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# Determining Suspended Particle Concentration in Vicinity of Cement Plant Flue

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***Abstract-*** Industrial development is one of inevitable necessities of human life. Therefore, rising number of industrial units means the production and entry of various pollutants to the surrounding production process and sometimes miles away or even other parts of our planet. Notably, along with the updated industries and accessories, industry-related pollution control systems and monitoring and measuring equipment have also been updated because human beings always require a clean and free from impurity for living. Suspended particles are one of major pollutants emitted from various resources especially cement plants. Considering the multiplicity of cement plants in Iran, dust and its adverse effects on environment, human, animals, and plants and the concerns of Iran's Environmental Protection Agency in terms of cement plant suspended particles are of great importance. This article aimed to investigate the level of suspended particle emission of five plants namely Khash, Khuzestan, Soufian, Bojnord, and Saveh Cement Plant, located in different five geographical and climatological locations. Considering the use of dust collector systems such as electro filter, filter bag, and bag house, suspended particles are expected to be in line with the environmental standards or even less. According to the results of modeling output suspended particles and field measurement validation, the average of suspended particles, considering the climatic conditions and sustainable climatic conditions, was 8 and 31.5μg/m$^3$ at 6476-m and 31.5-m distance from the flue foot.

***Keywords-*** *Cement, Air Pollution, Suspended Particles, Subsidence Distance, SCREEN MODEL 3*

## I. INTRODUCTION

Industrialization and growth of small and large industries cause the entry of various pollutants to surrounding areas. Clean air is one of basic needs of human beings. Cement industry is one of these industries. Dust emission is natural and inalienable at various stages of cement manufacturing from the supply of raw materials to cement packaging and loading. Suspended particles are the most important pollutants which sometimes cause the dissatisfaction of locals and stakeholders. Developing national environmental rules and regulations including cement would lead to clean air and realization of standards. Therefore, the pollution can be reduced or eliminated by taking proper measures into account and the use of proper dust collection equipment at various stages of manufacturing as numerous cement plants are considered green and environmentally-friendly units. Considering the importance of the topic and its adverse effects of local communities, it is essential to scientifically study the role of cement plants on suspended particle production and emission in surrounding areas. It is also necessary to measure $PM_{10}$ and $PM_{2.5}$, as the parameter of clean air inside plants according to the Environmental Protection Agency regulations. The pollutant emission caused by the manufacturing process through the flue s highlights the determination of clean air measurement stations outside of plants calculated by the air pollution modeling. Main flue emissions cause the dissatisfaction of locals and, in some cases, complaints to legal authorities. This article aimed to measure the emission of major flue s of five cement plants using Screen Model 3, which is air pollution modeling tool. As a result, dust subsidence distance is calculated in surrounding areas of plants. Then, the results were validated by field measurements.

## II. OBJECTIVES

- Determining suspended particle concentration of main flue of cement plants in surrounding areas
- Calculating the dust subsidence distance from the flue and its effect on local communities
- Determining the effectiveness of different parameters in emission and suspended particle subsidence place
- Determining the location and number of $PM_{10}$ and $PM_{2.5}$ measurement stations using air pollution modeling and subsidence points

## III. APPARATUS AND METHOD FOR MEASURING EXHAUST FLUE

Gravimetry is used to assess the suspended particles. In this method, isokinetic sampling is performed. Dust stays on filters after gas suction. Filter weight difference before and after the suction shows the amount of dust. Greasebye device was used to measure the output dust of the main flue in the plants under

consideration. The device for measuring the outlet dust of the main flue consists of a pump for sucking the air connected to a metal pipe. The main task of the metal pipe is to tolerate the flue's inner temperature. First, we weighed the absorbing filter for the measurement and leave it in the special holder. Then, we connect it to the pump. The measured values inside the flue can be modified to standard ones by measuring the flue's flow rate (isokinetic mode). It is essential to be careful to vertically insert the metal pipe into to the flue. Then, total the plant's total outlet particles are calculated by calculating the filter weight before and after the measurement.

## IV. Environmental Dust Measurement

TSI (8520 Model) was used to measure the suspended particles. In this device, suspended particles of the ambient air is deposited as the samples of gravity by a small sucking pump on a fiber glass paper in order to make the calculation of the concentration possible by weight considering the volume of passing air from the fiber glass pores.

## V. Modeling by Screen Model 3

Table 2 shows the information needed for modeling. Suspended particle receptors are embedded on the ground.

