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DUST EMISSIONS FROM AN INTEGRATED STEEL MILL IN CORRELATION WITH HUMAN EXPOSURE AND THEIR ADVERSE HEALTH EFFECTS

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ABSTRACT

Many of the metallurgical operations contribute to generation of the dust emissions if these are not properly controlled and managed. The relevant sectors as important sources for airborne dust are: coke oven plant, sintering equipments, blast furnaces, basic oxygen steelmaking, steel mills and also handling, preparation and transport of raw materials, products, by-products and residues. The annual average values of dust for metallurgical plant and period analysed not exceeds allowable level. The measurements showed that the daily average determined for settled dust varies very high. Sometimes, certain of these exceed the limits of the rules in force for air quality indicators. As result at exposure to generated dust (especially to particulate matter) appear adverse health problems at workers and population that lives in the neighbourhood of steelwork plant. Impact of dust emissions as air pollutant on the population of the vicinity areas is correlated with levels of incidence and prevalence of some specifically diseases. The indicators calculated for evaluation the health status (severity index, relative risk, professional etiological fraction) did not demonstrate the adverse health effects determined by exposure to dust particles in suspension on population that lives in vicinity of the plant. This influence is more likely to workers directly involved in metallurgical activity.

KEYWORKS: dust emissions, particulate matter, integrated steel mill, health status

1. Introduction

In terms of environmental protection, metallurgical processes involve operations that are dangerous because generate pollutants [1-3]. Emissions of pollutants represent one of the criteria for assessing the occupational risk associated with the work environment from metallurgical plants. Under European guidelines, for each sector must be identified the sources of pollutants emissions, the quantity of pollutants released to environment, their toxicity and their degree of hazard. The characteristics of pollutants are determined by the nature of the materials processed, the processes that happen (mechanical, thermal, physical, chemical) and by properties of products or by-products resulted (physical and chemical) [4]. One of the primary pollutants with adverse impacts on environmental from workplaces and from surrounding areas is dust. Many of the metallurgical operations contribute to generation of the dust emissions if these are not properly controlled and managed. As result, may appear health problems at exposure to generated dust.

The risks from exposure to dust emissions are dependent characteristics of dust emission, i.e. the quantity, chemical composition and species, particle shape and size as well as their biological aggressiveness. The major exposure of workers and population that lives in the neighbourhood of steelwork plant is achieved on air way by inhalation, ingestion and skin absorption of the dust particles present in the ambient air. Directive 2008/50/EC on ambient air quality and cleaner air for Europe has set mandatory limits for particulate matter. It is the first EU directive that includes limits on air concentrations of $PM_{2.5}$ (fine particulate matter). In these circumstances, the Directive requires Member States by 1 January 2015, the emission limit value for particulate matter should not exceed 25 micrograms per cubic meter as an annual average, while in 2020 to decrease to 20 micrograms per cubic meter [5].

For integrated steel mills, standards impose for particulate matter the following air emission levels: 20-50 mg/Nm^3 (lower value is for presence of toxic metals, reference conditions for thee limits are different). According to studies conducted in different countries, there is a correlation between respiratory systems and long-term exposure to particulate concentrations of approx. 30 - 35mg/m^3. More, simultaneous presence of dust and other pollutants cause synergetic negative effects for human health. The synergistic relationships between the airborne dust, sulphur dioxide and nitrogen oxides are relevant. To minimize the adverse effects on health and environmental, it is necessary the continuous management of all metallurgical activities and the application of emissions monitoring programs for all sectors of the integrated steel plant. This is based on evaluation of direct or indirect indicators of emissions and the effluents in the environmental factors. It is imposes the sources identifying and the emissions with significant impact on the human health and environment, during normal working operations and for special conditions. Thus may be taken measures for reducing of the pollution level (with dust and other pollutants) in accordance with environmental standards [6-8].

This paper presents an analysis of metallurgical activities in relevant sectors of an integrated steel mill in terms of dust emissions (especially particulate matter), that is necessary to identify sources of emissions released into the air. Dust emission levels generated for a certain period of time are presented, recommending solutions to reduce them in order to comply within the limits of the rules in force for air quality indicators. It also discusses the adverse effects of dust emissions on the health of workers and the population from surrounding areas of the plant, based on indicators that quantify the health of workers and the people from surrounding areas of the plant.

2. Sources of dust emissions and their level for a integrated steels mill

In all steps of steels production flow based on the blast furnace/basic-oxygen route can be identified important sources of dust emissions.

