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Chemometric interpretation of pesticide occurence in soil samples from an intensive horticulture area in north Portugal

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Abstract

An extensive monitoring programme of pesticides was carried out in soil samples from an intensive horticulture area in north of Portugal, putting into practice the needs for increased control of soil quality as far as organic pollution is concerned. The area under investigation was additionally defined as vulnerable to nitrates due to local soil and aquifer characteristics, which might be extended to pesticides contamination. Five sampling sites were selected and soils analysed at three depths in eight sampling campaigns, for the period of 2 years. A stepwise multivariate statistical approach was selected to uncover most relevant patterns inside a complex environmental data matrix. Cluster analysis was applied both to group pesticides and samples, giving a primary and unsupervised overlook of privileged relationships. Clusters of persistent pesticides and selected herbicides were identified, whereas sample classes were also formed and disposed geographically. Thirty eight percent of analysed soils samples fell into one class characterized by low contamination (class 1 in cluster analysis), which is entirely representative of the sampling site no. 1. Afterwards, linear discriminant analysis was applied to identify those pesticides, which had a higher impact in the definition of classes. Finally, factor analysis using a five component model was implemented in order to bring to light the constitution and data variance explained by each of the five main principal components, as well as, their relation to pest management practices. A factor was identified (PC1 – 22% variance) composed of chlorinated pesticides, which was representative of one of the investigated sites indicating its high contamination status. Qualitative main findings and class average concentration values were obtained through this multivariate statistical approach.

Keywords: Environmental monitoring; Soil; pesticides; Cluster analysis; Linear discriminant analysis; Factor analysis

1. Introduction

The distinctive feature of pesticides pollution is that extensive surface areas receive agrochemical treatments applied to soil or spayed over crop fields and hence they are deliberately released in the environment and available for contamination [1–3]. Furthermore, pesticides are toxic substances used for preventing, destroying or controlling any pest or unwanted plant or animal thus, often conceived to cause lethal effects [2]. The widespread detection of pesticides in the aquatic environment has forced the adoption of restrictive legislative measures, especially in the area of water policy. The potential for leaching and drainage of substances into the surface and groundwaters was mathematically expressed, amongst others models, by the DRASTIC aquifer vulnerability index, developed formerly by Aller et al. [4]. The soil dependence is therein represented by several parameters, one of them being soil type, weighed in the final index. Since the aquifer vulnerability to contamination will be different for different pollutants, the DRASTIC index for pesticide applications was also developed [5].

The uncontrolled use of pesticides in agricultural activities has degraded several soil functions including the soil's biological ability to remove other pollutants and resulted also in yield reduction in crops that follow in rotation due to phytotoxicity [6]. Soil compartment might also be regarded as a reservoir for many types of xenobiotics where various physicochemical transformation processes might take place. Adsorbed to soil particles or organic matter they may suffer transport, degradation or otherwise protection and retention for decades. Many examples can be found in the literature [7–10] where persistent organic

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