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SUSTAINABLE ECOLOGICAL DEVELOPMENT REDUCING NEGATIVE EFFECTS OF ROAD MAINTENANCE SALTS

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Abstract. To ensure traffic safety in winter, large amounts of technical salts (chlorides) are applied on roads. De-icing salts directly or indirectly contaminate the road environment and have a negative effect on the components of road environment. The analysis of the situation raises a question: how to ensure traffic safety in wintertime applying salts and achieve sustainable development. The article presents the investigations of chloride concentrations on the roadsides of a highway. In 5 recent years, complex environmental laboratory investigations and investigations under natural conditions of the effect of salts on the components of the road environment have been carried out proving their toxic effect. Consequently, to reduce a negative effect of salts on the road environment, measures of sustainable ecological development have to be taken. To achieve a balanced use of salts, the proposal is to apply alternative materials (formiates, molasses-based material). The introduction of biotechnical measures (an infiltration-grassy ditch, biological and chemical indication on roadsides) is expedient to eliminate the consequences but not the reasons of salt use.

Keywords: sustainable ecological development, road maintenance salts, chloride in roadside soil, antipollution of road environment, vegetation saving.

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1. Introduction

Sustainable development comprises 3 essential elements: economic, environmental and social development (Kavaliauskas 2008). Since 2005, the UN documents treat these components as interrelated and supplementing each other; however, in practice their balance is not always achieved. Lithuania's major priority is economic development (Diskienė *et al.* 2008; Grundey 2008). Also, one of sustainable development priorities is the reduction of the effect on the

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environment of the transport sector by increasing its ecological efficiency and including environmental interests in the strategy of its development (Ministry of State ... 2003). In the aspect of traffic safety, Lithuania is a country of increased risk and therefore comprehensive measures aimed at avoiding accidents, reducing the probability of traffic accident risk, traffic jams, consumer costs and environment pollution have to be taken (Žilionienė and Laurinavičius 2007). Irregularities in the transport infrastructure reduce communicative possibilities and result in economic losses in a large diversity of activities. Irregularities in the transport system raise difficulties to rational use of resources, reduce division of labour, have an adverse effect on the environment, aggravate population's economic welfare and the quality of life (Kryk and Zielinska 2007; Čiegis *et al.* 2008). During the cold period thousands of tons of de-icing and traffic safety improving chemical substances, mainly technical salts (chlorides), are applied in Lithuania. Technical sodium (NaCl) and calcium ($CaCl_2$) chlorides, their mixtures and technical salt/sand mixtures are most widely used in our country. Small amounts of red sodium, vacuum sodium and magnesium technical salts are also used in wintertime in Lithuania. Salt spreading rates depend on environmental weather conditions: environmental temperature, snow coat thickness as well as traffic intensity etc. Due to different properties of each salt and, in particular, different degree of freezing, technical salts of different types or mixtures thereof have to be applied in winter. Around 140,000 tons of technical sodium chloride salt or its mixtures with sand, or up to 25 kg per one square meter of the main streets and roads, are applied to reduce slipperiness in wintertime in Lithuania. According to the data published by the Environmental Protection Agency of the Ministry of Environment, more than 14,000 tons of sodium chloride and nearly 16,000 cubic meters of sand and sodium chloride mixture were applied on Vilnius streets to reduce slipperiness during the winter season 2005/2006. Technical salts used for road maintenance in winter are rather efficient at melting ice and snow, help ensure traffic safety but have a negative effect on the road environment, especially in cities. A negative effect of chlorides on the components of the road environment soil (Lundmark 2005), flora (Kayama *et al.* 2003), waters (Williams *et al.* 1999) was widely analysed in foreign countries. The first individual investigations of contamination with salts were performed in Lithuania in 1996 and were aimed at measuring the content of chlorides in a coat of snow accumulated nearby streets as well as in a rainwater drainage system at the start of snow melting. The recorded content of chlorides in snow on machine-salted/sanded Vilnius streets with heavy traffic was 1911–2571 mg/l. The content of chlorides in a rainwater drainage system was 438–1223 mg/l. The concentration of chlorides is 2.0 to 2.5 times lower in rainwater sewage than that in snow accumulated nearby streets (Laurinavičius and Čygas 1996). As increasing amounts of salts are used every year in Lithuania, big amounts of chlorides may get into open water bodies together with snow-melt runoff in spring (Storpirštytė *et al.* 2004), having a negative effect on surface waters (Oškinis and Kasperovičius 2005) and hydrobionts living therein (Vosylienė *et al.* 2006). Having accessed soil, road maintenance salts have a toxic effect on graminaceous plants (Baltrėnas *et al.* 2006; Baltrėnas and Kazlauskienė 2007a).