Screen 3 was employed for modeling in two modes: meteorologically stable conditions and constant conditions based on regional climatic conditions.

Comparing the results showed that environmental standards have been observed. Using the analysis of tables 3 and 4 helps us to draw a conclusion that, based on table 5, the average suspended particle concentration was 8 $\mu g/m^3$ in the vicinity of cement plant at 6476-m distance from the flue foot. It was, however, 31.5 $\mu g/m^3$, if meteorologically stable conditions were taken into account.

## VI. Environmental Suspended Particle Measurement

In order to validate the concentration of suspended particles, Screen 3 was employed to measure the concentration of suspended particles in the vicinity of cement plants. Due to scattered conditions of cement plants, Dynamic light scattering (DLS) was employed using TSI (8520 Model) at 500 southeast and 200 north to the nearest village. Tables 9 to 12 show the results. Wind direction was northwest-southeast.

The average of suspended particles shows the environmental standard observation in two sides of the plant. $PM_{2.5}$ was only greater than the standard limit on northern side of the plants. This is notable due to the direction of the wind.

## VII. Conclusion

Modeling diagrams show the following results:

Considering the regional climatic conditions, the concentration of the emitted suspended particles ranged between 1.5 and 3.9 $\mu g/m^3$ at 3627-3769-m distance in four measurement periods in Khash plant. It, however, ranged between 10.29 and 26.45 at 970-991-m distance if meteorologically stable conditions are taken into account.

Considering the regional climatic conditions, the concentration of the emitted suspended particles ranged between 1.02 and 8.89 $\mu g/m^3$ at 3788-4034-m distance in Khuzestan plant. It, however, ranged between 32 and 37.99 at 952-1018-m distance if meteorologically stable conditions are taken into account.

Considering the regional climatic conditions, the concentration of the emitted suspended particles ranged between 2.81 and 3.25 $\mu g/m^3$ at 5029-5257-m distance in Bojnourd plant. It, however, ranged between 14.23 and 29.67 at 976-983-m distance if meteorologically stable conditions are taken into account.

Considering the regional climatic conditions, the concentration of the emitted suspended particles ranged between 2.38 and 2.76 $\mu g/m^3$ at 5148-5197-m distance in Soufian plant. It, however, ranged between 23.45 and 28.15 at 1015-1056-m distance if meteorologically stable conditions are taken into account.

Considering the regional climatic conditions, the concentration of the emitted suspended particles ranged between 1.13 and 1.99 $\mu g/m^3$ at 5055-52294-m distance in Saveh plant. It, however, ranged between 18.63 and 3047 at 998-1036-m distance if meteorologically stable conditions are taken into account.

The modeling results in five plants showed that the average of suspended particles was 8 $\mu g/m^3$ at distances greater than 6 kilometers far from the plant. It was less than 1 $\mu g/m^3$ at distances greater than 23 kilometers. Considering the meteorologically stable conditions, the greatest concentration was 31.5 $\mu g/m^3$ at a distance 989 meters far from the plant. The concentration reached less than 1 $\mu g/m^3$ at distances 50 kilometers far from the flue foot. On the other hand, sampling in northern and southeastern side of Khuzestan plant showed rge standard suspended particles in the environment. Although the measurement results in the vicinity the plants were higher than the modeling results, it is acceptable and obvious due to the path suspended particles pass from the flue to environment. The concentration of suspended particles in the vicinity of plant is not only caused by the cement particles from the flue. Undoubtedly, they have been mixed with other particles which can be characterized by the chemical analysis. It is therefore claimed that the suspended particle emission is far lower than the standard developed by the Iran's Environmental Protection Agency if the filtration devices work properly. Accordingly, residential areas would not be affected. In this case, 25 kilometers is considered the safe radius. The plants under consideration in our study are located at distances greater than 20 km and the nearest village is located 2500 meters from the plant. According to the results, the effective concentration in ecological communities declined at distances greater than the national standards, while the highest concentration was

reported inside the plant and at distances fewer than one kilometer from the flue foot at meteorologically stable conditions. This would affect the health of staff and vegetation. Compared to the modeling results, the environmental measurement results showed that the suspended particle emission was higher. Therefore, it is concluded that the suspended particles in the vicinity of the plant was not only caused by cement and other environmental factors are involved including the emissions from other industries such as mineral depots, transportation, etc.

