PARTICULATE METALS IN WATERS OF A TYPICAL IRRIGATION RIVER: THE RIVER SAKURAGAWA, JAPAN

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Abstract. The particulate metallic elements in waters of a water system of the River Sakuragawa and Lake Kasumigaura were measured by the multielement analyses using particle-induced X-ray emission. The heavy metal particulates for environmental standards were less than 0.0001 ppm for Cd, 0.00037 ppm for Cr, and 0.00078 ppm both for Hg and Pb in the river waters. The predominant metal particles in the waters were Fe, Mn, and Zn.

1. Introduction

In Japan much attention has been given to metal pollution starting with Minamata Disease, a large scale Hg poisoning caused by the consumption of Hg-contaminated shellfish and finfish taken from Minamata Bay in Japan [1]. Later, there was the great problem of the Itai-Itai disease, caused by human bioaccumulation of Cd, resulting from Cd release from mining activities and its introduction into irrigation waters [2]. The significance of Hg and Cd pollution has been well understood to be largely related to its effects on human beings, although many other metals have just emerged from recent studies because of their impact on aquatic ecosystems as reviewed by Waldichuk [3].

In aquatic environments, metals are concentrated by the processes of bioaccumulation [e.g., 3, 4], sorption by clay minerals [e.g., 5-8] and natural humus [9]. These concentrations in water occur in particulate forms that are easily susceptible to further bioaccumulation through the food web: Thus processes towards these concentrations are favorable for the acceleration of catastrophic destruction of the aquatic ecosystem, followed by possible impact on the human society in various ways [3].

A serious impact exists in Japan starting with metal pollution of irrigation waters which resulted in the lethal bioaccumulation of metals in farm products; i.e., the cases well-known as Cd-contaminated watersheds of the River Usui and the River Watarase in Gumma Prefecture, Japan, where rice farming has now been prohibited. A considerable amount of research information has been published on the metal pollution in these particular rivers by environmental pollution agencies belonging to the Japanese Government or the Prefecture. However, little is known about the present state of irrigation rivers that are free from direct influence of metal pollution. Thus the River Sakuragawa was selected as a typical example of those irrigation rivers flowing through paddy fields.
2. Methods

The sampling stations (Figure 1) in the River Sakuragawa were on a mountain stream in Mount Tsukuba (Station 1) which is free from pollution, just above Tsuchiura City (Station 2) which is enriched by addition of agricultural wastes, at the river mouth (Station 3) which has the addition of secondary-treated domestic sewage, and at the estuary harbor of Tsuchiura (Station 4).

![Fig. 1. Location of sampling stations in the River Sakuragawa and Lake Kasumigaura.](image)

The water samples were aseptically collected with Hydroht sampling bottles from 10 cm depth. Each sample (with 1.00 µg of standard BaSO₄ suspension) for metal analysis was filtered on to a Nuclepore filter (Nuclepore Corporation, Pleasanton). The detection of metals in each sample was made by the method of Walter et al. [10] using a 12 UD pelletron tandem accelerator for α-particle beam irradiation with a target chamber for the detection of fluorescent X-rays from the sample. The 20 MeV α-particle beam was used and a spectrum of the fluorescent X-rays emitted from a Nuclepore filter as reference shows that Nuclepore filter is satisfactory for holding samples (Figure 2). Adenosine triphosphate (ATP) was determined using an Aminco Chem-Glow-Photometer; particulate organic carbon (POC) and particulate organic nitrogen (PON) using a Yanagimoto CHN analyzer; and chlorophyll a, extracted by freezing, was determined by