

DETERMINATION OF SOLID PARTICLE CONCENTRATION AT COAL TRANSSHIPMENT SITE**CIETO DAĻIŅU KONCENTRĀCIJAS NOTEIKŠANA OGĻU PĀRKRAUŠANAS VIETĀ**

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Introduction

Coal handling and grinding processes are associated with significant particulate matter emissions into the atmosphere. It is necessary to limit these amounts because particles have a serious impact on human health and the environment. Particles get into human lungs through the respiratory system and further to the alveoli and bronchi where they inflict serious damage. Research shows that PM₁₀ particles are the most harmful and can cause malignant tumors, cancer, cardiovascular diseases, chronic bronchitis, pneumoconiosis (black lung disease), lung emphysema and other diseases [1, 2, 3]. This problem is particularly urgent when a coal-processing company is located in a densely populated city or near it. Limitations for PM₁₀ concentrations are set in Latvia's Minister of Cabinet Regulation nr. 588 "Rules for air quality". The daily (24 hours) particle mass concentration must not exceed 50 µg/m³ more often than seven times a year [4]. PM_{2.5} particle limitations are set in Directive 2008/50/EC of the European Parliament and of the Council on ambient air quality and for cleaner air for Europe where the limitation for PM_{2.5} is 25 µg/m³ [5]. To evaluate particulate concentrations generated into the atmosphere from coal grinding and transshipment site according to the standardized methodology, it is necessary to conduct extended measurements using an automatic real-time, infrared dust and aerosol monitor. The compliance with regulatory values will be evaluated. It is theoretically known that meteorological data influences particle concentrations. The influence of wind direction and wind speed on measured particle concentrations are also analyzed in this research by viewing one measurement period.

Methods and materials

To achieve the goal of this research, continuous dust monitoring was conducted at an active coal transshipment site. On the site, the location of the equipment was determined according to the standard

LVS 12341 „Air quality - Determination of the PM₁₀ fraction of suspended particulate matter - Reference method and field test procedure to demonstrate reference equivalence of measurement methods". The equipment was placed 6 m above ground and 120 m away from the emission source – a coal crushing and handling site. There were no obstacles near the equipment that could cause an adjustment or change in wind speed or direction. The emission source could be seen directly by the human eye.

A continuous dust monitoring station was used. It consists of three elements: real-time dust monitor Mikrodust Pro, personal sampling pump APEX Lite and Dust Detective – a static air sampling enclosure. The particulate concentrations are measured using a near forward angle light scattering principle. An infrared light of 880 nm wavelength is projected through the sensing volume where contact with particles causes light to scatter. Depending on the level of scatter which is detected by photodetector, the mass concentration of the particulate matter is calculated. Mikrodust Pro has an internal logger which saves the measured values into its memory [6]. A special size of selective polyurethane foam filters were used for the determination of PM₁₀ and PM_{2.5} mass concentrations. Amount of Total Suspended Particles (TSP) was determined without filters. The pump was used to drive an air sample through the measurement chamber of the Mikrodust Pro.

The data logging interval was set to 22 seconds for TSP, PM₁₀ and PM_{2.5} and 55 seconds for some PM₁₀ measurements. Data was collected on site using a laptop after the end of each monitoring period (three to five days). After data collection, the equipment was calibrated for the next measurement according to the directions set in the manual.

Meteorological data was collected from the data base of the Latvian Environment, Geology, and Meteorology Agency. Wind speed and direction values were acquired from a weather station located eight km away from the site.

Results

Particulate concentrations were collected over the course of 41 days. TSP monitoring was carried out for seven days, PM₁₀ - during 22 and PM_{2.5} – during 12 days. The results indicated that PM₁₀ concentrations exceed the threshold (50 µg/m³) nine times during 17 diurnal days and PM_{2.5} concentrations exceeded the regulatory value (25 µg/m³) five times during 12 days,

as seen in Figure 1.

