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Investigating the environmental status of air pollution in Iran's ferroalloy industries (IFI)

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ABSTRACT

Ferrosilicon was used as a modifier in steel and cast-iron production. The most critical pollutants in the ferrosilicon industry are particulate matter ($PM_{2.5}$ and PM_{10}) and dust, CO, CO_2, NO_x, and So_x. This study aimed to investigate the environmental status of air pollution in Iran's ferroalloy industry by examining air pollutant control equipment. Iran's ferroalloys industries (IFI), with a production capacity of 60 thousand tons of ferrosilicon, is located in Lorestan province. Air pollutants were measured in the years 2020 and 2021. The exhaust gases and dust were measured by the XL350 and Westech portable particulate detectors, and ambient particulate matter was measured by the Dust Trak 8520. The data analysis was done using SPSS and Excel software. So that the normality of the data was reviewed using the Kolmogorov-Smirnov test and the average of the data was compared with the pollution standards using the one-sample t-test. The results showed that all measured parameters of gases, dust, and ambient particulate matter ($PM_{2.5}$ and PM_{10}) during the studied years of 2020 and 2021 were in accordance with the pollution standard. Having suitable environmental equipment including U-shaped pipes to cool the flue gases from the furnace area to the bag house, a cyclone separator for dust removal, the collection of particulate matter (PM), and bag filters in the baghouse have been used for collecting particulate matter (PM) and filtering dust. Also, green space, with more than 60% of the industry space, has played a very effective role in reducing industrial air pollution.

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1. Introduction

Ferroalloys are alloys containing iron with a high proportion of one or more other elements such as silicon, manganese, molybdenum, chromium, etc. They are used as alloying additions in steel to improve properties, especially wear, tensile strength, resistance, and corrosion. The iron and steel industry is the primary consumer of ferroalloy, so ferroalloy production is closely related to steel production. The main ferroalloys are ferrochromium, silicomanganese, ferrosilicon, ferromanganese, ferronickel, ferrovanadium, ferrotungsten, ferrotitanium, and ferromolybdenum. The shows of ferrosilicon in ferroalloy industries in the world are produced using the method of electric arc furnaces (Figure 1).

Ferrosilicon is an alloy of silicon and iron that contains between 15 and 90% silicon. Ferrosilicon alloy is used in the steel and foundry industry as an oxygen remover and an alloy component in the production of steel and cast iron as a modifier that is added in the melting process (Haque and Norgate, 2013; Hycnar et al., 2014). In this regard, air pollution is one of the most critical environmental issues of these industries (Faridi et al., 2018; Karimi et al., 2019). Air pollutants produced in the ferrosilicon production industry include particulate matter ($PM_{2.5}$ and PM_{10}), dust particulates, carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen oxides (NOx), and sulfur oxides (SOx) are mentioned.

Particulates ($PM_{2.5}$ and PM_{10}) are mainly in emptying and storing raw materials, transferring raw materials to the depot and storing them in the factory, transferring raw materials to the furnace, furnace process, smelting, purification process, and casting process. Grinding and refining, crushing, sieving, and packaging of the product are produced. The most critical air pollutant caused by the activity of the ferrosilicon production unit is particulates and dust in the smoke produced from furnaces. Of course, due to the ferrosilicon production process and the use of coal and coke, there is a possibility of releasing small amounts of nitrogen oxides (NOx) and sulfur oxides (SOx). Particulate matter is produced in bag filters that are commercially called microsilica, which are often used as concrete fillers and for use in cement and concrete industries, refractory and ceramic industries, chemical and polymer industries, and various applications. Another possible pollutant in the exhaust fumes is carbon monoxide (CO), which generally constitutes 70% of the gases in the ferrosilicon production industry and can be released through regenerators, electrodes, and carbon paste. There will also be the possibility of releasing sulfur dioxide gas (SO_2) through regenerators and nitrogen oxides (NOx) through combustion (Kero et al., 2017; Panjwani et al., 2020; Saevarsdottir et al., 2021). It seems that by referring to the existing specialized sources, very few researches have been done in Iran regarding the release of air pollutants from ferrosilicon-producing industries, some researchers outside of Iran studied this issue. Some of them can be mentioned. Panjwani and Olsen (2013) investigated a model to predict and increase the understanding of combustion and NOx formation in electric arc furnaces used to produce ferrosilicon and silicon. They showed that NOx emissions when using wet raw materials compared to using dry raw materials are reduced. Kero et al. (2015) investigated the size distribution of particulate emissions from ferroalloy industries (silicomanganese and ferrosilicon) by electric low-pressure impactors, which were able to identify particulate matter produced in the indoor air of metallurgical production centers. Nygard et al. (2019) investigated the absorption of carbon in molten salts as a method to absorb CO_2 from various flue gases related to electricity generation and high-energy industrial processes in the production of ferrosilicon. They found that the investigated way is an alternative technology. It is a good competition for full-scale CO_2 capture for ferrosilicon production with the aim of energy recovery. Kero et al. (2021) investigated the size distribution of airborne particles in a ferrosilicon smelter and identified various sources of dust and fumes present in the plant. So that thermal particles produced, called metallurgical fumes, have been recorded in this type of industry in tapping, refining, and other processes where the liquid alloy comes into contact with air. Air pollution is one of the most critical environmental issues of ferrosilicon-producing industries, and one of the requirements of these industries is to review the status of air pollutants and reduce these pollutants. Therefore, the purpose of this study was to investigate the environmental situation of air pollution in the ferrosilicon industry, focusing on Iran's ferroalloy industries, by examining air pollution control equipment.

