ASPECTS CONCERNING THE REQUIREMENTS OF ENVIRONMENTAL IMPACT IN CEMENT INDUSTRY FROM ROMANIA

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ABSTRACT: The environmental protection activity in the cement industry is complex, both in terms of the numerous compliance obligations that it needs to fulfill, as well as due to the fact that the Romanian industry has an important gap to make up from a technological perspective, in relation to the more developed countries from Western Europe. The fact that the cement industry from Romania has a tradition of over 100 years, and over the last 20 year it has fully benefited from the new manufacturing technologies brought by the largest multinational groups operating on the European and international market has helped in the rapid recovery of a important part of this gap. The first two chapters of this article briefly analyze the main activities of the cement production flow and how these impact the environment. Further in the paper, the most important legal requirements in the field of environmental protection, applicable to the Romanian cement industry, are analyzed and the main solutions and good practices that can help the cement plants to comply with these requirements are presented. In the end of the paper we set of conclusions, followed by proposals for future research directions.

KEY WORDS: Environmental impact, Cement Sustainability, Industrial emissions, CO_2 Capture, nonconventional technologies.

1. INTRODUCTION

Cement is an inorganic (mineral) binder, found in the form of very fine powder, and when it comes into contact with water, the mixture thus formed goes into a solid, compact state that maintains its strength and stability over time, even under water. This binder is widely used in the construction field, worldwide, especially in the preparation of concretes, mortars and screeds. The increased cement consumption recorded over the recent years, however, implies increasing challenges for the conservation of the raw materials and energy resources, as well as the reduction of greenhouse gas emissions [1].

Worldwide, the cement industry is in a continuous development, reaching an estimated production of 4,200 million tons in 2016.

From the analysis of the data presented in Table 1 it can be concluded that the biggest growth of the market is being recorded in the developing countries, having a large population such as China or India, in particular due to the need of infrastructure development.

At the opposite side, we found the developed countries, such as EU state members or USA, which are experiencing stagnation or even slight drops in cement production because of reduced infrastructure investments mostly due to the completion of large projects and the decrease of real estate markets.

Table 1. The cement production on the largest international markets between 2008 and 2016 [2]

CEMENT production (million tonnes)									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
China	1388.4	1644.0	1881.9	2063.2	2137.0	2420.0	2480.0	2350.0	2410.0
India	185.0	205.0	220.0	240.0	270.0	280.0	260.0	270.0	290.0
EU28	250.8	209.0	192.1	191.6	172.6	166.6	166.8	167.2	169.1
USA	86.3	63.9	65.2	68.6	74.9	77.4	83.2	83.4	85.9
Turkey	51.4	54.0	62.7	63.4	63.9	72.7	71.2	71.4	75.4
Indonesia	38.5	36.9	39.5	45.2	32.0	56.0	65.0	65.0	63.0
Saudi Arabia	37.4	37.8	42.5	48.0	50.0	57.0	55.0	55.0	61.0
Brazil	51.6	51.7	59.1	63.0	68.8	70.0	72.0	72.0	60.0
Russian Federation	53.5	44.3	50.4	56.1	53.0	72.0	68.4	69.0	56.0
Japan	67.6	59.6	56.6	56.4	51.3	57.4	53.8	55.0	56.0
South Korea	51.7	50.1	47.4	48.2	48.0	47.3	63.2	63.0	55.0
Mexico	37.1	35.1	34.5	35.4	35.4	34.6	35.0	39.8	40.8
Germany	33.6	30.4	29.9	33.5	32.4	31.5	32.1	31.1	32.7
Italy	43.0	36.3	34.4	33.1	26.2	23.1	21.4	20.8	19.3
France	21.2	18.1	18.0	19.4	18.0	17.5	16.4	15.6	15.9
South Africa	13.4	11.8	10.9	11.2	13.8	14.9	13.8	14.0	13.6
Canada	13.7	11.0	12.4	12.0	12.5	12.1	12.8	12.5	11.9
Argentina	9.7	9.4	10.4	11.6	10.7	11.9	11.8	12.2	10.9
United Kingdom	10.5	7.8	7.9	8.5	7.9	8.5	9.3	9.6	9.4
Australia	9.4	9.2	8.3	8.6	8.8	8.6	9.3	9.3	9.4
ROMANIA	11.2	8.3	7.3	7.9	8.0	7.4	7.6	8.0	7.7