The concentration values of the 26th to 28th April and the 22nd to 25th May are not to be taken into account as unauthorized access to the measurement equipment by a site worker occurred, which resulted in incorrect measurements for these periods.

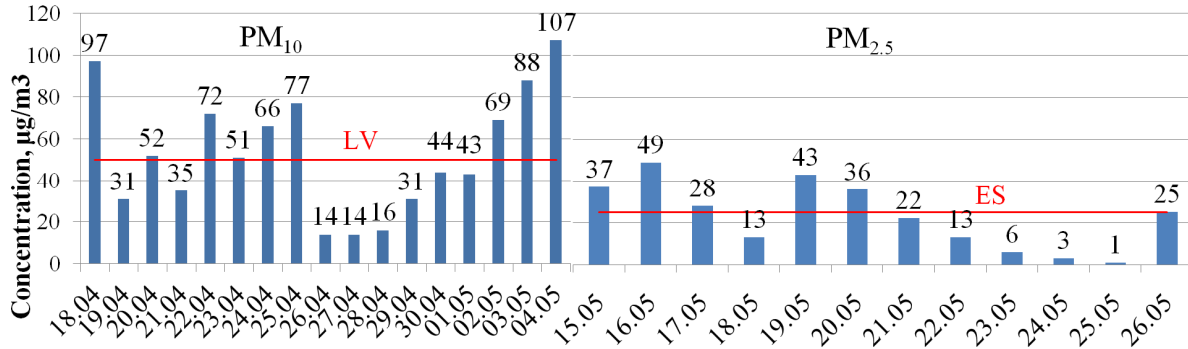


Fig. 1. PM₁₀ and PM_{2.5} concentrations

Concentration level changes during the monitoring periods were analyzed regarding wind behavior during the measurements. In Figure 2, TSP concentration change is viewed. The upper right corner shows the schematic placement of measurement equipment on the site map. Wind direction was represented in numerical values where 180° is the wind direction from South to North and 270° is the wind direction from the West to East side. If the wind direction value is 210°, the particles are blown directly from the emission source to the measurement equipment. If the wind direction value is 30°, emission sources particles are blown away from

the air inlet. There are two intervals (A and B) where concentration values excel. During interval A, the first pike was caused by a rapid wind direction change from 304° to 166° at a constant wind speed of 0.5 m/s. High concentration increase from 0.2 to 0.7 mg/m³ was caused by a wind direction change from 72° to 310° and a wind speed increase from 0 to 0.9 m/s, where the latter remained at that level of intensity until the beginning of Sunday (SV 00:00). The next rapid increase from 0.8 to 1.2 mg/m³ was caused by an intense increase of wind speed from 0.9 to 1.7 m/s while the wind kept coming from North-West side.