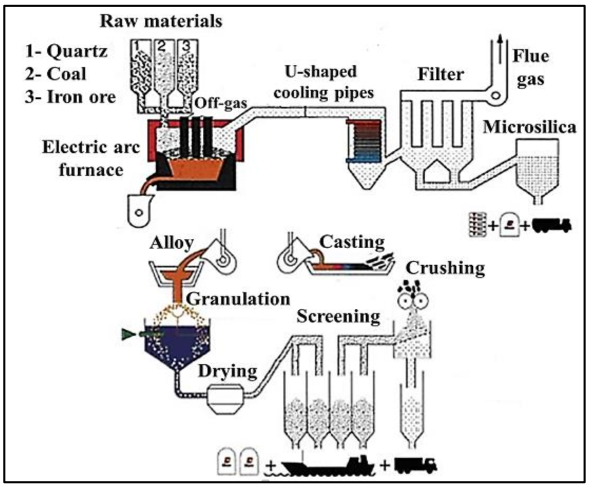

Fig. 1. Schematic of the ferrosilicon production process

2. Material and Methods

2.1. Study area

Iran's ferroalloy industries (IFI) are located in the southwestern part of Momen Abad of Azna city in Lorestan province and km 20 of Azna-Arak Road (Figure 2). This factory was established to produce ferrosilicon as one of the primary strategic raw materials of steel and cast iron industries in 1986 on a land of 70 hectares, its first phase operation was officially put into operation in February 1991. Currently, the factory is the largest producer and exporter of ferrosilicon in Iran and West Asia, with an annual production of 60,000 tons of ferrosilicon and 20,000 tons of microsilica powder with three furnaces. This factory is one of the largest producers of ferrosilicon in the world, and approximately 60% of the products of the collection are supplied to domestic markets, and the rest are exported to more than 25 countries, including Turkey, Germany, Italy, Czech Republic, France, Greece, Serbia, India, and Pakistan.

Fig. 2. Geographical location of Iran's ferroalloy industries

2.2. Measurement of air pollutants

Air pollutants, including gases and dust exhaust from the chimney and ambient particulate matter in Iran's ferroalloy industries (the results of environmental self-declaration), were measured once every three months for the years 2020 and 2021 according to the standards of the Environment Organization. The exhaust gases from the chimney were measured with ASTMD6522-EPACTM-030 standard and with XL350 gas meter from Testo Company. This device sucks the exhaust gases from the chimneys from the sampling location using a probe with high-temperature tolerance (1300 °C) by a pump towards the sensors in the device, each sensor reads its gas and analyzes its data. The dust exhaust of the chimneys was measured according to the ISO 9096 standard and by a Westech portable particulate measuring device made in England by gravimetric method and isokinetic. The height of the chimneys from the position of gas entry was 34.3 meters, the height of the sampling place was 31.3 meters from the place of gas entry, the longitude was 36°24'32" N, and the latitude was 37°17'30" E for the sampling location. Ambient particulate matter according to BS-EN-12341 standards was measured with Dust Trak 8520 ambient particulate matter measuring device from Tsi Company. The performance of the device in the form of weighing and direct reading is based on the method of sending laser beams, which measure airborne particulates ($PM_{2.5}$ and PM_{10}), and the measurement is done by way of reducing the absorption of beta rays. In this way, the device was placed in a suitable position and preferably slightly above the ground level (at the height of 1.5 meters from the ground level), and the relevant nozzles (2.5 and 10 microns) were installed on the device. Then, according to the location, the flow of the device was adjusted. After calibrating the device, sampling was done at a specific time, and according to the capabilities of the device, the average amount of particulate matter in the ambient air per volume unit (µg/m³) was calculated and presented.

