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STATISTICAL EVALUATION OF RELATIONSHIP BETWEEN THE GRAVEL ROAD DUSTINESS AND ENVIRONMENTAL CONDITIONS WHEN MIXTURES OF MOLASSES BASED SOLUTION AND $CaCl_2$ FOR REDUCING DUSTINESS ARE USED

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Abstract. The gravel road dust problem is quite acute. In order to minimize the harmful environmental components, dust reduction tests chosen mixtures with molasses base material and calcium chloride. Mixing $CaCl_2$ with a new generation of materials in the Lithuanian market for molasses-based (solution "*Safecote*") and using mixture for reducing dustiness to obtain the results of dustiness, this reflects the reduction in particulate matter in the air, using selected materials. Gravel road cover was treated with mixtures with different concentration solution "*Safecote*" (10 %, 20 %, 30 %) and 35.6 % $CaCl_2$, and cars drove 30 km/h speed during the experiment. Dustiness was measured at different distances from the road (0 m, 1 m, 2 m, 3 m). In the study showed that concentrations of particulate matter varied changing weather conditions (air temperature, humidity, wind speed, atmospheric pressure). Statistical analysis of the data showed that the dust moves further away as the road weakly and moderately correlated with temperature (correlation coefficient ranged from 0.25 to 0.57), with moisture correlated negatively, and the distance from the road intensifying inverse correlation (correlation coefficient ranges from 0.39 to 0.21), with the wind speed correlation intensify then distance is increasing (from 0.15 to 0.43), and with pressure correlation is strong negatively (from –0.95 to –0.60).

Keywords: correlation coefficient, gravel road, dustiness, molasses based material, calcium chloride, environmental conditions.

1. Introduction

Every year the number of gravel roads in Lithuania distinctly decreases. According to the data from Lithuanian Statistics (2009) and Lithuanian Road Administration under the Ministry of Transport and Communications (Lithuanian Roads 2011), in 2000 there were 9231 km of gravel roads (43.3 % of all roads), in 2005 – 8416 km (39.5 %), in 2006 – 8360 km (39.2 %), in 2007 – 8092 km (37.9 %), in 2008 – 7653 km (35.9 %), in 2010 – 7604 km (35.7 %).

Relations between environmental conditions and other parameters have been already discussed many times. E.g. Ozkan *et al.* (2009), Okoński (2007), Povilaitis and Querner (2008), Sendžikaitė and Pakalnis (2006) have analysed influence of environment conditions to the flora, Burinskienė and Rudzkienė (2008) to tourism, Laškova *et al.* (2007) to the spread of volatile organic compounds, Bimbaitė and Girgždienė (2007), Lokoshchenko and Elansky (2006), Tanner and Law (2002), Šimaitis and Baltrėnas (2002), Shangedova *et al.* (1998), Powley (1991) – to the distribution of atmospheric pollutants.

Girgždienė and Rameikytė (2007), Baltrėnas *et al.* (2008; 2007), Baltrėnas and Morkūnienė (2006), Baltrėnas and Kvasauskas (2005) studied dispersion of particulate matter.

Molasses based material (solution „*Safecote*") is a new substance to be used for reducing gravel road dustiness (Bradulienė (Zaveckytė) and Vasarevičius 2008; 2010). Substance is environment-friendly and has no corrosive effect on metals (Petkuvienė and Paliulis 2009).

Object of the article – evaluation of particulate matter concentration and their relation to environment conditions away from the gravel road, when solutions of different concentration are used for reduction of gravel road dustiness.

2. Object and methodology

Ambient air parameters (temperature, air moisture and wind speed) are measured by microclimate parameter analyser TESTO-400, with measuring range (–20–+70) °C, (0–100) %, (0–10) m/s, measuring error ±0.5 °C, ±2 %, ±0.03 m/s. Atmospheric pressure is measured with

barometer, with measuring range – (79.5–106.5) kPa, error ±0.005 kPa.

