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Evaluation of particulate matter $PM_{2.5}$ and PM_{10} (Case study: Khash cement company, Sistan and Baluchestan)

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ABSTRACT:

Introduction: One of the most important contaminants in the cement industry are environmental suspended particles ($PM_{2.5}$ and PM_{10}), which cause respiratory and pulmonary diseases in humans.

Materials and methods: This descriptive - analytical study was carried out in 2016-2017 on the peripheral particulate matter of Khash cement plant. Sampling was performed at 8 environmental stations of Khash Cement Company in spring, summer, fall and winter. A total of 576 samples were sampled of peripheral particulate matter.

Results: The amount of particulate matter was $PM_{2.5}$ 2.82 to 24.63 µg/m^3, respectively. The highest $PM_{2.5}$ content was obtained in spring (24.32±2.51 µg/m^3). The lowest amount of particulate matter $PM_{2.5}$ in different seasons were measured in substation ($P<0.05$). The amount of particulate matter was PM_{10} 19.98 to 68.22 µg/m^3, respectively. The highest PM_{10} content was obtained in autumn (64.92±3.76 µg/m^3). The lowest amount of particulate matter PM_{10} in spring and summer were measured in substation ($P<0.05$), but the lowest amounts in the autumn at the entrance door and in winter was observed in wastewater treatment.

Conclusion: In this study, the amount of $PM_{2.5}$ and PM_{10} peripheral particulate matter in Cement Company was lower than WHO and USEPA standard. According to the results it can be stated that the suspended particles Khash Cement Company environment for human respiration were within acceptable limits.

Introduction

Nowadays, air pollution is one of the major problems of urbanization and industrial life and the lives of all people in society have been affected by this problem. The cement industry is one of the key industries in developing countries which are widely used in various projects. However, this industry is considered one of the most polluting industries [1, 2]. The cement structure is composed of materials such as silicon dioxide, iron oxide, aluminum oxide and calcium oxide [3]. The cement and its related industries have long been regarded as one of the most important environmental pollutants. For this reason, monitoring and control of environmental pollutants is of particular importance in this industry [4].

Solid particles emitted from the cement industry without any precise control over them almost in-

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variably invade our living space and over time and accumulate the environment of these gases and particles, humans, plants and animals have been seriously threatened [5, 6]. Air pollutants due to the cement production process and its diffusion to the environment, depending on the nature of the contaminant and the exposure time, because various complications and diseases in humans, animals and plants and the synergistic effect on it, will have other air pollutants [7].

Environmental pollutants are one of the main pollutants from the cement production process. According to the World Health Organization (WHO) estimates in the early years of the 21st century, air pollution caused by particulate matter alone has killed about 800,000 people and is the thirteenth cause of human deaths [8, 9]. Airborne particles are those of solid or liquid dispersants larger than one molecule in diameter (0.0002 μm) and smaller than 500 μm. As a branch of pollutants, these materials are very diverse and complex, and their particle size and chemical composition, such as their concentration in the air, is an important feature of these materials [10, 11]. Suspended particles are sometimes in the form of live particles such as bacteria, algae, molds and spores, or in the form of non-living particles, including substances such as organic compounds; dust and sea salts are classified. Suspended particles are composed of the decomposition and disintegration of large pieces of material or the aggregation and aggregation of smaller particles, including molecules. The main source of suspended particulate matter by artificial sources of contamination includes the production and formation of aerosols (dispersed particles) of the main gas contaminants [12, 13].

High concentrations of suspended particulates are dangerous for humans, especially those with a history of respiratory illness. Diseases such as upper respiratory tract infections, pneumonia, pulmonary inflammation, cancerous effects, bronchitis, shortness of breath, heart disorders, adverse effects on the chest, and effects on defense and purification mechanisms are major particulate effects are suspended on humans [14, 15]. Therefore, identifying, investigating and monitoring the effects of air pollution on ecosystems has led to the development of environmental monitoring plans and sound planning with the aim of improving the output of industries to the environment and consequently these measurements can be improved [16].

The purpose of this study was to determine the concentration of $PM_{2.5}$ and PM_{10} suspended particles in different Seasons of Khash cement company from Sistan and Baluchestan province.

