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MEASURING OF BLACK CARBON CONCENTRATIONS, SUMMARIZING RAISED BLOOD PRESSURE DATA AND IDENTIFYING SPECULATIVE EFFECT ON RAISED BLOOD PRESSURE

Borut Jereb[1*], Gregor Šipek[1], Špela Kovše[1], Ana Vovk Korže[2], Petra Vrhovnik[3]

[1]*University of Maribor, Faculty of Logistics, Mariborska c. 7, SI-3000 Celje*
[2]*University of Maribor, Faculty of Arts, International Centre for Ecoremediation,*
Koroška c. 160, SI-2000 Maribor, Slovenia
[3]*Slovenian National Building and Civil Engineering Institute,*
Dimičeva 12, SI-1000 Ljubljana, Slovenia.
borut.jereb@um.si

Abstract: Black carbon, as one of the main air pollutants, has gained a significant amount of attention in the last few years. It affects Earth's climate as well as human health, especially in urban areas where it accumulates in greater amounts because of the dense setting of its sources such as traffic, industry and residential heating. The aim of this study was to investigate black carbon distribution and factors that influence its dispersion and consequently human health. Measurements were carried out in two separate parts, in winter 2017/2018 and spring 2017. Within sampling area, urban and background areas of Celje were included in the study. This setting of the measurements was selected with the purpose of investigating BC's distribution and changes in its concentrations, while also finding how temperatures, wind, precipitation and traffic affect BC's features. The results showed the highest black carbon concentrations always occur in the areas with heavy traffic flow, either in colder or warmer parts of the year (7.48 ± 6.48 $\mu g\ m^{-3}$ in winter and 7.25 ± 6.06 $\mu g\ m^{-3}$ in spring). Outcomes of the research also proved that wind speed, rainfall and temperatures affect black carbon dispersion as well as other factors like traffic density, time of day or day of the week. This study also revealed associations between black carbon oscillation and high blood pressure, especially during the winter period.

Key words: black carbon; city pollution; environment; health; blood pressure

1. INTRODUCTION

The health effects of combustion related air pollution are severe and were identified decades ago. The first mention of black particles was known as "British smoke" (BS), which was used for assessing air quality in Europe (WHO Europe, 2012). Later particulate matter (PM), especially inhalable or respirable fractions of suspended PM such as PM_{10} and $PM_{2.5}$ attracted the attention of researchers and the health sector. Later, the first guidelines for exposure limits were settled by WHO (1979). Even though health systems are more focused on PMs, it's extremely important to also take into consideration the remaining black particles, such as black carbon (BC).

BC, more known as soot, is a product of incomplete combustion of fossil or diesel fuels that contain carbon (Liu et al., 2018; Bond et al., 2005; Koelmans et al., 2006). It is named one of the most problematic pollutants not only because of its ability to very efficiently absorb sunlight and consequently vastly contribute to climate change and changes in the atmospheric environment, but it also has a major effect on human health (Rajesh et al., 2018; Ji et al., 2018). WHO Europe (2012) exposes that long- and short-term effects estimates are much higher for BC in comparison with PM_{10} and $PM_{2.5}$ (when particulate measures expressed per unit of mass concentration – $\mu g/m^3$). Moreover, Baumgartner et al. (2014) reported that BC is more strongly associated with blood pressure than $PM_{2.5}$ and water solluble organic mass (WSOM). BC may therefore be a useful indicator of the cardiovascular health and also climate benefits of interventions that lower air pollution concentrations and exposures.

High blood pressure (hypertension) is a common condition in which the long-term force of the blood against a person's artery walls is high enough that it may eventually cause health problems. It can quietly damage the human body for years before symptoms develop. With no proper treatment and control, it causes different disabilities, and can decrease life quality or even cause death. Hypertension causes several cardiovascular complications including brain stroke, cardiac infarct, kidney failure and dementia. Hypertension is the most common cause of death in the world.

According to Xing et al. (2018), BC's distribution is highly dependent on multiple factors of natural or anthropogenic origin, such as source strength, background concentrations and distance from the source or diffusivity parameter. Significant increase in concentrations can be visible in winter time while in summer concentrations of BC are usually substantially lower (Virkkula et al., 2007). During the winter, occurrence of inversion is also common in some areas of the world, and it has a major impact on suppression of BC particles in lower altitudes or in basins (Pereira et al., 2012). Seasonal changes of BC's concentrations are highly affected by biomass burning (BB) too. Kucbel et al. (2017) and Zhang et al. (2018) already stated that BC particles from BB are most commonly contributed by utilizing coal or wood for residential heating, which is exaggerated in winter when temperatures are lower.

