

# Occurrence of metals in waters: An overview

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## Abstract

Presence of metals in natural, drinking and waste waters can imply two types of circumstances (depending on concentration and specific metal): firstly, certain positive effects, especially, when the metals present in drinking water are essential for human life (e.g. Mo and Zn); secondly, some negative and toxicologically undesirable effects for both human consumption and the general environment (i.e. Cd, Hg).

This paper gives an overview of outstanding aspects related to the chemical behaviour, occurrence, physiology and toxicology of the 25 metals most frequently found in waters: Aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, sodium, selenium, silver, tin and zinc.

On the other hand, the maximum concentrations of metals in natural, drinking waters and waste waters are listed according to the actual Spanish regulations. Finally, references to the maximum levels of metals in drinking waters established by a recent proposal of Directive in the European Union, as well as the latest WHO's guideline values for metals have been also considered.

## Introduction

The concentrations of metals in water are a function of the particular chemical and electrochemical behaviour, as well as other conditions of the hydrological environment. These levels can vary from a few  $ng/l$  ( $10^{-9} g/l$ ) or  $ug/l$  ( $10^{-6} g/l$ ) in those known as **trace metals** (i. e. beryllium, cadmium, mercury...) to  $mg/l$  ( $10^{-3} g/l$ ) or even in some cases  $g/l$ , with respect to the **major metals** (calcium, magnesium, sodium).

On the other hand, the effects of the different metals present in waters range from beneficial (calcium, zinc) through troublesome, to being dangerously toxic in certain cases (lead, mercury). Thus, some metals are essential, while others may adversely affect water consumers, waste-water treatment equipment and systems, and receiving waters.

Summarising, some metals may be either beneficial or toxic, depending on their concentrations and physiological behaviour.

Along the following, we provide an overview of the occurrence, toxicology and other aspects of the 25 different metals most frequently found in the water environment.

## Aluminium

Atomic number 13

Symbol Al

Atomic mass 26.982

Oxidation number for dissolved substances:

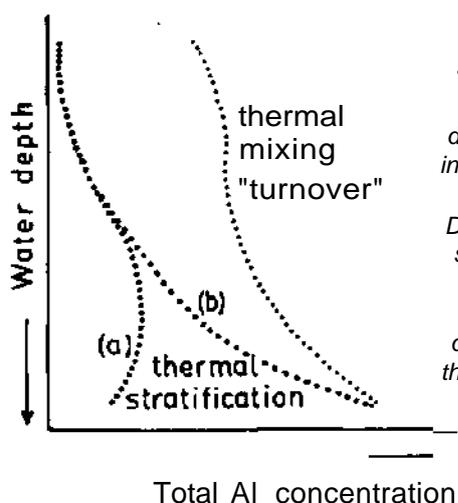
+1(aluminous ion), +3(aluminic or aluminate ions).

Al is one of the more common elements in the earth's crust, at 8.1 % by mass. Al in waters emanates from the dissolution processes of natural silicates; it can be found either as soluble salts or as colloidal compounds (Driscoll, 1985) ranging in concentration between 0.10 and 10  $mg/l$ .

The behaviour of Al in natural waters is a function of the erosion phenomenon of siliceous rocks which yield, firstly, colloidal Al, and later, dissolved Al (especially,  $Al^{3+}$ ). Furthermore, this metal can form a variety of complexes such as  $AlF_6^{2-}$  and  $AlCl_4^-$  (Hemm, 1986) and complexes with acetic, citric, tartaric and oxalic acids. Sparingly soluble salts of this metal are phosphate, oxinate and calcium aluminate (Pourbaix, 1966).

Al levels in river water can vary widely and a range of 0.012 to 2.250  $mg/l$  has been reported for USA rivers (Driscoll, 1985; Neal, 1994). In areas where acidic deposition has occurred, surface water with depressed pH values exhibits Al levels in the range of 0.10 to 0.80  $mg/l$  (Driscoll, 1985).

With respect to lakes and reservoirs, the Al levels increase slightly with depth during the thermal stratification period, with higher ranges during the mixing period (**turnover**) (Fig. 1 (a)). Thus, the total concentration of metal in water is related to the input of rich clays to lake water (Driscoll, 1985; Manñ Galvín, 1991 a-c). Conversely, very important increases of total Al in deep waters of reservoirs which experience strong anoxic conditions in depth during the stratification period (Fig. 1 (b)) can be detected (Marñ Galvín, 1995).



**Figure 1**  
General depth dynamics for total Al in a typical temperate zone reservoir. Dynamics during the stratification period can evolve in two different forms, depending whether the anoxic conditions in depth are moderate (a) or marked (b)