Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Assessment of Ambient Air Quality Level at 21 sites in cement sector, Egypt.

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Abstract

The cement industry is prospering in the Middle East countries, especially in Egypt due to the presence of raw materials, as well as increasing population growth in the region and increasing cement demand. Without activating and applying the regulations and laws, which enforced by local government to ensure compliance with national and international standards upon this industry, the increase of cement factories and complementary units in the region may damage air quality and threaten the ecosystems. This paper deals with the monitoring of the ambient pollutants surrounding 21 cement factories during the 2017 year: carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and particulate matter (TSP, PM_{10} and $PM_{2.5}$) emitted from the cement production processing. Air pollutants around the cement plants were determined using appropriate sampling techniques according to international standard methods. Results indicated that particulate matter concentrations were higher than all permissible guidelines for ambient air quality. Carbon monoxide concentrations of all sites were lower than permissible limits, while recorded gases concentrations (NO_2, SO_2, O_3) in some sites were comply with those limits. High concentrations of particulate matter at all sites could be attributed to the applied processes for cement production, such as raw materials mining, transportation, blending, quarrying, preparation, and stockpiles. Moreover, kilns operation, clinker cooling, and milling processes were responsible for gases and particulates emission operations.

Keywords: Cement industry; Raw material; Particulate matter; Air Pollution; Living standards

1. Introduction

Urban areas are recognized to be major sources and sinks for contaminants, due to the presence of high concentrations of pollutant emitting activities (Wiseman et al., 2013; Galal and Shehata 2015). Air pollution is the presence or introduction of a substance into the environment that has harmful or poisonous effects (Jeff and Hans 2004). It affects human health as well as plants and micro-organisms (Ganatsas et al. 2011). Many studies have recorded positive relations between air pollution and certain diseases including shortness of breath, sore throat, chest pain, nausea, asthma, bronchitis, and lung cancer (Dockery and Pope, 1994; U.S. EPA 1999a, b). It seems that humankind will not build their cities soon without the cement industry, since cement is a very important construction material used for infrastructure development, housing, and economic growth (Mishra and Siddiqui, 2014). Cement industry emissions play an important role in air pollution; they consist of gaseous pollutants like nitric oxides, carbon monoxide, sulfur dioxide, hydrocarbons, fine and coarse particulate matter like diesel soot, and airborne particulate-bound trace metals (Albeanu et al., 2004; Laschober et al., 2004). Almost 5-7% of global CO_2 emissions are caused by cement plants, while 900 kg CO_2 is emitted to the atmosphere to produce one ton of cement (Marland et al., 1989). The cement industry offers an excellent opportunity for studying the impact of dust, during the process of cement manufacture considerable amounts of dust are emitted from handling, spillage, and leakages (El-Khatib et al. 2012). Dust is produced from the quarrying of the major raw material limestone and ends with the packing and dispatch of cement from the industry (Abdul-Wahab, 2006; US EPA, 2010). Egypt has increased cement production from 4 million tons in 1975 to 46 million tons in 2009 and now accounts for around 1.5% of global cement production (EEAA 2010). Dust emissions contribute about 6% of the PM_{10} in Greater Cairo reaching as much as 30% in areas nearby the cement plants. New

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Received date 15 November 2021; revised date 11 January 2022; accepted date 24 January 2022
DOI: 10.21608/EJCHEM.2022.106133.4880

regulatory standards, which were released in 2010, are expected to reduce dust emission limits from 300 to 100 mg m^{-3} for existing plants and from 100 to 50 mg/m^3 for new plants. Online monitoring by the Egyptian Environmental Affairs Agency (EEAA) of the 72 main stacks in the 16 cement plants provides real-time information on dust emissions. New plants are 98% compliant and older plants are 92% compliant with the emission limits (EEAA 2010). The cement industry plays an important role in improving living standards in the entire world by creating direct jobs, and hence, it must face many problems due to environmental concerns and sustainability challenges (Mishra and Siddiqui, 2014). Therefore, the current study aims at monitoring the ambient pollutants surrounding 21 cement factories including carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and particulate matter (TSP, $PM_{10,}$ and $PM_{2.5}$) emitted from the cement production processing. This study can help in improving air quality standards around the cement factories.

