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Monitoring of Air Quality in the Cement Industry Sharrcem in Hani I Elezit, Kosova

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Abstract: Every enterprise operating in the territory of Kosovo is obliged to respect the local and EU laws on environmental protection, especially the air. They are obliged to enforce legal acts, over the permitted discharge limits for air contaminants. In all cement factories, dust, SOx and NOx are considered as the main pollutants of air. The cement factory-Sharrcem in Hani i Elezit besides the important investments in the technological process of production has installed equipments for dust reduction during production and equipment for controlling the emission of pollutants into the air, like: electrostatic capacitor (ESP-KES) and mechanical sack filters which are installed in locations with pollution potential, during the cement production process. The installation of these devices is done in order to improve the quality of air in the factory and to protect the health of Sharrcem employees. The analysis and control of the quality of polluted air is done in wards as: in the mill for the preparation of the raw material in the clinker preparation area and in the cement crushing and transport line. From the results of air monitoring for 2016 and 2017 and their comparison with emission limit values, it can be noted that the dust value is below permitted emission limit values. The Sulfur Oxide (SOx) and Nitrogen Oxides (NOx) concentration values after the installation of the equipment are also several times below the permissible emission values of air pollutants. So, referring to the EU and national standards for emission limit values, the results from the monitoring of pollutant air parameters in the factory show that, the polluted air emerging from various cement processing equipment is lower than the permitted emission limit values. Based on the published results, Sharrcem factory is a positive example of meeting the criteria for air pollution in Kosovo and beyond.

Key words: Permitted values, air pollution, technological process, EU standards, parameters, cement crushing

INTRODUCTION

Local and international companies during their operation in Kosovo are obliged to comply with the laws and sub-legal acts for environmental protection. According to the Law on Air Pollution Protection (No. 03/l-160), the term emission limit value is the "the maximum permissible amount of pollutant which is discharged into the air from a source of pollution whose level has been determined on the basis of scientific knowledge in order to avoid, prevent or reduce the harmful effects on human health and the environment as a whole, that may be reached within a given period but must not be overcome". However, the companies operating in the territory of the Republic of Kosovo must also respect the obligations deriving from other laws in the country as: Law on Environmental Protection No. 03/L-025, Law on Environmental Impact Assessment; Nr. 03/L-214 Waste Law No. 02/L-30, Law on Water Protection; No. 2004/24, Law on Nature Protection; Nr. 03/L-233 and the Law on Noise Protection; Nr. 02/L-102 (Anonymous, 2004, 2007, 20102016, 2017).

MATERIALS AND METHODS

Brief description of the technological process at the factory: A brief description of the activities at the Sharrcem factory like the: cement production technology as well the eventual impacts of each unit in the factory environment and beyond is given as.

The basic chemical process of cement production at the Sharrcem-Titan Group factory begins with the decomposition of the raw material, Calcium Carbon ($CaCO_3$) in thermal conditions at about 900°C. Calcium (CaO) is obtained from this thermal proces and the gas in the form of carbon dioxide is released. This proces in cement technology is known as the calcination process. The process proceeds with clinkerization in which high

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Table 1: Quantity of air emissions from the cement production proces

Cement production process	The amount of air emission from the filters	Efficiency of filters (mg/Nm^3)
Preparation of raw material mill and homogenization temperature; 115°	Mechanical filter with vibration sacks (m^3/h) 1. 391BF1C1-18.000 2. 392BF1C1-18.000 3. 411BF1C1-18.000	20
Production of clinker Gas temperature (80-120°C)	Electro filters (ESP)-230.000	<100
Transportation of clinker; temp. 1150°C	Mechanical filter with vibration sacks 1.491BF1-18.000 2.491BF2-6.600	20
Cement crushing; temp. 115°C	Mechanical filter with vibration sacks 1.562BF1C2 90.000 2.563BF1C3 36.000	20
The distribution station; temp. 115°C	Mechanical filter with vibration sacks Cement silos 2×18.000 Packing machines 2×18.000 Volume filling 2×6.600 Cement bunker 1×12.000	20

temperature calcium oxide (1400-1500°C) reacts with silicon, aluminum and iron oxide in which case silicates, aluminates and calcium iron are formed. In order to finalize the cement production process, continues the proces of crushing or grinding of clinker with gypsum and other additives. The main method of cement production at the Sharrcem-Titan factory is the process of raw material processing. In the process of raw material processing, firstly, the raw material is crushed and dried in the form of flowing dust. Usually, the process of raw material preparation and cement production follows some pre-processes: extraction of raw material, storage and preparation of raw material, the baking of clinker, cement milling and storage and packaging and transport of cement (Table 1).