Concentration of particulate matter in ambient air was measured by the dust concentration analyser Micro-Dust pro, with measuring range 0.01 – 25.0 mg/m^3 and error ±0.01 mg/m^3. Measurements were taken on the roadside (0 m), at 1 m, 2 m and 3 m distance away from the gravel road.

Car drove at 30 km/h speed.

The explored sections of gravel road were covered by a mixture of „*Safecote*“ solution with different concentrations (10 %, 20 %, 30 %) and 35.,6 % $CaCl_2$.

Solution preparation, road section preparation and other measuring peculiarities have been described in articles of Bradulienė (Zaveckytė) and Vasarevičius (2008; 2010).

Scale of correlation coefficient values used in this article follows:

a) Very high statistical relation between the data, when correlation coefficient is –1 and +1;

b) High statistical relation between the data, when correlation coefficient is from –1 to –0.7 and from +0.7 to +1;

c) Moderate statistical relation between the data, when correlation coefficient is from –0.7 to –0.5 and from +0.5 to +0.7;

d) Weak statistical relation between the data, when correlation coefficient is from –0.5 to –0.2 and from +0.2 to +0.,5;

e) Very weak statistical relation between the data, when correlation coefficient is from –0.2 to –0 and from +0 to +0.2;

f) Statistical relation between the data does not exist, when correlation coefficient is 0.

3. Results and discussion

Dustiness records received by experiment and parameters of environment conditions present during experiment were used for statistic evaluation. Correlation coefficient is used to evaluate statistical relation.

Statistical relations between environment parameters and PM concentrations in different distances from gravel road are given in Fig. 1–4.

As shown in Fig. 1, growing temperature on the roadside influences rise of PM concentration. Correlation coefficient of these parameters at control section is 0.1, consequently, statistical relation is very low, while on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.3, with 20 % „*Safecote*“ it is 0.3, with 30 % „*Safecote*“ solution, correlation coefficient is 0.3. Hence, treatment of road sections with a mixture of higher „*Safecote*“ concentration, impacts higher correlation relation between PM concentration and temperature. With growing moisture, PM concentration grows too. Correlation coefficient of these parameters on the control section is 0.4, therefore, reports about the weak statistical relation, and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.4, with 20 % „*Safecote*“ – it is 0.4, with 30 % „*Safecote*“ solution correlation coefficient is 0.3, statistical relation weak. Thus, correlation coefficient between PM concentration and moisture decreases because of road section treatment with a mixture having higher concentration of „*Safecote*“ solution.