2-Materials and methods

2.1. Study sites

Ambient air samples were monitored and collected from 21 cement factories that distribute in many Governorates in Egypt (Fig.1). Two cement factories are located in the Egyptian northern region in Alexandria Governorate, four factories in the central area in Greater Cairo, and the other four in the desert area of El-Ain Al-Sokhna in Suez Governorate. Besides, Beni Suef, El-Minya, and Qena Governorates have four, three, and two cement factories, respectively in the desert area at the east bank of the Nile River; while in the desert area at the west bank of the Nile River in Assiut Governorate, there are two factories (Table 1, Fig 1). All the cement factories have greenbelts around their fences; also all used dry methods in operation except the National Cement Company that applied both dry and wet methods. Much information about the studied cement factories is shown in Table 1 and 2.

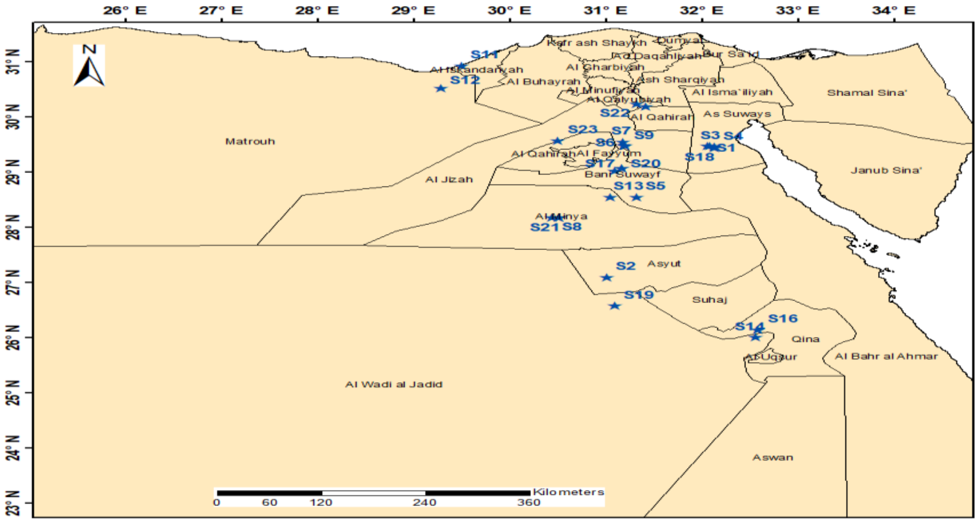

Fig.1. The location map shows the sites of the studied cement factories in Egypt.

Table1. Company name, Governorate name, coordinates, and location type of the sampling cement factories studied in Egypt.

Site no.	Company name	Governorate	Coordinates		Location type
			Latitude (N)	Longitude (E)	
1	Lafarge Cement Company	Suez	29° 48′12"	32° 05′ 19"	Desert
2	Assuit Cement Company	Assiut	27° 10′ 08"	31° 00′ 51"	Desert
3	Arabian Cement Company	Suez	29° 47′ 47"	32° 08′ 54"	Desert
4	Suez Cement Company	Suez	29° 46′ 16"	32° 12′ 43"	Desert
5	Kattameya Cement Company	Cairo	28° 55′ 09"	31° 31′ 53"	Desert
6	Helwan Cement	Cairo	29° 49′ 17"	31° 18′ 36"	Residential & agricultural