The relevant sectors are: coke oven plant, sinter equipments, blast furnaces, basic oxygen steelmaking and casting, steel mills and also handling, preparation and transport of materials, products, by-products and residues. The major part of dusts generated at modern steel works are controlled by adequate equipments (cyclones, wet scrubbers, electrostatic precipitators, bag filters).

The dust collected is recycled or controlled dumped. However, variable quantities of dusts are issued directly or indirectly to air as suspended particulate matter (PM), depending of efficiency of cleaning facilities. These particles can be classified by more properties: shape, physical behaviour in the air, size, biological activity, chemical species etc. [8-10]. The most common parameter used in occupational hygiene for defining the particulate matter is the aerodynamic diameter (Table 1) [8].

Table 1. *Fractions of particulate matter, defined by aerodynamic diameter*

Particulate matter fraction	**Aerodinamic diameter**, μm
Total suspended particulates (TSP)	≤ 10
PM_{10} or coarse fraction	≥2.5; ≤10
$PM_{2.5}$ fraction	≥1; ≤ 2.5
PM_1 or fine fraction	≥1; ≤0.1
Ultra fine fraction (UFP)	≤0.1

The airborne dust (formed by fine and very fine fractions of particulates with aerodynamic diameter) is susceptible to cause adverse health effects more than coarse particulates [11, 12]. Chemical composition emphasizes their biological aggressiveness. These particles may contain varying concentrations of mineral oxides, metals (e.g. arsenic, cadmium, mercury, lead, nickel, chromium, zinc, manganese), and the metal oxides. Also on their surface can adsorb some persistent organic pollutants (dioxins, furans and so on). The coarse fractions of particles remain airborne for short periods and are therefore deposited very close to the generation sources. Even these fractions of particles can be entrained in airflows and wind and carried on short distances [8].

In ferrous metallurgy, the particulate matter can be generated by physical processes (manipulation, transport of the raw materials, their storage on sol, the handling and processing of the materials), thermal and chemical processes (combustion, oxidation, condensation, reduction, etc.).

The main sectors that generate the largest quantities of dust are ordered according to the amount as shown in Figure 1 [13].

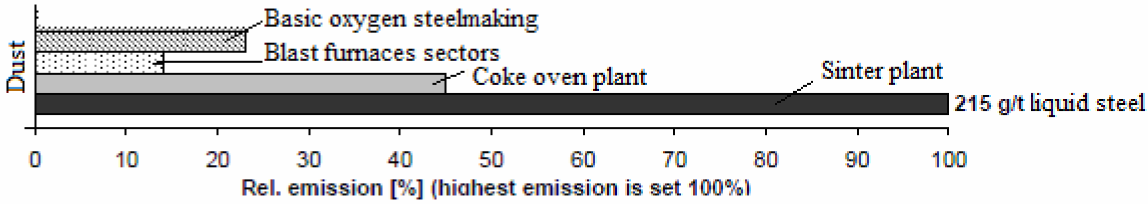

***Fig. 1**. Relative emissions of dust released from main sectors of integrated steel plant*

• Coke oven plants are the first production units of an integrated steelwork. They are placed on second place after sinter plants from point of view of the generation processes of the dust emissions as air pollutants. The conveying operations, handling, crushing, screening and loading of the coal are susceptible to generate important dusts quantities. Principally from coke ovens, the continuous emissions of particulate matter are the result of thermal processes. Intermittent emissions and fugitive can come from a large number of sources including oven doors, valves, charging holes etc. Other emissions may arise from processing of coke (quenching, crushing, sieving) and from the treatment of the off-gas (discontinuous emissions). For coke-oven plants in different EU Member States, 2005 year, the dust emissions to air ranged from 15.7 to 298g/t coke (higher value is for old plants with cracks in the oven walls) [14].

• Sinter plants generate the most significant amount of particulate matter in an integrated steel mill. From sintering operations may result amounts of dust about 20kg/t of steel (80% of particles smaller than 100 microns in diameter) [15]. Emissions from the sinter plant arise primarily from handling/preparation operations of the materials (transport, loading, unloading, crushing, sieving, mixing). The sintering strand and the wind-boxes are the primary sources of particulate emissions (mainly as iron oxides) for sinter machines. At the download area of the agglomerate from belt, emissions are mainly formed by oxides of iron and calcium. The crushing of the hot sinter, quenching and sieving are next hot-point for dust emissions [16, 17].

