C, N, P AND S IN RIVERS : FROM SOURCES TO GLOBAL INPUTS

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NATURAL SOURCES OF C, N, P AND S

Carbon, nitrogen, phosphorus and sulfur are essential elements found either as dissolved or particulate river-borne material. Their origins, their behaviours in aquatic systems, the occurrence of their specific forms, and the rates of transport by rivers are first considered in this paper. The anthropogenic influences on riverine C, N, P, and S are briefly presented. Finally the global fluvial budgets of the specific forms, including the anthropogenic loads are estimated.

The major specific forms of C, N, P and S commonly found in rivers are described in Table 1. There is now an accepted English jargon of abbreviation where D, P, and T stand for dissolved, particulate and total, respectively, and O and I for organic and inorganic. Thus PIC means particulate inorganic carbon. The particulate forms can be expressed either as concentration per unit volume of water plus suspended matter (mg/l), or as concentrations per unit mass of particulate matter (mg/g, and in % of total suspended matter TSS). Some specific forms are only operational: Kjeldahl nitrogen (NK) is a measure of both organic nitrogen (such as proteins) and ammonia nitrogen. This measurement can be made either on filtered (DNK) or on unfiltered (TNK) waters. The total phosphorus is a similar mixture of orthophosphates, and in some polluted waters, of polyphosphates, and of organic phosphorus on either dissolved or dissolved plus particulate material and inorganic particulate P. However, TP depends on the chemical attack made. Usually TP analysis is carried out on unfiltered waters after heating at 110° with H_2SO_4 as oxidant. The bulk organic P is thus mineralized into phosphate. Stronger acid or alkaline attacks may completely solubilize the inorganic particulate phosphorus (PIP) that includes the apatitic P and the non-apatitic P. Selective chemical attack of particulate matter may solubilize mixtures of various phosphorus forms. The method of Williams *et al.* (1976) thus separates: organic particulate P (POP), adsorbed P onto particles, apatitic P, and non-apatitic P (see also Berner *et al.*, this volume). Particulate nitrogen (PN), includes organic material and ammonia adsorbed onto clay minerals.

In rivers, where the pH range is usually from 6 to 8.4, DIC is generally in the form of bicarbonate (HCO_3^-). The difference between dissolved and particulate forms is still conventionally made by filtration on 0.45 μm to 0.5 μm filters. However, an important part of the organic colloïds still passes through 0.5 μm filters (Thurman, 1985). Size fractionation of organic matter is still very rarely done in rivers.

The natural sources of C, N, P and S in river-borne materials (Table 1) are multiple:

(i) chemical weathering of minerals such as calcite and dolomite (DIC), apatite (PO_4^{-3}),

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