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ASSESSING THE ENVIRONMENTAL IMPACT OF ROADWAY'S CONSTRUCTION ON ADJACENT WATER RESOURCES: A CASE STUDY OF THE SOUTHERN PART OF ALBANIA

Summary. Water is one of nature's resources. As urbanisation grows, new roadways and highways are constructed for the transport sector and development. Due to roadway infrastructure, the development of the quality of surface water bodies in close proximity to roads is deteriorating and has become a major environmental challenge. Considered as one of the major nonpoint pollution sources, the construction of new roadways can have short and long-term effects on water quality conditions. This study revealed that road construction activities may be responsible for introducing pollutants in nearby water sources, leading to the deterioration of water quality. The roadway expansion activities affect both the surface and groundwater quality. Furthermore, this study was conducted to assess the effects of a road construction project situated in the southern part of Albania, on physic-chemical parameters of surface water by collecting water samples from Skotini stream. The analysed parameters included pH, dissolved oxygen (DO), biological oxygen demand (BOD₅), chemical oxygen demand (COD), electrical conductivity (EC_w), total dissolved solids (TDS), salinity, nitrites (NO₂⁻), ammonium (NH₄⁺) and total phosphorus (P_{tot}). The results revealed that all physic-chemical parameters analysed in the laboratory are between the normal standards

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classifying these waters as very clean. Further surveillance for quality assessment of water sources near roadway's construction activities is needed. Various best management practices have been developed and implemented to prevent negative environmental impacts in the transport sector and roadway construction activities. Results of the water quality help strengthen the theory that roadway construction projects in the transport sector, using appropriate best management practices, could yield minimal impact on the overall water quality of surrounding water bodies.

Keywords: roadway construction, transport sector, environmental impact assessment, physic-chemical parameters

1. INTRODUCTION

While air pollution is the most visible and studied environmental consequence of the transportation system, water pollution issues are also of crucial importance in the transportation and environment nexus. Fuel, particle, and salt-laden runoff from streets, highways, and storage facilities damage public water supplies, ponds, lakes and surface streams, roadside soil, vegetation and trees, infrastructure and vehicles.

Due to rapid anthropogenic activities as well as industrialisation and urbanisation, water pollution has become one of the most global threats to humankind. Increasing population, urbanisation and modernisation in developing countries has created a significant risk on water quality [1]. Especially, roadway construction activities are a significant threat to both surface and groundwater quality [2]. The source of water quality degradation near transport sector construction activities primarily includes soil erosion, diesel and oil, construction debris and dirt on impervious road surfaces [3].

The major pollutants loaded during the construction of roads are propellants, lubricants, tannin, silicates, exhaust gases produced by combustion of fuels, abrasive products, asphalt, ashes, dust and organic bituminous compounds [4], contribute to road runoff that might enter nearby surface water bodies, which in turn leads to degradation of physical and chemical characteristics of water.

Pollutants reach adjacent water bodies through both direct discharges by workers operating at the sites, as well as non-direct discharges with the runoff water, leading to physical, chemical and biological degradation of their quality [5-7].

As urbanisation advances, new roadways and highways are constructed for transportation and development, and the stream ecosystems within highway corridors are susceptible to impacts from construction activities. Considered as one of the major nonpoint pollution sources, the construction of new highways can have short- and long-term effects on stream biotic and abiotic conditions [8]. These effects mainly resulted from sedimentation, habitat degradation, changing of leaf processing, and inputs of toxins from construction materials [9].

The roadway infrastructure causes measurable impacts on the morphology of stream and river channels. It has been reported that road construction projects and operational roads impose a remarkable threat to the water quality. Based on data from long-term observation of water bodies near such projects, it has been verified that there is a difference in the water quality before and after the roadway construction. Impact of roadway construction projects on natural water bodies in different countries showed that construction activities pose a notable threat on the water quality.

The pH of water has been identified as a chief factor in monitoring the water quality of different water bodies adjacent to construction sites [10]. pH is an important parameter that explains the acid-alkaline nature of water as it is considered an index for the degree of pollution. Severe river pollution has occurred in some cases during road construction [11].

Furthermore, it has been observed that discharges arising from road construction can be serious enough to warrant the implementation of control measures [12]. Similarly, loss of topsoil near the construction site was observed mainly due to the acquisition of agricultural land and construction dumps which also increased the levels of suspended particulate matter (SPM) in the water [13].