RESULTS AND DISCUSSION

Dust emission monitoring techniques: There are two kind of equipments which are used for dedusting and emission control in the Sharrcem factory: electrostatic condensator (ESP) and mechanic filter that are installed in potential sources of pollution during the process of production. Both the EPS and the fabric filters have their advantages and disadvantages. Both types have a very high dedusting efficiency during normal operation. During special conditions such as high concentration of CO_2, kiln start up, kiln shut down or switching from compound operation (raw mill on) to direct operation (raw mill off), the efficiency of EPS can be significantly reduced whereas the efficiency of fabric filters is not affected.

(a)

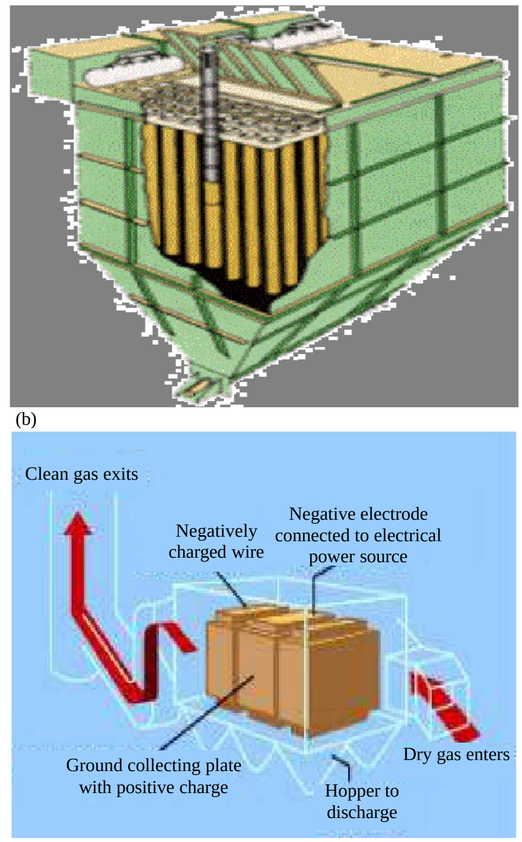

Fig. 1: System of continuous monitoring equipment in the main chimney: a) Mechanical bag filter and b) Electro filter

Therefore, fabric filters have a higher efficiency, they are well maintained and the filter bags are replaced periodically (Fig. 1).

Treatment of gas from the clinker cooler and the dust removal system: Gases that emerge from the clinker cooler enter into a heat exchanger where the amount of heated dust is cooled to a suitable temperature for the continuous operation of the filter with sacks. Cleaned gas is released into the atmosphere by a radial fan which is installed in the filter with sacks. Due to some circumstances, the temperature and the amount of gas vary to a relative degree. To cover these “non-regular” conditions, the design and control of the air/air heat exchanger is an important criterion of the concept of dust removal. The “SCHEUCH” heat exchanger is specially designed for this wide range of work conditions which results in a safe and stable dust removal system. The new process of the sack filter is designed for collecting dust from the clinker coolant gases for the working conditions shown in Table 2.

Table 2: Recycling of filter work in sacks, collecting of the dust from clinker cooling gases

Variables	Outgoing gases from the clinker cooler Normal	Maximum	Units
Working regime			
Gas volume flow-nominal	90.000	90.000	Nm^3/h
Gas volume flow-actual	141.500	142.800	Am^3/h
Gas temperature (during work)	140		°C
Gas temperature (maximum)		150	°C (peaks)
Compression on the flange	-25	-25	mbar
Static compression for mechanicaldesign	-50	-50	mbar
Concentration of dust at the entrance	10	10	g/Nm^3
Dust load (pure gas) (dry)	5	5	mg/Nm^3
The type of dust	Clinker dust		
Density of collection	approximately	(0.71.6)	t/m^3