2.3. Data analysis

After measuring the data of air pollutants during the studied years, data analysis was done using SPSS version 22 and Excel software. So that the normality of the data was checked using the Kolmogorov-Smirnov test and the average data was compared with the pollution standards using the one-sample t-test in the SPSS software.

3. Results and discussion

3.1. Kolmogorov-Smirnov and one-sample t-tests

Survey of the normality of the data of gases and dust coming out of the chimney and ambient particulate matter was done using the Kolmogorov-Smirnov test with a confidence level of 95% using SPSS version 22 software, and the results are shown in Table 1. In this test, if the value of sig (p-value) is greater than the significance level of 0.05, then the data is normal, and if it is less than 0.05, then the data is not normal (Mishra et al., 2019). Considering that the values of sig (p-value) for all data are greater than the significance level of 0.05, it indicates the normality of the data.

Table 1. Survey the normality of the data by the Kolmogorov-Smirnov test

Air parameters	Samples number	Average	Standard deviation	Kolmogorov-Smirnov test		
				Statistics	df	Sig (p-value)
SO_2	56	7.53	2.92	0.091	55	0.200
NOx	56	12.33	4.87	0.119	55	0.051
CO	56	15.87	6.28	0.113	55	0.077
Dust (dry)	56	79.38	7.97	0.026	55	0.200
Dust (wet)	56	59.98	5.56	0.088	55	0.200
$PM_{2.5}$	64	19.79	5.99	0.066	63	0.200
PM_{10}	64	25.14	8.49	0.050	63	0.200

Also, the results of comparing the average data with pollution standards using the one-sample t-test at the 95% confidence level are shown in Table 2. The single-sample t-test is used when we have a sample of the population and want to compare its average with a common standard. Among the assumptions of this test is the normality of the data, whose normal distribution was performed using the Kolmogorov-Smirnov test with a confidence level of 95% (Table 1). In this research, the average data values of gases and dust coming out of the chimney and ambient particulate matter were compared with the pollution standards of each parameter. In this test, hypothesis H_0 for the equality of the averages of the parameters with the standard value and hypothesis H_1 for the inequality of the averages of the parameters with the standard value were considered and it was investigated that there is a significant difference between the averages of the two methods or not. If the value of the sig (p-value) of this test is less than the significance level of 0.05, then it can be concluded that there is a statistically significant difference between the two real (parameter) and assumed (pollution standard) averages (Lianga et al., 2019). Considering that the average of all the parameters is lower than their standard average and the value of sig (p-value) for them is (0.000) and less than the significance level of 0.05, therefore the hypothesis H0 is rejected and there is a significant difference between their averages.

Table 2. The t-test statistic to compare the average data with pollution standards

Air parameters	t number	df	Sig (p-value)	Mean difference	Lower	Upper	Base average
SO_2	-691.06	55	0.000	-272.47	-273.26	-271.68	280
NOx	-575.50	55	0.000	-377.67	-378.94	-373.53	390
CO	-642.20	55	0.000	-544.13	-545.83	-542.43	560
Dust (dry)	-19.19	55	0.000	-20.62	-22.77	-18.47	100
Dust (wet)	-53.83	55	0.000	-40.02	-41.51	-38.53	100
$PM_{2.5}$	-19.54	63	0.000	-15.02	-16.56	-13.49	35
PM_{10}	-112.14	63	0.000	-124.54	-126.76	-122.32	50

