Distribution of chemical constituents according to particle size in torrential rivers of the Basque country

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Abstract

Surface sediment samples of the rivers Bidasoa, Lea and Oria (NE of Spain), with torrential character, were taken at 26 selected points, dried and sieved to eight fractions for size analysis (from >2 mm to <63 microns; first fraction >2 mm was rejected). Determined parameters include major (carbonates, organic carbon, Ca, Mg, Na, K, Si, Al and Fe) and microconstituents (Cu, Mn, Zn, Cr, Pb, Ni and Cd), measured mainly by AAS (flow spoiler and graphite furnace) and FIA. Results are discussed by calculation of factors of enrichment in the fine fraction and by graphs of correlation coefficients of parameters versus size fractions. Most microconstituents, organic carbon and Al (related to clays) were accumulated in the fine fractions of the sediments, suggesting pollution phenomena. The rest of the constituents seemed to be related to coarse fractions (Mg, carbonates) or not related to any particular size fraction. To discuss pollution phenomena, the comparison with major conservative elements (Al, Fe or Mg) was tried without success. A method was then proposed with the establishment of an index of quality for each pollutant constituent of sediments, based on the average earth's crust composition (or the average sedimentary rock content for organic carbon). With this method, fine samples show lower quality indices for most constituents, specially in the case of organic carbon, and total samples have much better indices suggesting organic carbon contamination only in seven cases.

Introduction

Sediment samples are often used as heavy metal pollution indicators in surface waters (Förstner and Salomons, 1980). The presence of heavy metals is affected by particle distribution of sediments (Thome and Nickless, 1981). In this sense, Yamagata and Shigematsu (1970) pointed out that heavy metals should be analysed not only in total sediment, but also according to particle size. Oguna et al. (1979) showed that the concentration of a pollutant is distributed into two fractions of the sediments, i.e. the fine and the coarse. Salomons (1980) considered that both:

- the adsorption capacity by unit of weight usually increases as the particle size of the solids decreases; and
- the capacity of flow transport increases as the particle size decreases.

Förstner and Salomons (1980) also suggested that it is necessary to consider the distribution of size particle to estimate the natural metal levels of river sediments, because there is a marked decrease in the metal content as the particle size increases. Ackermann (1980) used an assay procedure to correct for different particle sizes on heavy metal content in estuarine and coastal sediments. He found that the best results are obtained using cesium for correction.

The comparison of the content of a heavy metal with a conservative element has been suggested to estimate sediment pollution at different depth levels. Magnesium (Hilton et al., 1985), iron (Allen and Brunskill, 1977) or aluminium (Bruland et al., 1974) have been mainly proposed as conservative elements. But the distribution of conservative elements according to sediment particle size may be variable because of changes in mineralogical constituents.

In this paper results are presented which form part of a broader study entailing the identification, origin and physico-chemical factors affecting pollution of torrential river sediments by heavy metals. This work is firstly focused on establishing relations between chemical parameters and size data for studied sediment samples, with special emphasis on estimating the distribution of pollutants in river sediments according to size particle. A second objective is to propose pollution criteria when considering river sediments which vary in both chemical composition and size particle.

Materials and methods

Sampling area

Sediments were collected from the Lea, Oria and Bidasoa Rivers with torrential regime, belonging to the hydrographic basin of the Cantabric Sea, Spain (Fig. 1). Geographic locations and characteristics are the following:

The Bidasoa River has its basin divided between Navarra and Guipuzcoa. It rises in the Lesete peak near the Izpegaray pass. It flows for 50 km in Navarra and for 11 km in Guipuzcoa, forming the border with France until it discharges in the Cantabric Sea (Fuenterrabia). The drainage area is 706 km^2 (681 km^2 in Navarra). The most important tributaries are the Ezcurra, Echalar, Marin and Ondalasco (where most of the industrial factories are located).

The Oria is the most important river in Guipuzcoa. It rises near Otzaurte (Aitzgorri mountain) and flows into the Cantabric Sea at the town of Orio. Its length is 63 km, with a catchment basin area of 850 km^2. Numerous tributaries, such as Araxes, Agaunza, Leizaran, Mutiloa and Estanda, feed into this river and may influence the characteristics of the main river.

The Lea River is quite short (22 km) and located in Vizcaya. It rises in the slopes of Oiz peak (1 026 m) and flows into the Cantabric Sea at the town of Lekeitio. Its elongated basin has an area of 80 km^2. Along its course many small streams are incorporated, but its main tributaries are the Zulueta, Telleria, Muxo and Murela.

The three rivers have much reduced flows during the summer

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Received 1 February 1991; accepted in revisedform 7 November 1991.