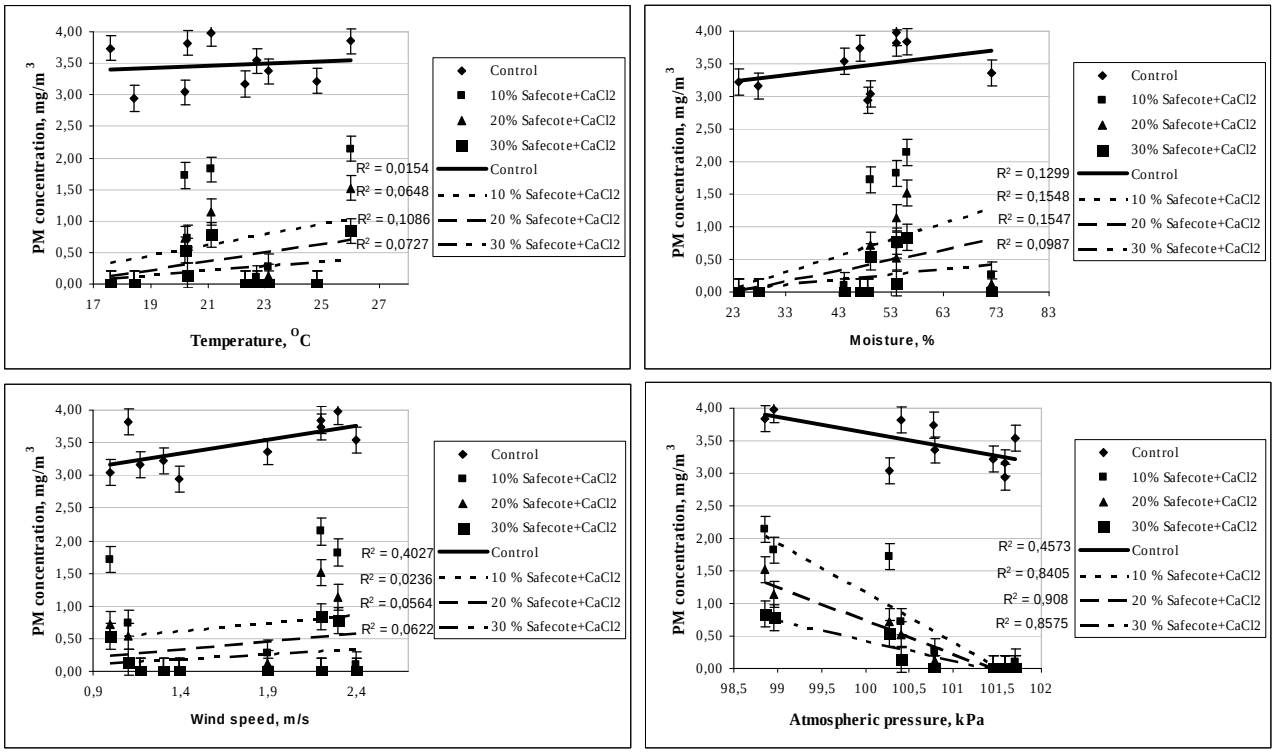

Fig 1. Statistical evaluation of relationship between the environmental conditions and PM concentration in roadside