The maintenance activities associated with the roadways and the chemical spills along roads are an important source of chemical pollutants along roadsides [14]. Some chemicals affect only the areas nearest to the road itself, while other chemicals are transported via water to greater distances from the road [15]. Toxic contaminants from roads enter water bodies through stormwater runoff. The contaminants in run-off differ greatly in size and magnitude, and include various hydrated ions and suspended matter.

Particles as sand, silt and clay on the road and roadbed mostly adsorb heavy metals and organic compounds and a complex and wide array of contaminants associated with vehicles are introduced to the landscape through roadway runoff. Among them are hydrocarbons, asbestos, leads, cadmium and copper. Moreover, chemicals related to the road itself or its maintenance including pesticides, insecticides and deicing salts combine with runoff and make their way into the stream water drainage system [16].

Highway construction in different watersheds had statistically significant effects on major water quality parameters on turbidity, total dissolved solids (TDS), and total iron during construction, effects on chloride and sulfate during and after construction, and effects on acidity and nitrate after construction. Construction-impacted water quality parameters should be considered for developing mitigation strategies and refining currently implemented best management practices for future highway constructions in the highlands region.

The nature of the interaction of roads with aquatic systems depends on their location relative to the drainage network and slope. The most damaging agent in aquatic habitats has been said to be siltation and increasing nutrient loads, rather than by chemicals. Roads act both as a source and a sink for water run-off from road surfaces and accumulation of water. In addition, they can act as barriers to water flowing downhill, and also expedite the removal of water as well. Road networks interact with stream networks, increasing the stream drainage density, the overall peak flow in the stream drainage, and the incidence of debris flows in the drainage basin [17].

Faster moving water enters the stream channels increasing the energy of the stream system, eroding channel banks, scouring the channel and increasing the likelihood of flooding downstream [18]. The effects of roads and pollutants in water run-offs from roads to the aquatic ecosystems have attracted increased attention, as these consequences may be both immediate and long-lasting. Water run-off may alter hydrology, increase sediment load, increase nutrients and result in the accumulation of many kinds of pollutants.

Proliferation in sediment load and changes in stream flows resulting from logging activities have caused concerns due to the removal of vegetation and exposure of the soil in a watershed, mass movement of earth leads to overbank deposition in watersheds and also results in changes to the morphology of streams, depositing in channels and creating shallower pools. The shallowness of the pools, combined with the increased turbidity of the water and less vegetated banks, raises the temperature of the water in the streams.

Various best management practices have been developed and implemented to prevent the environmental impacts of human activities. For highway and urban pollution, vegetated buffers and mulches, porous pavement materials, retention or detention basins and ponds, silt fence, seeding, and natural riparian wetlands have been implemented as best management practices to treat runoff and control soil erosion [19-22].

Best management practices (BMPs) are aimed at mitigating chemical contaminants at the roadside and are geared towards reducing the influx of particles into the surrounding landscape.

The efficacy of mitigation for chemical toxicity associated with roadway runoff depends on the extent to which contaminants associate themselves with particles that are removed by BMPs and the potency of BMPs [23].

Refining BMPs for future roadway and highway construction depends on a comprehensive understanding of environmental impacts from current construction methods.

2. MATERIALS AND METHODS

Assessment of environmental impact is the process performed for the overall assessment of significant adverse impacts, direct or indirect, by the project development. The drafting of the environmental impact assessment and the structure of its content are defined in the Albanian legislation.

The evaluation method should identify all impacts that may be caused directly or indirectly by the project implementation works. The determination of impacts was carried out by a good research team of the technical project, which predicted potential impacts that may arise during its various phases in the environment and the assessment of environmental sensitivity. Many different techniques have been developed to determine the methods of environmental impacts, each of which is characterised by its strengths and weaknesses.

In this study, data collected in different time periods at Skotini stream sites were used to assess the effects of roadway construction on the water quality in this watershed.

In this study, the matrix method, which is one of the most practiced methods, was used for the assessment of environmental impacts. All activities were identified based on the technical project from which impacts can be generated and the respective environmental hosts that may be affected by the impact, during the construction phase.