One of the most important anthropogenic pollutant sources is also traffic but because of great heterogeneity of traffic rates, driving modes and emission factors concentrations of traffic-related BC are highly variable (Targino et al., 2016). Time of day has a huge impact on vehicular emissions' concentrations say Backman et al. (2012) who reported that BC density is much higher at rush hours, especially in urban areas. Nazeer Hussain et al. (2018) also noted that BC in urban regions has a very noticeable weekend effect, which can be seen in significant reduction of BC's concentrations at the end of the week and at weekends. While density of traffic is important, distance from the source of BC is also significant, as is the presence or absence of canyons at the roadside. Zwack et al. (2011) labelled street canyons as one of the most important "hot spots" of air pollution.

Moreover, Durant et al. (2010) reported that concentrations of pollutants such as BC are elevated near highways and roadways, but they decrease within several hundred meters into the background as a consequence of dilution. According to Hagler et al. (2012), different obstacles, such as buildings or even solid noise barriers and trees at the roadside can also alter air pollutants' dispersion by capturing them and augmenting their concentrations.

Wind also affects BC's distribution, especially with its speed and direction throughout the day as it mixes the air masses. This causes a decrease in BC's concentrations (Ježek & Močnik, 2010). Bladwin et al. (2015) proved in their study that concentrations of BC coming from ground-level sources decreased generally when wind speed increased.

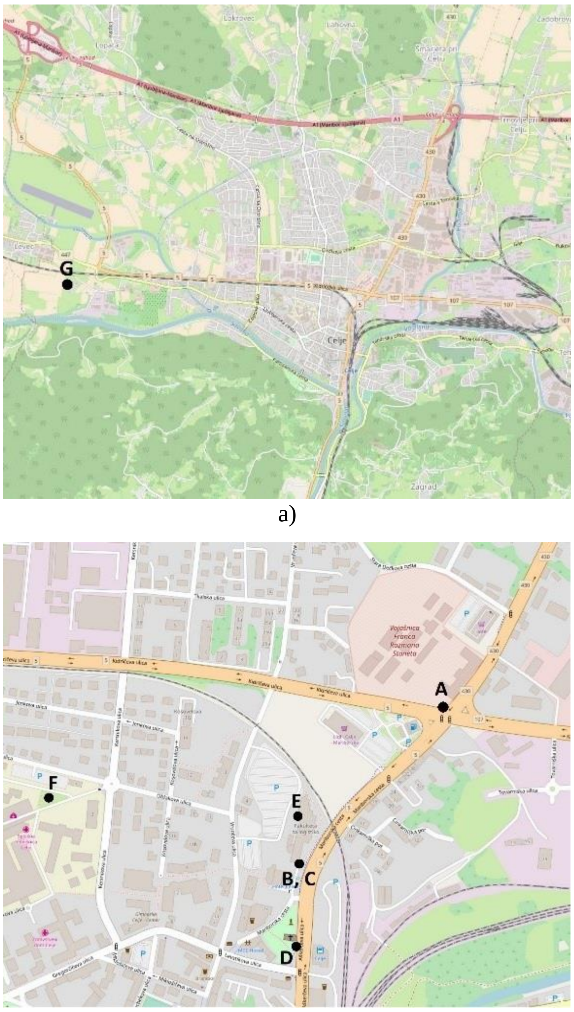
Any kind of precipitation, such as rain, snow or even fog, has a correlation with BC's concentrations, but association between precipitation and concentrations of BC is determined by hydrophobic character of freshly emitted BC particles and intensity of precipitation, say Kucbel et al. (2017).

2. MATERIALS AND METHODS

Data was gathered in several periods in winter and spring of 2017 and 2018. More precisely, from 14th March to 14th April 2017 and from 20th April to 29th April 2017. Winter measurements in 2018 were conducted as well. They went on throughout December 2017 and later from 1st January to 25th January 2018. Described measurements are identical to those, used in Jereb et al.'s (2018) article as results could be used in many different areas of exploration and for several different subjects' justification. These measurements gave enough insight into the BC's behaviour to enable identification of BC's distribution pattern.

Measurements took place in Slovenia's third biggest city Celje, in the Municipality of Celje (MOC). As already described in Jereb & Vovk Korže's (2018) article, five static measuring points were determined (A, B, C, D and E) as presented in Figure 1, where aethalometers were set up for gathering data for the express purpose of this research. Levels of pollution in the city background were provided by the measuring station Celje Hospital (Location F) while wind speed and direction as well as data on precipitation (rainfall and snowfall) were collected from the measuring station AMP Gaji (Location G). Both measuring stations are included in the state measuring network and they provide data on general air pollution and weather conditions in MOC. Because of describing the same measurements, in this article Figure 1 is the same as in Jereb

& Vovk Korže's (2018) article, only the naming of the measuring points has been altered for easier implying.



a)

b)

Fig. 1. A map representing points of BC measurements in MOC

2.1. *Static measuring point A*

Measuring point A was at the intersection of Mariborska Road and Kidričeva Street which is also Celje's biggest crossroads. Eight driving lanes with heavy traffic flow with up to 20,657 diesel-engine vehicles in an average day intersects here, and the numbers are even higher in the rush hour. The aethalometer was set up on a lamp post, approximately 3 m above ground level. Measurements at location A were conducted in spring as well as in winter.