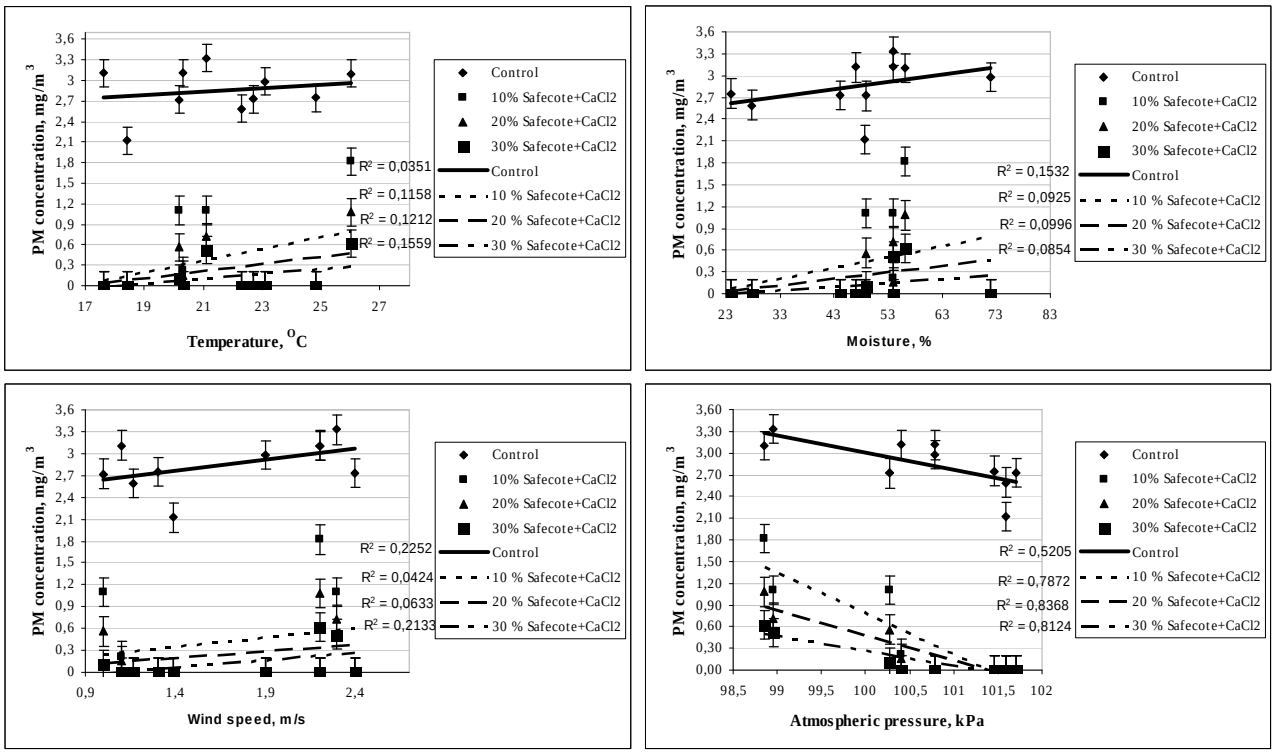

Fig 2. Statistical evaluation of relationship between the environmental conditions and PM concentration in 1 m distance from road

Wind speed increased, PM concentration increased, correlation coefficient on the control section is 0.6, statistical relation average, and on section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.2, with 20 % „*Safecote*“ – it is 0.2, with 30 % „*Safecote*“ solution correlation coefficient is 0.2. Therefore, on road sections treated with a mixture of higher „*Safecote*“ solution concentration, correlation relation between PM concentration and wind speed decreases. With growing atmospheric pressure, PM concentration decreased, correlation coefficient on the control section was –0.7, statistical relation is strong, and on section treated with 36.5 % $CaCl_2$ solution with 10 % „*Safecote*“ – it is –0.9, with 20 % „*Safecote*“ – it is –0.9, with 30 % „*Safecote*“ solution correlation coefficient is –0.9. Hence, correlation relation between PM concentration and atmospheric pressure intensifies negatively on road sections treated with a mixture having higher „*Safecote*“ solution concentration.

As shown in Fig. 2, temperature rising at 1 m distance from gravel road dustiness growing concentration of the PM too. Correlation coefficient of these parameters is 0.2, therefore statistical relation is weak and in the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.3, with 20 % „*Safecote*“ it is 0.3, with 30 % „*Safecote*“ solution correlation coefficient is 0.4. Hence, in the sections treated with „*Safecote*“ solution of higher concentration, correlation relation between PM and temperature – grows. With growing moisture, PM concentration grows too. Correlation coefficient of these parameters at the control section is 0.4 and therefore, means that statistical relation is weak and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.3, with 20 % „*Safecote*“ it is 0.3, with 30 % „*Safecote*“ solution correlation coefficient is 0.3, statistical relation is weak. Consequently, on the sections treated with a mixture of higher concentration of „*Safecote*“, correlation relation between PM concentration and moisture – weakens. Wind speed increased, PM concentration increased, correlation coefficient in the control section is 0.5, statistical relation is average and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ it is 0.2, with 20 % „*Safecote*“ it is 0.3, with 30 % „*Safecote*“ solution correlation coefficient is 0.5. Therefore, sections treated with a mixture of higher concentration „*Safecote*“ solution, correlation relation between PM concentration and wind speed – grows. With growing atmospheric pressure, PM concentration weakens, correlation coefficient on the control section is –0.7, statistical relations strong, and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ - it is –0.9, with 20 % „*Safecote*“ –0.9, with 30 % „*Safecote*“ solution correlation coefficient is –0.9. Hence, on the section treated with higher concentration „*Safecote*“ solution, correlation coefficient between PM concentration and atmospheric pressure – increases negatively.