Effects of project development on water resources quality near the study area have been evaluated for Skotini stream according to the results of the water analysis carried out in the laboratory. Water samples were collected and analysed in laboratories for pH, dissolved oxygen (mg/l O₂), biological oxygen demand (BOD₅, mg/l O₂), chemical oxygen demand (COD, mg/l O₂), electrical conductivity (EC_w, µs/cm), total dissolved solids (TDS, mg/l), salinity (g/l), nitrites (NO₂⁻, mg/l), ammonium (NH₄⁺, mg/l) and total phosphorus (P_{tot}, mg/l).

The analysis procedures of standard methods (APHA, ISO, SSH) were followed for these analyses.

3. RESULTS AND DISCUSSION

The study project area is close to the Fushbardh area with a potential hydrographic. Specifically, the area where the roadway and the tunnel pass is mainly affected by the basins of the two main streams in the area; the Piksi stream in the northern part of the study area and the Gulina stream in the southern part of the area (Figure 1).

The higher branches from where these streams originate touch our area in relatively small parts. The relief of this area is relatively mountainous. The mountains and the highest peaks that surround this area are between 803 to 1592 m a.s.l. Generally, the catchment area for both of these streams is partly rocky and bare and partly vegetated. In this area is a water source where the largest amount of water reaches the period of spring and early summer; then their flow decreases considerably. Reduction of flow is generally conditioned by the height of their location, which greatly limits the nutrient surface area of these sources.

Water supply of these springs is through rain and snow. The study area is almost in a high water content area because it is entirely limestone (Figure 2).

In the case of tributaries of streams that affect this area, the surface runoff has some effect on the amount of water in Skotini stream. During the rainy season, the amount of water in these streams increases with the fall of the rains.

The project area is situated in the Strict Nature Reserves and the buffer area has high natural values. The whole project area is an area where no economic activities are carried out. The quality of the environment is high, including surface water.

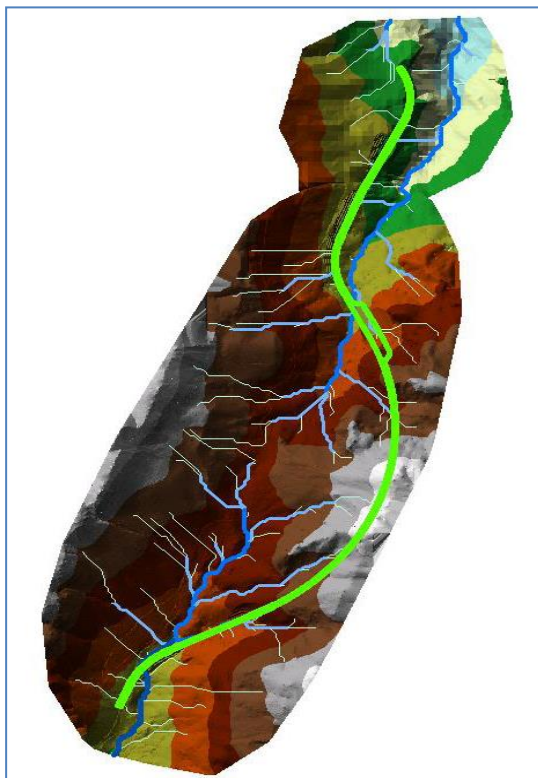


Fig. 1. Watershed of project area

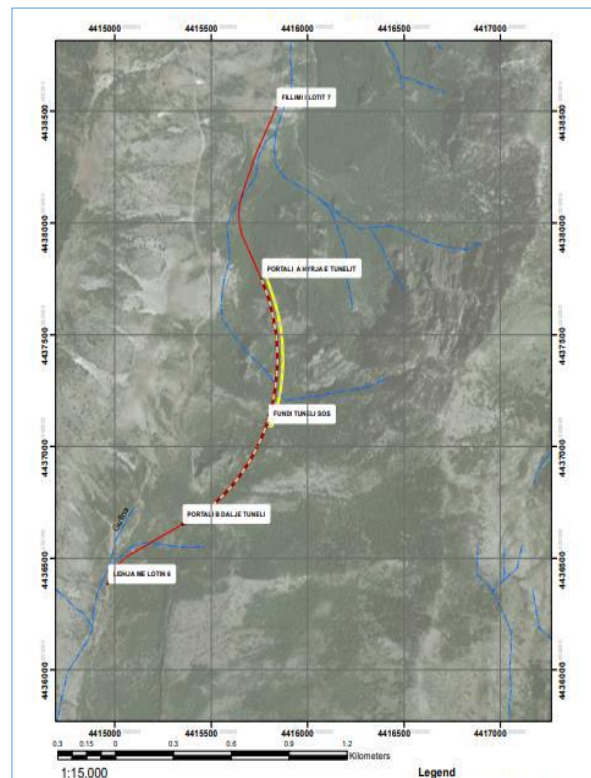


Fig. 2. Hydrographic map of the project area

Surface water quality has been monitored in laboratories located in the Albanian territory. For the assessment of the quality of the water sampled from Skotini stream, the results derived from the laboratory were compared with the limit values defined according to the WHO standards (Table 1). All indicators measured in the laboratory for the collected water samples from Skotini stream are between the normal standards, classifying these waters as very clean.