2. CEMENT TECHNOLOGICAL PROCESS AND ENVIRONMENTAL IMPLICATIONS

The cement production begins in quarries, where the main raw materials (limestone and clay) are extracted from. These materials are then ground very finely and introduced into the clinker kiln where, as a result of chemical reactions that occur at temperatures around 1450^o C, the main component of the cement, the clinker material, is obtained. After this process, the clinker together with other additional materials such as limestone filler, pozzolanic materials, fly ash residues originating from power plants or slag resulting from the metallurgical industry are ground very finely, the final product bearing the name of cement. In the figure 1, the cement production flow on dry process is presented in a simplified form.

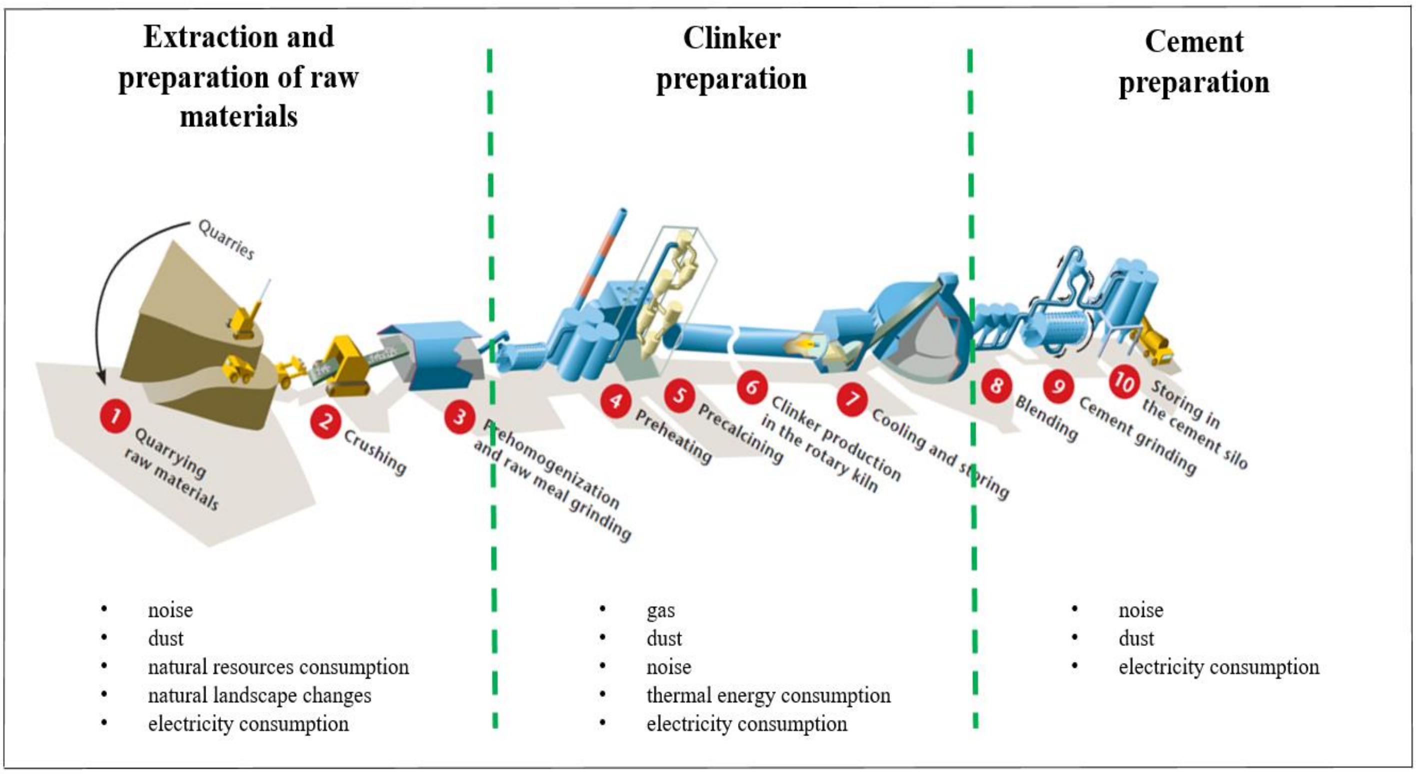

Figure 1. The cement production flow - dry process [3]