	Company				
7	Tourah Cement Company	Cairo	29° 55′ 28"	31° 18′ 06"	Residential & Desert
8	Elminya Cement Company	Minya	28° 18′ 04"	30° 44′ 49"	Desert
9	National Cement Company	Cairo	29° 47′ 21"	31° 19′ 55"	Residential & Desert
10	Beni suef cement Company	Beni Suef	29° 02′ 52"	31° 09′ 57"	Desert
11	Alexandria cement Company	Alexandria	31° 08′ 34"	29° 50′ 22"	Residential
12	Amreyah Cement Company	Alexandria	30° 52′ 47"	29° 28′ 01"	Agricultural & Desert
13	Misr Beni Suef Cement Co	Beni Suef	28° 55′ 12"	31° 04′ 38"	Desert
14	Asec portland cement (Qena)	Qena	26° 01′ 35"	32° 56′ 22"	Desert
15	ASEC Elminya Cement Co	Minya	28° 17′ 56"	30° 51′ 32"	Desert
16	El Nahda Cement Company	Qena	26° 15′ 06"	32° 58′ 06"	Desert
17	Wadi El Nile Cement Co	Beni Suef	29° 07′ 37"	31° 17′ 03"	Desert
18	El Sewedy Cement Company	Suez	29° 44′ 56"	32° 12′ 43"	Desert
19	Bemic Company	Assiut	26° 58′ 05"	31° 09′ 10"	Desert
20	South Valley Cement Co	Beni suef	29° 07′ 33′	31° 16′ 07"	Desert
21	Royal Cement Co	Elminya	28° 17′ 39"	30° 51′ 22"	Desert

Table 2. Production lines no, Establish and operation date, production rate, fuel type of the sampling cement factories studied in Egypt.

Site no.	Lines no	Establishment Date	Operation Date	Production m t/year	Fuel type
1	5	1998	2000	6.00	Alt & Coal
2	3	1990	1995	5.00	Alt & Coal
3	2	1997	2006	4.26	Alt & Coal
4	2	1974	1976	3.00	Alt & Coal
5	1	1976	1978	1.40	Alt & Coal
6	2	1929	1929	3.50	Coal
7	2	1927	1927	3.00	Coal
8	1	1992	1995	1.50	Mazoite
9	3	1956	1958	3.90	Natural gas
10	2	1993-2001	1995 -2010	2.87	Coal
11	1	1948 -2001	1949 -2002	1.67	Alt & Coal
12	2	1995	2000	3.10	Alt & Coal
13	2	1996 - 2008	1998-2011	2.80	Coal
14	1	2000	2001	1.50	Coal
15	1	2008	2013	2.10	Mazoite
16	1	2009	2012	2.10	Mazoite
17	1	2009	2011	2.20	Coal
18	1	2008	2011	1.80	Coal
19	1	2007	2011	1.65	Mazoite & Coal
20	1	2009	2011	2.20	Coal
21	1	2006	2010	1.60	Mazoite

Alt= Alternative fuel e.g., trash and agricultural waste

2.2. Ambient air monitoring

Ambient air monitoring was conducted from January to December 2017 in 21 cement factories. The monitoring of air pollutants includes total suspended particulate matter (TSP), particulate matter < 10 microns (PM_{10}), particulate matter < 2.5 microns ($PM_{2.5}$), CO, SO_2, NO_2, and O_3 were carried out simultaneously over the year 2017 using the overbuilding stations. TSP was sampled by using a high-volume air sampler with fiberglass filters and a flow rate of 1.5 m^3/min according to US EPA-IO 3.1 and IO 2.1 Standard method (MEP, 1995). Throughout the year, the high-volume sampler operates 24 hours for one day and then stops for two days in a row. Optical automatic analyzers were used for monitoring particulate matters ($PM_{10,}$ $PM_{2.5}$) continuously over the year according to the U.S.A EPA Reference method EQPM-1102-150. Moreover, the concentration of the gaseous air pollutants (CO, SO_2, $NO_{2,}$ and O_3) were measured continuously by automatic monitors fixed in stationary stations. The monitoring was carried out according to the EPA methods (Appendix J-Reference method FR, US-EPA Reference method – RFCA-0981-54, EQSA-0486-60, RFNA-1289-74 and EQQA-0880-47, respectively) (APHA, 1994).

