Chapter

Introductory Chapter: Cement Industry

Abeer M. El-Sayed, Abeer A. Faheim, Aida A. Salman and Hosam M. Saleh

Cement is a capital-intensive, energy-consuming and critical sector for the construction of nation-wide infrastructure. The international cement industry, while constituting a limited share of the world's output has been rising at an increasing pace compared to the local demand in recent years. Attempts to protect the environment in developing countries, particularly Europe have forced cement manufacturing plants to migrate to countries with less strict environmental regulations. Along with consistently rising real prices, this has provided a trend for economic performance and environmental enforcement [1].

It is worth noting that cement is known to be one of the most important construction materials in the world. It is primarily used in the manufacture of concrete. Concrete is a combination of inert mineral aggregates such as sand, gravel, crushed stones and cement. Consumption and production of cement are directly connected to the building sector and thus to the general economic activity. Cement is one of the most developed goods in the world, due to its importance as a building material and the geographical availability of the main raw materials, i.e. limestone, cement is manufactured in almost all countries. The widespread development is also due to the comparatively low price and high density of cement, which, due to the relatively high costs, decreases ground transport. Export trade (excluding border-based plants) is typically limited relative to global production.

Cement-based materials, such as concrete and mortars, are used in very significant amounts. For example, concrete production amounted to more than 10 billion tonnes in 2009. Cement plays an important role in terms of economic and social importance as it is necessary to develop and enhance infrastructure. This sector, on the other hand, is also a strong polluter. Cement processing emits 5–6% of the carbon dioxide emitted by human activity, accounting for around 4% of global warming. It may emit vast quantities of chronic chemical contaminants, such as dioxins and heavy metals and particulate matter. Energy use is also important. Cement production accounts for about 0.6% of all electricity generated in the United States. In the other hand, the chemistry driving the manufacture of cement and its applications can be very beneficial in solving these environmental concerns.

Cement manufacturing is an extremely energy-intensive method of processing. The energy consumption is measured at around 2% of global primary energy consumption, or approximately 5% of total manufacturing energy consumption [2], regarding to the prevalent use of carbon-intensive fuels, e.g. coal, in the manufacture of clinkers. In addition to energy consumption, the clinker process also releases CO_2 as a result of the calcination process. Ecofys Energy and Climate and Berkeley National Laboratory therefore carried out an appraisal for the IEA Greenhouse Gas R&D Program on the role of the cement industry in the development of CO_2 and the options for lowering carbon dioxide emissions. This discuss the historical development and global distribution of cement production [3].

Moreover, the cement industry needs raw materials, fuel and chemical additives, and these activities generate emissions which have a negative effect on the quality of the atmosphere. The gas emissions emitted are CO_2, CH_4, NOx, SOx, N_2O and particulate matter.

These emissions have an effect on the rise in global warming and the decrease in atmospheric air quality, which has an impact on human health and the atmosphere [4].

However, cement is the second primary source of anthropogenic pollution, source for about 7% of global CO_2 emissions. The technology for carbon dioxide capture and storage (CCS) is considered by the International Energy Agency (IEA) to be a crucial technology capable of lowering CO_2 emissions in the cement sector by 56% by 2050. CO_2 capture technologies for the cement production process and analyses economic and financial problems relevant to carbon dioxide capture in the cement production has an important trend for study [5].

The overall CO_2 emissions from cement manufacturing, including process and energy-related emissions has a significant interest. Actually, much of the relevant evidence only covers process pollution. CO_2 pollution control solutions for the cement industry are also discussed. In 1994, the projected gross carbon emissions from cement manufacturing is 307 million metric tonnes of carbon (MtC), 160 MtC from process carbon emissions and 147 MtC from electricity usage. Overall, the top 10 cement-producing countries accounted for 63% of the total carbon emissions from cement manufacturing in 1994. The estimated strength of carbon dioxide emissions from global cement output is 222 kg of C/t of cement. Emissions reduction solutions include enhancing energy quality, new methods, transitioning to low-carbon oil, using waste oils, the use of additives in cement processing, and gradually eliminating substitute cements and CO_2 from flue gas in clinker kilns [6].

Contamination of the atmosphere in the area of cement factories, e.g. some cement emissions around it, it may be claimed that CaO percentages were found to be higher (37.7%) particularly in surface soil samples taken near the cement factory. Based on the geo-accumulation index, soils in the study area could be graded as moderately to highly contaminate with (As, Cd, Pb and Ni) and highly contaminated with Cr, whereas soils in the study region were moderately polluted with Zn. On the other hand, the soils of the sample region are considerably polluted with As, Cd and Cu ($5 > EF > 20$) on the basis of the Enrichment Factor (EF). The most hazardous areas are clustered within 0 to 2 km of the cement plant [7].

As the health history of factory employees and certain inhabitants of nearby areas indicates a high incidence of respiratory and skin infections. Regulation of the regulations on pollution enforcement and the establishment of a buffer zone around the cement factory can protect the atmosphere and public health [8].

