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ROAD RUNOFF CHARACTERISTICS ON COSTAL ZONES - EXPLORATORY DATA ANALYSIS AND MODELING BASED ON A PILOT CASE STUDY

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KEYWORDS

Highway runoff, salt deposition, data analysis, modeling

engineering for countries with a significant coast line, as found in Portugal.

EXTENDED ABSTRACT

The work presented in this paper was developed under the PhD thesis entitled “Evaluation of the Effects of Salt Deposition in Highway Runoff in Coastal Zones”. The main goals for this study are the characterization of the physic-chemical particularities of highway runoff in coastal zones. An extended monitoring program, at a site located near to the sea of the A25 highway, was performed and the monitoring data was submitted to exploratory statistics techniques and modeling analysis, enabling a better understanding of the factors and process related to the phenomenon.

The monitoring work, that took place between 2008 and 2011, was performed under various climacteric conditions (30 different rainfall events). The operational procedures were adopted from previous monitoring work at the site (Antunes and Ramísio, 2010), including the automatic collection of runoff samples and measurements of the precipitation and highway runoff flow. A wet candle device methodology (ASTM, 2002) was selected to determine the salt deposition rate (amount of chlorides salts deposited from the atmosphere on a given area per unit time).

Road runoff is a linear source of diffuse pollution that can cause significant environmental impacts. The pollutants result from the traffic (including tire and brakes wear, oils and fuels leakages, deteriorating of paints and fuel emissions), the degradation of the road platform and other site structures, erosion of embankments and operations of road conservation and maintenance (Sansalone and Buchberger 1997). Previous studies have verified that the road runoff characteristics in coastal zones show a different pollution pattern, with higher levels of salinity and organic matter (Antunes and Barbosa, 2005).

Based on the qualitative data from the monitored events and the data provided from the Meteorological Station of the Aveiro University, the following objectives were analyzed: Hydrologic characterization of rain events; water quality parameters concentrations, including Event Mean Concentration (EMC) and Site Mean Concentration (SMC); pollutant loads; firsts-flush verification; descriptive statistics. For each pollutant, the obtained results were compared with those from other monitored sites.

In coastal environments, the marine aerosols, transported by the atmosphere, promotes the salt deposition in the road pavement, changing the highway runoff characteristics and their environmental effect.

In order to understand the relationship between the main variables, and by this way support the understanding of the processes, an exploratory data analysis with different statistical techniques, was done. The methods that were considered include: Pearson Correlations, Clusters Analysis (CA) and Principal Component Analysis (PCA).

If the processes involved in this phenomenon are better understood and quantified, a valuable contribution to knowledge can be achieved, enhancing a new approach regarding highway runoff management and road

In this study, the EMC's were considered dependent variables, while the independent variables, that induce these qualitative characteristics highway runoff, are related to rainfall event, road site and salt deposition characteristics.



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MAINLY RESULTS AND CONCLUSIONS

The outcomes confirm high levels of salt deposition in the pavement and the increase of salinity, organic matter and related parameters in highway runoff. Table 1 presents the summary statistics of the major analytical parameters concentrations.

Table 1: Summary statistics of highway runoff quality in A25 site

Parameter	Samples	Average	Median	Min	Max	St. Dev.
Conductivity ($\mu\text{S}/\text{cm}$)	215	325,5	243,0	55,6	1288,0	226,5
Salinity (mg/l)	217	163,8	100,0	50,0	600,0	113
Turbidity (FNU)	215	28,6	20,3	1,3	118,0	24,6
TSS (mg/l)	217	48,8	27,0	1,2	642,0	74,3
Chlorides (mg/l)	209	62,7	36,2	2,2	370,9	72,9
COD (mg O ₂ /l)	217	79,6	60,0	5,0	375,0	72,9

Pearson correlations were calculated to identify surrogate constituents within parameters. Significant correlation was found between pairs of salinity (or related parameters) with organic matter.

The dendrogram depicted in Figure 1 represents the clustering of the different runoff parameters analyzed through CA.

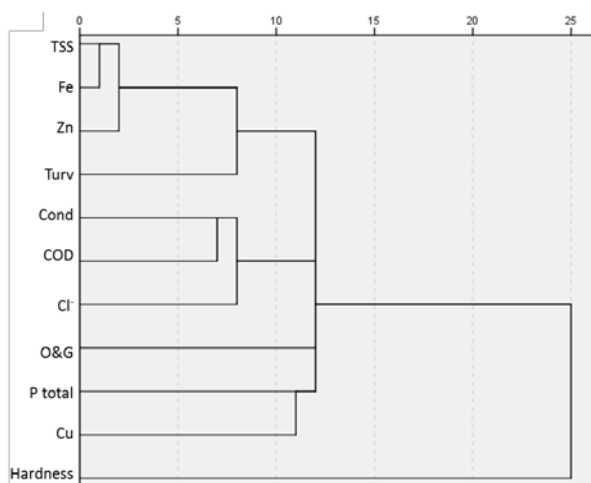


Figure 1: Dendrogram presenting the main parameter clustering in highway runoff studied

In the highway runoff studied, besides an expected compact cluster: with Fe, Zn and TSS; the CA revealed a specific parameters group related to salinity and organic matter. PCA confirms these characteristics relations.

CA and PCA also allowed to define relations and groups between dependent and independent variables (e.g. it is seen the Antecedent Dry Period have a great correlation with salinity and COD EMC's).

The modeling of the phenomenon using a statistical method (e.g. Multiple Linear Regression) and, if achievable, a more deterministic approach, is still to be complete.

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AUTHORS' BIOGRAPHIES



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