2.2. *Static measuring point B*

This measuring spot was situated on the ground floor of the building with dimensions 20 × 110 m. The aethalometer was placed in the room at a height of 3 m. This side of the building is facing the main traffic route Mariborska Road which is about 20 meters distant and ascends right from the road underpass that causes "a canyon effect". Measurements at this point were conducted in spring and in winter but latter measurements were non-authentic as the aethalometer was set up in a lecture room of the faculty and was therefore turned off several times because of students' ignorance and other reasons.

2.3. *Static measuring point C*

Static measuring point C was placed right above point B. The aethalometer was set up in one of the rooms on the 4th floor, at a height of approximately 18 m. This placement was selected with the purpose of observing changes in BC's concentrations with augmentation of height. Measurements here were conducted only in springtime.

2.4. *Static measuring point D*

The fourth measuring point was set up in spring. The aethalometer was attached to a lamppost right by the roadside, opposite Celje's main bus station at a height of approximately 3 m, and at a distance of about 2 m from the Mariborska Road.

2.5. *Static measuring point E*

As one of the goals of obtaining measurements was to determine how physical obstacles affect BC's distribution, this measuring spot was located on the ground floor (as well as point B) but at the back of the same building. It is important to stress that even though measurements were conducted in the back and the instrument was not facing the roadside, vehicles still slightly affected the results because a big public car park is situated at the backside of the building where cars and other vehicles mainly drive across the parking lot in the morning and at the end of working hours, since people park their vehicles here mostly while they are at work. Also, an 80 m distant and less important street with low traffic density may slightly affect the results of measurement at this measuring point. Measurements here were also conducted in spring time only.

2.6. *Measuring station F*

The first measuring station in Celje, labelled as Location F, is situated near the new ER premises where traffic isn't as dense as on main roads or intersections. Approximately 12,000 motorized vehicles pass by this measuring point on a daily basis, while on Mariborska Road, the number of vehicles is almost doubled – about 23,000 vehicles per day. Here at Celje Hospital sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon oxide (CO), PM_{10} particles concentrations and ozone concentrations are measured. Winter measurements in December 2017 and January 2018 were conducted at this spot.

2.7. *Measuring station G*

The second measuring station, labelled as Location G, is AMP Gaji which is placed at a municipal automatized measuring station. It is located in the eastern part of the city near the district heating plant. This station gathers data on sulphur dioxide (SO_2), nitrogen dioxide (NO_2), PM_{10} particles concentrations, benzene and ammonia as well as wind speed, wind direction and the amount of precipitation. Data on wind and precipitation for the purposes of this research was obtained from this weather station.

2.8. *Aethalometer measurements*

Measurements for observing BC's concentrations and distribution in MOC were conducted with several devices, all being Aethalometer® Model AE-33 provided by Magee Scientific, Aerosol d.o.o. This instrument's basic sampling principle is the same as in older models; the operation and calculations are based on the Ångström exponent. The air flow through the aethalometer enables continuous aerosol particles sampling onto the quartz filter where particle attenuation is measured at seven different wavelengths, which allows spectral analysis of the data (Drinovec et al., 2015). BC mass concentration is later calculated from the change in optical attenuation at 880 nm in selected time interval (Titos et al., 2015). For the purposes of this research all of the devices were set to 1 minute intervals but because received data on weather conditions were listed in time intervals of 30 minutes, all further processing was made in latter intervals.

All of the measurements were conducted in a different season (winter and spring) which means diverse meteorological conditions were encompassed and studied in the research. Also, average working days were selected for analysis of the gathered data. These were the days during the school year on which there were no annual vacations and public offices have longer working hours.

When studying the traffic density, it was assumed that one bus and/or truck equals four diesel-engine personal vehicles. This number stems from the fact that fuel consumption and therefore also the level of emitted particles is four times higher than average in buses and trucks than it is in personal vehicles when accelerating and/or driving with even speed. Although, it is important to stress that fuel consumption for trucks vary according to the amount of freight they are transporting (0 – 20 t in average).

3. RESULTS AND DISCUSSION

3.1. *Traffic characteristics*

Municipality of Celje (MOC) is intersected with numerous vital traffic communications, one of them being Mariborska Road with the biggest intersection in town which was also one of the static measuring points (measuring point A).