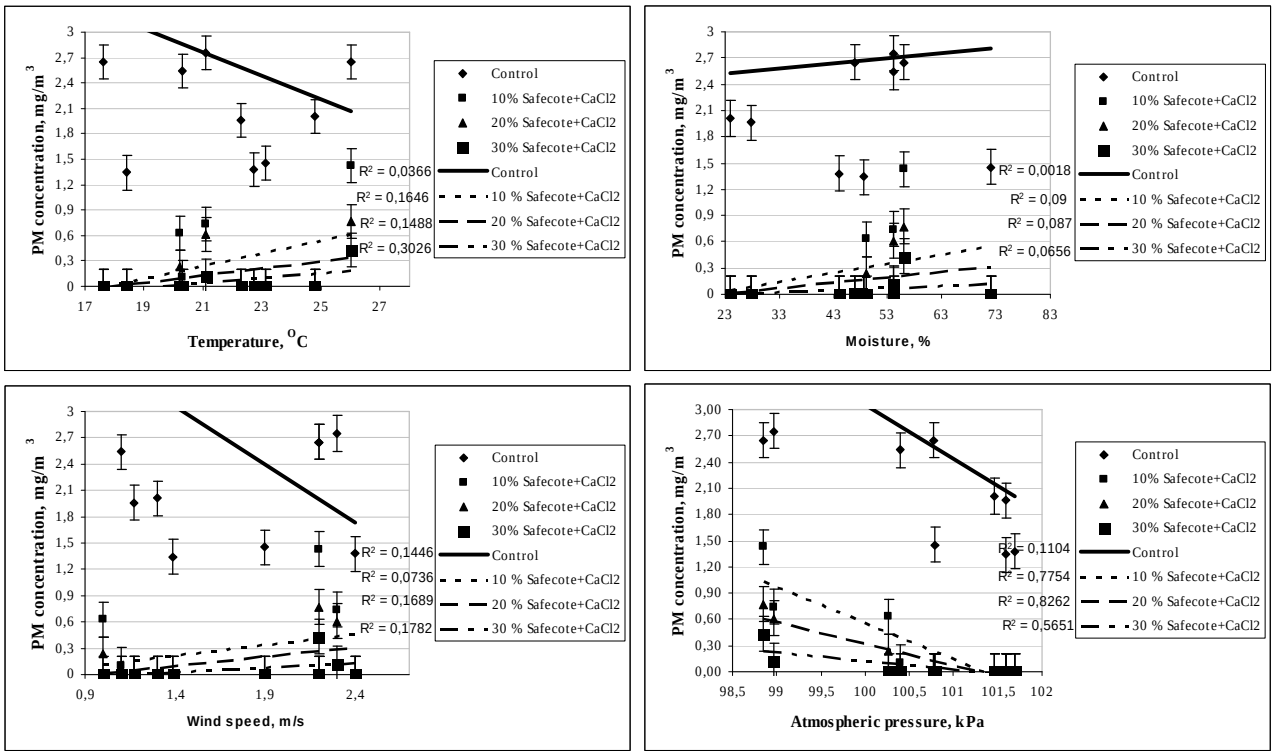

Fig 3. Statistical evaluation of relationship between the environmental conditions and PM concentration in 2 m distance from road

As shown in Fig. 3, temperature rising at 2 m distance from gravel road dustiness growing concentration of the PM too, except for the control section. Correlation coefficient of these parameters is –0.2, therefore statistical relation negatively is weak and in the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.4, with 20 % „*Safecote*“ it is 0.4, with 30 % „*Safecote*“ solution correlation coefficient is 0.6. Hence, in the sections treated with „*Safecote*“ solution of higher concentration, correlation relation between PM and temperature – grows. With growing moisture, PM concentration grows too. Correlation coefficient of these parameters at the control section is 0.1 and therefore, means that statistical relation is weak and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.3, with 20 % „*Safecote*“ it is 0.3, with 30 % „*Safecote*“ solution correlation coefficient is 0.3, statistical relation is weak. Consequently, on the sections treated with a mixture of higher concentration of „*Safecote*“, correlation relation between PM concentration and moisture – grows. Wind speed increased, PM concentration increased, correlation coefficient in the control section is –0.4, statistical relation is weak and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ it is 0.3, with 20 % „*Safecote*“ it is 0.4, with 30 % „*Safecote*“ solution correlation coefficient is 0.4. Therefore, sections treated with a mixture of higher concentration „*Safecote*“ solution, correlation relation between PM concentration and wind speed – grows. With growing atmospheric pressure, PM concentration weakens, correlation coefficient on the control section is –0.3, statistical relation is strong, and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ it is –0.9, with 20 % „*Safecote*“ –0.9, with 30 % „*Safecote*“ and $CaCl_2$ mixture, correlation coefficient is –0.8. Hence, on the section treated with higher concentration „*Safecote*“ solution, correlation coefficient between PM concentration and atmospheric pressure – negatively slightly weakens.