The analysis of the situation raises a question: how to ensure traffic safety in wintertime applying salts and achieve sustainable development. To ensure sustainable development, minimising an adverse effect of salts on the environment, it is purposeful to follow 2 principles of implementation set out in the National Sustainable Development Strategy. The first one is *the payback principle* laying down that the costs of environmental measures implementation should not be treated as inevitable additional expenses on the account of economic development. It is necessary to establish economic and organisational mechanisms increasing the economic efficiency of environment protection measures and ensuring their payback. The second, *the principle of replacement (transmaterialisation)*, implies the replacement of materials dangerous to the environment and human health with the safe ones as well as exhausting resources with the renewable ones (Ministry of State ... 2003; Poszyler-Adamska and Czerniak 2007).

Research on chloride concentrations in roadside soils of a highway under natural conditions and related results are described in detail in this article. When analysing current environmental quality changes as well as the opportunities of dealing with the most urgent environmental problems and likely threats, one of the most important environmental components, soil, should also receive attention. And the problems of landscape and biological diversity should also be addressed (Čiegis *et al.* 2005; Čiegis and Gineitienė 2008).

2. Research methodology

The aim of research is to measure chloride concentrations on the highways roadsides and evaluate the distribution of chloride concentrations in transverse profiles.

The object of research: A 24–90 km section of the highway A16 Vilnius–Prienai–Marijampolė was chosen to research on technogenic contamination of soil with chlorides. The selection of this road section was predetermined by the fact that it crosses 3 protected territories. Marijampolė–Prienai–Vilnius is a section of European highway E28. In wintertime road A16 is maintained according to maintenance level II by applying NaCl and $CaCl_2$ to reduce slipperiness. Soil sampling was done in 24 km, 42 km and 90 km. Soil samples were taken 3 times: in January, March and April 2008 as no durable and stable snow coat formed in the winter of 2007–2008. Technical salts were anyway used for road maintenance because, due to high humidity in the ambient air, a slippery ice film often formed on road paving and had to be removed with the aim to ensure traffic safety.

Soil sampling was done beside the highway's roadway and in a 2 and 5-meter distance from the roadway, forming transverse profiles on the left and right sides of the road (Baltrėnas and Vasarevičius 2003).

Chemical analysis. Soil samples, collected from the roadsides of the highway A16 Vilnius–Prienai–Marijampolė, were dried up, sieved through a 2 mm sieve and divided into 100 g portions. The soil samples prepared in the said manner were placed in glass vessels, topped with 200 ml of 5% HNO_3 solution and placed in a shaker for an hour. The settled samples were taken out of the shaker, filtered via a paper filter and poured into a 250 ml conical flask, in 100 ml portions. 1 ml of K_2CrO_4 10% was poured into each sample and titrated with $AgNO_3$ 0.02 mol/l solution until the sample's colour turned from yellowish to orange.

The chloride concentrations established by the titrimetric analysis are expressed and presented in mg/kg, when analysing the distribution of chlorides with a distance from the roadway increasing according to transverse profile. To record chloride concentrations, soil samples were taken on both sides of the road. A difference in the results obtained was statistically verified and therefore the article presents the results from one side of the highway. An error of 15% shown in diagrams is possible when measuring chloride concentrations by the titrimetric method of chemical analysis (LST EN 1744-1: 2003).

3. Research results

When measuring chloride concentrations in roadside soil, the background value of chlorides contained in soil was 5.0 mg/kg. Soil samples for measuring the background value were taken from relatively clean localities in at least 800-meter distance from the highway.