3.2. Gases and dust exhaust of the chimney

Exhaust gases from the chimney and dust with the permissible emission limits of air pollutants in industries (other industrial units with any production process that Iran's ferroalloy industries (IFI) are included in this group) based on the approval letter of the government (in 2015) regarding the determination of the permissible limits of standards the output from factories and industrial workshops were compared according to the proposal of the Environmental Protection Organization of Iran and based on the matter (15) of the law on how to prevent air pollution approved in 1995. The results of exhaust gases from the chimney of Iran's ferroalloy industries for the years 2020 and 2021 are shown in Tables 3 and 4, respectively. Also, the dust results are shown in Figures 3 and 4. The results of gases and dust particulates based on the mentioned grade 1 standard (dust particulates standard equal to 100 mg/Nm^3, SO_2 gases equal to 280 g/m^3, NOx equal to 390 g/m^3, and CO equal to 560 g/m^3) showed that all the parameters were measured according to the standard. There was no contamination regarding these parameters. The one-sample t-test to compare the average of gases and dust with their pollution standards also proved this issue. The highest amount of dry dust in all measurement years is 99.8 mg/Nm^3 in the furnace 1 outlet 2 in May 2020 (Figure 3), and the lowest amount is 58.1 mg/Nm^3 in the furnace 3 outlet 2 in February it was the year 2020 (Figure 3). Also, the highest amount of wet dust in all the measurement years is equal to 74.1 mg/Nm^3 in furnace 4 outlet 1 in May 2020 (Figure 3) and the lowest amount of 47.6 mg/Nm^3 in furnace 3 outlet 2 in it was in February 2020 (Figure 3). The reasons for this issue can be attributed to the different channeling systems of smoke transmission from the tapping and opening and closing of the damper valve of the furnaces, which in some parts of furnace 1 we see the wear and tear of this system.

Table 3. The results of exhaust gases from the chimney of Iran's ferroalloy industries (IFI) with electric arc fuel (the year 2020)

Sampling month	Sampling place	CO_2 %	CO g/m^3	NO g/m^3	NO_2 g/m^3	SO_2 g/m^3	H_2S g/m^3	The gas temperature of the chimney (°C)
May	Furnace 1, Outlet 1	2.1	19	9	0.5	12	0	**142**
	Furnace 1 Outlet 2	1.9	25	14	0.4	15	0	**139**
	Furnace 2 Outlet 1	1.7	22	18	2.1	7	1	**117**
	Furnace 2 Outlet 2	0.8	20	19	2.4	8	1	**114**
	Furnace 2 Outlet 3	0.9	30	16	2.1	10	1	**109**
	Furnace 3 Outlet 1	1.1	19	17	2	12	1	**114**
	Furnace 3 Outlet 2	1.6	21	17	2.4	12	1	**112**
	Furnace 3 Outlet 3	1.7	34	19	1.8	8	1	**117**
August	Furnace 2 Outlet 1	0.6	10	6	0.3	4	0	**118**
	Furnace 2 Outlet 2	0.9	10	4	0.6	7	0	**114**
	Furnace 2 Outlet 3	2.1	7	10.2	1.4	3	0	**109**
	Furnace 3 Outlet 1	0.2	12	5	0.9	4	0	**121**
	Furnace 3 Outlet 2	0.1	7	9	0.8	5	0	**115**
	Furnace 3 Outlet 3	0.3	8	8	8	3	0	**128**
November	Furnace 2 Outlet 1	1.6	15	9	1.2	4	1	**109**
	Furnace 2 Outlet 2	1.4	8	7	1.3	7	1	**107**
	Furnace 2 Outlet 3	0.7	6	11	2.3	7	0	**112**
	Furnace 3 Outlet 1	0.3	8	10	1.3	9	0	**121**
	Furnace 3 Outlet 2	0.5	12	9	1	9	0	**116**
	Furnace 3 Outlet 3	1.1	10	6	0.3	8	1	**114**
February	Furnace 2 Outlet 1	0.9	9	6	0.4	6	0	**101**
	Furnace 2 Outlet 2	1	6	4	0.8	9	0	**114**
	Furnace 2 Outlet 3	0.5	10	9	1.7	9	0	**104**
	Furnace 3 Outlet 1	0.2	12	7	1.8	5	0	**109**
	Furnace 3 Outlet 2	0.3	11	10	2.1	12	1	**106**
	Furnace 3 Outlet 3	0.1	8	8	1.5	10	1	**99**

Table 4. The results of exhaust gases from the chimney of Iran's ferroalloy industries (IFI) with electric arc fuel (the year 2021)

Sampling month	Sampling place	CO_2 %	CO g/m^3	NO g/m^3	NO_2 g/m^3	SO_2 g/m^{33}	H_2S g/m^3	The gas temperature of the chimney (°C)
June	Furnace 1 Outlet 1	1.6	11	17	1.2	6	0	**157**
	Furnace 1 Outlet 2	2	16	12	0.7	10	0	**151**
	Furnace 2 Outlet 1	2.6	19	14	1.5	4	0	**125**
	Furnace 2 Outlet 2	1	17	12	1.3	4	0	**127**
	Furnace 2 Outlet 3	0.7	25	18	2.4	8	0	**114**
	Furnace 3 Outlet 1	0.2	17	11	0.9	10	0	**131**
	Furnace 3 Outlet 2	0.8	18	10	1	9	0	**128**
	Furnace 3 Outlet 3	1.1	24	20	1.6	11	0	**129**
September	Furnace 2 Outlet 1	2.1	15	12	0.9	6	0	**116**