Generally, the dust emissions from sinter machine are controlled by capture and directed to de-dusting facilities. Only particles entrained by off-gas, which could not be kept entirely reach the air. These emissions can be a significant problem for people and the environment. In accordance with the literature, even performed electrostatic precipitators that equipped modern sinter plants have a low efficiency for fine fractions (rich in heavy metals and other hazardous compounds). From this reason, to minimise the dust, as advanced de-dusting technique considered for best available technique (BAT), is recommended the bag filter installed downstream to the existing electrostatic precipitator. Fabric filters enhanced with additives are highly efficient at reducing particulate matter emissions in the waste gas stream. They reduce emissions of PCDD/F, hydrochloric acid, hydrofluoric acid. Also, some emissions of VOCs and PAHs are more efficient reduced [18, 19]. To minimize pollutant emissions released and to reduce the amount of off-gas requiring end-of-pipe treatment, some modern sinter plants apply the recirculation of waste-gas through sinter strand [20].

• Particulate matter emissions generated by the blast furnace plant include emissions from the cast house and the cleaning of BF gas. The casting operation is higher source of particulate emissions from this sector (400 - 1500 g/t iron, depending on applied technique) [18]. Principally they are formed by iron oxides, magnesium oxide and carbonaceous compounds as particulate. Molten iron and slag emit smoke while travelling from the taphole to ladle and also to installation or pit for slag granulation. They are firstly determined by the contact of molten iron and slag surface with air. Also the drilling and plugging of the taphole can cause dusts emissions. These increase by utilisation of oxygen to open a clogged taphole. Casting emissions are controlled by capture hoods and gas cleaner facilities (usually the fabric filters). Also it can prevent the formation of pollutants with covered runner systems that exclude the ambient air contact with the molten surface. The following operations that generate dust emissions are mechanical processes at handling of materials. The transport of raw materials, loading and unloading of materials in and from bunkers at scaffold are the source of dusts formed from ores, sinter and coke particles. Gas leakage, from aspiration facility for space between cones, contain fine particles. Such particles can be simultaneous emitted with gas released in air at the blast furnace top, by opening of relief valve to the atmosphere for the pressure equalization. In these areas, dust emissions are controlled by gas cleaner facility (electrostatic precipitator).

The emissions are captured and cleaned in multistage de-dusting systems: bag filters to capture coarse fractions; Venturi scrubbers for fine particulates containing heavy metals and other compounds. The dust unloading from dry cleaning facilities can be emitted as particulates to air. Minor emissions may arise from firing process of combustible gas (blast furnace gas and methane) to hot stoves (cowpers).

• Particulate matter emissions from basic oxygen steelmaking arise from pre-treatment of hot metal(including hot metal transfer, desulphurization and deslagging processes); charging operations; oxygen blowing for reducing of carbon level and oxidation of impurities; tapping operations. The sources of pollutants emissions are grouped as sources of primary emissions (pre-treatment of hot metal, oxygen blowing into furnace, secondary metallurgy) and sources of secondary emissions (deslagging of hot metal, charging into furnaces of hot metal and scraps, tapping of liquid steel and slag from furnaces and ladles, secondary metallurgy, tapping operations, handling of additives, continuous casting) [14]. Most of dust emissions to air from all these processes (named point-sources or hot points) are controlled (by capturing in de-dusting systems). Some of these are dispersed into air and as result, the environment conditions are negative affected (principally the ambient air from workplaces). The gas released from the furnace during oxygen blowing contain an important quantity of particulate matter (mainly consisting of metal oxides, including heavy metals). Particulate matter are usually removed from gases by means of Venturi scrubbers or dry electrostatic precipitators. When suppressed combustion is applied, Venturi scrubbers may achieve a particulate matter concentration of 5-10mg/Nm^3 (but concentrations up to 50mg/Nm^3 are possible also) in the gas. This corresponds to 1g/t liquid steel [14]

3. Analyse of the dust emissions customized for a Romanian integrated iron and steel plant

The integrated steel mill has in operation in period analyzed the following: coke ovens, sinter plants, blast furnaces, basic oxygen steelmaking plants and steels mills. Also, there are supplementary facilities for: unloading of materials from ships and trains; transport and storage of materials on soil; raw materials preparation (crushing, sieving, weighing etc.). There were also additional facilities for: unloading of materials from ships and trains; transport and storage of materials on soil; materials preparation (crushing, sorting, weighing etc.). Practically, majority of the activities developed in these sectors generate dust. In terms of potential effects on human health and environmental quality, the air factor is the main medium to transfer the fugitive emissions from the source to receivers (workers, population from vicinity of the metallurgical plant). Air emissions were sometimes visible from distance and perceived not only in industrial area but also in large neighbouring areas.

