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Ecohydrological systemic solutions for reduction of siltation, eutophication and dioxin-induced toxicity. The pilot study of the Asella BioFarm Park lake, Ethiopia

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Abstract

This study introduced the spatial pattern of PCDD, PCDF and dl-PCB concentration in the sediments of Ethiopian small river-lake system. Among the analyzed samples the highest contamination was observed in the lake littoral (222.11 ng kg^{-1} d.w.). The lowest concentration was noted at the outflow from the lake (26.65 ng kg^{-1} d.w.). The WHO-TEQ concentrations showed decreasing trend along the river-lake system with highest value in the inflow (2.32 ng TEQ kg^{-1} d.w.) and the lowest at the outflow (0.55 ng TEQ kg^{-1} d.w.). The concentration of PCDD, PCDF and dl-PCB in the lake causes diseases among local population and prevents of use of water resources except from the outflow. Moreover the lake persistence and its ecosystem services provided for the local community were endangered by erosion of land and nutrient load from pastoral landscape, which could generate toxic algal blooms. For reversing the lake pollution the ecohydrological systemic solutions which integrated methodology to prevent all those threats to sustainable water and ecosystems was designed and implemented.

Key words: PCDD, PCDF, dl-PCB, water quality, toxic algal blooms, ecosystem services.

1. Introduction

Ethiopia is an African country of great cultural and historical background. Good natural conditions in most of the country, with fertile soil and high precipitation are a great asset and have potential for food production covering the existing needs. However dynamic demographic growth and pastoral land use overgrazing leads to degradation of the landscape. The research done in Gumera and Tana basins and Asella River valley within the project "Ecohydrology – a transdisciplinary science – for integrated water management and sustainable development in Ethiopia" (project no 1280/2008, 1018/2009, 944/2010 and 23/2011) demonstrated that the major impacts in Ethiopia are degrading sustainable development

potential of the basin, land overgrazing, erosion and nutrients overload by livestock as well as emission of micropllutants such as PCDD, PCDF and dl-PCB (called also dioxins)[1] from point and non-point sources. Those processes have been amplified by deforestation, which intensified stochasticity of the river outflow and intensified erosion and input of nutrients and micropllutants to rivers and lakes.

The transfer of PCDD, PCDF and dl-PCB along river continuum is well know and indicated permanent increase of their content in the river sediments (Konieczka *et al.* 2005; Rodziewicz *et al.* 2004; Kowalewska *et al.* 2003; Camusso *et al.* 2000; Crunkilton *et al.* 1997; Fox *et al.* 1983; Hilscherova *et al.* 2003; Huntley *et al.* 1997; Kannan *et al.* 2001; 2008; Koh *et al.* 2004; Sapozhnikova *et al.* 2005; Walker *et al.* 1999). Nevertheless there is still lack of empirical data demonstrating the role of lakes and reservoirs in reduction of PCDD, PCDF and dl-PCB transfer in river continuum as it is a system of a high degree of complexity and various ecological processes continuously changing along its continuum (River Continuum Concept) (Vannote *et al.* 1980; Bowes *et al.* 2003). Lakes are considered as an efficient trap for sediments (Devault *et al.* 2009). As far as there is a well know process of absorption of PCDD, PCDF and dl-PCB with sediments (Devault *et al.* 2009) it can be expected that a lake can play a role as storage compartment for the long-term release of the sediment-associated pollutants and pose a threat to aquatic organisms and, in consequence, to human health as a result of consumption and recreational use of such water bodies (Knezovich *et al.* 1987). Therefore, we hypothesized that the reduction of PCDD, PCDF and dl-PCB contamination before they reach the lake ecosystem by construction of the Sequentional BioFiltering System is crucial for improving the quality of the lake and the lower part of the river.

Following the above, this paper introduce the results of the PCDD, PCDF and dl-PCB distribution along the river-lake sediments. The obtained results inspired the designing and applying the ecohydrological systemic solution (including the Sequentional BioFiltering System) for diminishing the transfer and deposition of PCDD, PCDF and dl-PCB in the Asella BioFarm Park Lake.

2. Material and Methods

2.1. Study area

Asella is a city in central Ethiopia and one of the largest of three in Tiyo woreda. Located in the Arsi zone of the Oromia region about 175 kilometers from Addis Ababa (Fig. 1). The latitude and longitude of the city is 7° 57′ N 39° 7′ E / 7.95° N 39.117° E / 7.95; 39.117, with an elevation of 2430 meters. The total population of the city is 84 645 (CSA 2005).

2.2. Sampling

The sediment samples (10-25 cm thickness) were taken once during the dry season (November) of 2009 from the inflow and outflow of the lake as well as from littoral zones of the lake. The sediment samples were placed into black jars (to avoid sunlight) and transported to the laboratory where they were freeze dried (-40°C, 1mba, 72 h; Edwards Freeze Dryer) and sieved trough 2 mm mesh sieve.

[1] PCDDs – polychlorinated dibenzo-p-dioxins; PCDFs – polychlorinated dibenzofurans, dl-PCB – dioxin-like polychlorinated biphenyls.

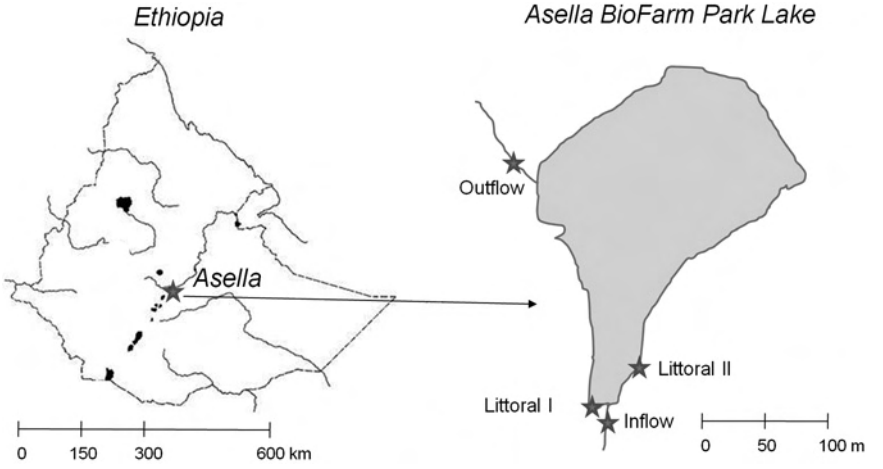

Fig. 1. Sediment samples collection sites in the Asella BioFarm Park river and lake.