As shown in Fig. 4, temperature rising at 3 m distance from gravel road dustiness growing concentration of the PM too. Correlation coefficient of these parameters is 0.3, therefore statistical relation is weak and in the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.5, with 20 % „*Safecote*“ it is 0.4, with 30 % „*Safecote*“ solution correlation coefficient is 0.6, statistical relation moderate. Hence, in the sections treated with „*Safecote*“ solution of higher concentration, correlation relation between PM and temperature – grows. With growing moisture, PM concentration grows too. Correlation coefficient of these parameters at the control section is 0.1 and therefore, means that statistical relation is very weak and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.3, with 20 % „*Safecote*“ it is 0.3, with 30 % „*Safecote*“ solution correlation coefficient is 0.2, statistical relation is weak. Consequently, on the sections treated with a mixture of higher concentration of „*Safecote*“, correlation relation between PM concentration and moisture – weakens. With growing wind speed, PM concentration grows too, correlation coefficient at the control section is 0.2, statistical relation weak, and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is 0.3, with 20 % „*Safecote*“ it is 0.4, with 30 % „*Safecote*“ solution correlation coefficient is 0.3.

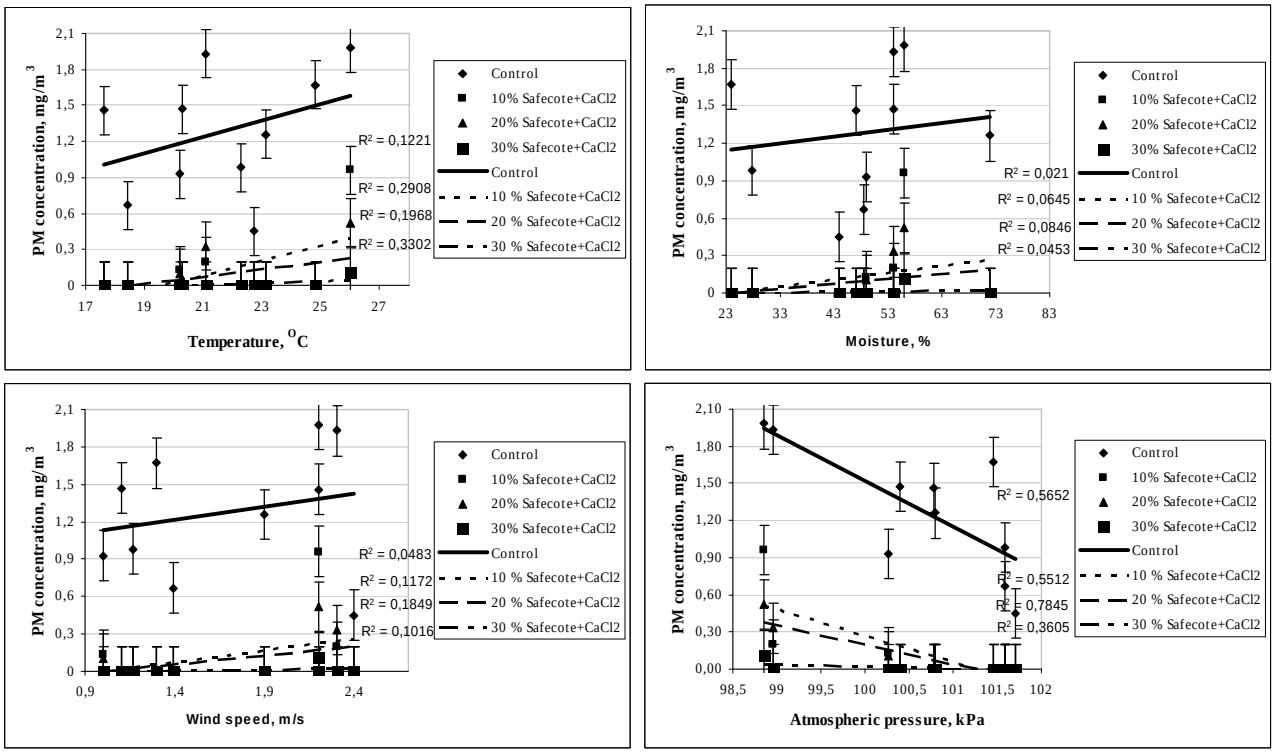

Fig 4. Statistical evaluation of relationship between the environmental conditions and PM concentration in 3 m distance from road

Hence, on the section treated with higher concentration „*Safecote*“ solution, correlation coefficient between PM concentration and wind speed weakens. With growing atmospheric pressure, correlation coefficient of these parameters at the control section is –0.8, statistical relation is strong, and on the section treated with 36.5 % $CaCl_2$ mixture with 10 % „*Safecote*“ – it is –0.7, with 20 % „*Safecote*“ it is –0.9, with 30 % „*Safecote*“ solution correlation coefficient is –0.6. Hence, on the section treated with higher concentration „*Safecote*“ solution, correlation coefficient between PM concentration and atmospheric pressure negatively weakened.