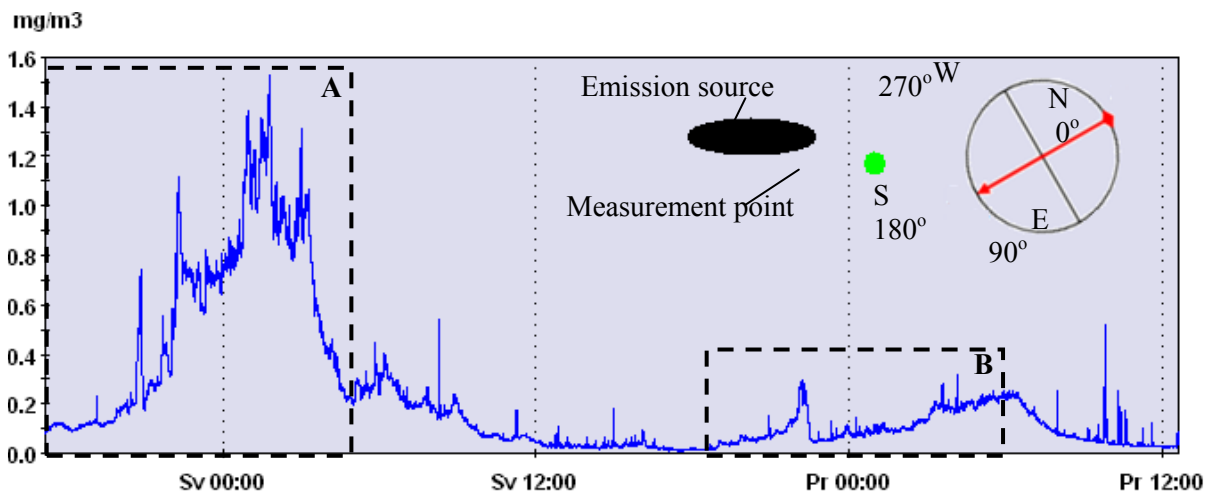


Fig. 2. TSP concentration values and wind direction

The decrease of concentration to 0.95 mg/m³ is caused by a wind speed decrease to 0.5 m/s and a wind direction change to 26°, where lower readings occur. At

the start of period B, the gradual increase is caused by an increase in wind speed (from 1.1 to 3.9 m/s), at that time the wind direction is approx. 340°, but when the

rapid decrease happens it changes to 60° (particles are driven away from measurement system) which remains more or less constant until the end of selected period. In this case, the gradual increase of concentration values does not occur when the wind velocity continues to increase, but when it decreases (from 3.9 m/s to 1.2 m/s). This occurs because with a decrease of wind speed, the intensity with which the particles are driven away from equipment decreases. With lower wind speed, a much higher amount of particles is able to stay within the territory and travel to the measurement system.

Discussion

Until now, no specific on-site measurements were made to qualitatively evaluate air quality at this coal transshipment site, but after this study it is now clear that concentration values are higher than permitted in Latvia and the EU. To decrease the particulate amount into the atmosphere it is necessary to take preventive measures to reduce dust emissions from the coal handling and grinding processes. This can be achieved by utilizing the best available techniques for the prevention of dust emissions, like water spraying, water curtains, reduction of wind attack areas, keeping the area clean of deposited dust, optimizing coal handling with grabs etc. As a result of this study, theoretical knowledge of the impact of wind behavior on the measured concentration values is quantitatively proven. It is now understood that if wind comes from dust emission source to the measurement system, the increase in wind speed increases particle concentration as all particles in the air and those raised from coal piles are driven towards the equipment. However, if wind comes from the opposite direction, the decrease of wind velocity results in an increase in the concentration values as the emitted dust cloud stays within the territory of the measurement. Overall after this study the situation of coal transshipment site impact level on air quality has become more clear and it is evident that much stricter regulations must be introduced for coal processing sites.

References

1. BBB - McKenna D.J., Turner H. J., McKenna P. J. Fine particle (2,5 microns) emissions – Hoboken: John Wiley & sons, Inc, 2008 – P.26-38.
 2. Effects of Particles on the Cardiovascular System/ prepared by – Nicholas L. Mills, David E. Newby, William MacNee, Ken Donaldson // New York: CRC press Taylor & Francis group, 2007, P.259-275.
 3. Freidlander, K. S. Smoke, Dust, and Haze – New York, Oxford University press, 2000 – P.370-378.
 4. Rules of Ministers Kabinet nr. 588. „Rules for ambient air”
 5. Directive 2008/50/EC of the European Parliament and of the Council on ambient air quality and cleaner air for Europe
 6. Mikrodust Pro users handbook HB3275-05 – Bedford, CASELLA CEL 2002 – P.7-9.
- Kaspars Siliņš, Aivars Žandeckis, Sarma Valtere, Cieto daļiņu koncentrācijas noteikšana ogļu pārkraušanas vietā**
Akmeņogļu pārkraušanas un smalcināšanas procesi ir saistīti ar būtiskām cieto daļiņu emisijām atmosfērā. Minētā problēma ir īpaši aktuāla gadījumos, kad ogļu apstrādes uzņēmums atrodas blīvi apdzīvotā pilsētā vai tās tiešā tuvumā. Lai kvantitatīvi novērtētu šīs darbības radītos izmešus gaisā atbilstoši standartizētai metodikai, ir nepieciešams veikt ilgstošus mērījumus ar automātisko cieto daļiņu koncentrācijas infrasarkano mērītāju. Šī pētījuma ietvaros tika veikti lauka mērījumi ogļu pārkraušanas uzņēmuma teritorijā. Izmantojot cieto daļiņu koncentrācijas noteikšanas sistēmu Dust Detective kit, tika veikts kopējo cieto daļiņu (TSP), cieto daļiņu, kas mazākas par 10 mikrometriem (PM₁₀) un cieto daļiņu, kas mazākas par 2.5 mikrometriem (PM_{2.5}) koncentrāciju monitorings. Iekārtas tika izvietotas 6 m augstumā virs zemes un 120 m attālumā no paša emisiju avota – ogļu smalcināšanas un pārkraušanas vietas. TSP monitorings tika veikts četrus diennakšus, PM₁₀ tika veikts 17 diennakšus un PM_{2.5} 12 dienu laikā. Salīdzinot iegūtos rezultātus ar Latvijas un Eiropas Savienības