Air pollution in coking plants is mainly due to diffuse emission sources rather than those controlled by de-dusting plants. Transport facilities, crushing and screening of coal and coke, which are likely to generate significant quantities of dust are equipped with electrostatic precipitators. Because the concentration of the particulates contained by off-gas released to air from these facilities was in 1997 about 100 mg/Nm^3, was imposed their modernisation. As result of insufficient capture capacity, during the preparing operations of coals, the diffuse emissions were at higher level, 0.6 – 1.5 g/Nm^3. For this reason was necessary the resizing of suction facilities. The emissions generated from combustions chambers were mostly captured and was directly discharged to stack. Coke batteries release important dust quantities, consisting of a complex mixture of organic and inorganic compounds, past including heavy metals. The raw gas resulted from coking process was captured and directed to chemical section for cleaning and recovering of valuable elements. To diminish the diffuse emissions from loading and unloading of coke batteries, these were equipped with hydroinjection installations. Their modernisation led to decreasing of dust emissions from 35 – 40 mg/Nm^3 to 18 – 20 mg/Nm^3. The transport operations, related to coke quenching, produce particulate matter in range of 0.5 – 0.7 mg/Nm^3. The filter bags reduce these emissions to 0.03 – 0.04 mg/Nm^3. Inherent particulate emissions from coke quenching were substantially reduced by adopting a dry technique. The level of particulates released from discharging zone of coke after its quenching was high. For decreasing of emission from quenching facilities was proposed a multistage cleaner solution: multistage cyclone and the wet scrubber followed by fabric filters. These ensures reaching an emission level of 38 - 45 mg/Nm^3. The diffuse emissions dust quantified to coke transport on the conveyer belts, especially at discharge ends (points tranship) were high, 1.2 – 2.7g/Nm^3 [21, 22].

For these hot-points were recommended and applied the solution: wet cyclone and fabric filter to ensure the level 38 - 42mg/Nm^3. An electrostatic precipitator can be supplementary attached to sieving area of coke for maximal reducing of the dust emissions. On the flow of sinter - blast furnaces, the first major sources of diffuse emissions are from the storage of raw materials piles on uncovered sites. The particulate matter emitted carry with them variable concentrations of heavy metals (Pb, Zn, Mn, Cr, Cu, Ni, Cd etc.). In these areas heavy metals present in dusts (especially those generated from ores) are mainly accumulated in/on soil. Sometimes wind drives the fine fractions to neighbouring areas, generating a significant hazard to the environment and humans. The materials preparation (crushing, sieving, mixing, transport) and their conveying on belts generates also dust emissions. These were captured and removed with an electrostatic precipitator. Because suction network of cleaner facility that stretched on large areas, the efficiency of capture was low. This makes visible dust sitting on the ground of the preparing materials sector. Resizing of network suction and the installation of equipment in local emission points can improve system efficiency. Homogenization of raw materials in mixing drums and loading on sintering belts do not generate significant dust emissions because the material handling is wet. Agglomeration process itself generates large quantities of dust that contain heavy metals and alkali metal compounds, (due to the high temperatures in the combustion zone and to the high depression). From sinter strand results a high flow of gases (about 5.000 m_3/m_2 sinter belt surface). These carries the important quantities of dust (coarse and fine particles) to electrostatic precipitator. Coarse particles (of approx. 100 microns) come from the loading of materials mixture and from bottom layer of sintering strand.

They have the composition in correlation with the mixture subjected to sintering. Fine particles (0.1-1 microns) are formed in the sintering zone, after complete evaporation of moisture from the mixture. These are rich in heavy metals (Pb, Zn) and the chlorides of Na and K. These chlorides from the fine dust lead to low efficiency of removing at only 60% (functioning of electrostatic precipitator is worsened as result of increasing of dust resistivity), and the emissions were located between 50-100mg/Nm^3. Unloading on sintering belts, hot crushing, sieving and especially sinter cooling are other important emissions sources for the dust. In Table 2 are given the dust emissions levels that were measured at suction hoods of electrostatic precipitator in different areas of this sector.