Table 3: Emitted amounts of pollutants from 2006-2011

Variables	Units	2006	2007	2008	2009	2010	2011
Dust	mg/m^3	100	60	77	81	68	76
SO_2	mg/m^3	350	182	234	306	118	45
NO_x	mg/m^3	580	564	593	536	511	469

Table 4: Emission limit values of air pollutants for cement producers

Pollution parameteras	Limit values (mg/m^3)
Dust	50
Nitrogen Oxides NOx	800
Sulfur Oxides SO_2	400

Table 3 and Fig. 2 show the emissions of pollutants from 2006-2011. Even before the installation of cleaning and monitoring equipment for pollutant parameters from Table 3 and Fig. 2 shown, we see that from year to year, we have decreased the amounts of the three main pollutant parameters; Dust, SO_2 oxide and nitrogen oxides.

Emission limit values of air pollutants for cement producers: These values are directly based on emission limit values for some technological processes of the administrative instruction on air emission rules and rates, from steady sources of pollution (Article 28, ESC of the technological process of cement production with a voluminous oxygen content of 10%) which derives from the Law on Air Protection from Pollution No. 2004/30, known as UNMIK Regulation No. 2004/48 of 25 November 2004 (Anonymous, 2004). Pollution parameters and allowed limit values are shown in Table 4.

Continuous monitoring system: Monitoring of emissions and the reduction of impacts in the air and environment is a prerequisite for the operation of cement production companies. The Sharrcem company has installed equipments for continuous measurement of dust and gas emissions in the furnace chimney. Through these equipments it will be possible to monitor the

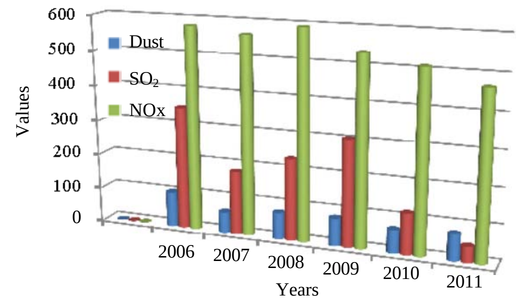

Fig. 2: Tabular representation of the emissions of pollutants from 2016-2011

environmental situation for all pollutant parameters. In 2012, Sharrcem's factory was the first company in the country to have installed independent continuous monitoring systems running online 24 h/day. The measurement system is the most advanced technology system "INSITU", from the manufacturer of the German company SICK-MAIHAK.

These devices are now in the furnace chimney and have been in operation, since, 2012. The measurements are made on a monthly basis by the licensed electronic measurement company RI-EPM from Skopje whose equipment is calibrated and certified by an independent party according to European standards. Continuous measurements enable the company to closely monitor emissions on a real-time basis and take actions in accordance with the circumstances created. At the same time, the company offers access to information for the interested ones. Data is monitored and processed using licensed software MEAC 2000. Measurement values are submitted in compliance with legal requirements and reported on a monthly and annual basis at the Ministry of Environment and Spatial Planning (MESP).

The types of installed equipment, their installations at the factory and the parameters that are evaluated are presented in Table 5.

Dust emissions in the air: The main sources of dust emission in cement factories are the oven sinks and the open surfaces that create the dust which comes off from the transportation of the materials. From 2012, continuous automatic air monitoring for 24 h is carried out where parameters are measured and emissions are recorded on a real-time basis.

SO_2 emissions: The presence of Sulfur (S) in raw materials during the cement production process is the main cause of SOx emission. SOx emission in Sharrcem is significantly below the limits allowed by national and EU regulations for concentrations of pollutants in the

Table 5: Type of installe equipment, location and pollutant parameters for 2012 and 2013