Mariborska Road represents the main traffic route of MOC and therefore has heavy traffic flow. On an average working day, 20,657 diesel-engine vehicles drive through the intersection of location A, of those 16,175 private vehicles, 233 buses and 4,249 freight vehicles. The NNV at this point can be seen in Figure 2 and is presented with the red line. Following this line across the graph shows that vehicles at point A are most numerous in the morning rush hour between 6.30 a.m. and 8.00 a.m. The graph peaks heavily in that time period because the working class is headed to work at that time. The same happens in the afternoon rush hour between 1.00 p.m. and 3.30 p.m. when people leave work. The NNV in this time period reaches its highest values which start to diminish after 4.00 p.m.

At the second measuring point B, numbers are slightly lower. The NNV for this measuring spot is also shown in Figure 2 and is marked with the blue line. The blue line also shows the average number of NNV for measuring points C and D as the traffic flow is the same for all three measurement areas. Here 12,920 diesel vehicles represent the mean traffic flow in a working day. 10,011 of those are private motorized vehicles, the number of buses is 204 and freight vehicles are numbered at 2,705. Of course, daily rush hours were taken into consideration as well as at point A. Morning rush hour at this spot is again most vivid between 6 a.m. and 8 a.m. when daily commuters are on their way to work and/or school. Slight deviation upwards is seen on the graph (Figure 2) in this time period. This is also the main reason for an increase in the number of private motorized vehicles on the roadside. Because Mariborska Road is the most important route in Celje, it also represents the main bus route therefore an increase in the number of buses in the morning rush hour is evident, especially during the school year. Again, afternoon rush hour begins at 1.00 p.m. and is most prominent until 3.30 p.m. as most of the working class leave their jobs. In Figure 2, a peak can be distinguished shortly after 1.30 p.m. and is moderately descending until 4.00 p.m. Afterwards the blue line can be seen plunging faster until 9.00 p.m.

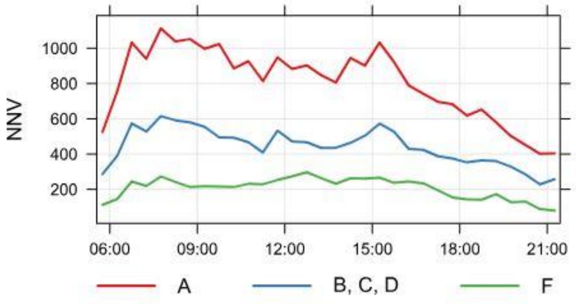


Fig. 2. Normalized number of vehicles (NNV) on an average day at measuring points

Another measuring spot (point F) was put up at an urban background, where the Slovenian Environment Agency (ARSO) has placed a measuring station. The NNV for this spot is marked in the Figure 2 with a green line. Here, the traffic flow is significantly lower than at A or B measuring points, which can be unquestionably seen from the graph. Average number of diesel vehicles in a working day here stands at about 5,655, of which the vast majority are private motorized vehicles, numbered at 5,286. The number of buses is 93 and the amount of freight vehicles is 276. Here, in the urban background, morning rush hour can be partitioned into two parts – one taking time from 6.00 a.m. to 7.00 a.m. and other between 7.30 a.m. and 8.15 a.m.

This occurrence is also visible from the Figure 2. In the first part, the number of private motorized vehicles raises the most as this is the time of people's first daily migrations to work. In the second period of morning rush hour, the rest of the workers head to work. Also at this time the number of buses increases, particularly throughout the school year, not only in the morning, but also in the afternoon rush hour, thus two timeframes can be taken in consideration.

The first one is evident from 10.30 a.m. to 1.00 p.m., while the second can be observed between 1.45 p.m. and 3.15 p.m. Again, the number of private motorized vehicles is augmented because of the end of the working day, and the same goes for buses, especially during the school year. It is important to note that in the afternoon the number of freight vehicles is increased, too. Delivery may be the main reason for that.