Data analysis

After testing the data normality, a one-way analysis of variance (ANOVA) was applied to assess the significance of variations of ambient air pollutants among the 21 sites using SPSS software (SPSS, 2012). To test the significance of the difference between replicas of the ambient pollutants, repeated measures ANOVA test was used, assuming that the dependent variables are normally distributed, the variance of all difference scores among the dependent variables is equal and the observations are independent. So, the repeated measures ANOVA test was used for this purpose. Finally, there is no significant difference between the replicas of all pollutants as the significance values are less than 0.05.

3- Results

Ambient air pollutants

The ambient air pollutants were monitored during the study period in 21 sites of cement factories. Table 3 shows that kattameya Cement Company (Site 5) has the lowest recorded concentration for particulate matter (TSP, PM_{10}, and $PM_{2.5}$) with a non-significant difference at $P < 0.05$. The highest values for TSP and PM_{10} were recorded at Misr Beni Suef Cement Company (Site 13) were non-significant differences from each other at p < 0.05. Moreover, South Valley Cement Company (Site 20) has the highest values recorded for $PM_{2.5}$. The lowest values of NO_2, SO_2, and O_3 were recorded in Wadi El Nile Cement Company (Site 17), while the lowest CO content was recorded in Asec Portland Cement Company (Site 14). Moreover, the highest concentrations of all pollutant gases recorded in National Cement Company (Site 9) (Greater Cairo Governorate) were not significantly different at $P < 0.05$.

The recorded average concentrations of total suspended particulate (TSP) ranged between 542 to 1446 µg/m^3 for Kattameya Cement Company (Site 5) and Misr Beni Suef cement company (Site 13), respectively, were not significantly different at $P < 0.05$ (Table 3). The recorded annual concentration for particulate matter (PM_{10}) varied from 479 in Kattameya Cement Company (Site 5) to 1273 µg/m^3 in Misr Beni Suef Cement Company (Site 13). Besides, the concentrations of particulate matter ($PM_{2.5}$) ranged from ٣٠١ in site ٥ to ١٠٠٧ µg/m^3 in South Valley Cement Company (Site 13), (Beni Suef Governorate).

The average annual concentrations of nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) ranged between 44.8 and 6.8 µg/m^3 in Wadi El Nile Cement Company (Site 13) to 155.3 and 45.7 µg/m^3 in National Cement Company (Site 9), respectively. While the concentration of carbon monoxide (CO) ranged from 0.27 in Asec portland cement (Site 14) to 1.23 mg/m^3 in National Cement Company (Site 9) and ozone has a different concentration, which varied between 79.47 µg/m^3 in Wadi El Nile Cement Company (Site 17) to 178.67 µg/m^3 in National Cement Company (Site 9). Finally, there were no significant differences between all pollutants replicas at $p \leq 0.05$ (Table 3).

Table 3. Particulate matter (TSP, PM_{10}, and $PM_{2.5}$) in ambient air (mean ± std) during the 2017 year at 21 cement factories. Maximum and minimum values are underlined in bold.

Site no.	TSP µg/m^3	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3
1	880.00±2.00	725.00±1.00	613.67±2.08
2	765.00±1.00	630.00±2.00	423.00±2.65
3	655.33±1.53	539.676±0.58	385.33±1.53
4	1436.00±1.00	1155.67±2.08	752.00±1.00

5	**542.33±2.08**	**479.33±1.15**	**300.67±0.58**
6	678.67±0.58	549.67±2.08	471.67±1.53
7	895.00±2.00	710.33±1.53	565.67±1.53
8	1268.33±1.15	1050.67±2.08	655.00±1.00
9	1375.00±1.00	1125.67±2.08	872.33±1.53
10	890.00±2.00	739.33±2.08	616.33±1.53
11	713.33±1.53	589.33±1.53	455.33±2.08
12	974.33±3.79	814.67±2.08	676.33±1.53
13	**1457.33±1.53**	**1273.33±1.53**	956.00±2.65
14	555.00±2.65	479.67±2.52	411.33±1.53
15	956.67±1.53	790.33±1.53	643.67±2.08
16	735.67±2.08	640.67±0.58	581.00±2.65
17	1167.67±1.53	1083.00±2.65	876.33±1.53
18	650.00±2.65	515.00±2.65	452.67±3.06
19	1371.33±1.53	1201.67±1.53	983.33±1.53
20	1446.33±2.08	1216.33±1.53	**1006.67±1.53**