	Furnace 2 Outlet 2	0.6	11	9	0.6	6	0	**111**
	Furnace 2 Outlet 3	1	19	10	0.6	9	0	**104**
	Furnace 3 Outlet 1	0	14	8	0.4	6	0	**119**
	Furnace 3 Outlet 2	0.1	16	7	0.3	5	0	**115**
	Furnace 3 Outlet 3	0	19	10	0.4	4	0	**114**
November	Furnace 1 Outlet 1	2	15	15	0.9	8	0	**148**
	Furnace 1 Outlet 2	1.8	21	8	0.4	12	0	**159**
	Furnace 2 Outlet 1	2.7	12	19	1.9	8	0	**138**
	Furnace 2 Outlet 2	0.4	18	11	0.9	10	0	**140**
	Furnace 2 Outlet 3	0.7	26	16	1.1	11	0	**136**
	Furnace 3 Outlet 1	0	20	6	0	8	0	**127**
	Furnace 3 Outlet 2	0	20	6	0	8	0	**127**
	Furnace 3 Outlet 3	0	15	6	0	6	0	**133**
March	Furnace 1 Outlet 1	2.1	21	11	0.4	4	0	**130**
	Furnace 1 Outlet 2	2.3	16	5	0.1	9	0	**134**
	Furnace 2 Outlet 1	2.2	18	14	1.3	10	0	**125**
	Furnace 2 Outlet 2	0.7	22	9	0.7	7	0	**128**
	Furnace 2 Outlet 3	0.2	23	14	1.6	6	0	**121**
	Furnace 3 Outlet 1	0	15	11	1.2	3	0	**104**
	Furnace 3 Outlet 2	0	15	18	1.7	1	0	**101**
	Furnace 3 Outlet 3	0	11	9	0.7	0	0	**114**

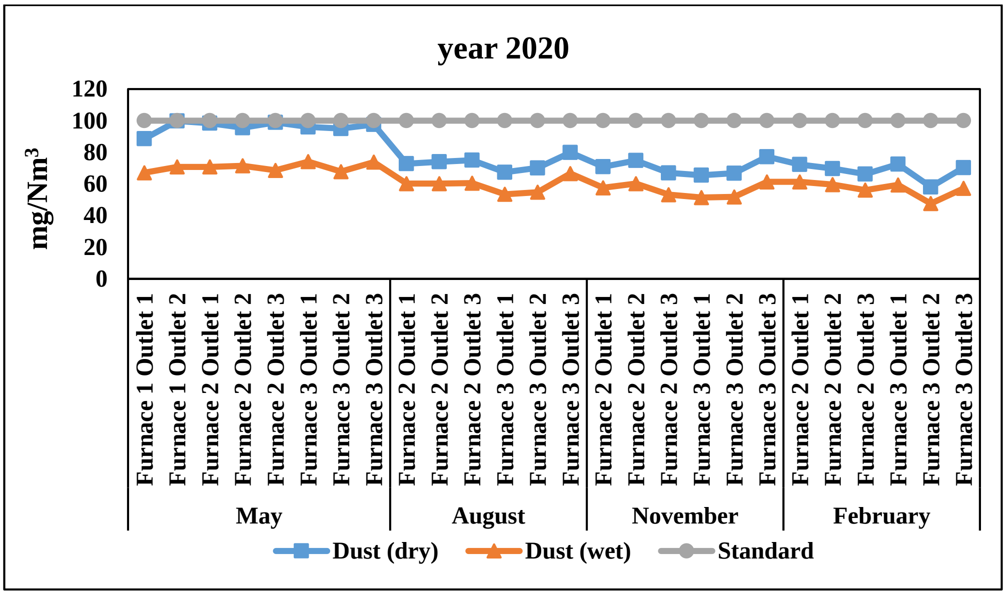

Fig. 3. The results of the dust exhaust from the chimney of Iran's ferroalloy industries (IFI) (the year 2020)