3.2. *Black carbon concentrations*

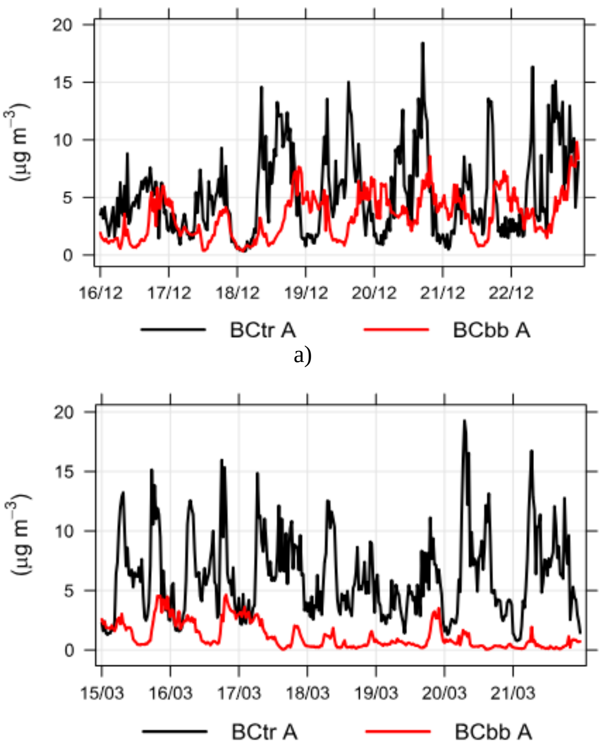
Table 1 contains mean concentrations of measured BC, wind speed and air temperature obtained from measuring points A, B, C, D, E and F in winter and spring time.

This study confirmed BC concentrations' typical seasonal (and temporal) fluctuations which can be seen in Figure 3. For easier understanding as well as to describe our findings best, only the days with the most prominent results of measurements are presented in the figures.

Table 1

Data on average BC concentration values, wind speed and air temperature at measuring points A, B, C, D, E and F

Measurement site	Winter measurements (December 2017 – January 2018)			Spring measurements (March – April 2017)		
	BC (μg m^{-3})	WS (m s^{-1})	*T* (°C)	BC (μg m^{-3})	WS (m s^{-1})	*T* (°C)
A	7.48 ± 6.48	2.01 ± 1.84	4.93 ± 2.91	7.25 ± 6.06	1.91 ± 1.43	11.70 ± 6.47
B	6.32 ± 4.86			2.85 ± 2.69		
C				2.83 ± 2.31		
D				4.04 ± 2.57		
E				1.67 ± 1.43		
F	5.86 ± 5.67			3.22 ± 3.09		



a)

b)

Fig. 3. BC concentrations originating from traffic (BCtr) and biomass burning (BCbb) during winter (graph a) and spring (graph b) time at measuring point A

Knowing that wind speed has a big impact on BC concentrations trends, it was in our interest to find out exactly how this influences the BC's dispersion. It is clearly visible from Figure 4 that in the calm periods when there was no wind or when wind reached speeds up to 1 ms^{-1}, the concentrations of BC were rising (for example, around December 16th and 17th). In lengthy wind periods, when the speeds were up to 2 or 3 ms^{-1}, concentrations started dropping (for example around December 14th). Also, when windy, concentrations during rush hours were consequently lower.

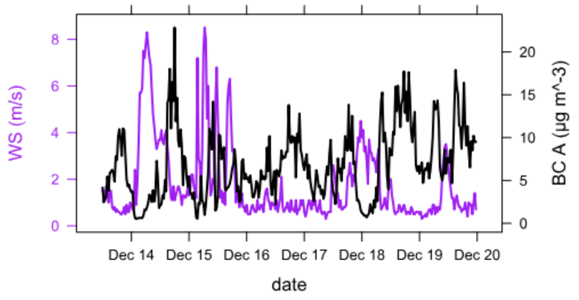
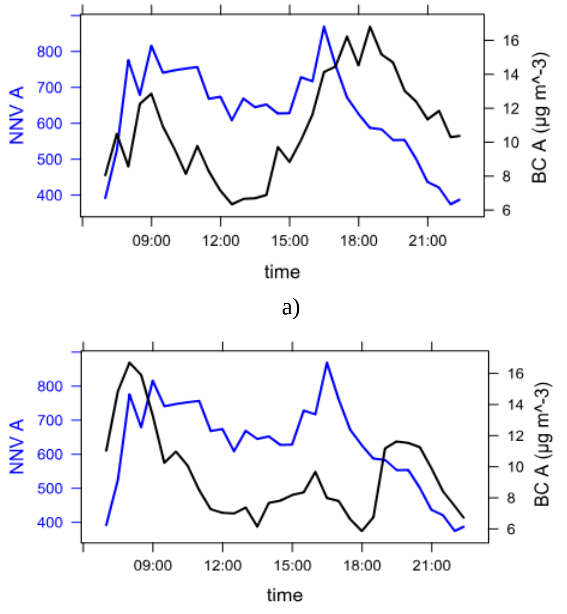


Fig. 4. BC concentrations in dependence to wind speed at measuring point A

As already stated, BC concentrations peaked at morning and afternoon rush hours as a consequence of larger density of traffic which can again be seen from Figure 5. This occurrence was visible at every measuring spot.