As Fig. 1 shows, the highest concentration of chlorides in soil (248.7 mg/kg) at 24th km was recorded by the roadway during the second sampling done in March. Compared to chloride concentration measured beside the roadway, this concentration in the road ditch (at a 2 m distance from the roadway) is around 3 times lower and that on the ditch's external slope, on average, 5 times lower. There are no dwelling houses in the road environment at km 24; there is only a thin immature forest on the left. Open uncultivated lands with individual fir-trees and young birch groves stretch on the right. At 24th km the road crosses the territory of Trakai National Historic Park.

As Fig. 2 shows, the highest chloride concentrations in soil were also recorded by the roadway at 42nd kilometre. The lowest chloride concentrations were determined in the profile at a 2 m distance from the roadway (32.6–26.7 mg/kg). The 42nd kilometre of road A16 goes along an embankment, a mature forest stretches along the roadsides, there are no road ditches. At 42nd kilometre the road crosses the territory of Aukštadvaris Regional Park. Chloride concentrations determined at 42nd kilometre are, on average, 3 times lower compared to those recorded at 24th kilometre. Possible reason: the 24th kilometre is close to the entrance to Trakai town and therefore larger amounts of chlorides might be used for road maintenance in winter.

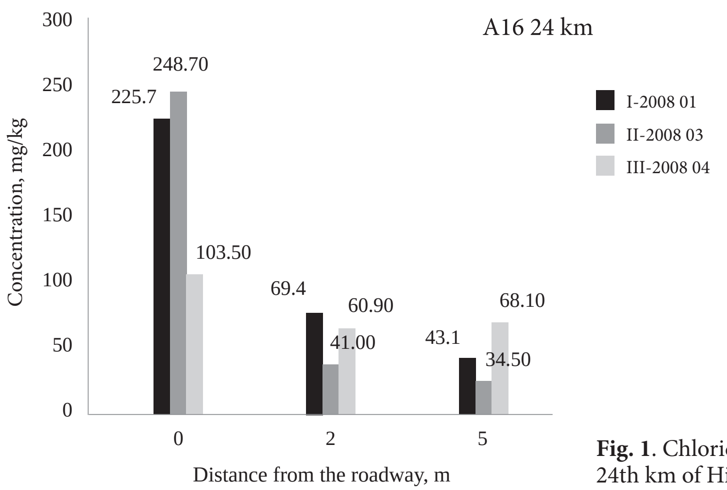

Fig. 1. Chloride concentration in soil at 24th km of Highway No A16

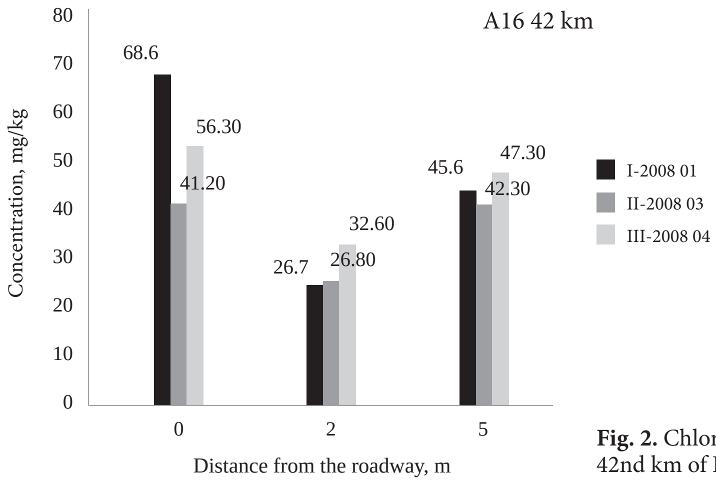

Fig. 2. Chloride concentration in soil at 42nd km of Highway No A16

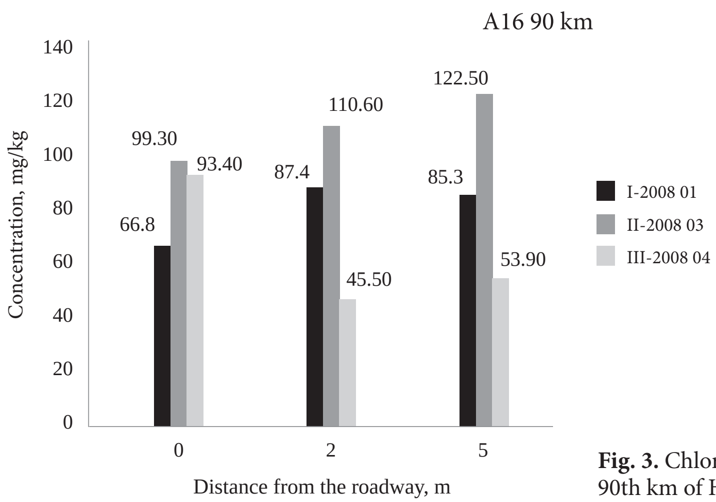

Fig. 3. Chloride concentration in soil at 90th km of Highway No A16

The highest chloride concentration in soil (122.5 mg/kg) at 90th km of highway A16 was determined on the ditch's external slope, i.e. at 5 m distance from the roadway during the second soil sampling in March. Chloride concentrations in soil at a 2 m distance from the roadway differ from the concentrations at a 5 m distance within the error. The lowest chloride concentration (45.5 mg/kg) was determined during the third soil sampling at 2 m distance from the road (Fig. 3). The 90th km runs by the entrance to Birštonas town. Most probably higher chloride concentrations were found at a bigger distance from the road during the first 2 soil samplings because of high flows of vehicles, which cause wind puffs carrying road maintenance salts away from the roadway. At the 90th kilometre the road runs along a pit, there are road ditches, and individual trees and dwelling houses on the roadsides. Road A16 crosses the territory of Nemunas Bends Regional Parks.

Conclusions

1. The research findings show that chloride concentrations determined in soil at a 0–5 m distance from the roadway exceed the background value (5 mg/kg) 5.3–49.7 times.