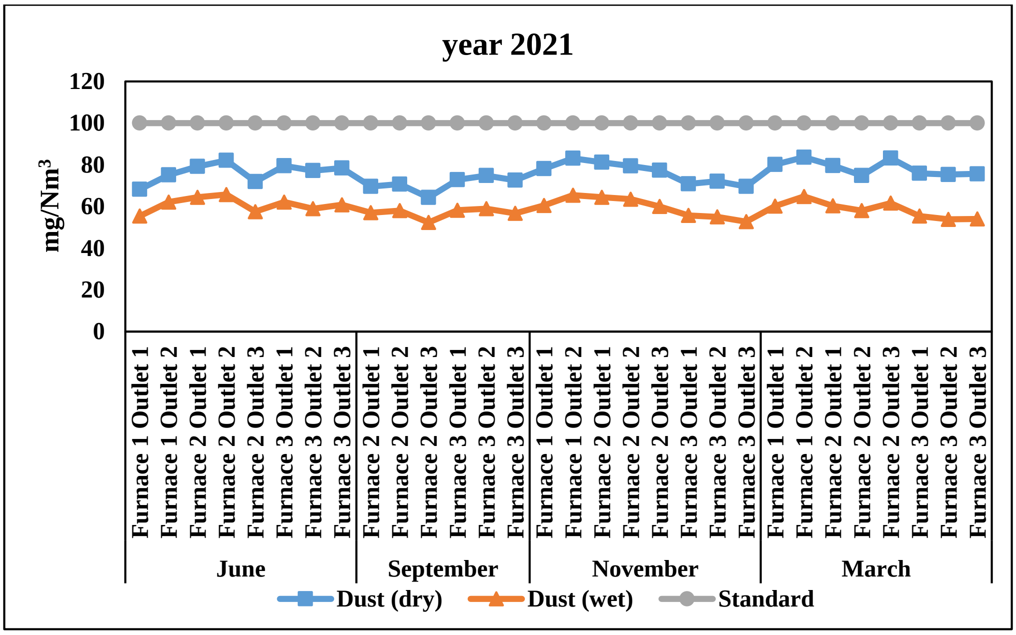

Fig. 4. The results of the dust exhaust from the chimney of Iran's ferroalloy industries (IFI) (the year 2021)

3.3. Ambient particulate matter

The results of ambient particulate matter were also compared with the permitted emission of air pollutants in industries (approved by the government in 2015) and the matter (15) of the law on how to prevent air pollution approved in 1995. So that the changes in the amount of ambient particulate matter ($PM_{2.5}$ and PM_{10}) for Iran's ferroalloy industries for the years, 2020 and 2021 are shown in Figures 6 and 7, respectively. An image of the sampling locations of the measuring stations (from A to H) is shown in Figure 5. The measuring values were compared with the standard of free air quality according to the standards of the Environmental Organization (for $PM_{2.5}$ equal to 35 µg/m^3 and PM_{10} equal to 150 µg/m^3). In all measured stations for the years 2020 and 2021, the measured values of ambient particulate matter ($PM_{2.5}$ and PM_{10}) were lower than the standard limits. The one-sample t-test for comparing the average of ambient particles matter ($PM_{2.5}$ and PM_{10}) with their pollution standards also proved this issue. The lowest amount of $PM_{2.5}$ in all measurement years is equal to 11 µg/m^3 in stations H (February 2020) and G (June 2021), and the highest value is equal to 34 µg/m^3 in station H in June 2021. Also, the lowest amount of PM_{10} in all measurement years is equal to 14 µg/m^3 in stations H (August 2020 and March 2020) and G (June 2021), and the highest value is 54 µg/m^3 in Station B in June 2020. In all the measuring stations for the years 2020 and 2021, the measured values of ambient particulate matter ($PM_{2.5}$ and PM_{10}) were lower than the standard limits, and there was no pollution for these particulates in Iran's ferroalloy industries (IFI). It was not observed that the concentration of ambient particulate matter in these years could be considered acceptable. In a similar study, Petrov and Movchan (2017) evaluated the impact of the production of the Tikhvin ferroalloy factory located in Russia on the components of the environment and human societies, which analysis of social and health monitoring data showed that after the start of ferroalloy production in the ferroalloy factory Tikhvin, the number of disease occurrences among the urban population had increased significantly, while the results of this study showed that no pollution was observed for the measured parameters of Iran's ferroalloy industries (IFI).