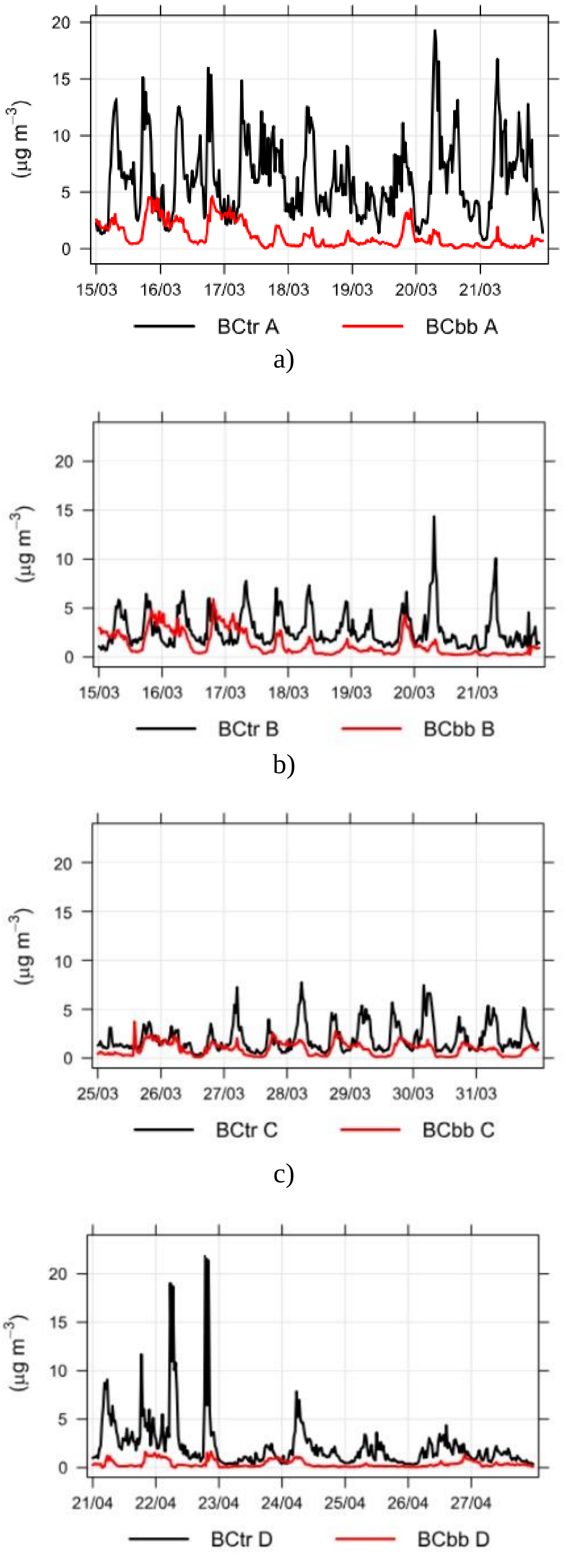
a)

b)

Fig. 5. BC concentrations in dependence to normalized number of vehicles (NNV) in winter (graph a) and spring (graph b) at measuring point A

When it comes to observing dependence of BC on traffic density, day of the week is also an important factor. Traffic flow is decreased on weekends, namely. Distance from the source plays a big role in BC concentrations too. The comparison of BC concentrations at measuring points A, B, C and D is presented in the following paragraphs and can be seen in the bottom group of graphs (Figure 6). Even though an increase in BC particle density was visible at all measuring points, results from measuring point A stood out. Concentrations here were the highest regardless of winter or springtime (7.48 ± 6.48 µg m^{-3} in winter and 7.25 ± 6.06 µg m^{-3} in spring). The main reason was location and role. The crossroads at measuring point A is the biggest intersection in MOC, has traffic lights installed and vehicles here tend to queue and accelerate a lot.

Still, spring measurement results were 3 % lower in concentration than those in wintertime. At measuring point B which was set up in one of the rooms on the ground floor of the before-mentioned building, concentrations were slightly lower as this spot was situated 3 m above ground level and 20 m distant from an area where Mariborska Road ascends from the road underpass. Mean BC values reached 6.32 ± 4.86 µg m^{-3} in winter and 2.85 ± 2.69 µg m^{-3} in spring.



a)

b)

c)

d)

Fig. 6: Comparison of spring-time BC concentrations at measuring points B, C and D to BC concentrations at measuring point A

In the warmer spring period, concentrations dropped by more than 50 %. In spring, measurements were also conducted at measuring point C, which was located on the fourth floor, 20 m above measuring point B. Here average concentrations of BC were somewhat higher, namely 2.83 ± 3.31 μg m^{-3}. The hypothesis said that considering 20 m of height difference will affect concentrations to the effect of being lower than at point B but it was proven wrong. The wind speed in that period was 1.91 ± 1.43 ms^{-1} which was not a big influence factor but still, observing the results it can be concluded that BC persists longer in higher altitudes than it does near ground level. The last spring measuring point (D) was 135 m distant from measuring spot B and set up 2 m from the roadside where Mariborska Road turns into Levstikova Street, near the main bus station in Celje.