In the EU countries, the cement is produced based on strict standards. Depending on the content and the type of additions materials and additives, the cement may be divided into five main types [4]:

- CEM I - Portland cement (with a clincher content >95%)
- CEM II Portland-composite cement (with a clincher content between 65-94%)
- CEM III Blastfurnace cement (with a clincher content between 5-64%)
- CEM IV Pozzolanic cement (with a clincher content between 45-89%)
- CEM V Composite cement (with a clincher content between 20-64%)

From all of these cement types, the most widely used in the construction industry in Romania are the cements types I and II or Portland cements.

There are currently seven plants operating in Romania, which produce cement through the dry process, a procedure that is much more efficient in terms of the consumption of thermal energy thus lower impact on the environment, compared to the wet process.

It is well known that cement manufacturing processes involve a very high consumption of natural resources, thermal energy and electricity [5]. The requirement of thermal energy for clinker production may depend on the output of the combustion plant, but in most cases it is around 3000-3300 MJ/ton of clinker produced.

The main consumers for electricity are the grinding equipment, kiln drives and cooling fans, which account for approximately 80% of the total plant consumption. The electricity requirement in this case is likely to be between 90 and 150 kWh/ton of cement.

The main activities specific for the cement industry, known to have a significant impact on the environment are:

- **Extracting of the non-renewable natural resources** - The most important quantities of raw materials used in the preparation of cement are limestone and clay. These materials are extracted from quarries, which leads to a significant landscape change, often in protected natural areas, and the depletion of natural resources.
- **Consumption of thermal energy** - The clinker production process in rotary kilns is a major consumer of thermal energy. In order to produce this thermal energy, significant quantities of waste gases are released into the atmosphere, such as nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO) and carbon dioxide (CO_2).
- **Consumption of electricity** - The grinding equipment, the rotary kiln drives and the fans use a high quantity of energy. Depending on how this energy is produced, the indirect impact on the environment it can be a significant one.

- **Dust emissions** - During all the important stages of the cement production process, from the extraction of raw materials from the quarry, to the shipment of the cement to customers, a considerable quantity of dust is released into the environment. This quantity may vary significantly, depending on the humidity of the materials or the efficiency of the dust retention and filters installed on the technological flow.
- **Noise emissions** - Noise occurs mostly during extraction, transport, crushing and processing of the raw material and finished product, and is generated by heavy machinery, such as heavy-duty vehicles, crushers, rotary ball mills, fans and belt conveyor systems.
- **CO_2 emissions** - Approximately two thirds of the total amount of CO_2 released into the atmosphere results from the decarbonization reaction of limestone (CaCO3, when exposed to high temperatures of around 900^0 C, is transformed into $CaO + CO_2\uparrow$).
- **Waste generation** - The cement production process generates a moderate quantity of waste, thus the impact on the environment is lower compared to other heavy industries. This is due to the fact that most residues are either reused, by including them as final additions in cement, as is the case of clinker kiln dust (CKD), or collected separately and recycled, as is the case of mineral oils, metal waste, paper, plastic, rubber etc.

For the cement industry from Romania, environmental protection remains a top priority in the business strategy [6]. Although important progress has been made over the last 20 years, evidenced through major investments made to ensure the highest level of compliance with the legal obligations in the field of environmental protection, there are still enough aspects to be improved.

3. LEGAL ASPECTS CONCERNING ENVIROMNETAL PROTECTION APPLICABLE IN ROMANIAN CEMENT INDUSTRY

Environmental protection, in general, and climate change prevention, in particular, represent two major challenges worldwide, in particular in the context of the industrial development registered in the last century. Currently, increasingly more countries, mostly those with developed economies, have announced more and more restrictive measures regarding the protection of the environment and the substantial reduction of greenhouse gas emissions into the atmosphere.

In turn, Romania has undertaken the responsibility for environmental protection, including through the commitments made at European and international level, such as those established within the European Directives and Regulations, the United Nations Framework Convention on Climate Change or the Kyoto Protocol [7].

