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

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EXTENDED ABSTRACT

Road runoff is a linear source of diffuse pollution that can cause significant environmental impacts. The pollutants result from both mobile and stationary sources. Stationary sources include the degradation of the road platform, erosion of embankments and the degradation of urban infrastructures. Mobile sources are due to the road traffic (including tire and brakes wear, oils and fuels leakages, deteriorating of paints and fuel emissions). Operations of road conservation, including the application of pesticides and fertilizers, and litter, may also contribute also contribute to this type of pollution (Sansalone and Buchberger 1997).

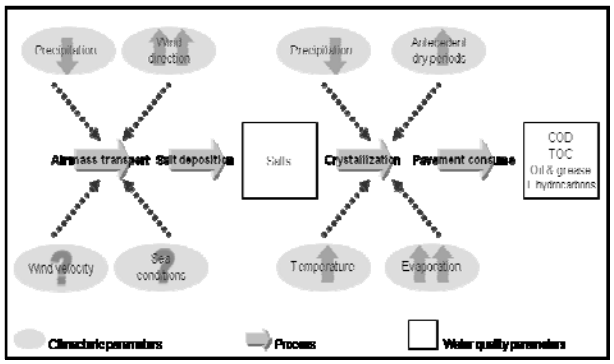
In coastal areas, maritime salts are transported by the atmosphere to large distances (Warneck 1999) and deposited in the pavement. There crystallization, during dry periods between rainfall events, can change highway runoff characteristics and, eventually, be responsible for pavement degradation (Woodbridge et al. 2002).

If the phenomena and processes involved are better understood and quantified, a valuable contribution to knowledge can be achieved and enhance a new approach regarding highway runoff management and road engineering for countries with a significant coast line, as found in Portugal,.

These matters are the major concern of a Ph.D. thesis (in the Engineering School of the University of Minho), based on field monitoring work (including innovated monitoring methodologies) in a site of the A25 highway, located at approximately 5 km east of the Atlantic Ocean. This site was previously monitored and high level of salinity and organic matter where found (Barbosa and Antunes 2004; Barbosa et al. 2006). Barbosa et al. (2006) detected similar evidences at another Portuguese coastal road. On the other hand, pollutants typical for road runoff characterization, such as total suspended solids and the heavy metals, clearly indicate different levels of pollution. Such evidences have been related to the proximity of the Atlantic Ocean (Barbosa et al. 2006; Antunes and Barbosa 2005), since the non-coastal Portuguese roads did not show this pattern.

The diagram presented in Figure describes the conceptual processes and the leading variables that could be more relevant in understanding the related phenomena.

Figure: The conceptual processes and the leading variables.



Statistical exploratory techniques will be used in order to evaluate the relationship between the pollutants and the help to understand the most relevant relationships between variables.

Multivariate exploratory statistical techniques where applied to a set of coastal and non-coastal Portuguese roads. The result of this analysis indicated different patterns for the two groups, in terms of salinity, conductivity and chlorides, as expected, but also of COD concentration (Barbosa et al. 2006).

In fact, possible correlations among road runoff quality parameters and independent variables are being studied. These belong to three different groups: i) rainfall event characteristics; ii) air masses transport and salt deposition, and iii) road site characteristics.

The results with a summary statistic of the major parameters concentrations (related to the objectives of the research), from the first 20 monitoring rain events (total of 40) at the A25 monitoring site are presented in the table

Table: Summary statistics of highway runoff quality in A25 site, from the winter 2004; autumn 2009 and winter 2010.

Parameter	nº samples	Average	Median	Range values		St. Dev.
				min.	**max.**	
Conductivity (µS/cm)	143	344,5	257	58,6	970	220,7
Salinity (mg/l)	143	178,6	115	50	520	112,6
Turbidity (FNU)	143	34,3	24,6	2	118	26,4
TSS (mg/l)	143	60,4	33	1,5	642	86,6
Total Hardness (mg $CaCO_3$/l)	143	77,5	70	3	208	36,6
Chlorides (mg/l)	135	74	43,1	1,3	370,9	77,9
Total P (mg/l)	143	0,8	0,3	-	7,4	1,4
COD (mg O_2 /l)	143	92,8	69,4	3,3	375	77,9
BOD_5 (mg O_2 /l)	108	12,6	5,9	-	90	14,4

Therefore, based on the results the applicability of several statistical methods where evaluated in order to select the most promising techniques for the implementation of this research project.

To identify surrogate constituents within parameters, at first attempt, Spearman correlations where made, selecting pairs with Spearman coefficients elevated. The strongest correlations were observed between parameters associated with dissolved minerals; organic carbon and particulate matter. Within the metals category, total iron concentration was highly correlated with most total metal concentrations.

As suspected, the strongest correlation was found between pairs of salinity (or related parameters) with organic matter, especially in terms of COD. The BOD_5 concentration is independent from the salt deposition.

With lack of linearity, Spearman Correlations don't permit to establish solid correlations between Event Mean Concentration (EMC) and process related to salt deposition. Although some variables, as event antecedent dry period, could be linked to higher levels of COD, using this method.

Principal Component Analysis permits to reveal data patterns, especially when the variables are measured in very different units and scales. This can be applicable to foreseen relations within parameters and between them and other pertinent variables to the phenomenon. It is seen the Antecedent Dry Period and Rain Depth have a great correlation with salinity and COD.

Clusters Analysis is a more complex method with a higher reliability, that confirm the correlations observed between parameters.

Factorial Analysis demonstrates to be reliable to evaluate quantitative coefficients between EMC and other variables (event conditions; site characteristics; air mass transport/salt deposition). This exploratory statistical technique also permits to establish links between exploratory data analysis and the modeling by Multivariate Analysis, gathering coefficients to the variables relevant to EMC.

It is expected that the data of the monitored events, completed with the data from the next two monitoring periods at the A25 site will provide enough data for simple and advanced statistical analysis that will support the identification of the particular characteristics and processes, concerning road runoff in coastal areas.

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