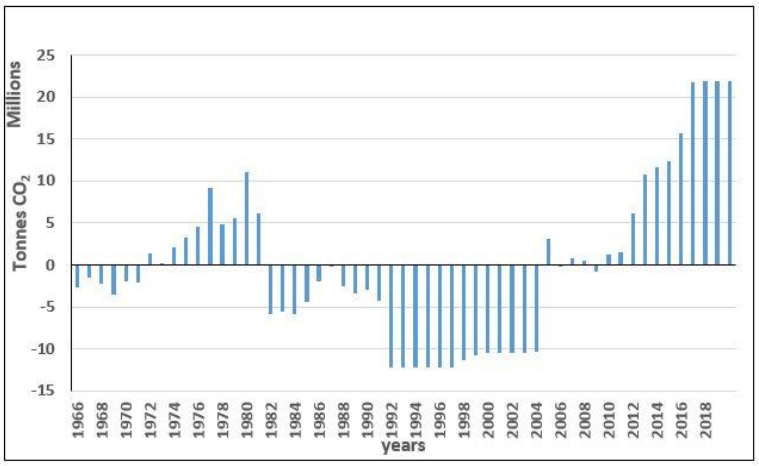

Fig. (7) Anomaly of annual co_2 emission due to gas flaring

Figure (8) shows the annual increase in globally averaged atmospheric Methane, and there are other gases released into the atmosphere as a result of burning natural gas, including hydrogen sulfide and carbon monoxide, and the gas flaring adds to the atmosphere black carbon BC**[25].**

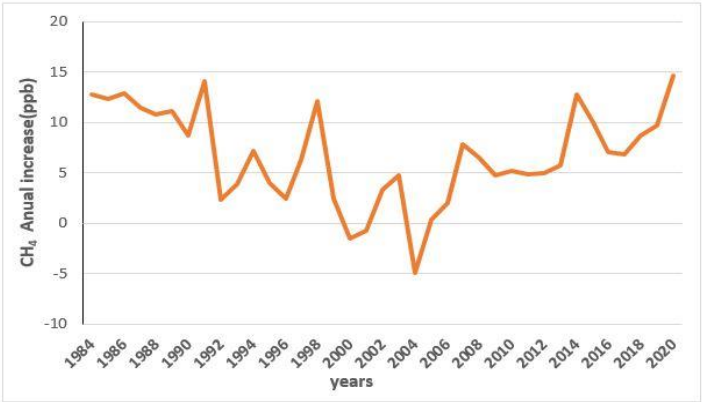

Fig. (8) Annual Increase in Globally Averaged Atmospheric Methane

3. Gas flaring adding Black carbon (BC) to the atmosphere

BC aerosols are the second-largest global warming factor after carbon dioxide.**[11, 13]** Unfortunately, there is no measurement to BC in Basra but everybody in Basra near natural gas flaring can see the black smoke rising in the sky from the tip of a stack. **Figure (9)** shows the rising plume during gas flaring in the northern Rumaila field. The researcher took this photograph on 10/15/2020, its location (30°12'53.3"N 47°23'16.3"E) as a sample of gas flaring in Basra. As we mentioned, Iraq is the second- largest country in the world in gas flaring after Russia, Basra contributes in 70% of that of Iraq, the annual average BC emissions from Russian flaring were 68.3 Gg/year, with 64.1 and 4.2 Gg/year from upstream and downstream flares, respectively. **[26]** We conclude from this, Iraq, and Basra Governorate, emit an enormous amount of BC after Russia to the atmosphere

Picture. (9) Photograph of rising plume during gas flaring in the northern Rumaila field. The Photograph was taken by the researcher

4. Air pollution due to gas flaring

The atmosphere has certain percentage of gases, any change by increasing or decreasing in the composition of these gases is harmful to survival. Air pollutants resulting from NG flaring include CH4, CO2, NOx, CO, H2S, N2O, hydrocarbons, PM, etc. PM from NG flaring mainly takes the form of soot or (BC). **[22]** Natural gas flaring has other harmful emissions, such as sulfur oxides and nitrogen oxides, which form acid rain, produced when these two types of pollutants combine with water in the atmosphere and then falls down on the surface of the Earth. In a study conducted on the acid rain in Basra, the results of the analysis of rain samples revealed a decrease in the pH values of pH below 5.6 for both observations, especially in areas close to Oil production fields in the districts of Al-Zubayr, Madinah, Qurna, Siba district**[27]**, which

can cause many problems in ecosystems and the environment. In addition to harming the environment, as a result of natural gas flaring or venting, polluting the air with toxic gases, including methane, hydrogen sulfide, and other gases, in addition to BC and soot, has a great impact on human and all living organisms and plants. The symptoms of this pollution appeared on the health of Basra residents and workers in the oil sector, who suffer from cancerous diseases, allergies, asthma and other diseases of the respiratory system. **Figure (10)** shows annually increasing in the number of cancer cases in Basra Province, which is directly proportional to the increase in the amount of annual gas flaring in the region. The relationship between gas flaring and cancer was examined by using Pearson correlation coefficient, its value equals (0.91754) showing a very strong and positive relationship.