4- Discussion:

Air quality standards, regulations, and laws are the pollutants concentrations during a certain period that are considered to be accepted as a basis for protecting human health from adverse effects of air pollutants (WHO, 2000; Charles et al., 2005). Table 6 represents the air quality guidelines as suggested by different national and international scientific agencies (Egyptian law #4/1994, CPCB, WHO, World Bank, US EPA, BNAAQS, NAAQ, and Pakistan Standard). Accordingly, the annual average concentrations of total suspended particulate (TSP) in Table (3) are exceeding the threshold limit values of national and international laws. However, the recorded concentrations comply with the corresponding concentrations found by Zhang et al. (2014), who reported that TSP annual concentrations in Urumqi, China, fluctuated between 300 and 700 µg/m^3 from 1986 to 2012, with a maximum of 716 µg/m^3 in 1990 and a minimum of 260 µg/m^3 in 2005.

TSP levels in different Egyptian industrial locations were measured on an annual basis and recorded by several studies. For example, TSP concentration was 394 µg/m^3 in the Helwan area (El-Mekawy, 2007), and 348.5 µg/m^3 in Sadat city (Ezzo, 2005), and 695.7 µg/m^3 in Shoubra El-Kheima area (Shakour et al. 2001). TSP concentration was found to be 470.9 µg/m^3 at the upwind urban direction of Shaq El-Teeban industrial zone at Cairo, compared to 1220.1 µg/m^3 at Shaq El-Teeban downwind direction (Abd el-maksoud, 2011). The analysis of all recorded data in various regions in Egypt revealed that practically all TSP monitoring concentrations surpassed national and international limits, and the same was true in the current study. In the present study, the annual concentration of particulate matter <10 microns (PM_{10}) ranged from 479 µg/m^3 to 1273 µg/m^3 and exceeded the permissible limits of Egyptian and international guidelines. Concentration levels of particulate matter < 2.5 microns ($PM_{2.5}$) for all sites were also higher than the maximum allowed levels set by Egyptian law and global guidelines.

2. Cement is produced usually by many industrial processes (i.e. wet, semi-wet, or dry method) which play important role in pollutants emissions. In Egypt, all the cement factories apply the dry method, except one factory applies both dry and wet methods, and consequently, high emissions concentrations of SO_2, CO, NO_2, O_3 are expected. Different cement factories in Egypt turned, during the past decades, to apply stacks treatment units and other facilities (electrostatic filter, bag house filter, and cyclones) to reduce pollutants emissions. By using the previous control technologies in the cement industry by many other countries, and emission was found to be reduced and low pollutants concentrations were recorded. Concerning monitoring particulate matter (PM_{10}, $PM_{2.5}$), other studies were conducted by WHO (2014) and TERI (2015) and reported the annual average concentration of PM_{10} and $PM_{2.5}$ in different regions of the world from 2008 to 2012: for instance Brazil (17 and 9 µg/m^3), Mexico (93 and zero µg/m^3), USA (6 and 2 µg/m^3), Pakistan

(540 and 117 μg/m^3), and India (329 and 153 μg/m^3. Besides, WHO (2014) reported that the highest income countries recorded the lowest PM_{10}, $PM_{2.5}$ values, and the lowest income countries recorded the highest PM_{10}, $PM_{2.5}$ concentrations. Consequently, the recorded concentrations of PM_{10}, $PM_{2.5}$ pollutants in the present study are strong evidence for this fact.