According to tables 4 and 5, the highest suspended particles are as follows in the nearest residential areas:

Considering the climatic conditions, the highest concentration of suspended particles ranges from 1.4 to 3.52 $\mu g/m^3$ in the nearest village to Khash plant. It, however, ranged from 4 to 10 $\mu g/m^3$ if stable conditions are taken into account. This is consistent with the environmental standards.

Considering the climatic conditions, the highest concentration of suspended particles ranges from 0.9 to 1.8 $\mu g/m^3$ in the nearest village to Bojnourd plant. It, however, ranged from 7 to 15 $\mu g/m^3$ if stable conditions are taken into account. This is consistent with the environmental standards.

Considering the climatic conditions, the highest concentration of suspended particles ranges from 1.1 to 1.8 $\mu g/m^3$ in the nearest village to Saveh plant. It, however, ranged from 7 to 9 $\mu g/m^3$ if stable conditions are taken into account. This is consistent with the environmental standards.

Considering the climatic conditions, the highest concentration of suspended particles ranges from 0.9 to 1.8 $\mu g/m^3$ in the nearest village to Khuzestan plant. It, however, ranged from 7 to 55 $\mu g/m^3$ if stable conditions are taken into account. This is consistent with the environmental standards. In spring 2015, the outlet dust was greater than the environmental standards due to the failure of Line 2 filtration.

Considering the climatic conditions, the highest concentration of suspended particles ranges from 0.6 to 1.5 $\mu g/m^3$ in the nearest village to Soufian plant. It, however, ranged from 7 to 16 $\mu g/m^3$ if stable conditions are taken into account. This is consistent with the environmental standards.

Considering above issues, the distance of villages from the plants according to tables 6 and 6, and the observation of environmental standards, it is claimed that the nearest villages are affected by the suspended particles. Therefore, other sources than cement needs to be sought. An important and vital issue in controlling and decreasing the suspended particles in cement industry is the proper performance of filtration systems, timely maintenance, and observation of environmental standards.

## VIII. Discussion

The results of our study are consistent with those of the study by Goudarzi et al. (2014) who studied the emission of suspended particles in Lorestan Cement Plant using Gauss method which is the basis of Screen 3 modeling. Their results showed that the highest concentration was 64.283 $\mu g/m^3$ at 760 meters from the flue foot. The results of our study also showed that the highest concentration was 8.17 $\mu g/m^3$ at 6474 m in climatic conditions. In meteorologically stable conditions, the highest concentration was 31.54 $\mu g/m^3$ at 988 meter from the flue foot.

Nour Pour et al. (2015) studied the emission of pollution in Abyek Cement Plant using AERMOD model. The results showed that the highest concentration was 68.43 $\mu g/m^3$ at 1500 to the east and 2100 meters from the north of the plant. The results are consistent with the modeling results considering the climatic conditions.

Asghar Azad et al. (2013) studied the concentration using Gauss by Disper 4. The results showed that the maximum concentration was 54.7 $\mu g/m^3$ at 221 meter distance and the maximum NOx was 6.70 $\mu g/m^3$ at 1415 meter distance. Maximum concentration of CO was 6.05 $\mu g/m^3$ at 1045 meter distance. The results are consistent with those of modeling at meteorologically stable conditions. Therefore, it is claimed that the highest concentration was at distances closer than 1000 meters from the flue foot. The maximum concentration would reach 6500 meters if regional winds are taken into account.

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TABLE I. AIR POLLUTANTS IN CEMENT INDUSTRY

| No. | Pollutant | Major Polluting Processes in Daily Activities of Cement Plant | | | | |
|---|---|---|---|---|---|---|
| | | Heating | Raw Material Grinding | Cement Grinding | Packing & Shipping | heating, cooling, transport |
| 1 | $NO_X$ | * | | | | * |
| 2 | CO&$CO_2$ | * | | | | * |
| 3 | $SO_2$ | * | | | | * |
| 4 | THC | * | | | | * |
| 5 | TSPM | * | * | * | * | * |
| 6 | Dust | * | * | * | * | * |