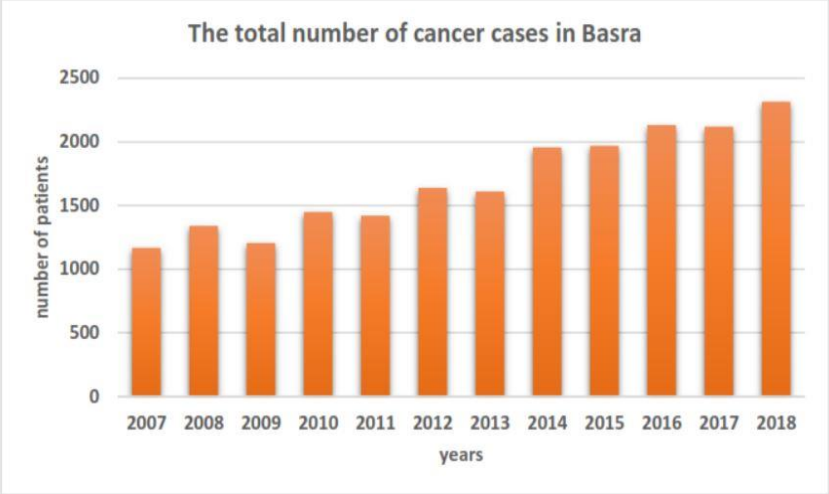

Fig. (10) Annually total number of cancer cases in Basra

The measurement shown in **tables (1 and 2)** and the results presented in many previously published papers indicate that some pollutants in different areas are over the international levels, which is a serious problem to the people and lives **[28]** and has effects on health like (CO, CO2. SO2, NO2). All these chemicals leading to exogenous estrogen (xenoestrogens) that mimic the action of hormones or directly affect pathways of endogenous hormones which in final result produce genotoxic substances.**[29]** Other studies (Global) suggest a link between air pollution and breast cancer.**[30]**

Table (1) monthly and annually average of (co and pm10) concentration in Basra city (air quality station in kour zaber) for the year 2018

month	CO ppm	Pm10 µg/m^3
January	5.620	604.667
February	5.510	547.380
march	7.570	…….
April	7.980	246.413
May	6.890	3205.000
June	8.920	288.163
July	7.660	291.813
august	8.000	547.380
September	7.450	293.677
October	7.720	278.281
November	7.470	252.223
December	……	345.590
Annual rat	7.345	627.326

Table (2) Annual average of pollutant gases and pm10 concentration Measurement in Basra (air quality stations) for the year 2018

Stations of Air quality	SO_2 ppm	NO Ppm	No_2 ppm	NOx ppm	CO ppm	CH_4 ppm	Pm10 µg/m3
Abu Al-Khasib	0.012	0.116	0.023	0.015	0.113	1.834	93.333
Basra Environment Office	0.005	0.250	0.015	0.023	0.110	0.984	

Another study showed annual and seasonal air quality index with AQI values, found high concentrations of pollutants distributed clearly in the study stations, as winter record the greatest values that most concentrations were higher than the global limitations.[31]

5. Economic Effects

Besides the impact of NG flaring on the environment, it has a significant impact on the national economy of the producing state[32]. NG is one of the most important alternative energy sources for oil, and one of Iraq's wealth that has not been optimally used for decades and has not been used to serve the development process and maximize resources well.

Iraq suffers from a severe shortage of gas supplies, which carries the public budget and balance of payments exorbitant costs to import it. Iraqi economic losses related to gas are estimated at approximately 45 billion US dollars, which is equivalent to 196,000 (B/D) crude oil at $70. Gas production and use, recently increased to 29.4 and 13.8 billion cubic meters annually, respectively, which means that gas-burning increased to 15.9 Bcm, which is equivalent to about 260 thousand (B/D), or a loss of about 20 million dollars per day [33]. This extensive amount

of NG flaring resources can help to employ the unemployed and contribute to the growth and prosperity of Iraq's economy.

Conclusion

We have concluded that natural gas flaring in Basra governorate contributes to adding heat to the atmosphere in addition to adding greenhouse gases. The neighboring countries of Basra also contributed by adding heat and greenhouse gases to the atmosphere regionally and globally. This is one reason for the high temperature in recent years in Basra Governorate and the region, which reached its highest levels. Besides harming the environment, polluting the air with toxic gases has a great impact on human health which leads to an increase in disease cases, including cancer, we found a strong statistical relationship between the increase in cancer cases and the increase in natural gas flaring.

Recommendation

In order to avoid this huge waste in the national wealth represented by burning natural gas, we recommend investing it instead of burning, thus we avoid the harmful impact on the environment and the contribution in climate changes. We hope Basra Gas Company (BGC), one of the largest flare reduction projects in the world, executing its plan to invest in natural gas.

"Conflict of Interest: The authors declare that they have no conflicts of interest."

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