



# Incorporation of probabilistic health risk assessment of heavy metals into biosolids land application guidelines

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## Abstract

The objective of this paper was to assess the health risk for the ingestion of vegetable and rice grown on farm lands fertilized by waste activated sludge. Three heavy metals Cadmium, Copper and Zinc were chosen. After estimating the concentration of heavy metals in soil, their concentration in plants was calculated using regression uptake models. The Monte-Carlo simulation was then used to perform a probabilistic health risk assessment. The results showed that rice ingestion has more contribution to hazard index (HI) when low amount of fertilizer applied on land. It was also found that Cadmium has the most contribution to HI. The findings of this study revealed that for one-time consumption of fertilizer, the 95<sup>th</sup> percentile of HI is less than 1 even at 100 t/ha consumption rate. However, when long-term application of fertilizer was considered, only at 5 t/ha consumption rate, the HI value was less than 1.

**Keywords:** Fertilizer, Heavy metals, Health risk assessment, Land application, Waste activated sludge

## 1. INTRODUCTION

Biological sludge or waste activated sludge (WAS) is the byproduct of any biological wastewater treatment process. There have been various disposal practices of the sludge such as ocean dumping, incineration, land filling. However, the application of biological sludge as the land fertilizer has been commonly used. One of the reason is that WAS or sometimes called biosolid is rich in organic matter and nutrients. In addition, recycling application of biosolids has been known as a means of avoiding the environmental and economic costs of disposal [1].

Exposure to heavy metals at high concentrations can cause various types of harm to humans, plants and animals. Most heavy metals can be also enriched through the food chain causing serious health problems. Chronic exposure to cadmium (Cd) can have effects such as lung cancer, prostatic proliferative lesions, bone fractures, kidney dysfunction and hypertension [2]. Chronic oral and inhalation exposure to arsenic (As) can lead to skin lesions and lung cancer, respectively. Exposure to lead (Pb) may cause anemia, nephropathy, gastrointestinal colic and central nervous system symptoms [3]. Hexavalent chromium is considered to be a known human carcinogen by both the Nickel can cause lung cancer, chronic bronchitis, emphysema and asthma [4].

Considering above explanations, the health risk assessment was performed considering the application of WAS as fertilizer for vegetable and rice ingestion scenarios. The risk assessment was done assuming that the concentration of three heavy metals (Cd, Cu and Zn) in fertilizer is equal to their maximum allowable level regulated under the Organic Matter Recycling Regulation (OMRR) in British Columbia, Canada. However, the approach applied in this paper can be extended to evaluate other regulations and also be used for development of new guidelines in countries like Iran. It is noteworthy that these three heavy metals was chosen because of the availability of soil/plant uptake regression model.

## 2. BIOSOLID RECYCLING REGULATION IN BRITISH COLUMBIA

In British Columbia, biosolids recycling is regulated under the Organic Matter Recycling Regulation (OMRR). OMRR is enabled under the Environmental Management Act (administered by the BC Ministry of Environment) and the Health Act (administered by the Ministry of Health). For land application of biosolids, a Land Application Plan (LAP) has to be