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An empirical study of analysis of indicators for roads impact assessment

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Abstract

The impact caused by motorways depends on many factors that can be assessed using environmental indicators. The processing of empirical data to obtain equations for detecting indicator changes as a function of the flow of cars was made using statistical data processing methods, i.e. correlation and regression analysis. The relationship between the parameters in order to select the type of regression equation was found with the help of single-factor linear and non-linear models and by performing a regression analysis. The best choice of equation has been determined using values of correlation coefficient R and square of correlation coefficient R2. The uncertainty of the calculations made with the model has been described by the confidence interval of the mean value (i.e. the regression curve), whereas for new measurements, the interval of the specific value of the indicators is used. The regression analysis of data used in the paper has made it possible to obtain an empirical equation that shows the effects of independent variables (number of vehicles) upon the noise volume and the amount of PM10, NOx emissions in the air.

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Keywords: environmental indicator; regression analysis method; road; noise; NO_x; PM; benchmark

1. Introduction

With the development of environmental awareness within society and on the state level environmental questions has became more important in social political as well as in economical sphere. Indicator approach is used in many different fields, where quantitative environmental impact assessment is one of them. According to Garrido J. and Requena I. environmental indicator is an element which gives information about the state of the environment [1]. That is value which is measured, calculated or obtained with a help of model, therefore giving the highest possible

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objective result in the process of assessment of environmental impact. The transportation sector in Europe Union is the second largest source of GHG emissions followed by energy sector, with a tendency for emission growth. The road transportation was accounted for 20 % of total GHG emissions in 2012. Between 1990 and 2012, CO_2 emissions from road transportation increased by 11 % [2]. The traffic impact on the environment, including air quality, is caused by traffic and motorway interaction, which is enhanced by natural causes – meteorological, relief, environmental conditions, growth of vegetation [3]. Pollutant emissions of vehicles depend on many parameters such as vehicle weight, fuel type, engine capacity, driving pattern, road gradient and the level of maintenance of the vehicle [4]. The main impacts of road vehicles are pollutant (NO_x, PM, CO, SO_x and benzene) emissions in the air and the noise [5, 6]. The concentration of air pollutants and noise is directly depending on motor transport intensity and also driving habits [7, 8]. The correlation between the pollutant emission concentration and the number of cars was found [8]. Mathematical statistical methods such as correlation and regression analysis are still widely used to find the relationship between two or more parameters [9]. An empirical model is still the most appropriate way to express the magnitude and fluctuations of traffic noise [10]. The aim of this paper is to find parameters by the help of one-factor linear and non-linear models by regression analysis and to select the type of regression.

2. Methods

Emissions of air pollutants (PM, NO_x) and noise correlation with the number of cars on the road for a time unit are based on the actual measurements and model calculations. The data on the most relevant environmental indicators have been obtained from EIA reports of motor road projects in Latvia. The processing of empirical data to obtain equations for detecting indicator changes as a function of the flow of cars was made using statistical data processing methods-correlation and regression analysis. In this study, the processing of statistical data and the development of a single-factor empirical model was performed using STATGRAPHICSPlus software. 95 % credibility intervals for the mean and individual indicator values have been set for all indicator changes with the help of the model calculations of uncertainty characterized by average values (regression line) confidence interval, while the new measurement uncertainty of the forecasts used indicator of individual values of the interval.

2.1. Determination of the noise indicator model and its parameters

The size of the data set used to determine the changes in the noise indicator was 20. The relationship between the parameters in order to select the type of regression equation has been clarified with the help of single-factor linear and non-linear models and by performing a regression analysis. The selection of the best equation was made on the basis of the values of the correlation coefficient and the square of the correlation coefficient. The closeness of the link (correlation) between the random independent (flow of cars) and dependent (indicators) variables can be measured using a correlation coefficient R. In the case of a single-factor mathematical model, the Pearson expression is used (Eq. (1)):

$$R = \frac{\sum_{i=1}^{m}(x_i - x)(y_i - y)}{(m-1)S_x * S_y}, \tag{1}$$

where

xi, yi	pairs of independent and their corresponding dependent variables;
x, y	average arithmetic values of the pairs of independent and their corresponding dependent variables;
S_x, S_y	sample variance of the variables.

A comparative analysis of various models shows that when determining changes in the noise indicator, better parameters can be obtained using a non-linear model:

$$Y=aX-b \tag{2}$$