In conclusion, on the sections treated with „*Safecote*“ solution and $CaCl_2$ mixture, when car drove at 30 km/h speed, PM concentration and temperature correlation coefficients fluctuate from 0.3 to 0.7, i.e. statistical relation is weak and average, PM concentration and moisture correlation coefficients fluctuate from –0.9 (strong relation) to 0.2 (weak relation), PM concentration and wind speed correlation coefficients fluctuate from –0.7 (strong relation) to 0.3 (weak relation).

4. Conclusions

1. In the sections treated with a mixture of solution „*Safecote*“ of different concentrations (10 %, 20 %. 30 %) and 35.6 % $CaCl_2$, when car driving speed is 30 km/h, under the correlation coefficients, with higher temperature, PM concentration was recorded higher. When humidity is higher, PM concentration was lower in most of the cases - that was also noticed in growing distance from the gravel road. When wind speed is big, PM concentration grew, and that is mostly vivid on the roadside. When atmospheric pressure is higher, PM concentration declined.
2. The strongest correlation relation (correlation coefficient 0.9) was received between PM concentration and temperature, PM concentration relation with humidity and wind speed varied from weak to strong and exposed either on the roadside, or at a distance from the road, i.e. one tendency to grow or decrease was not recorded, PM concentration relation with atmospheric pressure negatively either grew, or weakened.

References

Baltrėnas, P.; Fröhner, K.-D.; Pranskevičius, M. 2007. Investigation of seaport air dustiness and dust spread. *Journal of Environmental Engineering and Landscape Management*, 15(1): 15–23.

Baltrėnas, P.; Morkūnienė, J. 2006. Investigation of particulate matter concentration in the air of Žvėrynas district of Vilnius. *Journal of Environmental Engineering and Landscape Management*, 14(1): 23−30.

Baltrėnas, P.; Morkūnienė, J.; Vaitiekūnas, P. 2008. Mathematical simulation of solid particle dispersion in the air of Vilnius city. *Journal of Environmental Engineering and Landscape Management*, 16(1): 15–22.

Baltrėnas, P.; Kvasauskas, M. 2005. Experimental investigation of particle concentration using mass and optical methods. *Journal of Environmental Engineering and Landscape Management*, 12(2): 57−64.

Bimbaitė, V.; Girgždienė, R. 2007. Evaluation of Lithuanian air quality monitoring data applying synoptical analysis. *Journal of Environmental Engineering and Landscape Management*, 15(3): 173–181.