One of the problems that can be caused by road construction activities is the pollution of such surface water by construction materials and generated waste. The technical report envisages activities that avoid surface water pollution. One of these measures is the construction

of drainage of carriageways, which will include the construction of layers with drainage material, filtration/drainage channels and water supply from the side slopes, carriageways and other areas paved in surface streams. Drainages will consist of channels, drainage pipes, grilles, gravel/drainage with suitable granulometry for water filtration, etc.

Storage and disposal of construction site chemicals such as oils, gasoline, degreasers, antifreeze, concrete and asphalt products, sealers, paints, and wash water associated with these products to minimise their entry into a runoff is so important.

One way to do this is to define specific areas where these products are frequently used, such as fuelling areas and equipment washing areas. This can help prevent dangerous chemicals from entering adjacent surface waters. This measure also applies to the proper storage of road deicing materials.

This study is mainly focused on the effects of a roadway construction in the southern part of Albania. Referring to previous studies, long-term monitoring is needed to illustrate the subsequent impacts such as heavy metals, nutrients, and hydrocarbons pollution from daily transportation [24, 25], chloride from deicing [26], and subsequent urbanisation [27, 28].

Tab. 1.

Results of the analysis of water samples from Skotini stream

Indicators	Method of measurement	Unit	Result	WHO standard
pH	ISO 10523:2008		7.54	6.5-8.5
Dissolved oxygen (O ₂)	ISO 5814:2012	mg/l O ₂	5.87	6
Chemical oxygen demand (COD)	SSH ISO 15705:2002	mg/l O ₂	10.01	10
Biological oxygen demand (BOD ₅)	SSH EN 5815-2:2009	mg/l O ₂	1.9	50
Electrical conductivity (EC _w)	ISO 7888:1985	µs/cm	745	1000
Total dissolved solids (TDS)	APHA 2540 B:2017	mg/l	273	500-1000
Salinity	APHA 2540 B:2017	g/l	0.22	0.5-1
Nitrite(NO ₂ ⁻)	ISO 11905-1:1197	mg/l	0.05	3
Ammonium (NH ₄ ⁺)	ISO 7150-1:1984	mg/l	0.10	0.5
Total phosphorus (P _{tot})	ISO 6878:2004	mg/l	< 0.05	0.05

Laying materials for coating layers should be done mostly by hand. During the realisation of concrete gutters, in the procedure of its pouring, the placement of a thin final layer can be included, using for this purpose, a sliding mould. For the implementation of asphalt-concrete works, for the coating layer of the gutters and the protection of the end part of the ditches or curved channels, measures should be taken so that the water continues to flow away from the body of the road and not be obstructed by the asphalt edges.

The removal of water from road construction can be realised through the drainage network of the carriageway, from where the water is sent to the permanent drainage network. This could be done through pipes and culverts, carrying out the relevant earthworks as above.

An activity that may affect surface water quality is the discharge of groundwater generated by excavations for tunnel openings. Water veins may be encountered during the excavation of the tunnel opening. If this is the case, the groundwater should be collected, analysed using physic-chemical parameters, and then discharged outside the protected area.

The movement of heavy tonnage vehicles should be within open access to other lots. Any accidental spillage of hydrocarbons that may occur on the track will be fully manageable. Based on the above analysis, during the development of the project, the quality of surface water will not be affected. Further monitoring of surface water in the project area should be carried out as the results help strengthen the theory that construction projects using appropriate BMP could yield minimal impact on the water quality of adjacent water bodies.

4. CONCLUSIONS AND RECOMMENDATIONS

This study focuses on the effects of roadway construction, with a case study of the southern part of Albania. It revealed that most of the physic-chemical parameters analysed are within the permissible limit. Previous studies indicate that the water quality of surface water bodies in close proximity to roads may deteriorate due to highway expansion activities in the transport sector if mitigation measures are not taken.