2. The distribution of chloride concentrations in soil depends on the level of road maintenance, geomorphological environmental conditions (whether a road runs along a pit or a bed, road ditch gradient, prevailing plants), climatic conditions (temperature and its changes, snow coat thickness, wind direction and speed, climatic zone), traffic intensity (turbulence rate of air puffs caused by vehicles).
3. Roadside contamination with chlorides is an inevitable consequence of road maintenance in wintertime. However, with the aim to regulate the contamination and reduce its adverse effect the proposal is to take the below analysed measures.

4. Measures to reduce a negative effect of road maintenance salts on the environment

There are many alternative snow melting materials that can replace salts.However, salt remains in the first place because of its low price as well as availability and efficiency of de-icing and snow melting. With the aim to protect the components of the environment against a negative effect of road maintenance salts the below analysed measures are proposed.

Reduction of de-icing salt amounts

In Lithuania, sand/salt mixtures are applied for reducing the use of road maintenance salts. Where the use of salts is mandatory, the proposal is to apply as small amounts as possible following the norms. The Law on Green Areas of the Republic of Lithuania (Lietuvos Respublikos Želdynų įstatymas 2007) also stipulates the reduction of road maintenance salt amounts. The use of alternative de-icing salts and agents, such as calcium chloride, acetates, formiates or molasses-based organic substances is recommended. The most prospective technique of *concrete protection against the effect of salts is physical-chemical treatment of concrete surface with materials* providing concrete pores and capillaries with hydrophobic properties.

Maintenance of soil quality conditions and humidity with biotechnical aids

These aids reduce additional stress of plants and help them fight against withering. Where possible, trees and bushes should be cleared of salt spatter in early spring for removing salt residues from delicate buds and leaves. It is expedient to improve the structure and drainage system of the soils with poor drainage. The amount balance of potasium and magnesium that were leached from soil is restored by fertilisation.

A biotechnical solution for the prevention and reduction of the road environment has been proposed. An *infiltration-grassy ditch* belongs to motor road installations that are built and operated at the beds of motor road soil and used for the take-off of surface water. This road ditch extends the functions of the water take-off ditch by applying it for reducing a complex adverse effect in the road environment.