At national level, environmental protection activities are managed by the Ministry of the Environment through the National Agency for Environmental Protection, the National Agency for Protected Natural Areas and the National Environmental Guard and the Ministry of Waters and Forests through the National Water Administration, institutions with regulatory, guidance and/or control role.

The main legal act in the field of environmental protection also applicable to the facilities in the cement industry from Romania is Government Emergency Ordinance no. 195/2005 [7]. This framework document sets out how the environmental principles and objectives should be implemented to ensure a durable and sustainable development of society from the perspective of environmental protection.

Other legislation in the field of environmental protection with a significant impact in the cement industry from Romania regulates issues related to: air quality, water quality, control of industrial pollution and climate change, nature protection and efficient management of waste and hazardous substances.

4. ENVIRONMENTAL IMPACT FACTORS RELATED TO THE SPECIFIC REGULATIONS

In order to better highlight the areas and factors with a significant environmental impact, the cement production flow was divided into four main stages, as described in Table 2:

Table 2. Localization of environmental impact factors

Main stages	Environmental impact factors
Extraction of raw materials from quarries	- noise emissions - dust emissions - consumption of non-renewable natural resources - changes on the natural landscape
Raw material processing (transport, grinding and storage)	- noise emissions - dust emissions - consumption of electricity
Clinker preparation	- gas emissions - dust emissions - noise emissions

Main stages	Environmental impact factors
	- consumption of thermal energy - consumption of electricity
Cement preparation	- noise emissions - dust emissions - consumption of electricity

The environmental impact factors mentioned in Table 2 are characteristic for all cement plants in Romania, given that they have relatively similar technological flows and production processes.

Further in the paper we will analyze the aspects related the authorization requirements from the perspective of environmental protection, as well as how the main factors with impact on the environment specific to the activities performed by cement plants in Romania are managed.

4.1 The authorization of cement production activities from the perspective of environmental protection

In order to be able to operate on the territory of Romania, each cement production facility needs to obtain an Integrated Environmental Authorization according to the provisions of Government Order no. 818/2003. Furthermore, for the quarries where the raw materials (limestone and clay) are extracted from, Environmental Authorizations should be obtained pursuant to Government Order no. 1798/2007.

The two types of regulatory acts listed above set out, among others, the conditions under which the facility can operate so that the environmental impact may be minimized.

In terms of water management, the activities for the quarries and the cement plant should comply with the provisions of Government Order no. 662/2006. This regulatory act sets out the conditions in which the clean water may be collected, how to treatment and discharging of waste water is carried out, and the measures related to the prevention of accidental pollution of surface water and groundwater.

Another important authorization, in particular due to the economic impact it has on the facility, is the authorization regulating the carbon dioxide emissions (considered the main greenhouse gas), authorization that is issued pursuant to Government Order no. 3420/2012.

4.2 Emissions of Air Pollutants

The cement industry is known to have a significant impact on the environment mostly due to the major emissions of gases into the air, resulting from production processes. At national level, industrial emissions are regulated by Law no. 278/2013, while the quality of the surrounding air is regulated by Law no. 104/2011.

The most significant air emissions resulting from the cement production process are those of dust, nitrogen oxides (NO_x), sulfur oxides (SO_x) and carbon oxides (CO_2 and CO).

Table 3 lists the reference standards and the recommendations for "Best Available Techniques (BAT)" regarding the reference limit values of these air quality indicators [8].

Table 3. Reference standards and BAT recommendations

Relevant Quality Indicators	Reference Standards	BAT Recommendations - Reference Values
Dust	SR ISO 9096 SR ISO 13284-1 SR EN 13284-2 SR EN 15267-1:3 SR EN 14181	<30 mg/Nm^3 (Normal cubic meter; (continuous monitoring)
NO_2	EN 14792 EN 50379 SR ISO 11564 SR EN 15267-1:3 SR EN 14181	<500 mg/Nm^3 (continuous monitoring)
SO_2	EN 14791 EN 50379 ISO 11632 SR EN 15267-1:3 SR EN 14181 SR ISO 7935	<400 mg/Nm^3 (continuous monitoring)
CO	EN 50379 EN 15058 SR ISO 12039	<2000 mg/Nm^3 (continuous monitoring)

According to the European Cement Association (CEMBUREAU) based in Europe, having as members the cement national associations and companies in the European Union (except for Malta and Slovakia), the quantity of emissions of gases and dust related to the ton of clinker produced are clearly on a downward trend over the last years [4, 6].