Fig. 5. Sampling locations of stations measured for ambient particulate matter ($PM_{2.5}$ and PM_{10})

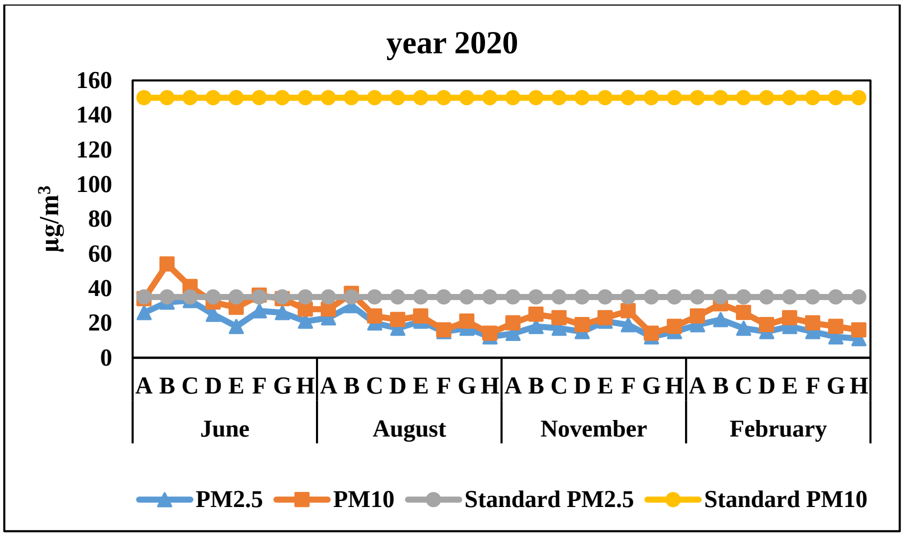

Fig. 6. The results of ambient particulate matter of Iran's ferroalloy industries (IFI) (the year 2020)

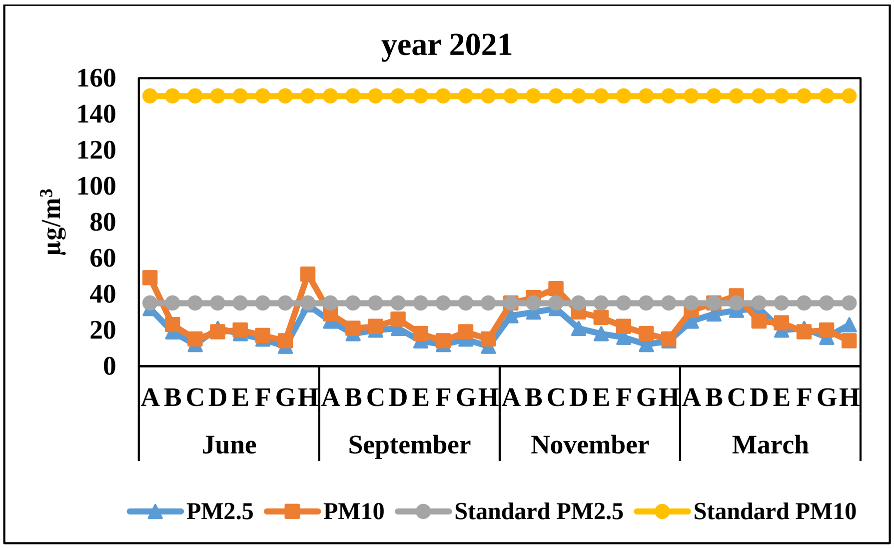

Fig. 7. The results of ambient particulate matter of Iran's ferroalloy industries (IFI) (the year 2021)