Equipments	Sub-type	Measured parameters	Installation date	Location
Sick dusthunter SB100	Dust concentration monitor	Dust	April, 2012	Kiln and raw mill stack
Sick GM 32	In-situ gas analysis	SO_2, NOx_1, T, P	April, 2012	Kiln and raw mill stack
Sick GM 35	Gas analysis for CO_2, CO_2 and H_2O	CO, CO_2, H_2O, T_1P	April, 2012	Kiln and raw mill stack
Sick flowsic100 H	Gas velocity monitor	Velocity of gas speed of sound	April, 2012	Kiln and raw mill stack
Sick zirkor 302 P	Oxygen analysis	O_2	April, 2012	Kiln and raw mill stack
Sick dusthunter SP 100	Dust concentration monitor	Dust	January, 2013	Clinker cooler chimney
Sick flowsic 100/200	Gas velocity monitor	Velocity	January, 2013	Clinker cooler chimney

Table 6: Air quality monitoring within the environment of the factory

Factory parameters	2016	2017	EU LV and IPPC (mg/m³)
PM_{10}	0.137	0.170	0.05
$PM_{2.5}$	0.089	0.139	0.025
NO_2	0.022	0.029	0.04
SO_2	0.014	0.012	0.0125
O_3	0.057	0.068	0.12
Noise during the day	66	64	70 dB
Noise during the night	65	63	55 dB

Table 7: Air quality monitoring within the environment of the quarry

Quarry parameters	2016	2017	EU LV (mg/m³)
PM_{10}	10 0.139	0.153	0.05
$PM_{2.5}$	0.093	0.101	0.025
Noise during the day	60.140	60	70 (dB)
Noise during the night	53.000	55	55 (dB)

air. Figure 3 is a diagram of pollution monitoring for 5 months, January-May. The 2016 in the kiln and in the raw material mill (killn and raw mill stack).

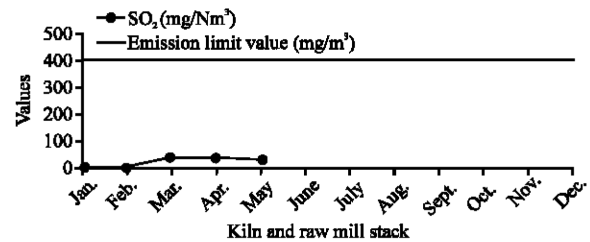

Fig. 3: January-May, 2016 - SO_2 concentrations in kiln and raw material mill

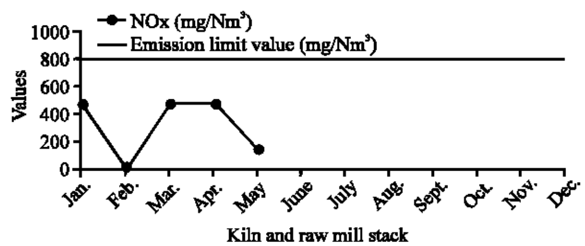

Fig. 4: January-May, 2016- NOx concent ations in kiln and raw mateial mill

NOx emissions in the air: Burning raw materials at high temperatures leads to the release of NOx. Scientific studies have shown that NOx emissions can contribute to the formation of acid rain and fog. In 2012, total NOx emissions in Sharrcem were significantly below the permissible limits of air pollutant concentrations as defined by national and EU regulations (Fig. 4).

The company voluntarily decided to set up and operate a Continuous Emission Monitoring System (CEMS). Since, the beginning of 2013, a neutral third party, periodically verifies and ensures the quality of the data. CEMS equipment is calibrated and controlled according to EN 14181 and BS EN 13284-01. SHARRCEM operates in accordance with the best possible emission reduction techniques for cement industry under Directive 2010/75/EU and IPPC law (O'Connor, 2010). Air quality monitoring at the location of Hani i Elezit is perceived continuously through the monitoring station of the Hydrometeorological Institute of Kosovo (IHMK). Data are monitored and published on monthly and yearly basis by the Kosovo Environmental Protection Agency (KEPA). Despite these measurements, Sharrcem company also performs periodic measurements of air quality and noise level at several points within the factory with the aim of identifying the most influential sources in the air quality. From the measurement results, it is concluded that the greatest impacts come from the clinker storage space, so, Sharrcem took the decision to close it and it's still under construction (Table 6 and 7).

Instant measurement in the kiln and raw material mill: Instant measurements in the rotating furnace chimney and in the mill of the materials during the two oven working procedures are extracted for the following parameters: N_2O; POPs (Dioxin and Furan); HCl; HF; Hg (Cd and Tl); Heavy metals (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V); TOC. The calibration of continuous measurement equipment in the rotary kiln, clinker cooler and grinding mills was carried out by the certified company 'Cambas' from Greece.