TABLE II. PLANT'S ENVIRONMENTAL PARAMETERS

| Plant/Parameter | Khash | Khuzestan | | Bojnourd | Soufian | | Saveh Gray Cement |
|---|---|---|---|---|---|---|---|
| | | Line 1 | Line 2 | | Furnace3 | Furnace4 | |
| Flue Height from Ground (m) | 86 | 110 | 110 | 106 | 120 | 120 | 126 |
| Nearest Residential Area from Flue (m) | 5000 | 3000 | 3000 | 2500 | 2500 | 2500 | 7000 |
| Receptor Height from Ground (m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wind Speed (m/s) | 14.8 | 7.6 | | 8 | 16 | | 15.2 |

TABLE III. SUSPENDED PARTICLES AFTER EMISSION FROM FLUE (REGIONAL CLIMATIC CONDITION)

| No. | Unit | Measurement Period | Maximum Concentration of Suspended Particles ($\mu g/m^3$) | Distance from Flue Foot (m) | Suspended Particle Deposition Distance (m) | Suspended Particle Concentration in Village Vicinity ($\mu g/m^3$) | Distance between Village and Plant (m) |
|---|---|---|---|---|---|---|---|
| 1 | Khash | 1st Quarter, 1394 [1] | 1.5 | 3627 | 10000 | 1.4 | 5000 |
| 2 | Khash | 2nd Quarter, 1394[2] | 3.45 | 3643 | 17000 | 3.2 | |
| 3 | Khash | 3rd Quarter, 1394[3] | 3.90 | 3769 | 20000 | 3.52 | |
| 4 | Khahs | 4th Quarter, 1394[4] | 1.91 | 3397 | 10000 | 1.7 | |
| Average | | | 2.69 | 3609 | 14250 | 2.45 | |
| 5 | Khuzestan Line 1 | 1st Quarter, 1394 [5] | 3.67 | 6176 | 30000 | 2 | 3000 |
| 6 | Khuzestan Line 1 | 2nd Quarter, 1394[6] | 3.72 | 6485 | 34000 | 1.9 | |
| 7 | Khuzestan Line 1 | 3rd Quarter, 1394[7] | 1.02 | 3788 | 5000 | 0.9 | |
| Average | | | 2.80 | 5483 | 23000 | 1.6 | |
| 8 | Khuzestan Line 2 | 1st Quarter, 1394 [8] | 8.89 | 4034 | 40000 | 8.1 | 3000 |
| 9 | Khuzestan Line 2 | 2nd Quarter, 1394[9] | 3.67 | 7474 | 38000 | 1.5 | |
| 10 | Khuzestan Line 2 | 3rd Quarter, 1394[10] | 4.57 | 7810 | 50000 | 1.6 | |
| 11 | Khuzestan Line 2 | 4th Quarter, 1394[11] | 3.77 | 5500 | 28000 | 2.5 | |
| Average | | | 5.22 | 6204 | 39000 | 3.42 | |
| 12 | Bojnourd | 1st Quarter, 1394 [12] | 2.81 | 5257 | 22000 | 1.4 | 2500 |
| 13 | Bojnourd | 2nd Quarter, 1394[13] | 3.25 | 5029 | 25000 | 1.8 | |
| 14 | Bojnourd | 3rd Quarter, 1394[14] | 2.46 | 5081 | 18000 | 0.9 | |
| Average | | | 2.84 | 5122 | 21600 | 1.36 | |
| 15 | Soufian Furnace 3 | 1st Quarter, 1394 [15] | 1.66 | 4503 | 12000 | 1.05 | 2500 |
| 16 | Soufian Furnace 3 | 2nd Quarter, 1394[16] | 0.91 | 4568 | 5000 | 0.6 | |
| 17 | Soufian Furnace 3 | 3rd Quarter, 1394[17] | 0.96 | 4533 | 5000 | 0.6 | |
| Average | | | 1.17 | 4534 | 7300 | 1.12 | |
| 18 | Soufian Furnace 4 | 1st Quarter, 1394 [18] | 2.64 | 4992 | More than 50000 | 1.5 | 2500 |
| 19 | Soufian Furnace 4 | 2nd Quarter, 1394[19] | 2.38 | 5148 | More than 50000 | 1.3 | |
| 20 | Soufian Furnace 4 | 3rd Quarter, 1394[20] | 2.76 | 5197 | More than 50000 | 1.5 | |
| Average | | | 7.78 | 5112 | More than 50000 | 1.5 | |
| 21 | Saveh | 1st Quarter, 1394 [21] | 1.99 | 5229 | 12000 | 1.8 | 7000 |
| 22 | Saveh | 2nd Quarter, 1394[22] | 1.13 | 5055 | 7000 | 1.1 | |
| 23 | Saveh | 3rd Quarter, 1394[23] | 1.35 | 4938 | 9000 | 1.3 | |
| Average | | | 1.49 | 5074 | 9300 | 4.2 | |