normatīvajos dokumentos noteiktajām robežvērtībām, tika secināts, ka PM_{10} vidējā diennakts koncentrācija septiņpadsmit diennakšu laikā deviņas reizes pārsniedza gan Latvijā, gan ES noteiktos robežlielumus. $PM_{2.5}$ vidējā diennakts koncentrācija 12 dienu laikā četras reizes pārsniedza Eiropas Savienības direktīvā 2008/50/EK noteikto $25 \mu\text{g}/\text{m}^3$ robežvērtību.

Nosakot vēja ietekmi uz koncentrāciju mērījumiem, tika noskaidrots sekojošais: ja vējš pūš no avota uz mēraparātu, tad pieaugot vēja ātrumam, koncentrācija pieaug, jo visas daļiņas kas paceltas gaisā tiek nestas uz iekārtu un no kaudzes ceļas papildus emisijas vēja iedarbības dēļ. Ja vējš pūš prom no mērīšanas punkta uz avotu, tad ir pretējais – jo mazāks vēja ātrums, jo lielāks putekļu mākonis veidojas un paliek uzņēmuma teritorijā, kas arī parādās mērījumos. Tika pierādīts tas, ka vēja ātrumam mainoties, koncentrācijas mainās pakāpeniski. Mainoties vēja virzienam, koncentrācijas mainās strauji.

Balstoties uz iegūtiem rezultātiem, tika secināts, ka darbā apskatītājā objektā pastāv aktuāla problēma ar būtiskām cieto daļiņu emisijām gaisā. Šajā uzņēmumā ir nepieciešams veikt preventīvus pasākumus putekļu emisiju samazināšanai no akmeņogļu pārkraušanas un smalcināšanas procesiem. Ir kvantitatīvi apstiprinātas esošās zināšanas par vēja ietekmi uz putekļu daudzumu atmosfērā.

Kaspars Silins, Aivars Zandekis, Sarma Valtere, Determination of solid particle concentration at coal transshipment site

Coal handling and grinding processes are associated with significant particulate matter emissions into the atmosphere. This problem is particularly urgent when a coal-processing company is located in or nearby a densely populated city. To quantitatively evaluate concentrations generated into the atmosphere according to the standardized methodology, it is necessary to make extensive measurements using an automatic real-time, infrared dust and aerosol monitor. Before the experiments, the impact of particulate matter on human health and the environment was explored, six solid particle concentration detection methods and best available techniques for particulate matter emission prevention was described. During this study field measurements were carried out at on the territory of a coal transshipment company. Using the solid particle concentration detection system Dust Detective kit, concentration monitoring of total particulate matter (TSP), PM_{10} and $PM_{2.5}$ was carried out. The equipment was located 6 m above ground and 120 m away from the emission source - coal crushing and handling site. TSP monitoring was carried out during four diurnal, PM_{10} - during 17 diurnal and $PM_{2.5}$ - during 12 days. After comparison of results with concentration values set in normative documents of Latvia and EU, it was found out that average 17 diurnal day concentration values of PM_{10} exceeded normative values for nine times. $PM_{2.5}$ daily average concentrations of 12 days exceeded for four times exceeded the value of $25 \mu\text{g}/\text{m}^3$, which is mentioned in Directive 2008/50/EC of EU.