***Table 2**. Dust level for various sites of sintering installations, 1997 [21]*

Different areas from sintering process		**Level,** mg/m^3
Raw materials preparation	Crushing installations	295 – 300
Weighting	Weighting station	185 – 205
Homogenizing of raw material	Primary mixing drum	167 – 180
	Secondary mixing drum	135 – 148
	Belts for fines return	178 – 195
Sinter sieving	Hot sinter screening	302 – 353
	Cooled sinter sieving	245 – 265
Cooling sinter	Cooling installation (without fan function)	272 – 286
	Cooling installation (with fan function)	180 – 196

After de-dusting by electrostatic precipitator, the dust emission were diminished in the range 40 - 70mg/Nm^3 (higher values are in correlation with some leaks from conveyors mantles and also from incorrectly utilisation of de-dusting equipments).

As a final conclusion it was found that significant environment problem in the sintering sector is represented by diffuse dust emissions which are present practically on all flow line. Because in the period under review (1997), the dust content in air was higher that the values admissible from European standard, were recommended the adoption of following measures for the reduction these diffuse particulate emissions from sintering flow: enclosures for transhipment areas of raw materials; modification of discharging hoppers of materials; wetting of material in summer; placing of the additional de-dusting systems to raw material sector. Also, was required the upgrading of the capture systems and de-dusting installations type electrostatic precipitator to reduce diffuse emissions in the zone of sintering machines. Better for the sector would be to use the dusting equipment, bag filters.

In sector of blast furnaces were identified sources of dust generation, some emissions exceed admissible levels. The solid particles (generated from transport, loading and unloading of materials from bunkers at blast furnace scaffold) released to stack with off-gas were in 1997 in the range of 44 - 69 mg/Nm^3 (between 7 and 40 kg/t iron). About 3 – 5 % of this amount was released to air at pressure equalisation operations between the bells of charging installation. Off-gas released of blast furnace top is treated and used in various combustion processes. The preparing of coal for injection into blast furnace is a minor source for dust (about 2 - 50 g/t iron), the installation for injection being equipped with adapted systems for emissions control. Same situation is considered at firing process of combustible gas (mixture consisting of blast furnace gas and methane) to cowpers, typically emissions were limited to about 10 mg/Nm^3 [21]. At casting of iron and slag are released great and variable quantity of brown fumes, 400 – 1500 g/t pig iron. These are the result of interaction of hot iron and oxygen from air, being largest to skimmer gate and tilting runner areas. Also casting house air are polluted with dust emitted at beginning and ending of tapping due the ramming mass and its utilisation.

Emission sources of air pollutants at basic oxygen furnaces steelmaking are grouped into primary and secondary emission sources. Most emissions generated can be partial controlled (captured and conducted to cleaner systems). A small amount of these is dispersed in air, and lead to worsening of environmental conditions in the workplaces. The emissions from pre-treatment of the iron (desulphurization, slag separation etc.) are diminished by simultaneous suction with gases in local hoods and by further treatment into fabric filters. Thus the dust emitted to air is reduced below admissible level. For the pig iron mixers not equipped with special facilities for gas capture were assessed following quantities of dust: 12 g/t iron for loading of furnace; 18 g/t iron for unloading from furnace. During oxygen blowing, the gas emitted is polluted with 15 – 20 kg particulate matter/t steel. These emissions are retained in wet cleaners Venturi (until 25 - 100 mg/Nm^3). When applying wet scrubber, air pollution problems transferred to other environmental factors: to water-waste water is polluted with solid suspensions containing heavy metals, cyanides, nitrogen compounds etc.; to sol – sludge is formed, from which a little fraction is recycled, most being uncontrolled dumped. The air emissions from the secondary treatment of the steels are minor. AOD installation was equipped with filter bags. The pig iron pouring, loading of furnace, steel and slag tapping from furnaces and ladles, treatment with additives and continuous casting are operations characterized by dust emissions (brown fumes).

Measured or estimated dust emissions shows that many workplaces were affected by exceeding the level of dust emissions allowed. Besides air pollution in work areas, metallurgical activities from this metallurgical plant had negative effect on air quality from adjacent areas. To illustrate the level of population exposure at this pollutant released from Romanian steel plant, can analyse data presented in Tables 3-5. There are the results of statistical processing of the data measured by legal environmental control institutions and laboratory of steel plant itself [22].

Although the annual average values exceeds allowable level, it appears that the daily average determined for settled dust varies very high. For same class of dust, the annual average monitored in certain areas of Galati town was normal.

Similar conclusions arising from the analysis of isoconcentration curves of daily and annual average concentrations presented as cartographic maps made by modelling of temporal and spatial dispersion of particulate matter. Modelling dust emission for the Romanian steel plant and its surrounding residential area was conducted by ICEM Bucharest [21].