In Table 8 and Fig. 5, the permissible concentrations of certain pollutant emission parameters for 2016 for rotary kiln, clinker coolant and grinding mills are presented.

Because of the limitation of the submission of all the results, we have been looking for, we are obliged to present the results for only one month from 2016 and only one month 2017, just to show it clearly and as a research chronology. Months selection is random, monthly values between months within 2016 and 2017 do not have any major difference (Table 9 and 10).

From Fig. 6 are presented some diagrams derived from Table 10, of the continuous monitoring results of the main pollutants from the sources of pollution into clinker cooler, cement mill 1 and 2 and kiln and raw mill.

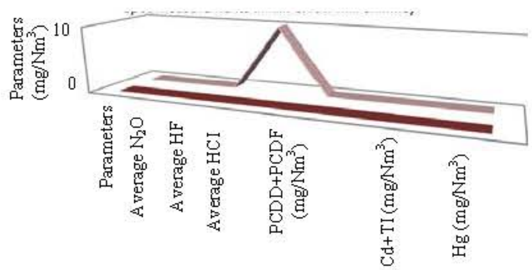

Fig. 5: Instant measurements kiln and raw mill chimney

Table 8: Instant measuremens in kiln and raw mill chimney, year 2016

Variables	2016 @10%O_2 dry (mg/Nm^3)	2017 @10%O_2 dry (mg/Nm^3)	IPPC ELV @10%O_2dry (mg/Nm^3)
Average N_2O	8.600	2.100	Na
Average HF	<0.250	0.000	1.0
Average HCL	1.600	1.670	10
PCDD+PCDF	0.004	0.0012	0.3
Total heavy metals	0.320	0.0380	0.05
Cd+Tl	0.003	0.0190	0.05
Hg	0.011	0.0014	0.058

Table 9: Dust, NOx and SO_2 pollution for clinker cooler, cement mill 1and 2 and from kiln and raw mill for May, 2016

December, 2016	Dust (mg/Nm^3)	ELV (mg/m^3)	Dust (mg/Nm^3)	ELV (mg/m^3)	Dust (mg/Nm^3)	ELV (mg/m^3)	SO2 (mg/Nm^3)	ELV (mg/m^3)	Nox (mg/Nm^3)	ELV (mg/Nm^3)
1	2.46	20	1.18	20	3.21	50	0.88	400	653.76	800
2	2.64	20	0.90	20	2.83	50	0.24	400	508.70	800
3	2.02	20	NOP	20	2.47	50	0.37	400	315.11	800
4	2.49	20	NOP	20	3.18	50	0.81	400	291.23	800
5	2.54	20	NOP	20	3.31	50	1.08	400	420.08	800
6	2.59	20	NOP	20	3.19	50	2.31	400	460.76	800
7	NOP	20	NOP	20	NOP	50	NOP	400	NOP	800
8	2.92	20	NOP	20	3.13	50	1.27	400	387.07	800
9	3.18	20	NOP	20	3.14	50	0.79	400	455.63	800
10	2.59	20	NOP	20	3.15	50	0.11	400	494.37	800
11	2.76	20	NOP	20	3.28	50	0.98	400	426.07	800
12	2.30	20	NOP	20	3.09	50	1.06	400	400.80	800
13	1.86	20	NOP	20	2.97	50	0.71	400	305.05	800
14	2.46	20	1.86	20	3.16	50	0.88	400	364.49	800
15	2.40	20	1.30	20	3.06	50	0.86	400	554.03	800
16	2.40	20	1.30	20	3.06	50	0.86	400	554.03	800
17	2.40	20	1.30	20	3.06	50	0.86	400	554.03	800
18	2.40	20	1.30	20	3.06	50	0.86	400	554.03	800
19	3.31	20	1.83	20	3.59	50	2.10	400	627.47	800
20	2.72	20	1.00	20	3.37	50	17.37	400	450.15	800
21	2.29	20	1.09	20	3.51	50	1.10	400	580.57	800
22	2.21	20	2.80	20	3.40	50	1.35	400	500.97	800
23	2.09	20	NOP	20	3.29	50	0.00	400	458.23	800
24	NOP	20	NOP	20	NOP	50	NOP	400	NOP	800
25	NOP	20	NOP	20	NOP	50	NOP	400	NOP	800
26	NOP	20	NOP	20	NOP	50	NOP	400	NOP	800
27	NOP	20	NOP	20	NOP	50	NOP	400	NOP	800
28	1.52	20	0.73	20	3.63	50	0.37	400	370.79	800
29	1.58	20	1.14	20	3.38	50	0.32	400	367.35	800
30	1.62	20	0.83	20	3.35	50	0.65	400	396.13	800
31	1.94	20	1.21	20	3.71	50	0.27	400	406.56	800
Average	2.36	20	1.52	20	3.23	50	1.59	400	517.06	800