The construction operator must implement mitigation measures that are related to avoiding impacts on surface water and groundwater. In any case, accidental fuel spills should be removed immediately. Due to the relief of the project area, the accumulation of soil in those places where streams are created should be avoided.

The polluted water in the tunnel mainly derives from the water processed in the wells drilled in the rock, during the opening, and to a lesser extent, is the dirty water of the rocks, which is added during the rain periods. These waters enter the canal that leads to the portals, where they are collected in special wells. Here, the water will be separated from the oil/fuel, and then discharged into the environment, while the oil/fuel will be collected separately. If necessary, the part of the purified water can be used again for drilling processes in the tunnel.

Roadway construction has significant effects on major water quality parameters such as turbidity, TSS, and total iron during construction, effects on chloride and sulfate during and after construction, and effects on acidity and nitrate after construction. Water quality parameters that are impacted by construction works should be considered for developing mitigation strategies and refining currently implemented best management practices for future highway constructions in the highlands region.

Periodic monitoring of surface water in the project area should be carried out. These results helped to strengthen the theory that construction projects using appropriate best management practices could yield minimal impact on the overall water quality of surrounding water bodies.

References

1. Rana A., S.K. Bhardwaj, M. Thakur. 2016. „Surface water quality and associated aquatic insect fauna under different land-uses in Solan (district Solan), Himachal Pradesh”. *Indian Journal of Ecology* 43(1): 58-64. ISSN: 0304-5250.
2. Shridharan M., D.N. Senthil. 2017. „Groundwater quality assessment for domestic and agriculture purposes in Puducherry region”. *Applied Water Science* 7: 4037-4053. DOI: 10.1007/s13201-017-0556.

3. Armah Frederic A., David O. Yawson, Alex A.N.M. Pappoe. 2010. „A systems dynamics approach to explore traffic congestion and air pollution link in the city of Accra, Ghana”. *Sustainability* 2: 252-265. DOI: 10.3390/su2010252.
4. Shabbir Yasir, Muhammad F. Khokhar, Reza Shaiganfar, Thomas Wagner. 2016. „Spatial variation and assessment of Nitrogen dioxide pollution in major cities of Pakistan along NS-Highway”. *Journal of Environmental Sciences* 43: 4-14. DOI: 10.1016/j.jes.2015.04.038.
5. Stavros Y., S. Basbas, I. Giannopoulou. 2013. „Waterbody’s pollution due to highways storm water runoff: Measures and legislative framework”. *Global Nest Journal* 15(1): 85-92.
6. Yew Connie P., Paul B. Makowski. 1989. „Water quality monitoring of highway construction”. *Proceedings of the 1989 National Conference on Hydraulic Engineering*, ASCE. New York. P. 157-162.
7. Yunn-Jinn Wang, Chi-Feng Chen, Jen-Yang Lin. 2013. „The measurement of dry deposition and surface runoff to quantify urban road pollution in Taipei, Taiwan”. *International Journal of Environmental Research and Public Health* 10: 5130-5145. DOI: 10.3390/ijerph10105130.
8. Hedrick Lara B., Stuart A. Welsh, James T. Anderson. 2007. „Effects of highway construction on sediment and benthic macro invertebrates in two tributaries of the Lost River, West Virginia”. *Journal of Freshwater Ecology* 22: 561-569. DOI: 10.1080/02705060.2007.9664817.
9. Eldin N.N. 2002. „Road construction: Materials and methods”. *Journal of Environmental Engineering* 128: 423-430.
10. Abewickrema A.W.N., R.W.M. Amanthika, A.L.T.M. Abeysinghe, R.K. Tennakoon, A.H. Tennakoon, H.M.M. Caldera, M. Safnas, N.P. Miguntanna. 2013. „Assessment of water quality impacts of highway and road construction projects”. *South Asian Institute of Technology and Medicine Research Symposium on Engineering Advancements – RSEA*. P. 136-143.
11. McNeill A. 1996. „Road Construction and River Pollution in South-West Scotland”. *Journal of the Institution of Water and Environmental Management* 10: 175-182. DOI: 10.1111/j.1747-6593.1996.tb00028.x.
12. Extence C.A. 1978. „The effects of motorway construction on an urban stream”. *Environmental Pollution* 17: 245-252. DOI: <http://worldcat.org/issn/02697491>.
13. Modi Ashwini Jajda, N.P. Shinkar. 2012. „Environmental impact assessment of road from Ujjain to Jaora”. *International Journal of Engineering and Advance Technology* 1: 2249-8958. ISSN: 2249-8958.
14. Grant S.B., N.V. Rekhi, N.R. Pise, R.L. Reeves, M. Matsumoto, A. Wistrom, L. Moussa, S. Bay, M.A. Kayhanian. 2003. *Review of the contaminants and toxicity associated with particles in storm water runoff*. Caltrans, Department of Transportation, Sacramento, CA.
15. Forman Richard T.T., Daniel Sperling, John A. Bissonette, Anthony P. Clevenger, Carol D. Cutshalland, Virginia H. Dale, Lenore Fahrig, Robert France, Charles R. Goldman, Kevin Heanue, Julia A. Jones, Frederick J. Swanson, Thomas Turrentine, Thomas C. Winter. 2003. *Road Ecology. Science and solutions*. Washington DC. DOI: 10.1002/ep.670220307.
16. Stephen C., Christopher A. Frissell Trombulakand. 2000. „Review of ecological effects of roads on terrestrial and aquatic communities”. *Conservation Biology* 14: 18-30. DOI: 10.1046/j.1523-1739.2000.99084.x.