Many international studies were carried out to examine the air pollutions state level. For example, Colbeck et al. (2010) reported that the average concentrations of annual particulate matter (PM_{10}) in various cities of Asian countries during 2004 were 30, 31, 60, 60.25, 80, 90.25, 120.66, 129, 131, and 204.5 μg/m^3, in Japan, Singapore, Thailand, South Korea, Sri Lanka, China, India, Nepal, Bangladesh, and Pakistan, respectively. The above results are different from the concentrations recorded in the present study, but still, the developed countries with the highest income have low concentrations of all pollutants and the other countries with low income have the highest concentrations of pollutants.

Hindy and Abdel Maksoud (2016), in their study at different areas in Egypt, reported similar concentrations of PM_{10} and $PM_{2.5}$ to that recorded in the present study. The recorded annual concentrations of PM_{10} and $PM_{2.5}$ at the semi-residential areas in Dhaka, Bangladesh from 1996 to 2015, were 96.85 μg/m^3 for PM_{10} and 35.88 μg/m^3 for $PM_{2.5}$ (Hopke and Begum, 2018). These levels were complying with the global guidelines and disagree with the results of the present study. In contrast, more than 80% of the Indian cities were reported to have an increased PM_{10} over the permissible limit of 60 μg/m^3 in 2012 (CPCB, 2014).

The three types of particulate matter emitted from the cement industry's processes, such as quarrying, transportation of raw materials, blending, preparation, mixing, burning of fossil fuels, and leaks during the process had high concentrations of particulate matter, which had many harmful effects on human health (Abril et al., 2016). According to previous studies, high concentrations of particulate matter increase the risk of lung cancer, respiratory illnesses, and arteriosclerosis, according to (Alves et al., 2000). Aerosol particles also have an impact on the environment in areas including visibility and building staining (de Kok et al., 2006; Sun et al., 2004; Virtanen et al., 2006).

Ghauri et al. (2007) reported concentrations of 406.67, 206.17, 57, 49.67, 4.67, and 43 μg/m^3 in six cities, Pakistan, during four seasons in 2004 for TSP, PM_{10}, SO_2, NO_2, CO, and O_3; respectively. All of the data collected in this study did not comply with all global and national requirements and was similar to the recorded data in the present study. In another study, Zhang et al. (2016) reported that the actions were taken by China to decrease the use of fossil fuels predominating reducing emissions of GHG and air pollutants. Monitoring of total $PM_{2.5}$ emission in china in 2010 was 12 Mt/year with different spatial distribution over the cities while sharing in cement industry amounted to 14% of the total emissions. At the same time recorded annual average was 78 μg/m^3 for $PM_{2.5}$ with complying with all guidelines and dissimilar to the present study.

The annual concentrations recorded of nitrogen oxide (NO_2) varied between 44.8 to 155.33 μg/m^3 and above the limits set by law guidelines. These concentrations were different from those recorded by Dash and Dash (2015) and Mishra et al. (2019). NO_2 is released to the atmosphere from human-made sources through the cement production process (e.g. burning of fossil fuels, trucks movement, and mining) and many studies recorded the impacts of nitrogen oxides (NO_x) on human health (e.g. Chen et al., 2007).

Annual recorded concentrations of sulfur dioxide (SO_2) ranged from 6.81 μg/m^3 to 45.72 μg/m^3. All the recorded values in the 21 sites of cement companies were less than the maximum permissible limits of the standards recorded in Table 6 except the average for the two sites. The recorded data of SO_2 in the present study are similar to many other studies (e.g., Dash and Dash, 2015; Chaurasia and Tiwari, 2016; Hindy and Abdel Maksoud, 2016; Maji and Sarkar, 2020), but dissimilar to that reported by Abdel Hameed et al. (2012).