The infiltration-grassy ditch (Fig. 4) used for waste water collection from the road surface consists of: soil base (1), ditch bottom in the form of a chute (2), filtering sand layer (3), a layer of fertile soil mixed with 10% (of the soil volume) of the natural zeolite (clinoptilolite)

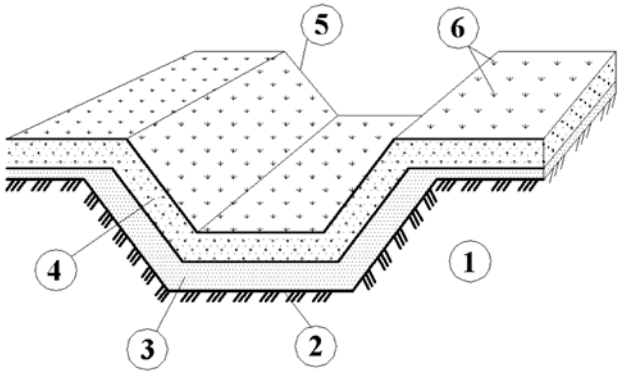

Fig. 4. Scheme of infiltration-grassy ditch

of 3–5 mm fraction (4) and ditch slopes (5) sown with the mixture of grassy vegetation, i.e. perennial rye-grass (*Lolium perenne L.*) and fescue grass (*Festuca pratensis Huds.*) (6).

When the snow melts or it rains, waste water from the road surface runs to the infiltration-grassy ditch used to collect waste water from road surface, passes through the ditch slopes (5) sown with the grassy vegetation, perennial ryegrass and fescue grass (6), subsequently is filtered through the layer of fertile soil mixed with 10% (of the soil volume) of the natural zeolite (clinoptilolite) of 3–5 mm fraction (4), afterwards passes through the sand layer (3) until it reaches the ditch bottom in the form of chute (2) and soaks in the soil base (1).

The recommendation is to sow roadsides with the mixture of perennial rye-grass, which shows very high resistance to the toxic effect of salt, and fescue-grass (ranked 2nd by resistance to salt) (70%:30%), when building new roads and reconstructing the existing ones. The use of mixture is recommended with the aim to ensure variety of species (Juhanson *et al.* 2007; Jankaitė and Vasarevičius 2005, 2007; Claus *et al.* 2007).

The application of the natural substance clinoptilolite on roadsides is recommended for preventing and reducing motor vehicle pollution and the improvement of soil and vegetation condition due to its numerous unique properties (in particular, cation exchange) (Pitcher *et al.* 2004; Brannvall and Kazlauskienė 2005; Baltrėnas and Brannvall 2006; Mažeikienė *et al.* 2008).

The recommendation is to install a multifunctional installation i.e. an infiltration-grassy ditch, on the roadsides of heavy traffic when building new roads or reconstructing and renewing the existing ones (Baltrėnas and Kazlauskienė 2007b).

Alternative materials

Acetates and *formiates* can be applied with the aim to reduce road sliperness and as a measure of road paving deicing. These are efficient, environment-friendly materials having no corrosive effect. They can be of a dry (granulated) or liquid form. The trade names of formiates are *Clearway* and *Meltium*.

The main advantage characteristic of acetates/formiates is that they do not stimulate corrosion (even though do not protect against it), i.e. they do not have an inhibition effect.

The aggressiveness of magnesium acetate with respect to corrosion is 3 times lower than that of $CaCl_2$ and 2 times smaller than that $MgCl_2$. Taking into consideration this property and expensiveness, acetates are used only in certain cases (for the maintenance of bridges, viaducts, tunnel pavings etc.). Calcium and magnesium acetates do not affect water bodies or stimulate their accretion as they are discharged from solutions after some time and precipitate out. On the other hand, calcium and magnesium ions improve soil structure and fertility. However, the application possibilities of acetates are rather limited because of their expensiveness. In practice, these materials should be applied only on very important road sections that are dangerous for traffic (De-icers 2008).