17. Jones Julia A., Frederick J. Swanson, Beverley C. Wemple, Kai U. Snyder. 2000. „Effects of roads on hydrology, geomorphology and disturbance patches in stream networks”. *Conservation Biology* 14(1): 76-85. DOI: 10.1046/j.1523-1739.2000.99083.x.
18. Dunneand Thomas, Luna B. Leopold. 1978. *Water in Environmental Planning*. W.H. Freeman, San Francisco. ISBN: 0716700794.
19. Dell'Acqua, Gianluca, Mario De Luca, Carlo Giacomo Prato, Olegas Prentkovskis, Raimundas Junevicius. 2016. „The impact of vehicle movement on exploitation parameters of roads and runways: a short review of the special issue”. *Transport* 31(2) Special Issue: 127-132.
20. Hogan Dianna M., Mark R. Walbridge. 2007. „Best Management practices for nutrient and sediment retention in urban stormwater runoff”. *Journal of Environmental Quality* 36: 386-395. DOI: 10.2134/jeq2006.0142.
21. Houser Darci L., Heidi Pruess. 2009. The effects of construction on water quality: A case study of the culverting of Abram Creek. *Environmental Monitoring and Assessment* 155: 431-442. DOI: 10.1007/s10661-008-0445-9.
22. Staniek M., P. Czech. 2016. “Self-correcting neural network in road pavement diagnostics”. *Automation in Construction* 96: 75-87. DOI: 10.1016/j.autcon.2018.09.001.
23. Kashish Walia, R.K. Aggarwal, S.K. Bhardwaj. 2017. „Environment Impact Assessment of Highway Expansion – A review”. *Current world environment* 12(3): 507-519. ISSN: 0973-4929. DOI: 10.12944/CWE.12.3.04.
24. Kayhanian Masoud, Claus Suverkropp, A. Ruby, Kuen Tsay. 2007. „Characterization and prediction of highway runoff constituent event mean concentration”. *Journal of Environmental Management* 85: 279-295. DOI: 10.1016/j.jenvman.2006.09.024.
25. Lee-Hyung Kim, Kyung-Duk Zoh, Sang-man Jeong, Masoud Kayhanian, Michael. K. Stenstrom. 2006. „Estimating pollutant mass accumulation on highways during dry periods”. *Journal of Environmental Engineering* 132: 985-993. ISSN: 1943-7870.
26. Ostendorf David W., D.C. Peeling, T.J. Mitchell, S.J. Pollock. 2001. „Chloride persistence in a deiced access road drainage system”. *Journal of Environmental Quality* 30: 1756-1770. DOI: 10.2134/jeq2001.3051756x.
27. Line Dan E., N.M. White. 2007. „Effects of development on runoff and pollutant export”. *Water Environment Research* 79: 185-190. DOI: 10.2175/106143006X111736.
28. Wheeler Andrew P., Paul L. Angermeier, Amanda E. Rosenberger. 2005. „Impacts of new highways and subsequent landscape urbanization on stream habitat and biota”. *Reviews in Fisheries Science* 13: 141-164. DOI: 10.1080/10641260590964449.

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