As it may be noted in Figure 2, one of the main environmental issues that the cement industry in Europe has been facing over the last decades was the need to reduce dust emissions.

As part of the cement production process, the activities with high particulate emissions are the preparation, handling, transport and grinding of raw materials, clinker preparation and cement grinding.

Due to the retrofitting efforts made by cement manufacturers in Europe, it has been possible to reduce the dust emissions by approximately 72% between 2000 and 2016, from 43.3 g/t of clinker in 2000 to 12.1 g/t of clinker in 2016.

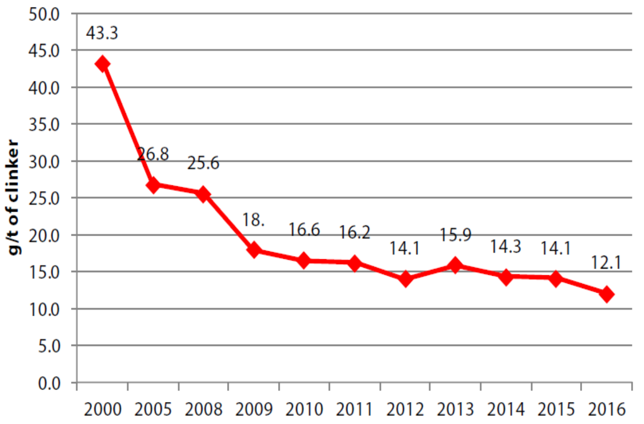

Figure 2. DUST average emission – CEMBUREAU members [2]

Another important environmental quality factor with a significant drop is the group of nitrogen oxides (NO_x), resulting from the fuel combustion process in the clinker kiln.

Due to the high temperatures generated during the combustion process, nitrogen oxides are formed, NO and NO_2 being predominant [8].

Thus, between 2000 and 2016, the cement industry in Europe achieved a reduction of approximately 37% of the quantity of NO_x released into the atmosphere, from 1671 g/t of clinker in 2000 to 1057 g/t of clinker in 2016, as can also be seen in Figure 3.

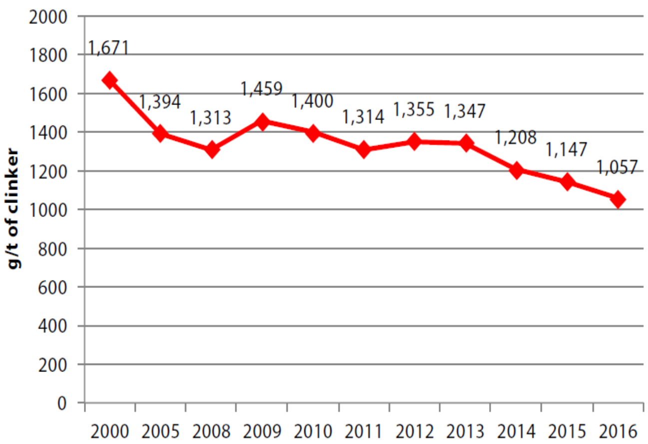

Figure 3. NO_x average emission – CEMBUREAU members [2].

In terms of sulfur oxide emissions, these are mainly dependent on the quantity of volatile sulfur compounds in the raw materials and the type of fuel used.

From the analysis of the data in Figure no. 4, it may be observed that the quantity of SO_2 released into the atmosphere has remained relatively constant between 2000 and 2016.

The carbon oxide (CO and CO_2) emissions result partly from the burning of fossil fuels, but mainly through the reactions of decarbonization of limestone.