Table 3. *Airborne dust: annual and daily average*

Year	Mean annual value,	Maximum daily value	Minimum daily value	Frequency of exceed	Total number of samples
	[mg/m^3]		[mg/m^3]	[%]	
1999	0.0520	0.149	0.002	0	1012
2000	0.0560	0.145	0.016	0	304

Table 4. *Dust settled, annual and daily average*

Year	Mean annual value,	Maximum daily value	Minimum daily value	Frequency of exceed	Total number of samples
	[mg/m^3]		[mg/m^3]	[%]	
1996	24.15	95.01	2.61	56.38	94
1997	28.90	217.4	2.32	60.8	97
1998	29.01	92.42	2.53	50	104
1999	14.45	363.04	1.02	15.6	96
2000	9.42	254.78	0.51	28.18	110

***Table 5**. Mean annual values of settled particles, according to monitoring by the Department of Public Health Galati, mg/m^3*

Collection points	Year										
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Domnească Street	20.2	36.8	21.3	18.9	18.5	26.5	19.8	17.8	16.7	15.2	15.3
Traian Street	20.7	23.4	23.6	22.3	19.4	21.0	18.2	21.5	24.2	22.6	35.6
Filesti Station	25.7	30.5	26.2	26.9	18.6	22.2	23.2	19.3	18.8	19.6	16.5
Drumul Viilor Street	20.1	22.2	22.3	30.9	17.8	22.9	21.9	17.3	18.3	19.0	19.5
Moruzzi Place	-	17.7	20.8	16.1	14.4	24.8	24.4	19.0	25.0	19.0	19.1
Pensioners Home	-	19.0	24.4	20.6	22.6	20.9	17.0	16.8	15.8	13.5	19.6

For modelling of the concentrations of dust (and other air pollutants), the Gaussian model, ISC - AERMOD View, was used. Maps obtained (Figure 2 and Figure 3) show that annual average concentrations of particulate matter shall not exceed the limits imposed by European regulations on air quality.

For steel mill and in its vicinity areas were exceeded hourly average concentrations of particulate matter.