After analysis of wind behaviour impact on the concentration values it is now understood that if wind comes from the dust emission source to the measurement system, the increase in wind speed increases particle concentration as all particles in the air and those raised from coal piles are driven towards the equipment. If wind comes from the opposite direction, the

decrease of wind velocity results in an increase of concentration values as emitted dust cloud stays within the territory of the measurement. It was observed that wind speed causes the concentrations to change gradually, but wind direction is responsible for rapid concentration changes.

The obtained results prove that there is an urgent problem with significant particulate matter emissions into the air at the coal transshipment site. It is necessary to take preventive measures to reduce dust emissions from the coal handling and grinding processes in this company.

Overall after this study the situation of coal transshipment site impact level on air quality has become more clear and it is apparent that much stricter regulations must be introduced for coal processing sites.

Каспарс Силиньш, Айварс Жандецкис, Сарма Валтере, Определение концентрации твёрдых частиц в месте перегрузки угля

Процессы перегрузки и измельчения каменного угля связаны со значительными выбросами твёрдых частиц в атмосферу. Данная проблема особенно актуальна в случаях, когда предприятие расположено на территории густонаселённого города или непосредственно в его близости. Для объективного определения производимых выбросов необходимо провести длительные измерения, в соответствии с стандартизированной методикой, используя автоматическое инфракрасное измерительное оборудование. В рамках данного исследования были проведены полевые измерения на территории предприятия по перегрузке угля. Используя систему для определения концентрации твёрдых частиц Dust Detective kit, был проведён длительный мониторинг общей концентрации пыли, а также твёрдых частиц PM_{10} и $PM_{2.5}$. Оборудование было размещено на высоте 6 метров и на отдалении 120 метров от источника эмиссий – места перегрузки и измельчения угля. Мониторинг общей концентрации проводился в течении четырёх суток, мониторинг PM_{10} – 17 суток и $PM_{2.5}$ - 12 суток. Сравнивая полученные результаты с предельными значениями нормативных документов Латвии и Европейского Союза был сделан вывод, что средняя дневная концентрация PM_{10} на протяжении 17 суток была превышена в девять раз (предельные значения Латвии и ЕС). Средняя дневная концентрация $PM_{2.5}$ на протяжении 12 суток в четыре раза превысила в директиве Европейского Союза 2008/50/EK определённый лимит – $25 \mu\text{g}/\text{m}^3$.

Определяя влияние ветра на измеренные концентрации были сделаны следующие выводы. Если ветер дует от источника эмиссий к измерительному прибору, концентрация пыли возрастает потому что все твёрдые частицы сносит ветром в сторону оборудования и в результате воздействия ветра с куч угля поднимаются дополнительные эмиссии. Если ветер дует от места измерений, то результат противоположный – чем меньше скорость ветра, тем большее облако пыли образуется над территорией. Было доказано, что при изменении скорости ветра концентрация меняется постепенно. При изменении направления ветра наблюдаются резкие изменения концентрации.

На основании полученных результатов сделан вывод, что на рассмотренном объекте существует актуальная

проблема со значительными выбросами твёрдых частиц в атмосферу. На данном предприятии необходимо провести превентивные мероприятия по снижению выбросов твёрдых частиц в воздух. Было также подтверждено уже существующие знания о влиянии ветра на количество твёрдых частиц в атмосфере.