NOP-Not Operation Explanations: The monthly average values are calculated on the half hour emission values. Measured values of the concentrations are calculated at 10 vol. of O_2; Results of the measurements are represented in Nm (Nm^3 -T = 273K, P = 101, 3kP, dry gas) c

Table 10: Dust, NOx and SO_2 pollution for clinker cooler, cement mill 1 and 2 and from kiln and raw mill for May, 2017

May, 2017	Dust (mg/Nm^3)	ELV (20 mg/m^3)	Dust (mg/Nm^3)	ELV (20 mg/m^3)	Dust (mg/Nm^3)	ELV (20 mg/m^3)	SO_2 (mg/Nm^3)	ELV (400 mg/m^3)	NOx (mg/Nm^3)	ELV (800 mg/Nm^3)
1	2.19	20	1.77	20	2.33	50	NOP	400	NOP	800
2	2.22	20	1.79	20	2.09	50	NOP	400	NOP	800
3	2.15	20	1.61	20	2.26	50	NOP	400	NOP	800
4	2.10	20	1.31	20	2.35	50	NOP	400	NOP	800
5	1.91	20	1.45	20	2.38	50	NOP	400	NOP	800
6	1.85	20	1.47	20	2.34	50	NOP	400	NOP	800
7	2.05	20	1.35	20	2.44	50	NOP	400	NOP	800
8	1.87	20	1.21	20	2.24	50	NOP	400	NOP	800
9	1.88	20	1.29	20	2.35	50	NOP	400	NOP	800
10	1.90	20	1.33	20	2.29	50	NOP	400	NOP	800
11	2.00	20	1.34	20	2.78	50	NOP	400	NOP	800
12	2.05	20	1.35	20	2.09	50	NOP	400	NOP	800
13	2.13	20	1.55	20	2.22	50	NOP	400	NOP	800
14	1.97	20	1.57	20	2.18	50	NOP	400	NOP	800

Table 10: Continue

May, 2017	Dust (mg/Nm³)	ELV (20 mg/m³)	Dust (mg/Nm³)	ELV (20 mg/m³)	Dust (mg/Nm³)	ELV (20 mg/m³)	SO_2 (mg/Nm³)	ELV (400 mg/m³)	Nox (mg/Nm³)	ELV (800 mg/Nm³)
15	1.85	20	1.47	20	2.48	50	4.60	400	98.300	800
16	1.87	20	1.37	20	2.86	50	31.13	400	183.61	800
17	2.10	20	1.36	20	2.76	50	22.91	400	195.48	800
18	1.97	20	1.25	20	2.69	50	115.25	400	131.59	800
19	1.93	20	1.29	20	2.98	50	31.31	400	337.05	800
20	1.93	20	1.25	20	2.89	50	30.72	400	216.85	800
21	1.90	20	1.30	20	2.90	50	69.09	400	143.18	800
22	1.97	20	1.29	20	3.25	50	73.47	400	135.43	800
24	2.01	20	1.24	20	3.07	50	48.91	400	273.78	800
25	1.88	20	1.14	20	2.69	50	6.67	400	290.38	800
26	1.89	20	1.18	20	3.01	50	7.30	400	355.72	800
27	2.02	20	1.23	20	2.94	50	8.32	400	393.17	800
28	2.05	20	1.21	20	2.85	50	5.88	400	181.54	800
29	2.14	20	1.29	20	3.22	50	12.29	400	512.06	800
30	2.07	20	1.29	20	2.89	50	51.67	400	103.82	800
31	2.01	20	NOP	20	3.14	50	43.20	400	372.03	800
Average	2.00	20	1.36	20	2.65	50	31.16	400	134.25	800