Sulfur dioxide is emitted mainly from man-made sources such as the combustion of fossil fuels (e.g., coal, oil, and natural gas) (Alves et al., 2000 and de Kok et al., 2006). A high concentration of SO_2 in the atmosphere can cause passing breathing difficulty for humans with asthma. Longer-term exposures to a high concentration of SO_2, in addition to particulate matter, cause respiratory illness and aggravate existing heart disease (Nguyen et al., 2006). The presence of high concentrations of SO_2 and NO_2 in the air is considered the main contributor to acidification (Virtanen et al., 2006). Also, Nguyen et al., 2006) recorded that acid rain has high impacts on forests and crops, as well as could change soil components. Abdel Hameed et al. 2012 reported that annual concentrations of NO_2 and SO_2 in the Helwan area, Egypt are 83.7 and 67.0 μg/m^3, respectively. The observed trend in the present study is similar to that of previous studies conducted in Egypt (e.g., Ali and Nassralla, 1990; Khoder, 1997; Ezzo, 2005; Hassan, 2000, 2006a; El-Mekawy, 2007) and in other countries (Rossli et al., 2001; Salvador et al., 2004; Sharma et al., 2005; Basha et al., 2007).

The recorded concentrations of carbon monoxide (CO) varied from 0.27 to1.23 mg/m^3 and comply with Huang et al. (2018) and other studies in the world. Carbon monoxide has no limits in the local and international standards. CO is a poisonous gas emitted during the incomplete burning of carbonaceous raw material. Fang et al. (2006) recorded that the moment that absorbed CO diffuse to plasma, binds to hemoglobin (Hb) forming carboxyhemoglobin (COHb).In this case, Hb is unable to combine with oxygen. Annual monitoring of ozone in 21 sites of cement companies recorded concentrations that ranged from 79.47 µg/m^3 to178.67 µg/m^3. In contrast, concentrations recorded in 15 sites were exceeded the permissible limits of CPCB (100 µg/m^3). The concentration trend of ozone in the present study is similar to that reported by Huang et al. (2018) but disagrees with the study conducted by Maji and Sarkar (2020) who recorded low concentrations of ozone. Many studies reported that NO_x and volatile organic compounds react in the atmosphere in the presence of sunlight to form ozone (Muir et al., 2006; Bono et al., 2007). This ground-level concentration of ozone, when breathed, causes respiratory disease and other health problems (EPA, 2014).

Exhaust emissions can be controlled by the type of fuel used such as natural gas, coal, pet coke, Mazoite, diesel, or any other alternative fuel. The use of natural gas may be used as suitable fuel with a low pollutant emission factor and using alternative fuel may increase pollutant emission (Khoo et al., 2006). Cement plants turned into using coal as fuel combustion and alternative fuel in burning the raw material during the cement processing in the last four years. According to Ibrahiem (2015), Egypt is facing a major difficulty in achieving industrial development, which is a limited energy resource. As a result, the government is considering the use of another source of energy, such as coal. Even though coal is a major source of air pollution, Egypt is plagued by industrial pollution. By calculating the resulting emissions of SO_x, NO_x, PM_{10}, and $PM_{2.5}$ from the use of different combustion fossil fuels (coal vs. diesel and natural gas) in three energy-intensive industries and industrial pollution emissions in Egypt during 2013. The study found that utilizing coal as a combustion fuel increased SO_x, PM_{10}, and $PM_{2.5}$ emissions in all three sectors, but using diesel and natural gas increased NO_x pollution. Coal produced the most pollutants and was ranked first, followed by diesel, which was ranked second, while natural gas produced the least amount of pollution. According to the above information, using coal as a combustion fuel is the main source of excessive pollutant concentrations in the current study.

The cement industry is not the only major cause of air pollution; power plants are also a major source of pollution due to the vast amount of utilized fuel. Many pollutants, such as TSP, PM_{10}, SO_2, and NO_2, were measured from the ISCC power plant in the Kuraymat area of Egypt from April 2009 to March 2012. (Hindy and Abdel Maksoud, 2016). Annual concentrations of TSP, PM_{10}, NO_2, and SO_2 were found to be (680.4, 546.7, and 466.2 µg/m^3), (318.3, 239.2 and 175.6 µg/m^3),(14.2, 17.9, and 19.0 µg/m^3) and (8.1, 10.3, and 8.8 µg/m^3) respectively. The average concentrations of TSP and PM_{10} during three years were extremely high when compared to all national and international guidelines. Nevertheless, SO_2 and NO_2 concentrations were within the acceptable limits, and all other pollutants values were comparable to those found in the current study.