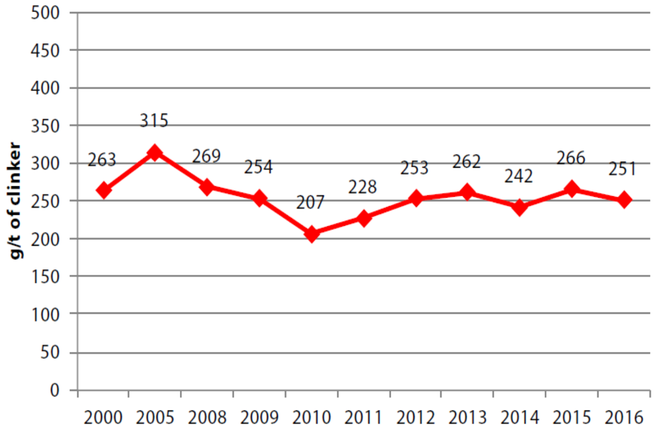

Figure 4. SO_2 average emission – CEMBUREAU members [2].

The combustion process of the fuels used in the production process accounts for approximately 33% of CO_2 emissions, while the limestone decarbonization process in the clinker kiln generates the remaining 67% of CO_2 emissions [2].

Basically, for every ton of clinker produced, approximately 0.9 tons of CO_2 are generated, these emissions being extremely important for the companies especially from the perspective of the high economic value.

This is the reason why they are also strictly regulated at national level by Decision no. 780/2006 “establishing a scheme for greenhouse gas emission allowance trading” and tracked pursuant to Regulation no. 601/2012 “on the monitoring and reporting of greenhouse gas emissions pursuant to Directive no. 2003/87/EC of the European Parliament and of the Council” [7].

Worldwide, it is estimated that about 5% of the quantity of CO_2 released from human activities comes from the cement industry [9, 10].

4.3 Emissions of Water Pollutants

The cement production process through the dry process does not generate significant quantities of waste water, therefore the industry is not known to be a polluter of surface water or groundwater.

Nevertheless cement plants should comply with water protection requirements, regulated mainly by "Water Law" no. 107/1996 and the Decision no. 188/2002 " for the approval of certain norms concerning the conditions of discharging the wastewater into aquatic environment" [7].

Furthermore, cement plants should also obtain from the Romanian Waters National Administration, a Management Authorization regulating in particular the way of collecting the groundwater and the way of discharging the waste water.

4.4 Noise Emissions

Noise emissions arise during the activities of preparation, processing and transport of raw materials and products, are mostly generated by heavy machinery, crushers, ball mills, rotary kilns, large fans or belt conveyors.

In order to reduce the discomfort created by the operation of such equipment, cement plants should make sure that the noise level generated is kept within the limits set by standard SR 10009/2017 or by the regulatory acts such as the Integrated Environmental Authorization or the Environmental Authorization, if the values set out therein are more restrictive.

4.5 Waste Management

The waste management activity is regulated at national level mainly by Law no. 211/2011 „on wastes regime", Decision no. 856/2002 "on waste management records" and Decision no. 1.061 / 2008 "on the transport of hazardous/non-hazardous wastes on Romanian territory" [7].

For certain special types of wastes such as: packaging waste, worn tires, batteries and accumulators, oils waste, electrical and electronic waste equipment etc., the national authorities have issued several legislative acts, setting out in detail how these should be managed.

As part of the waste management activity in the Romanian cement industry, the focus is on reducing the quantities generated from their own activity, and on their separate collection in view of recycling. This means that the efforts should be focused on the prevention component, so that we can talk about a sustainable development of the industry.

The existence of an integrated waste management process solves many of the environmental issues that the industry is faced with, since the measures may be coordinated among them more ease.

Given the complexity of the manufacturing processes and the large quantities of materials used, the cement industry generates enough waste so that the management thereof may be considered as having a significant impact on the environment.

The types of waste that a cement plant generates from its own activity, their storage method, treatment and recycling or disposal are typically mentioned in a special chapter of the Integrated Environmental Authorization or the Environmental Authorization.

4.6 Management of Hazardous Substances

Hazardous substances are those materials presenting a danger to human health, the environment or goods, due to the chemical or physical characteristics these possess.

The management of hazardous substances is subject to strict EU regulations, having the aim of protecting workers and maintaining a clean and healthy environment. Basically, any chemical considered hazardous should be registered, assessed and authorized pursuant to Regulation no. 1907/2006 and classified, labeled and packaged pursuant to Regulation no. 1272/2008 [7].