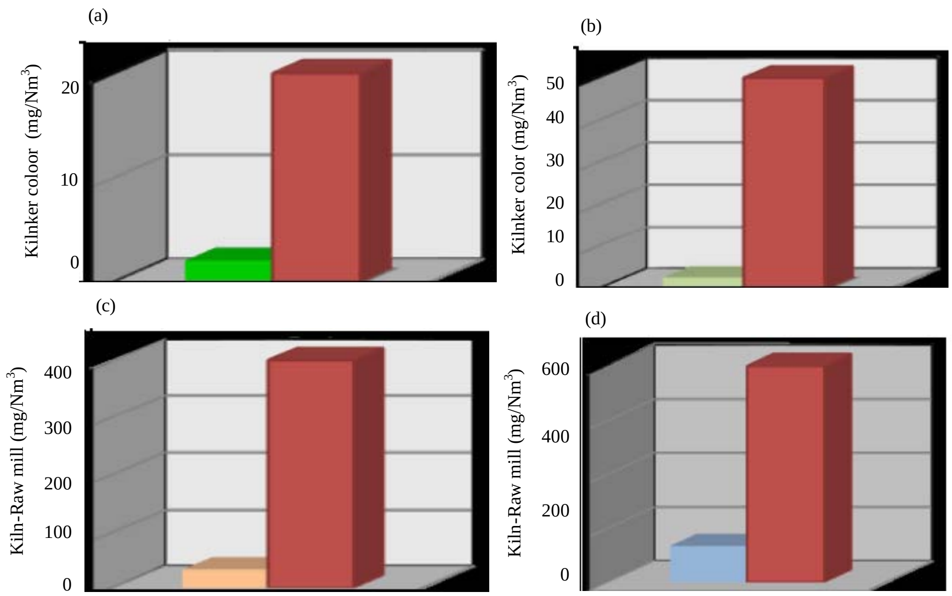

Fig. 6: Dust, NOx and SO_2 pollution for clinker cooler, cement mill 1 and 2 and from kiln and raw mill for May, 2017: a) Dust monthly average ELV; b) Dust monthly average ELV; c) SO_2 monthly average ELV and d) NOx monthly average ELV

CONCLUSION

Based on the results achieved by this air pollution monitoring research within Sharrcem factory facilities, for the period 2016 and 2017, we can draw some conclusions as it follows:

From the 2006 air monitoring results it can be seen that concentrations of dust, Sulfur Oxides (SOx) and Nitrogen Oxides (NOx) are constantly decreasing and have a positive impact on air quality at the Scharrcem factory and in the town of Hani i Elezit.

The emission limit values for air pollutants at the Sharrcem plant, based on national and EU standards are fully respected and are clearly below the allowed limits. Dust emissions in 2016 and 2017 at the Sharrcem plant (clinker cooler, cement mill 1 and 2 and in kiln and raw mill) are clearly below the permissible limits of air pollutant concentrations (VKE), referring to national and EU laws.

SOx emissions in 2016 and 2017 at the Sharrcem plant (clinker cooler, cement mill 1 and 2 and in kiln and raw mill) are clearly below the permissible limits of air pollutant concentrations (VKE), referring to national and EU laws.

NOx emissions in 2016 and 2017 at the Sharrcem plant (clinker cooler, cement mill 1 and 2 and in kiln and raw mill) are clearly below the permissible limits of air pollutant concentrations (VKE), referring to national and EU laws.

In instant measurements, in the rotary kiln and in the raw material preparation mill it is seen that most of the pollutant emission parameters are significantly below the permissible values of concentrations (limited pollution values) according to the integrated environmental permit.

Therefore, from the pollutant emission monitoring results (dust, SOx and NOx) at the Sharrcem factory in Hani i Elezit for 2016 and 2017 (Ceka *et al*., 2016), we can conclude that the factory operates successfully by strictly respecting local and EU standards on the permitted limitations of air pollution for Cement production factories.

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