Materials and methods

Research location

Khash city is located in 2 km from Zahedan, the capital of Sistan and Baluchistan province. The city has a warm and dry climate with a height of 2 m above sea level. Khash cement Ccompany is the oldest cement production plant in the southeastern region of Iran in Sistan and Baluchestan province.

Sampling

This descriptive - analytical study was carried out in 2016-2017 on the peripheral particulate matter of Khash cement plant. Sampling was performed at 8 environmental stations of Khash cement company in spring, summer, autumn and winter. A total of 228 samples of peripheral particulate matter were sampled. The exact location of the stations under study at Khash cement company is presented in Table 1.

Parameters measurement

The standard method (No. BS-EN-12341) was used for measuring particulate environment based on the photometry and the photometer. Sampling and measurement of ambient particulate matter was carried out during office hours with a device. In this method, the Dust Trak (Made in USA) device was first calibrated with a detection limit of 0.001 to 400 mg/m^3. The device was positioned slightly and preferably slightly above the ground (1.5 m above ground). Flow was then adjusted and sampled for 60 min, taking into account wind direction and stable atmospheric conditions [17].

Statistical analysis

SPSS 24 was used for data analysis and Excel for drawing tables and diagrams. Kolmogorov-Smirnov test was used to evaluate the normality of the data. T-test was used to compare mean particle concentration in different seasons and one-way ANOVA and Duncan test were used to compare data in the studied stations.

Results and discussion

The amount of particulate matter was $PM_{2.5}$ 2.82 to 24.63 µg/m^3, respectively. In the spring, autumn and winter seasons, the highest $PM_{2.5}$ content was observed at scale station ($P<0.05$). In summer, the amount of these particles was higher at the soil warehouse station ($P<0.05$). The highest $PM_{2.5}$ content was obtained in spring (24.32±2.51 µg/m^3). The lowest amount of particulate matter $PM_{2.5}$ in different seasons were measured in substation ($P<0.05$). Comparison of mean $PM_{2.5}$ in different seasons showed that the amount of $PM_{2.5}$ in spring was higher than other seasons ($P<0.05$). Also, autumn season had the lowest amount of $PM_{2.5}$ peripheral particulate matter ($P<0.05$) (Table 2).

Table 1. Profile of sampling in Khash cement company 2016-2017

Geographical position	Sampling location	Sampling time	Floor material	Pump flow (m^3/min)	Suction volume (m)
North	Scale	60 min	Cement	0.0017	0.102
Northwest	Soil warehouse	60 min	Cement	0.0017	0.102
West	Turret guard	60 min	Cement	0.0017	0.102
Southwest	Substation	60 min	Cement	0.0017	0.102
South	Turret guard	60 min	Cement	0.0017	0.102
Southeast	Entrance door	60 min	Cement	0.0017	0.102
East	Sewage treatment	60 min	Cement	0.0017	0.102
Northeast	Office of Education	60 min	Cement	0.0017	0.102

Table 2. Results of $PM_{2.5}$ peripheral particulate matter of Khash Cement Company (µg/m^3), 2016-2017

Sampling location	Spring	Summer	Autumn	Winter
Scale	24.32±2.51[a]	22.60±1.31[a]	5.72±1.25[a]	18.90±1.43[a]
Soil warehouse	22.03±1.67[a]	24.21±2.29[a]	5±1.11[a]	17.39±1.23[a]
Turret guard	23.67±1.26[a]	20.90±2.54[b]	3.12±1.68[b]	11.34±1.53[b]
Substation	16.41±2.39[b]	14.70±1.09[c]	2.60±1.39[b]	10.14±1.17[b]
Turret guard	17.20±1.59[b]	15.56±1.36[c]	3.20±1.59[b]	12.45±1.89[b]
Entrance door	21.65±1.78[c]	18.32±1.62[d]	3.56±1.78[b]	14.70±1.59[c]
Sewage treatment	21±2.05[c]	19.81±1.21[d]	3.39±2.05[b]	14.02±2.83[c]
Office of Education	19.55±1.90[d]	17.12±1.58[d]	4.31±1.90[b]	10.29±1.64[b]

[*]a, b, c, d showed a significant difference (P <0.05).