The organic material used to reduce road slipperiness, which is an agricultural by-product obtained from waste in the sugar production process, also known as molasses. The patented name of this material in Europe is *Safecote.* In the USA this product is known as *Geo-Melt.*

In 2002 the product was introduced in the market of Great Britain. It boasted positive results and feedbacks from the users. This material was successfully tested in Eastern Europe in 2004. It has been used longest in the US and Canada – 10 years, Great Britain – 5 years. In Europe (Germany, Switzerland, Slovenia, Norway, Sweden, Poland, Hungary, Ireland, Austria, Estonia) it has been applied from 2 to 3 years. In Lithuania, the first trials to use this material for street slipperiness reduction were made during the winter season of 2005/2006 in Vilnius. 18 tons of Safecote were used in Vilnius during the winter season of 2006/2007. This material is applied on Vilnius city streets by UAB Grinda.

Safecote properties. When added to a sodium chloride solution, this material helps the solution to remain on a road paving 7 times longer and therefore no additional application is required. Consequently, the amount of spreader's working hours as well as the length of trips decrease. No additional capital investment in equipment is required because Safecote can be used with the existing equipment and does not cause corrosion of spreaders and other mechanisms. The volume of technical salts required can be decreased from 30% to 50%; it substantially reduces concrete spalling, damage to bridges, viaducts and road structures, and asphalt binder's cracking.

Safecote is not suitable for the application on the roads with low traffic intensity because it can form a slippery film causing threats to traffic safety before it mixes up with a snow layer. This material is viscous, dark brown, and when applied in big amounts it requires additional water input for street and road as well as vehicle wash in spring. The prices of materials that are less harmful to the environment are much higher. With the aim to reduce the application of traditional technical salts the recommendation is to use a mixture composed of 90% of technical sodium chloride and 10% of Safecote. Despite the fact that the price of one ton of such a mixture is 1.5 to 2.0 times higher compared to that of technical sodium chloride, the Safecote/salt mixture not only causes less harm to the environment and road structures but also to vehicles. The mixture of Safecote and sodium chloride salt is a perfect solution for de-icing and the prevention of slipperiness. The mentioned material can also be applied in summertime to reduce dustiness by inserting it into water intended for street watering. The performance parameters of this material comply with the British water quality standard as well as Environmental Agency's standards set for highways relating with heavy metals and other chemical substances (Safecote product 2008).

5. Conclusions

Investigations carried out both in Lithuania and abroad show that technical salts applied on motor roads to reduce sliperness have a negative effect on road environment components (soil, vegetation, hydrobionts, surface waters and inanimate environment). Lithuania has just started using such road manitenance products as *Safecote* and various formiates. No complex environmental research on the effect of these materials on the road enviroment components has been carried out. It would be expedient to investigate the the specificity of applying these materials under Lithuania's climatic and geographical conditions.

Formiates can be applied for the maintenance of streets grouped under maintenance level 1, sections of European network corridors crossing protected terriories, road sections dangerous with respect to traffic, pavings of bridges, viaducts, tunnels and overhead roads, city squares etc.

Prices of more environment-friendly materials are much higher but as Lithuania has become full-fledged member of the European Union, regulations of the sustainable development concept and the optimum ratio between consumption and natural enviroment will be well-established in length of time.

References

Baltrėnas, P.; Brannvall, E. 2006. Experimental investigation of a filter with natural sorbent charge for runoff cleaning from heavy metals and petroleum products, *Journal of Environmental Engineering and Landscape Management* 14(1): 31–36.

Baltrėnas, P.; Kazlauskienė, A. 2007a. Grass vegetation dynamics in soil contaminated with salt, *Ekologija* 53(3): 58–63.

Baltrėnas, P.; Kazlauskienė, A. 2007b. Patentas Nr. 5446. *Infiltracinis-žolinis griovys* [Patent No 5446. Seepage–grassy trench].

Baltrėnas, P.; Kazlauskienė, A.; Zaveckytė, J. 2006. Experimental investigation into toxic impact of road maintenance salt on grass vegetation, *Journal of Environmental Engineering and Landscape Management* 14(2): 83–88.