[1] Mach 2015 to May 2015
[2] June 2015 to August 2015
[3] September 2015 to November 2015
[4] December 201 to February 2016
[5] Mach 2015 to May 2015
[6] June 2015 to August 2015
[7] September 2015 to November 2015
[8] Mach 2015 to May 2015
[9] June 2015 to August 2015
[10] September 2015 to November 2015
[11] December 201 to February 2016
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[13] June 2015 to August 2015
[14] September 2015 to November 2015
[15] Mach 2015 to May 2015
[16] June 2015 to August 2015
[17] September 2015 to November 2015
[18] Mach 2015 to May 2015
[19] June 2015 to August 2015
[20] September 2015 to November 2015
[21] Mach 2015 to May 2015
[22] June 2015 to August 2015
[23] September 2015 to November 2015

TABLE IV. SUSPENDED PARTICLES AFTER EMISSION FROM FLUE (METEOROLOGICALLY STABLE CONDITIONS)

| No. | Unit | Measurement Period | Maximum Concentration of Suspended Particles ($\mu g/m^3$) | Distance from Flue Foot (m) | Suspended Particle Deposition Distance (m) | Suspended Particle Concentration in Village Vicinity ($\mu g/m^3$) | Distance between Village and Plant (m) |
|---|---|---|---|---|---|---|---|
| 1 | Khash | 1st Quarter, 1394 [1] | 10.29 | 970 | More than 50000 | 4 | 5000 |
| 2 | Khash | 2nd Quarter, 1394[2] | 22.90 | 982 | More than 50000 | 9 | |
| 3 | Khash | 3rd Quarter, 1394[3] | 26.45 | 991 | More than 50000 | 10 | |
| 4 | Khahs | 4th Quarter, 1394[4] | 17.72 | 951 | More than 50000 | 5 | |
| Average | | | 18.09 | 973.5 | More than 50000 | 7 | |
| 5 | Khuzestan Line 1 | 1st Quarter, 1394 [5] | 32 | 952 | More than 50000 | 16 | 3000 |
| 6 | Khuzestan Line 1 | 2nd Quarter, 1394[6] | 33.41 | 964 | More than 50000 | 17 | |
| 7 | Khuzestan Line 1 | 3rd Quarter, 1394[7] | 11.95 | 781 | More than 50000 | 7 | |
| Average | | | 25.78 | 899 | More than 50000 | 13.3 | |
| 8 | Khuzestan Line 2 | 1st Quarter, 1394 [8] | 115 | 774 | More than 50000 | 55 | 3000 |
| 9 | Khuzestan Line 2 | 2nd Quarter, 1394[9] | 29.74 | 1065 | More than 50000 | 15 | |
| 10 | Khuzestan Line 2 | 3rd Quarter, 1394[10] | 37.99 | 1078 | More than 50000 | 19 | |
| 11 | Khuzestan Line 2 | 4th Quarter, 1394[11] | 32.80 | 1018 | More than 50000 | 16 | |
| Average | | | 53.88 | 983.75 | More than 50000 | 26.25 | |
| 12 | Bojnourd | 1st Quarter, 1394 [12] | 25 | 1005 | More than 50000 | 13 | 2500 |
| 13 | Bojnourd | 2nd Quarter, 1394[13] | 29.67 | 976 | More than 50000 | 15 | |
| 14 | Bojnourd | 3rd Quarter, 1394[14] | 14.23 | 983 | More than 50000 | 7 | |
| Average | | | 22.96 | 988 | More than 50000 | 11.66 | |
| 15 | Soufian Furnace 3 | 1st Quarter, 1394 [15] | 26.85 | 964 | More than 50000 | 14 | 2500 |
| 16 | Soufian Furnace 3 | 2nd Quarter, 1394[16] | 13.65 | 995 | More than 50000 | 7 | |
| 17 | Soufian Furnace 3 | 3rd Quarter, 1394[17] | 14.48 | 989 | More than 50000 | 7 | |
| Average | | | 18.32 | 982.6 | More than 50000 | 9.33 | |
| 18 | Soufian Furnace 4 | 1st Quarter, 1394 [18] | 28.15 | 1015 | More than 50000 | 16 | 2500 |
| 19 | Soufian Furnace 4 | 2nd Quarter, 1394[19] | 23.45 | 1056 | More than 50000 | 14 | |
| 20 | Soufian Furnace 4 | 3rd Quarter, 1394[20] | 27.06 | 1062 | More than 50000 | 15 | |
| Average | | | 78.66 | 1044.3 | More than 50000 | 15 | |
| 21 | Saveh | 1st Quarter, 1394 [21] | 30.47 | 1036 | More than 50000 | 9 | 7000 |
| 22 | Saveh | 2nd Quarter, 1394[22] | 18.63 | 998 | More than 50000 | 7 | |
| 23 | Saveh | 3rd Quarter, 1394[23] | 23.50 | 970 | More than 50000 | 8 | |
| Average | | | 24.2 | 1001.3 | More than 50000 | 8 | |