In the cement industry from Romania, the use of hazardous substances is relatively limited, these being used in small quantities and mostly in activities related to production. From this perspective, the environmental impact generated by the use of hazardous substances is small in normal operating conditions.

4.7 Impact on Nature and Biodiversity

The limestone and clay extraction from quarries, is considered an activity with environmental impact, in particular from the perspective of the fact it changes the natural landscape and may disrupt the biodiversity in the area concerned.

When the quarries are located in protected natural areas, additional measures for the conservation of natural habitats, flora and fauna should be established, in compliance with the provisions of Government Emergency Ordinance no. 57/2007.

Another relevant aspect is the fact that, upon the completion of the exploitation of mineral resources from the quarry, a plan of environmental restoration should be implemented in compliance with the provisions of Government Order no. 202/2013.

5. RECOMMENDATIONS OF BEST PRACTICES FOR CEMENT SUSTAINABILITY

5.1 Use of Management Systems

The implementation of the environmental management system pursuant to the ISO 14001 standard is a common practice in the cement industry from Romania.

The structured working system provided from the standard has allowed a continuous improvement of the environmental performance, with cement plants being stimulated to establish clear strategic directions and ambitious objectives in line with theirs environmental needs and problems.

5.2 Reduction of Dust Emissions

The most common practices for reducing particulate emissions consist in:

- Installing filters and suction systems for dust removal;
- Installing filters for the retention of particulates from the gases released from the kiln (electric filters and/or bag filters);
- Isolating in closed premises the activities producing dust particulates;
- Appropriately developing the roads and wetting the traffic ways for motor vehicles;
- Reducing the spillage of powder materials;
- Storing in confined spaces the powder materials or those that may generate small particulates;
- Reducing the height from which bulk materials are being tipped/unloaded.

5.3 Reduction of NO_x Emissions

Using chemicals to reduce the quantity of NO_x released into the air (e.g.: NH_4OH - ammonium hydroxide), installing burners with low NO_x emissions, using raw materials or additions.

These reduce the clinkering temperature or establishing an adequate mix of fuels materials, are just some of the methods used over the last years to reduce the NO_x emissions.

5.4 Reduction of Noise Level

The sound insulation of the equipment generating a high level of noise or the placement thereof in closed premises has allowed for a substantial reduction in noise pollution.

In order to further reduce the noise level in areas located at the premises limits, if the level is approaching the alert threshold, it is recommended to install sound-absorbing panels.

Other measures that have proven their efficiency consist in separating the noise sources and keeping closed the doors and windows in the rooms where the noise generating equipment are located.

5.5 Energy Consumption Optimization

The most common solutions used in cement plants for energy consumption optimization refer to:

- Implementing energy management systems and making energy balances, in order to identify the possibilities for optimizing the consumption;
- Recovering the heat from waste gases resulting from the combustion process in the kiln for drying and preheating raw materials. Residual heat may also be used in some plants to produce electricity;
- Using equipment and machinery with high energy efficiency, in particular gear motors and fans;
- Using alternative fuels.

This last solution is also the main lever for cement manufacturers, allowing for a further increase in energy efficiency. In fact, the use of alternative fuels has seen a significant increase in recent years.

The advantages of using alternative fuels are certain, both for the cement plant, which may thus reduce its production costs, but most of all for the environment, because significant quantities of waste with extremely long biodegradation time (e.g. plastic waste), that would otherwise end up significantly polluting the environment, are then eliminated [1].

Among the most important alternative fuels used in the cement industry from Romania are: sorted and shredded municipal waste, worn tires, oil waste, oil sludge, waste from plastic matter or waste from wood mass.

5.6 Reduction of CO_2 Emissions

Reducing the quantity of clinker needed to produce a ton of cement by replacing it with other addition materials, such as limestone, clinker kiln dust (CKD), pozzolanic materials, fly ash residues originating from power plants or slag from the metallurgical industry represents a common practice. This substitution has helped the industry overall to significantly reduce the environmental impact generated by the gas emissions resulting from the limestone decarbonization and fuel combustion processes. In fact, Yin et al. (2018) concluded in their paper that the recycling of CKD resulting from cement production is an important decision that cement manufacturers have to make if they want to limit the impact on the environment [11].