3.4. Air pollution control equipment

In Iran's ferroalloy industries', a series of equipment has been installed to control and purify particulates from exhaust fumes (containing gases). This environmental equipment to control air pollutants includes U-shaped pipes to cool the transfer smoke containing gases from the furnace to the baghouse, a cyclone separator, a device for dust removal and collection of particulate matter in gases (cyclonic separation is a universal mechanical method that separates it is done by using the centrifugal force resulting from the rotation of the fluid so that the dust-carrying gas flow enters the cyclone from the upper wall of the cyclone body, which is cylindrical and leads to an incomplete cone, and flows downwards. After contacting the cyclone wall and separating from the gas stream, the dust particulates fall to the bottom of the cyclone by gravity and exit the cyclone through the outlet (Hualin et al., 2012)) and 5748 bag filters (bag filters it is commonly used to collect particulates and to filter the dust in the gas. In this system, the dust is discharged from the bags through pipes using a compressed air injection method and in an intelligent way, taking into account the pressure difference in the application chamber, and the discharge of dust from the bag's surface takes place. In these filters, particulates small around microns are separated with an efficiency of more than 99% (Kanaoka, 2019)), in the baghouse (which has 14 compartments in each compartment, each compartment has 121 bag filters) and furnaces for separation of the particulates are tiny. The bag filters are of the French media filter type, which is made of fiberglass and withstand temperatures between 200 and 260 °C. The useful life and efficiency of these filters are ten years. In a similar study, Els et al. (2010) improved the furnace smoke control system by installing a baghouse containing membrane filter bags and a cooler containing U-shaped pipes in the Chelyabinsk Ferroalloy Plant in Russia, which includes effective absorption of steam and heat produced in the furnace hood was to filter particulates from the gas stream and minimize greenhouse gas emissions to the atmosphere, which is consistent with the results of this study. In addition to helping to preserve the environment, the act of separating particulates prevents the loss of microsilica powder along with the smoke. It produces a side product that has a very high economic value and significant industrial applications. In a study by Rahman et al. (2020), excellent microsilica particulates were investigated as a filler that can be placed in the space between cement particulates, that microsilica powder has a significant ability to partially replace cement in concrete and improve it had mechanical properties and durability. In the baghouse system, the smoke-containing dust, after passing through cyclones and bag filters and removing its particulates and dust is removed from the smoke inside the bags and moves to the top of the hall and the upper floors, and through vents in the highest part of the hall is removed. The smoke output from furnace 1 is about 206,000 cubic meters per hour under normal conditions and should have a temperature of about 550 °C. To cool it and transfer it to the dust collection hall, two fans move this smoke to the hall and increase its flow rate to about 325,000 m^3/h under normal conditions. In the dust removal hall of the furnace, the gas temperature when leaving the filter chamber was less than 250 °C. The smoke output in each of furnaces 2 and 3 is about 150,000 m^3/h under normal conditions and must have a temperature of about 550 °C, which requires two fans of this smoke to cool it and transfer it to the dust collector. It was transferred to the hall, and its flow rate was increased to about 236,650 m^3/h under normal conditions, and in the furnace dust removal hall, the gas temperature when leaving the filter chamber was less than 350 °C. As it is known, the U-shaped cooling pipes include a series of pipes and vertical bends that create a radiant heat transfer zone that reduces the temperature of the transfer smoke containing gases from the furnace to the dusty hall. It has provided the safety function of bag filters (Mc Dougall, 2013).

3.5. Vegetation in industry

Plants can filter certain pollutants through absorption, surface adsorption, and metabolism. Therefore, plants act as essential absorbers of air pollutants, which are excellent biological filters against air pollution. Their ability to tolerate air pollutants depends on their biochemical, physiological, and morphological characteristics (Shrestha et al., 2021). In Iran's ferroalloy industries (IFI), with the development of vegetation, very appropriate measures have been taken to reduce air pollution by creating a green belt and planting spruce saplings to prevent air pollution from leaking to the surrounding villages on the outskirts of the factory and the annual development of green space in the mine of the factory. In this industry, more than 60% of the factory comprises green space, which has increased by more than 10% in the last five years. So that the type and types of greenery for Iran's ferroalloy industries (IFI) are such that out of the 400 thousand square meters of green space of the factory, about 85% of the trees are of fruitful types (apples, peaches, nectarines, almonds, walnuts, cherries, cherries, green tomato, apricot, mulberry), non-fruitful trees of all kinds of sparrow tongue, acacia, pine (needle, cypress, cypress), sycamore, fir, willow, Majnoon willow, willow, maple, arar, elm, Mahlab, and purple shrubs. , boxwood, purple tree jasmine, and bedag. About 10% of the green space is made up of all kinds of flowers, including roses, chrysanthemums, wild planets, planets, Ahar, Akhtar, Mahbub Shab, Shab Bo, Atlantic, Violet, Rana Ziba, Laden, Candle, etc. Also, about 5% of the green space is covered by grass.

4. Conclusion

This study aimed to investigate the environmental status of air pollution in Iran's ferroalloy industries (IFI) by examining air pollution control equipment. The results showed that all the measured parameters of gases and dust exhaust from the chimney and ambient particulate matter during the years 2020 and 2021 were according to the standards of the Environmental Organization. So, the one-sample t-test also proved this issue statistically.

The reason for this in Iran's ferroalloy industries (IFI) is the environmental equipment suitable for controlling pollutants and planting the right green space with various tree and shrub species. This equipment includes control and purification of particulates from the exhaust smoke to control air pollutants, including U-shaped pipes to cool the transfer smoke containing gases from the furnace to the baghouse, cyclone separator for dust removal, and collection of particulate matter in gases and bag filters. Therefore, it can be said that no pollution has been observed for the investigated parameters in Iran's ferroalloy industries (IFI) and the factory is taking steps toward reaching the green industry.

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