Results of these measurements gave the average BC concentrations of 4.04 ± 2.57 μg m^{-3}. It is important to emphasise that spot D is in close proximity to another crossroads. In this intersection (next to measuring point D) vehicles queue and accelerate just like at point A, but the latter crossroads is bigger, has more driving lanes and the traffic flow is much higher. Also, measuring point D is at a more open area where wind at lower speed can more actively affect BC's concentrations and its distribution.

Another measuring point (point E) was set up in spring. The latter was placed at the back of the FL UM building, next to a public car park of MOC. Mean values of BC concentrations here fluctuated at 1.67 ± 1.43 μg m^{-3}. It is necessary to emphasise that rush hour in this area does not have a significant influence on BC concentrations, while peaks in individual time periods can be ascribed to movement of vehicles around the parking lot and to deliveries.

In the urban background at measuring spot F, winter and spring measurements were conducted. Main winter concentrations were 5.86 ± 5.67 μg m^{-3} in December and 3.22 ± 3.09 μg m^{-3} in January. The latter concentrations were around 25% lower compared to the ones from measuring point A and almost 50% lower than those in December at the same measuring spot. The reason for such deviation between December and January is a decrease in BB concentrations as the average temperature in January was 2.2°C higher than in December and therefore the need for residential heating also decreased. The speed of wind was also an important factor. In December, average wind speed was 1.91 ± 1.86 ms^{-1} while in January it was higher, 2.04 ± 1.70 ms^{-1}.

While conducting the research and discussing the gathered data, a slight downtrend in BC's concentrations was noticed when precipitation was present. Even though the same occurrence has been described by some authors dismally, this research doesn't have enough data to link rainfall and decrease in BC concentrations with certainty, as at the time of these measurements the amount of precipitation was inadequate. Still, on some days this occurrence was detected, but more measurements would have to be conducted to confirm it.

3.3. *BC health effects*

According to EUROSTAT, Slovenia is in the top 4 countries (Latvia, Bulgaria, Hungary) in the EU where around 35% of the population suffer because of raised blood pressure (RBP). According to the Slovenian national program for preventive cardiovascular diseases from 2016, in average 34% of Slovenians have detected hypertension, and Celje is above average with 38%. According to available data from the WHO, the Slovenian national percentage of RBP from year 2008 is above the WHO region (Slovenia: 43.3 male and 32.8 female) WHO region: 33.1 male, 25.5 female). Even though in comparison to the latest data from Celje, the % is slightly decreased, the average in Celje is still higher than in the WHO region.

If we compare acquired data with the health statistics from Slovenia or even just from the Celje region, it is clear that there are correlations between BC oscillation and RBP. Even though at the moment interpretation of our findings remains largely speculative, we can find some confirmations within broad study of Corsonello et al. (2003) where they were studying associations between unrecognized hypertension and cold weather. Despite extensive evidence in the literature for this phenomena, some surveys have documented higher RBP during the winter (Wang et al., 2003; Sinha et al., 2010a; Hopstock et al., 2012). Also, Woodhouse et al. (1993) explains that decreased living temperature is associated with raised RBP. Most of the studies about RBP are related to the elder population, but also children, adolescents and young adults are taken into account, and within this group the same pattern can be observed (Miersch et al., 2013). While BC from biomass and fossil fuel burning is a major climate-forcing component of PM, Baumgartner et al. (2014) found that BC exposure from biomass smoke is more strongly associated with RBP. On the other hand, places without or with minimal temperature variations during the year (India, Africa, Japan, Turkey, Australia, etc.) noticed the same phenomena (Sinha et al., 2010a, b; Wang et al., 2003; Hozawa et al., 2011; Kunutsor et al., 2010; Polat et al., 2006). For this reason, we think that this particular study reveals new findings that can lead us to a better understanding of BC influences on RBP and consequently to its convalescence.

To completely relay our findings and due to large oscillation of BC and EBP during the year, seasonal variations should be observed in the prevalence of unrecognized RBP. Thus further detailed environmental and health studies must be carried out hand in hand to reveal the real effects of BC on RBP.

4. CONCLUSIONS

This study mainly focused on retrieving data on BC concentrations in different time periods and contrasting weather conditions. Results have shown major differences in concentrations of BC, especially when winter and spring months were compared. Results of analysis for measuring point A showed minimal contrast, as concentrations differed for approximately 4%, while measuring point B for example displayed a difference in concentrations as big as good 50%. These results have shown that people are exposed to health threats arising from magnified BC concentrations throughout the entire year, but in colder months people's exposure and therefore their liability to health effects magnifies.