Bradulienė, J.; Vasarevičius, S. 2010. Žvyrkelių dulkėtumo mažinimo tirpalu „Safecote“ ir jo mišiniu su $CaCl_2$ eksperimentiniai tyrimai [Experimental investigation into reduction of gravel road dustiness using “Safecote” solution and its mixture with $CaCl_2$]. *Journal of Environmental Engineering and Landscape Management*, 18(2): 145–153.

Burinskienė, M.; Rudzkienė, V. 2008. Modeling and forecasting of country tourism development in Lithuania. *Journal of Environmental Engineering and Landscape Management*, 13(3): 116–120.

Girgždienė, R.; Rameikytė, R. 2007. Variation of PM_{10} mass and aerosol number concentrations in Šiauliai. *Journal of Environmental Engineering and Landscape Management*, 15(1): 47–53.

Laškova, T.; Zabukas, V.; Vaitiekūnas, P. 2007. Meteorologinių sąlygų įtaka lakiųjų organinių junginių sklaidai pažemės atmosferos sluoksnyje [Influence of meteorological conditions on volatile organic compound spread in the atmospheric boundary layer]. *Journal of Environmental Engineering and Landscape* Managemen,t 15(3): 135–143.

Lietuvos keliai [Roads of Lithuania] [online]. 2011 [cited 7 January 2011]. Available on the Internet: <www.lra.lt>.

Lietuvos statistikos departamentas [Statistical department of Lithuania]. 2009. Transportas ir ryšiai 2008 m. [Transport and communications 2008]. Vilnius: 179 p. ISSN 1648-0279.

Lokoshchenko, M. A.; Elansky, N. F. 2006. Dynamics of surface-air pollution during the passage of a cold front. *Izvestiya Atmospheric and Oceanic Physics*, 42(2): 148–155.

Okonski, B. 2007. Hydrological response to land use changes in central European lowland forest catchments. *Journal of Environmental Engineering and Landscape Management*, 15(1): 3–13.

Ozkan, K.; Senol, H.; Gulsoy, S.; Mert, A.; Suel, H.; Eser, Y. 2009. Vegetation-environmental relationship in mediterranean mountain forests on límeles bedrocks of southern Anatolia, Turkey. *Journal of Environmental Engineering and Landscape Management*, 17(3): 154–163.

Petkuvienė, J.; Paliulis, D. 2009. Experimental research of road maintenance salts and molasses (“Safecote”) corrosive impact on metals. *Journal of Environmental Engineering and Landscape Management*, 17(4): 236–243.

Powley, J. F. 1991. The impact of climate upon variation in air pollution using a synoptic climatological approach. *Dissertation Abstracts International*, 52(9), Section: B, 192 p.

Povilaitis, A.; Querner, E. P. 2008. Possibilities to restore natural water regime in the Žuvıntas Lake and surrounding wetlands – modeling analysis approach. *Journal of Environmental Engineering and Landscape Management*, 16(3):105–112.

Shangedova, M.; Burt, T. P.; Davies, T. D. 1998. Synoptic climatology of air pollution in Moscow. *Theoretical and Applied Climatology*, 61, Iss ½: 85–102.

Sendžikaitė, J.; Pakalnis, R. 2006. Extensive use of sown meadows – a tool for restoration of botanical diversity. *Journal of Environmental Engineering and Landscape Management*, 14(3): 149–158.

Šimaitis, R.; Baltrėnas, P. 2002. Oro teršalų koncentracija Vilniuje ir jos įtaka sveikatingumui [Air pollutant concentrations in Vilnius and its impact on wellness]. *Journal of Environmental Engineering and Landscape Management*, 10(1):. Ia–If.

Tanner, P. A.; Law, P. 2002. Effects of synoptic weather systems upon the air quality in an Asian megacity. *Water, Air and Soil Pollution*, 136(1–4): 105–124.

Zaveckytė, J.; Vasarevičius, S. 2008. Experimental investigation of solution “Safecote” usage to reduce road dustiness. In *The 7th International Conference “Environmental Engineering”:* Selected papers, vol. 1. May 22–23, 2008, Vilnius, Lithuania. Vilnius: Technika, 460–465. ISBN 9789955282631.