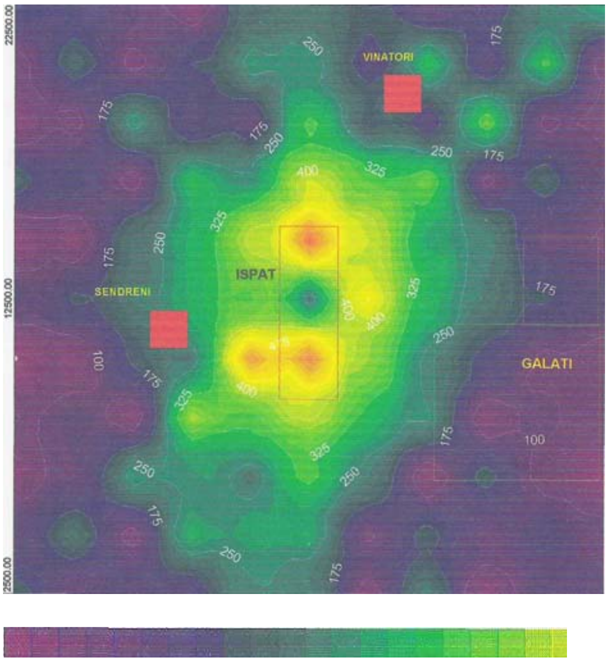

***Fig. 2.** Map of particulate matter dispersion (hourly concentration, µg/Nm^3)*

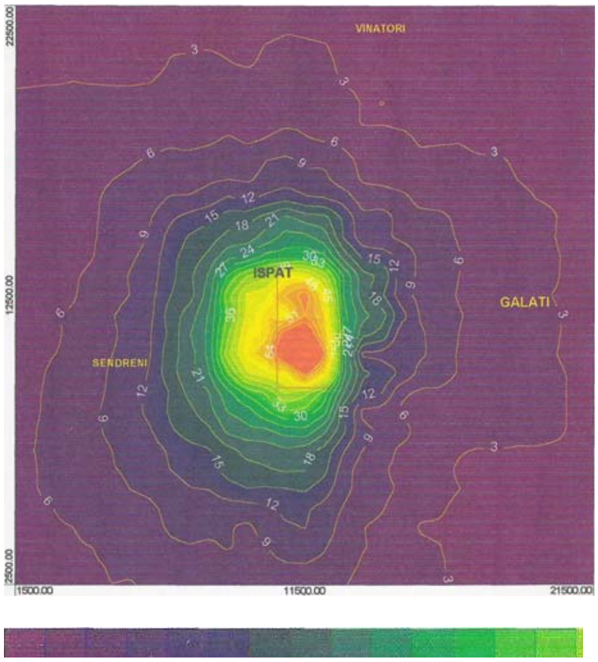

***Fig 3**. Map of particulate matter dispersion (annual concentration, µg/Nm^3)*

4. Effects of exposure of workers and population to dust emissions

Air pollution is a real risk to human health and disease incidence is linearly proportional to the nature and concentration of the pollutant that exceeds the reference value and the number of people exposed. For integrated iron and steel plant, is predominant the continuous exposition to low concentrations of dust emissions during normal operation of the plant. Incidentally, people may be exposed to high concentrations of pollutants for a short period of time following the occurrence of undesirable events. Their action on the human body translates into acute and chronic effects that can be quantified by modifying some specific indicators (mortality, morbidity and so on). Fraction of fine particles ($PM_{2.5}$ and PM_{10} even) is a special health problem because they can penetrate deep respiratory system and can be absorbed into the blood. Effects of exposure depends on the air concentration, aerodynamic diameter of the dust particles in question, and exposure time/duration. The studies have found the causing of chronic respiratory diseases both for workers and for people in adjacent areas [23].

The dust released affect the immediate worker, leading to occupational disease or work-related diseases. The evaluation of demonstration causal relationship between pollution and diseases can be discussed by way of the analysis of mortality and morbidity indicators. To determine these indicators for Romanian integrated steel plant were used clinical data available on the situation of occupational health office.

The dust emissions can be linked mainly to respiratory diseases (asthma, chronic bronchitis) and sometimes to other like skin diseases (contact dermatitis) or medical diseases of the eyes. The situation of occupational disease cases, as severity index (IG - as number of days of temporary disability relative to the average number of employees) reported in the period 1996-2001 and calculated by ICEM Bucharest [21] is presented in the Table 5. We chose only the data for sectors for which the dust emissions are analysed in this paper.

***Table 5**. Severity index (IG) for sectors of Romanian steel plants, during 1996-2001, %*

Years	1996	1997	1998	1999	2000	2001
Coking sector	846.9	781.01	866.77	844.29	778.43	596.22
Blast furnaces	709.08	709.82	689.06	681.84	615.97	569.47
BOF sector	761.41	771.9	801.65	599.47	618.83	598.6

The aetiology of respiratory diseases is difficult to be discussed in correlation only with a particular pollutant. Studies relating to diseases caused only by exposure to dust can not be achieved. However it can appreciated that exposure to high fugitive emissions of fine dust particles of coal/coke and brown fumes (together with exposure to irritants and toxic gases emissions) it favourable to emergence and negative evolution of the diseases in some workplaces. The eye diseases manifest themselves in areas where personnel are exposed to harmful dust (metals, coal/coke) and also to irritating gas or overexposure to light in welding operations.

The severity index on group of diseases determined by exposure to dust emissions (together with other pollutants) is given in Table 6. The highest value was recorded for coke, which is higher than that of the entire factory. This can be attributed to the simultaneous action of dust with more pollutants (BaP, HPA, BTX, PAHs) generated by activities developed in this sector.

Also, the values of indicator named professional etiological fraction (PEF) for the sectors of integrated plant are evaluated by ICEM Bucharest [21]. To evaluated this indicator was used the values of relative risk (RR as ratio of incidence in terms of occupational exposure and incidence in the benchmark group). Professional etiological fraction (EFF) based on RR, validates the percentages above 20% the causality of work-related diseases.

***Table 6**. IG on group of diseases in relationship with dust exposure, during 2000-2001, %*

Group of diseases	**All sectors of metallurgical plant**	**Sector**		
		Coking	**Blast furnaces**	**Basic oxygen furnaces**
Respiratory diseases (without flu and pneumonia)	6.31	7.45	4.65	6.17
Skin diseases	3.59	3.9	3.25	3.4
Eyes diseases	1.29	1.42	1.20	1.17

Highest relative risk value was recorded for the period 1999-2000 to coke ovens plants: risk of disease was 3-4 times higher. Simultaneously, the highest percentage of PEF were recorded to sectors: coke oven plants, pig iron making (including sinter sectors), basic oxygen steelmaking (Table 7) [21]. Analyzing indicators, is find that between 1998 1999, professional etiological fraction (EFF) was significant at Romanian integrated plant, representing 25 to 33% compared with benchmark group, illustrating a link between work-related diseases and conditions relating to microclimate.