Exaggerated use of BB for residential heating in colder months is the main reason for this occurrence, as it was seen from Figure 3, where graph, showing concentrations originating from BB escalated evidently in winter period. At this point it is important to emphasise that black and grey carbon should not be equated as they have different sources and dissimilar dispersion patterns. But it is not only BB that causes trouble in air pollution. Vehicles' exhaust pipes are the main source of BC pollutants, which has been proven with measurements. BC concentrations were determined to be the highest (7.48 ± 6.48 µg m^{-3} in winter and 7.25 ± 6.06 µg m^{-3} in spring) at measuring point A where vehicles passing are the most numerous. All of these data can be seen in Figure 6. What is also important is that wind with its speed and direction is important as it mixes air masses at different heights and therefore enables reduction in BC's concentrations, but only when wind's speed reached a minimum of 2 ms^{-1}. Diminishment of BC can be executed with different benevolent measures as well. Because BC's concentrations drop with distance from the source, one of the most important measures should be moving of pedestrian and bicycle lanes away from the main roads. More on this subject was already written by Jereb et al. (2018). Better traffic management would equivalently enable better traffic flow with less queuing which could improve air quality, diminish human exposure to air pollutants and consequently also ameliorate human health.

Regarding the available health data related to RBP and their correlation with our study, we conclude that our results could indicate effects of BC exposure on RBP but for stronger evidence this correlation must be further observed with a broader selection of data in different climate zones. Also a thorough analysis and comparison of solid numerical values on BC concentrations and RBP data should be performed to gain sufficient amount of proof for correlation between BC an RBP. In addition, assumption that humans in colder climate zones are exposed to particles resulting from biomass burning for heating homes could be examined in future researches, as well as observing and measuring BC concentrations in warmer climate zones where people might be exposed to the same particles due to rapid use of open fires. No such data currently exists, which could completely confirm this. In further studies we should try and understand whether there are correlations between warmer climate zones and RBP levels, especially in women (while they usually use open fire to cook) or if there are no such positive correlations. This particular study reveals new findings that can lead us to a better understanding of RBP and consequently to its convalescence.

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Резиме

МЕРЕЊА НА КОНЦЕНТРАЦИИТЕ НА ЦРН ЈАГЛЕРОД, СУМИРАЊЕ НА ПОДАТОЦИ ЗА ЗГОЛЕМЕН КРВЕН ПРИТИСОК И ОПРЕДЕЛУВАЊЕ ПРЕТПОСТАВУВАН ЕФЕКТ ВРЗ ЗГОЛЕМУВАЊЕ НА КРВНИОТ ПРИТИСОК

Борут Јереб[1], Грегор Шипек[1], Шпела Ковше[1], Ана Вовк Корже[2], Петра Врховник[3]

[1]Универзитет во Марибор, Факултет за логистика, Мариборска цеста 7, СЛ-3000 Целје
[2]Универзитет во Марибор, Факултет за уметности, Интернационален центар за екоремедијација, Корошка цеста 160, СЛ-2000 Марибор, Словенија
[3]Словенечки национален институт за градежништво, Димичева 12, СЛ-1000 Љубљана, Словенија
borut.jereb@um.si

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Црниот јаглерод (саѓи), како еден од главните полутанти, има добиено значително внимание во последните неколку години. Тој влијае врз климата на Земјата и врз човековото здравје, особено во населените области каде што се акумулира во поголеми количества поради густината на неговите извори – сообраќај, индустрија и загревање на домаќинствата. Целта на ова проучување беше да се истражи дистрибуцијата на црниот јаглерод и факторите кои влијаат врз неговата дисперзија и последователно врз човековото здравје. Мерењата се изведени двапати, во зимата 2017/2018 и пролетта 2017. Во истражуваната област беа вклучени населени и ненаселени делови на Целје. Ваквата поставеност на мерењата беше одбрана заради истражување на дистрибуцијата на црниот јаглерод и промените на неговите концентрации, но исто така беше проучувано и влијанието на температурата, ветерот, врнежите и сообраќајот врз неговите карактеристики. Резултатите покажаа дека највисоки концентрации на црниот јаглерод се јавуваат во областите со густ сообраќај, или пак во поладните или потопли делови на годината (7.48 ± 6.48 µg m^{-3} во зима и 7.25 ± 6.06 µg m^{-3} во пролет). Резултатите од истражувањето покажаа дека врз дисперзијата на црниот јаглерод влијаат: брзината на ветерот, врнежите и температурите, како и други фактори како што се густината на сообраќајот, период од денот или ден од неделата. Ова проучување исто така ја откри поврзаноста помеѓу осцилациите на црниот јаглерод и високиот крвен притисок, особено во зимскиот период.