Baltrėnas, P.; Vasarevičius, S. 2003. Transporto sistemos aplinkosauginis vertinimas [Environment assessment of transport system], iš *Transportas: technologijos, ekonomika, aplinka, sveikata* [Transport: technologies, economy, environment, health]. Vilnius: Technika, 685–775.

Brannvall, E.; Kazlauskienė, A. 2005. Experimental research on sorption of Pb^{2+}, Zn^{2+}, Cu^{2+}, Mn^{2+}, Ni^{2+}, Na^{+}, Ca^{2+} and Cl^{-} from solutions on clinoptilolite, in *Proceedings of 6th International Conference "Environmental Engineering"*. Vilnius: Technika, 1: 49–53.

Claus, D.; Dietze, H.; Gerth, A.; Grosser, W.; Hebner, A. 2007. Application of agronomic practice improves phytoextraction on a multipolluted site, *Journal of Environmental Engineering and Landscape Management* 15(4): 208–212.

Čiegis, R.; Gavėnauskas, A.; Petkevičiūtė, N.; Štreimikienė, D. 2008. Ethical values and sustainable development: Lithuanian experience in the context of globalization, *Technological and Economic Development of Economy* 14(1): 29–37.

Čiegis, R.; Gineitienė, D. 2008. Participatory aspects of strategic sustainable development planning in local communities: experience of Lithuania, *Technological and Economic Development of Economy* 14(2): 107–117.

Čiegis, R.; Grundey, D.; Štreimikienė, D. 2005. Darnaus vystymosi strateginis planavimas: municipaliniai aspektai [Economic aspects of cities sustainable development strategic planning], *Technological and Economic Development of Economy* 11(4): 260–269.

De-icers (for airports, for maintenance of roads, cities). 2008. Available from Internet: <www.esspo.lt>.

Diskienė, D.; Galinienė, B.; Marčinskas, A. A. 2008. Strategic management model for economic development, *Technological and Economic Development of Economy* 14(3): 375–387.

Grundey, D. 2008. Applying sustainability principles in the economy, *Technological and Economic Development of Economy* 14(2): 101–106.

Jankaitė, A.; Vasarevičius, S. 2005. Remediation technologies for soils contaminated with heavy metals, *Journal of Environmental Engineering and Landscape Management* 13(2): 109a–113a.

Jankaitė, A.; Vasarevičius, S. 2007. Use of grassy plants to decontaminate soil from heavy metals, *Ekologija* 4: 84–89.

Juhanson, J.; Truu, J.; Heinaru, E.; Heinaru, A. 2007. Temporal dynamics of microbial community in soil during phytoremediation field experiment, *Journal of Environmental Engineering and Landscape Management* 15(4): 213–220.

Kayama, M.; Quoreshi, A. M.; Kitaoka, S.; Kitahashi, Y.; Sakamoto, Y.; Maruyama, Y.; Kitao, M.; Koike, T. 2003. Effects of deicing salt on the vitality and health of two spruce species, *Picea abies* Karst. and *Picea glehnii* Masters planted along roadsides in northern Japan, *Environmental Pollution* 124: 127–137.

Kavaliauskas, P. A. 2008. Concept of sustainable development for regional land use planning: Lithuanian experience, *Technological and Economic Development of Economy* 14(1): 51–63.

Kryk, B.; Zielinska, A. 2007. Role of human capital in education for sustainable development: The case of Poland, *Transformations in Business & Economics* 6(2(12)): 100–114.

Laurinavičius, A.; Čygas, D. 1996. Cheminės medžiagos automobilių kelių ir gatvių dangų priežiūrai žiemą [Chemical materials for maintenance of motor roads and street pavings in winter], *Aplinkos inžinerija* [Environmental Engineering] 2(6): 60–65.

Lietuvos Respublikos Želdynų įstatymas. 2007 [The Law on Green Areas of the Republic of Lithuania]. Vilnius, *Valstybės žinios* Nr. 80-3215. 18 p.

LST EN 1744-1:2003. 2 leidimas. Užpildų cheminių savybių nustatymo metodai. 1 dalis. Cheminė analizė. 45 p. [Tests for chemical properties of aggregates – Part 1: Chemical analysis].