[1] Mach 2015 to May 2015
[2] June 2015 to August 2015
[3] September 2015 to November 2015
[4] December 201 to February 2016
[5] Mach 2015 to May 2015
[6] June 2015 to August 2015
[7] September 2015 to November 2015
[8] Mach 2015 to May 2015
[9] June 2015 to August 2015
[10] September 2015 to November 2015
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[13] June 2015 to August 2015
[14] September 2015 to November 2015
[15] Mach 2015 to May 2015
[16] June 2015 to August 2015
[17] September 2015 to November 2015
[18] Mach 2015 to May 2015
[19] June 2015 to August 2015
[20] September 2015 to November 2015
[21] Mach 2015 to May 2015
[22] June 2015 to August 2015
[23] September 2015 to November 2015

TABLE V. AVERAGE CONCENTRATION OF SUSPENDED PARTICLES IN THE VICINITY OF CEMENT PLANT

| Parameter/ Condition | Maximum Concentration of Suspended Particles (μg/m$^3$) | Distance from Flue Foot (m) | Suspended Particle Deposition Distance (m) |
|---|---|---|---|
| Regional Climatic Conditions | 8 | 6476 | 23492 |
| Meteorologically Stable Conditions | 31.5 | 989 | More than 50000 |

TABLE VI. $PM_{10}$ CONCENTRATION IN SOUTH EAST OF KHUZESTAN CEMENT PLANT

| No.1 | Sampling Location | Concentration (μg/m$^3$) |
|---|---|---|
| 1 | 1000 meters from plant | 49 |
| 2 | 1500 meters from plant | 45 |
| 3 | 2000 meters from plant | 51 |
| 4 | 2500 meters from plant | 46 |
| 5 | 3000 meters from plant | 50 |
| Average | | 48.2 |
| Iran's Environmental Protection Agency | | 50 |

TABLE VII. $PM_{10}$ CONCENTRATION IN NORTH OF KHUZESTAN CEMENT PLANT

| No.1 | Sampling Location | Concentration (μg/m$^3$) |
|---|---|---|
| 1 | 200 meters from plant | 41 |
| 2 | 400 meters from plant | 57 |
| 3 | 600 meters from plant | 44 |
| 4 | 800 meters from plant | 50 |
| 5 | 1000 meters from plant | 41 |
| Average | | 46.6 |
| Iran's Environmental Protection Agency | | 50 |

TABLE VIII. $PM_{2.5}$ CONCENTRATION IN SOUTH EAST OF KHUZESTAN CEMENT PLANT

| No.1 | Sampling Location | Concentration (μg/m$^3$) |
|---|---|---|
| 1 | 1000 meters from plant | 23 |
| 2 | 1500 meters from plant | 26 |
| 3 | 2000 meters from plant | 31 |
| 4 | 2500 meters from plant | 24 |
| 5 | 3000 meters from plant | 20 |
| Average | | 24.8 |
| Iran's Environmental Protection Agency | | 25 |

TABLE IX. $PM_{2.5}$ CONCENTRATION IN NORTH OF KHUZESTAN CEMENT PLANT

| No.1 | Sampling Location | Concentration (μg/m$^3$) |
|---|---|---|
| 1 | 200 meters from plant | 19 |
| 2 | 400 meters from plant | 33 |
| 3 | 600 meters from plant | 30 |
| 4 | 800 meters from plant | 27 |
| 5 | 1000 meters from plant | 24 |
| Average | | 26.6 |
| Iran's Environmental Protection Agency | | 25 |