***Table 7.** Professional etiological fraction (PEF) in sectors of integrated plant*

Sector	1997	1998	1999	2000	2001
Coking sector	50.82	43.79	68.01	75.49	53.85
Blast furnaces	45.14	8.97	60.43	51.56	32.55
BOF sector	44.35	40.75	53.43	67.97	52.08
All sectors of integrated plant	37.30	28.52	66.76	65.39	49.09

Impact of dust emissions as air pollutant on the population of the vicinity areas can correlate, especially, with incidence levels and prevalence of respiratory diseases. Health Department of Galati district has selected 35 diseases likely to be affected by air pollution, classified into 5 categories: airborne infectious diseases, acute respiratory diseases, conjunctivitis diseases, ENT diseases, chronic diseases. Environmental report conducted by ICEM Bucharest [21], to express morbidity in investigating the relationship between air pollution and health have used „incidence" and „prevalence": for acute diseases - their incidence was calculated (for 1995) by class of diseases (number of diagnosed new cases reported per 100,000 inhabitants); for chronic diseases was calculated the prevalence (for 1995) by classes of disease (number of existing cases reported per 100,000 population).

Levels of incidence and prevalence by classes of diseases were calculated for Galați town separately for areas that have different exposures (as exposed and unexposed areas) for 1995, Table 8. [21].

***Table 8.** Levels of morbidity indicators in Galați*

Diseases	**Areas**			
	Exposed		**Unexposed**	
	Adults	**Children (under 14 years)**	**Adults**	**Children (under 14 years)**
infectious diseases	70.54	9312.6	146.09	6466.49
conjunctivitis diseases	30.41	1985.49	55.10	1423.54
ENT diseases	160.55	3910.50	249.89	3175.97
acute respiratory diseases	3521.09	84015.31	2688.65	54392.54
chronic respiratory diseases	108.25	372.91	78.15	3295.42
other chronic diseases	42.57	377.94	4.48	263.43

To estimate the effects of pollution on the health of the population has become analyzing the morbidity levels (expressed as all phenomena of disease) that can be considered an indicator of the body's response to exposure.

Examination of the trend morbidity levels over a long period of time and comparing them to the national average can confirm or disprove if there is any influence of the presence of pollutants in the environment on the levels of these indices. Table 9 shows the comparative evolution of morbidity for Galati and Romania during 1991-2000 in terms of respiratory diseases.

In terms of respiratory diseases percentage in Galati town compared to the situation on at national level, they were below 1%.

It can be appreciated that the industrial activity of integrated steel mill from Romania (including also the exposure to dust emissions) does not a major negative impact on the health of the population.

***Table 9**. Respiratory diseases for all Romania and Galati, during 1991-2000**

Year	1991	1992	1993	1994	1995
România	6350	6887	7188	7321	7439
Galați	52070	63235	55381	48822	43211
	0.82	0.91	0.77	0.66	0.58
Year	1996	1997	1998	1999	2000
România	8060	7160	6913	6584	6749
Galați	42635	11109	29144	42547	40540
	0.52	0.15	0.42	0.64	0.60

* Data provided by the Ministry of Health.

5. Conclusions

Particulate matter (PM) may be generated by multiple sources identified in each process step of an integrated iron and steel plant. They may contain varying concentrations of mineral oxides, metals, metal oxides and some adsorbed organic pollutants.

Sources include thermal processing of materials (coal processing; coke quenching; sinter process; tapping and casting of pig iron, steel and slag; melting and refining into blast furnaces, basic oxygen furnaces, pig iron mixers; installations of secondary metallurgy etc.); air heating furnaces (cawpers); mechanical actions (e.g. crushing, sieving, conveying weighing, loading, unloading etc.); and handling of materials (e.g. raw materials, additive, recycled and waste materials, and by-products).

The level of dust emissions in point-sources placed on industrial site and also on surrounding areas requires a continuous monitoring. The results allow to take necessary measures to reduce the level of dust emissions at hot sources. A dust release affect the immediate worker, but it may spread throughout the workplace and affect the population of the vicinity areas. Based on the analysis of air quality monitoring data and morbidity data can not demonstrate with certainty affirm the influence air pollution (including dust particles in suspension) on the population living in vicinity of the plant. This influence is more likely to plant workers directly involved in its activity.

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