Lundmark, A. 2005. *Modeling the impacts of deicing salt on soil water in a roadside environment.* TRITA-LWR LIC 2024. Licentiate Thesis, KTH Land and water resources engineering, Stockholm. 32 p.

Mažeikienė, A.; Valentukevičienė, M.; Rimeika, M.; Matuzevičius, A.B.; Dauknys, R. 2008. Removal of nitrates and ammonium ions from water using natural sorbent zeolite (clinoptilolite), *Journal of Environmental Engineering and Landscape Management* 16(1): 38–44.

Ministry of State for Environment of the Republic of Lithuania. 2003. The Lithuanian Strategy for Sustainable Development. Vilnius.

Oškinis, V.; Kasperovičius, T. 2005. Impact of road maintenance salts on water ecosystems according to diatom flora investigation, *Journal of Environmental Engineering and Landscape Management* 13(1): 51–55.

Pitcher, S. K.; Slade, R. C. T.; Ward, N. 2004. Heavy metal removal from motorway stormway using zeolites, *Science of the Total Environment* 334–335: 161–166.

Poszyler-Adamska, A.; Czerniak, A. 2007. Biological and chemical indication of roadside ecotone zones, *Journal of Environmental Engineering and Landscape Management* 15(2): 113a–118a.

Safecote product. 2008. Available from Internet: <www.safecote.com>.

Storpirštytė, I.; Kazlauskienė, A.; Ščupakas, D. 2004. Chloridų koncentracijos sniego dangoje intensyvaus eismo Lietuvos kelių pakelėse tyrimai [Investigation of chloride concentration in snow cover on roadsides of Lithuanian roads with intensive traffic], *Journal of Environmental Engineering and Landscape Management* 12(Suppl 2): 60–66.

Vosylienė, M. Z.; Baltrėnas, P.; Kazlauskienė, A. 2006. Toxicity of road maintenance salts to Rainbow Trout *Oncorhynchus mykiss, Ekologija* 2: 15–20.

Williams, D. D.; Williams, N. E.; Cao, Y. 1999. Road salt contamination of groundwater in a major metropolitan area and development of a biological index to monitor its impact, *Water Research* 34(1): 127–138.

Žilionienė, D.; Laurinavičius, A. 2007. De-icing experience in Lithuania, *The Baltic Journal of Road and Bridge Engineering* 2(2): 73–79.

DARNUS EKOLOGINIS VYSTYMAS, MAŽINANT NEIGIAMĄ KELIŲ PRIEŽIŪROS DRUSKŲ POVEIKĮ

P. Baltrėnas, A. Kazlauskienė

Santrauka

Žiemos sezonu eismo saugumui užtikrinti naudojami dideli kiekiai techninių druskų (chloridų). Slidumui šalinti barstomosios druskos tiesiogiai ir netiesiogiai užteršia kelio aplinką ir neigiamai veikia kelio aplinkos komponentus. Todėl kyla klausimas – kaip užtikrinti eismo saugumą žiemą naudojant druskas bei įgyvendinti darnaus vystymosi nuostatas. Straipsnyje pateikti chloridų koncentracijų tyrimai magistralinio kelio, kertančio saugomas teritorijas, pakelių dirvožemyje. Pastaruosius penkerius metus vykdomi kompleksiniai aplinkosaugos laboratoriniai ir natūriniai druskų poveikio kelio aplinkos komponentams tyrimai įrodo nuodingą jų poveikį. Todėl būtina imtis darnaus ekologinio vystymo priemonių, mažinant neigiamą druskų įtaką kelio aplinkai. Siekiant nepadidinti naudojamų druskų kiekio, siūlomos alternatyvios medžiagos (formiatai, melasos pagrindu pagaminta medžiaga). Druskų sukeliamoms pasekmėms (ne priežastims) pašalinti tikslinga įdiegti biotechnines priemones (infiltracinis-žolinis griovys, biologinė ir cheminė indikacija pakelėse).

Reikšminiai žodžiai: darnus ekologinis vystymas, kelių priežiūros druskos, chloridai pakelių dirvožemyje, kelio aplinkos apsauga nuo taršos, augalijos apsauga.

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