Egypt increased cement production from 4 million tonnes in 1975 to 46 million tonnes in 2009 and now accounts for about 1.5 percent of global cement supply. Dust emissions account for around 6% of PM10 in Greater Cairo, hitting as much as 30% in areas near cement plants. New regulatory requirements, due to be approved in 2010, would-the emissions of dust from 300 to 100 mg/m^3 for existing plants and from 100 to 50 mg/m^3 for new plants. Online tracking of the 72 main stacks in the 16 cement plants by the Egyptian Environmental Affairs Agency (EEAA) offers real-time details on the emissions of carbon. New plants are 98% compliant and older plants are 92% compliant with pollution standards. No manual monitoring of SO_X and NO_X pollution is performed. Cleaner development and pollution control prospects for the cement sector include: i) the use of alternative fuels in cement kilns; ii) the reduction of NO_X; iii) the removal of dust emissions; iv) the use of silica waste to manufacture new cement products; v) the reuse of bypass dust; and vi) the disposal of radioactive waste [9].

As far as processing is concerned, there are many alternate products that can be used to mitigate carbon dioxide emissions and limit energy consumption, such as calcium sulfoaluminate and b-Ca_2SiO_4-rich cements. The use of residues from other manufacturing industries will also increase the sustainability of the cement industry. Under suitable conditions, waste materials such as tires, fuels, urban solid waste and solvents can be used as additional fuel in cement plants. Concrete can be used to encapsulate discarded products such as rubber, plastics and glasses. In this manner, certain aspects of the cement industry related to environmental science are explored. Other problems, such as economic considerations, the chemistry of cement manufacturing and its properties, are also addressed. Special attention is paid to the role that cement chemistry can play in terms of sustainability. The most important elements, such as the use of substitute products, are outlined; fresh opportunities as well as the recycling of products. It is also argued that the role of research and development required to boost the sustainability of cement is a significant feature [10].

Author details

Abeer M. El-Sayed[1], Abeer A. Faheim[1], Aida A. Salman[1] and Hosam M. Saleh[2*]

1 Chemistry Department, Faculty of Science, Al Azhar University, Egypt

2 Radioisotope Department, Nuclear Research Center, Atomic Energy Authority, Giza, Egypt

*Address all correspondence to: hosam.saleh@eaea.org.eg; hosamsaleh70@yahoo.com

References

[1] T. Selim and A. Salem, "Global cement industry: Competitive and institutional dimensions," 2010.

[2] N. Martin, M. D. Levine, L. Price, and E. Worrell, "Efficient use of energy utilizing high technology: An assessment of energy use in industry and buildings," *London World Energy Counc.*, 1995.

[3] C. A. Hendriks, E. Worrell, D. De Jager, K. Blok, and P. Riemer, "Emission reduction of greenhouse gases from the cement industry," in *Proceedings of the fourth international conference on greenhouse gas control technologies*, 1998, pp. 939-944.

[4] C. Chen, G. Habert, Y. Bouzidi, and A. Jullien, "Environmental impact of cement production: detail of the different processes and cement plant variability evaluation," *J. Clean. Prod.*, vol. 18, no. 5, pp. 478-485, 2010.

[5] J. Li, P. Tharakan, D. Macdonald, and X. Liang, "Technological, economic and financial prospects of carbon dioxide capture in the cement industry," *Energy Policy*, vol. 61, pp. 1377-1387, 2013.

[6] E. Worrell, L. Price, N. Martin, C. Hendriks, and L. O. Meida, "Carbon dioxide emissions from the global cement industry," *Annu. Rev. energy Environ.*, vol. 26, no. 1, pp. 303-329, 2001.

[7] A. M. Al-Omran, S. E. El-Maghraby, E. A. Nadeem, A. M. El-Eter, and S. M. I. Al-Qahtani, "Impact of cement dust on some soil properties around the cement factory in Al-Hasa Oasis, Saudi Arabia," *Am. J Agric Env. Sci*, vol. 11, no. 6, pp. 840-846, 2011.

[8] O. Oguntoke, A. E. Awanu, and H. J. Annegarn, "Impact of cement factory operations on air quality and human health in Ewekoro Local Government Area, South-Western Nigeria," *Int. J. Environ. Stud.*, vol. 69, no. 6, pp. 934-945, 2012.

[9] Y. Askar, P. Jago, M. M. Mourad, and D. Huisingh, "The cement industry in Egypt: Challenges and innovative cleaner production solutions," in *Knowledge Collaboration & Learning for Sustainable Innovation: 14th European Roundtable on Sustainable Consumption and Production (ERSCP) conference and the 6th Environmental Management for Sustainable Universities (EMSU) conference, Delft, The Netherland*, 2010.

[10] F. A. Rodrigues and I. Joekes, "Cement industry: sustainability, challenges and perspectives," *Environ. Chem. Lett.*, vol. 9, no. 2, pp. 151-166, 2011.