Many developing countries, in particular, pay great attention to the monitoring process of pollutants in the ambient air. For example, a Chinese study conducted in 74 cities from 2013 to 2017 for six pollutants PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, and O_3, (Huang et al., 2018). The authors reported annual concentrations of 118.4,105.3, 92.6, 84.9 and 83.3 µg/m^3 for PM_{10}, 72.2, 63·6, 55.2, 49.7, 47.0 µg/m^3 for $PM_{2.5}$, 43.9, 41.4, 39.1, 39.2, 39.2 µg/m^3 for NO_2, 39.9, 32.1, 25.0, 20.9, 17.0 µg/m^3 for SO_2, CO concentrations are 2.5, 2.0, 2.1, 2.1 1.9, 1.7 mg/m^3, and O_3 concentrations are 139.2 , 145.4, 150.6, 154.0, 162.9 µg/m^3 over the years of the study. Except for O_3, annual average concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO decreased throughout the 5 years. Comparing the results of the Chinese study with the current investigation in Egypt, showed that the two studies have a similar trend of gaseous pollutants concentrations, but particulate matter levels were higher in the Egyptian study than in the Chinese study.

Concentrations levels of ambient air pollution in cement sector areas were found to vary depending on several factors such as site activity (cement industry), geographical location (desert, residential, and agriculture) (Schuhmacher, et al., 2004). Chaurasia and Tiwari **(**2016**)** reported that the annual average concentration of PM_{10}, $PM_{2.5}$, SO_2, and NO_x in three cement plants in India during 2013 were 93.77, 58.33, 14.44, and 25.44 µg/m^3, respectively. All the concentrations of pollutants were lower than NAAQ standard limits and pollutants concentration recorded in the present study.

One of the most critical impacts of cement manufacturing is the generated dust during milling, packing, storage, transport, etc. Atmospheric dust is an important source of air pollution particularly in dry climates (Chaurasia et al., 2013). Besides, Barman and Bhargava et al. (2008) and Chaurasia et al. (2013) reported that 1 kg of cement manufactured in Egypt generates about 0.07 kg of dust in the atmosphere. In another study conducted around cement factories at four different locations in India during 2016 and 2017, the annual average concentrations were 94.35, 36.6, 3.96, and 30.33µg/m^3 for PM_{10}, $PM_{2.5}$, SO_2, and NO_x, respectively (Mishra et al., 2019) which differ from the present study recorded data.

Over four years (2015–2018), Maji and Sarkar's (2020) found that the annual average of $PM_{2.5}$ concentrations across 1600 monitoring stations in China reduced from 50.9 to 41.8 µg/m^3. In addition, O_3 levels increased from 72.4 to 80.9 µg/m^3. While the concentration of NO_2 did not change considerably from 32.1 to 30.6 µg/m^3. Sulfur dioxide (SO_2) levels in the atmosphere dropped from 24.5 to 13.0 µg/m^3. All previous data from all monitoring sites were drastically different from the current study, and pollutant concentrations were lower than national and global guidelines.

5- Conclusions and Recommendations:

The overall goal of this study was to determine the impact of the cement industry on the quality of the ambient air. This study presents baseline knowledge about the particulate matter and gaseous pollutants emitted from the cement industrial sector in Egypt. This study indicated that the annual mean particulate matter concentrations were substantially greater than the permissible limits of air quality guidelines, while annual mean concentrations of other gaseous pollutants were lower than the permissible limits of air quality guidelines. In conclusion, we recommend for the cement manufacturers in Egypt to reduce adverse emissions from this sector to 1- use clean energy source for operation processes, 2- use ideal combustion techniques technologies, 3- apply interlocking mechanisms to all process and pollution control units, and 4- continuously monitor the pollutants emissions.

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