The amount of particulate matter was PM_{10} 19.98 to 68.22 μg/m³, respectively. In the spring and autumn seasons, the highest PM_{10} content was observed at scale station ($P<0.05$). In summer and winter, the amount of these particles was higher at the soil warehouse station ($P<0.05$). The highest PM_{10} content was obtained in autumn (64.92±3.76 μg/m³). The lowest amount of particulate matter PM_{10} in spring and summer were measured in substation ($P<0.05$), but the lowest amounts in the autumn at the entrance door and in winter was observed in wastewater treatment. Comparison of mean PM_{10} in different seasons showed that the amount of PM_{10} in winter was lower than other seasons ($P<0.05$) (Table 3).

In this study, the amount of $PM_{2.5}$ peripheral particulate matter in Cement Company was lower than WHO standard (25 μg/m³). Also PM_{10} peripheral particulate matter was lower than 50 μg/m³ (WHO standard) [18] (Table 4). The US Environmental Protection Agency has set the standard $PM_{2.5}$ and PM_{10} concentrations of environmental pollutants of 35 and 15 g/m³, respectively [19].

Most particles fall into the group of very fine particles that contain particles of diameter 0.1 μm or less. In terms of surface area, these particles are the most dominant airborne particulates but have a small share in the overall mass of the airborne particles. These portions of the particulate matter are mainly derived from combustion and are secondarily generated as secondary particles from gas to particle conversion [20, 11]. These particles are inherently unstable and, through coagulation and compression, become larger particles. Sulfates and nitrates are the predominant compounds in these particles. Fine particles include particles ranging in size from 0.1 to 2.5 μm, known as $PM_{2.5}$ along with fine particles. Fine particles basically contain particles that are created by combustion or result from coagulation

Table 3. Results of PM_{10} peripheral particulate matter of Khash cement company (μg/m³), 2016-2017

Sampling location	Spring	Summer	Autumn	Winter
Scale	46.32±1.25^a	47.22±2.49^a	63.17±4.67^a	36.26±1.28^a
Soil warehouse	43.03±2.35^a	48.90±3.24^a	64.92±3.76^a	32.16±1.48^b
Turret guard	27.67±1.40^b	41.60±3.06^b	33.12±2.38^b	29.43±2.92^c
Substation	23.41±1.75^c	32.53±1.12^c	44.10±2.67^c	25.45±1.88^d
Turret guard	31.20±1.60^d	34.82±2.22^d	39.79±1.46^d	32.20±2.13^c
Entrance door	41.65±1.39^e	39.10±2.11^e	30.63±1.44^e	27.19±2.25^c
Sewage treatment	43.65±1.18^a	41.32±1.76^b	32.51±1.22^b	21.87±1.75^e
Office of Education	39.55±1.28^e	35.78±1.92^d	42.36±1.39^c	30.32±1.49^f

*a, b, c, d, e, f showed a significant difference ($P<0.05$).

Table 4. Comparison of $PM_{2.5}$ and PM_{10} peripheral particulates with WHO standard

Mean	$PM_{2.5}$	PM_{10}
Spring	20.72±2.35^a	37.06±2.62^a
Summer	19.15±1.12^a	40.14±1.98^a
Autumn	3.86±1.48^a	43.82±2.68^b
Winter	13.65±1.59^c	29.36±1.16^c
Total mean	14.34±1.71	37.59±2.24^c
WHO	25	50

and compression of secondary particles. PM_{10} particles include all particles (fine particles, fine particles, and coarse particles) with a diameter of 10 μm or less [21, 22].

Airborne particulates of natural and human origin have significant effects on climate, the environment and human health [23]. Large structures such as cement factories that bring large amounts of dust particles into the environment always cause significant problems. Therefore, considering the level of contamination of these structures and the use of modern methods to control the pollution created by them such as bag filters, baggage, electrostatic precipitators and hybrid filters can greatly reduce environmental and health damage. Especially reduce the harmful effects for the staff in this area. In general, it can be concluded that an increase in the concentration of dust particles, in particular dust generated by industrial activity and a decrease in air quality, have adverse effects on human health in the long run [2, 24].

Conclusion

The particulate matter $PM_{2.5}$ and PM_{10} in environment of Khash cement company were lower compared to the standard 25 and 50 $\mu g/m^3$. According to the results, it can be stated that the suspended particles in environment of Khash cement company for human respiration were within acceptable limits.

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Competing interests

The authors declare that there are no competing interests.

Ethical considerations

Ethical issues have been completely observed by the authors.

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