A BMP selection process based on the granulometry of runoff solids in a separate urban catchment

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Abstract

This article presents the methodology and results of the field survey carried out to characterise the pollution associated with the stormwater runoff from an urban catchment in Galicia (Spain). Various instruments were installed in the control section of this catchment measuring some 55 ha and located in the separate sewer system outlet, to obtain samples associated with stormwater events. In particular, precipitation and flow were recorded, in addition to the pollution associated with such flows. On the basis of this information it was possible to determine a series of pollution parameters (solids, BOD_5, COD, TOC) and the most important event parameters (event mean concentration, maximum concentration, mobilised load per net hectare) were calculated. These results were compared with those from other similar catchments. The analysis of the results includes the determination of probability distribution as well as the study of the particle size distribution of the samples during different periods of the event, which thus enabled us to obtain the relationship between the total rainfall and the particle size distribution of each event. Finally, a study of potential best management practices using the process selection diagrams is presented.

Keywords: separate urban catchments; runoff pollution; best management practices; suspended solids; particle size distribution

Introduction

The world's population has become more and more concentrated in cities, which has had a considerable impact on the growing complexity of the infrastructures, especially those related to the management of water (Butler and Davies, 2000). This high concentration has been responsible for land development and an increase in the impervious surface area of the catchments. Some of the most obvious consequences are the greater volume of runoff and velocity of circulating flux, shorter concentration times and shallower volumes during low water periods. The end result is an overall increase in pollution levels (Novotny and Olem, 1994).

In separate sewage systems, such as the one analysed in this study, the pollution drawn in by runoff waters is the result of both the activities that take place on the surface of the catchments and the re-suspension of sediments within the network.

Studies on the characterisation of pollution in urban runoff have increased significantly in number in recent years. From the first environmental analyses (Sartor and Boyd, 1972, USEPA, 1983), up to the most recent studies (i.e. Taebi and Droste, 2004 and Chebbo and Gromaire, 2004), the general consensus is that the main sources of runoff pollution are sediments accumulated on the street surface and conduit inverts, traffic emissions and chemical substances used to melt ice. These studies also show that most of the pollutants are associated with the finest fractions of the sediments which are the ones most difficult to eliminate by using sedimentation techniques.

Another field where a significant amount of scientific research has been carried out over the past few years is the characterisation and transport of sediments in sewer networks (Crabtree, 1989, Ackers et al., 1996, Ashley et al., 2003, Butler et al., 2003, Ota and Nalluri, 2003). In the case of stormwater sewer systems the sediments found can be classified into two types: stormwater solids and grit material. Stormwater solids, consisting generally of one-fourth organic matter, are transported in suspension, and the characteristic values quoted in the literature vary widely. Thus, the average relative density of the sediment is approximately 2.4, with 90% of the particles being smaller than 100 µm in size.

Grit sediment constitutes the largest part of the sediments found to be deposited in the sewer networks. These sediments are usually transported along the bed. Although differentiating stormwater sediments is complicated, they are usually defined as the inorganic fraction greater than 150 µm with specific density of around 2.7 (Ackers et al., 1996).

The main objective of this study is the characterisation and analysis of the pollution generated by solids in a separate urban catchment outfall during wet periods. For this purpose, a control section was implemented in the catchment outlet, where continuous values of flow and pollution were recorded. Precipitation was obtained using a rain gauge located near the control section, and the volumes and discharges were measured using a flow meter.

The results were analysed using various procedures. On the one hand, significant parameters for each of the events were calculated, i.e., average, maximum and minimum values of rainfall and volume. Moreover, in the pollution study, the variability of pollutants in events may be very high. Therefore, some studies (USEPA, 1983) propose an approach that would work with total flow-weighted concentrations to obtain an "event mean concentration" (EMC):

$$EMC = \frac{Mass}{Volume} = \frac{\sum_{i=1}^{N} \overline{Q}_i \overline{C}_i \Delta t_i}{\sum_{i=1}^{N} \overline{Q}_i \Delta t_i} \quad (1)$$

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