Recent research has allowed the identification of alternative, nonconventional solutions, promising to substantially reduce the impact on the environment.

A first solution would be to produce alternative binders for Portland cement, with a lower impact on the environment, materialized through the reduction of greenhouse gas emissions from production processes. There are studies proposing the replacement of limestone ($CaCO_3$) with other materials such as magnesium silicate (MgO_3Si). The cement thus obtained would allow a drastic reduction in the quantity of CO_2 released, compared to the classic "Portland" cement [1, 12 and 13].

Another nonconventional solution is the capture and storage of CO_2 in underground warehouses, in order to avoid the release into the atmosphere using the

"Carbon Capture and Storage of CO_2" (CCS) process [14]. The CCS project began to take shape in his early stage about 20 years ago, being developed as a result of a partnership between some of the largest energy companies in the world and non-governmental organizations. Broadly, the CCS process is composed of three main stages [14]:

- CO_2 capture
- CO_2 transport
- CO_2 storage in appropriate geological formations.

However, all the three stages listed above pose challenges in finding and implementing the most economically and efficient technical solutions, so that they may be adopted by the industry on a large scale. Yet, of these three stages, CO_2 capture is the most difficult, while also very expensive from an economic point of view (it accounts for approximately 80% of the total cost of the CCS process) [15].

In recent years, sustained efforts have been made in order for CCS to become a practical solution for reducing CO_2 emissions worldwide, this being considered an important step in fighting against climate changes.

As a matter of fact, Stuart et al. stated in their paper published in 2008 that the carbon capture solution could be one of the very few opportunities to achieve major reductions in CO_2 emissions in the cement industry [16].

In another study conducted in 2017 by Cormos et al., the possibility of "reducing the carbon footprint of cement industry by post-combustion CO2 capture" was analyzed, and the conclusion was that "the calcium looping technology offers better techno-economic performances in comparison to a more technologically and commercial mature CO_2 capture method based on gas–liquid absorption" [17].

According to another study conducted by Leeson et al. and published in 2017, it results that currently, the costs for carbon capture in the cement industry is estimated up to $70 per ton of CO_2, which is a very high value to be economically sustainable [18].

In the latest years, especially at European level, efforts have been intensified in the field of research, in order to find technical solutions to capture CO_2, including the use of nonconventional technologies abovementioned. According to a report published by the European Cement Research Academy in 2016, there is already an on-going pilot project to reduce CO_2 in company Norcem from Norway, but also others projects in advanced laboratory studies which has generated encouraging results [15].

The European Union regulations are becoming increasingly restrictive regarding the greenhouse gas emissions, especially CO_2 [20]. According to the report "The role of CEMENT in the 2050 low carbon economy" published by the European Cement Association in 2009, the efforts of the cement and concrete manufacturing industry will focus on five main routes to reduce CO_2 emissions by 80% by 2050, as follows [21]:

- Increasing energy efficiency (thermal and electrical);
- Increasing the efficiency of exploiting the resources (e.g. clinker substitution, use of alternative materials, increase the quantity of alternative fuels etc.)
- CO_2 capture and storage/ reuse;
- Developing a low carbon footprint concrete products
- Efficient management of the industry's downstream processes (e.g. recycling the concrete, developing sustainable buildings etc.).

6. CONLUSIONS

The current legislation in the field of environmental protection applicable to the cement industry from Romania has strict requirements, mostly due to the need to comply with the legislation of the European Union.

A lack of clear strategies and good practice guides on national level that would help organizations and the population to implement the requirements related to separate waste collection is felt. These strategies and good practice guides could help to provide of a cleaner environment, and also the cement industry from Romania, which could use a part of this waste as an alternative fuel.

The cement industry in the EU, including here the plants in Romania, should accelerate the process of implementing new technologies allowing the reduction of emissions, otherwise there is a risk that in the future, some of the cement plants will be forced to reduce their activity or even be closed.

As future research directions, we consider that a priority is the need to conduct an analysis on the impact that the obligations to reduce CO_2 emissions will have, over medium and long term, on cement industry in Romania.

The new technologies, classic or nonconventional ones, even in early stages of development should also be subject of researches in order to prevent environmental degradation.

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