EFFECTS OF ANNUAL PRECIPITATION ON HEAVY METALS IN RUNOFF FROM SOILS IN THE US GREAT PLAINS

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INTRODUCTION

High-intensity rainfalls can generate runoff events that transport dissolved soil elements and sediment from agricultural watersheds to surface water. Anthropogenic activities can contribute greater amounts of elements to soils and natural waters. Losses of elements by runoff from agricultural land have received little attention from agronomists and soil scientists. The goal of this 2-year project was to study the effects of annual precipitation on the concentration of elements in surface runoff entering natural water systems in the Roca watershed, Nebraska which is located in the north central region of the US Great Plains. The specific objectives were to assess the effects of annual precipitation on: i) the dissolved and sediment-associated forms of Al, Fe, Mn, Cu, and Zn in runoff water, and ii) the impact of element loading into Salt Creek.

MATERIALS & METHODS

During the period from March through November for both 2009 and 2010, 35 weekly stream water samples were collected from Salt Creek. The stream water samples were filtered and the solid particle samples were dried at 105ºC. The concentration of the reactive form of elements in the sediment sample was determined by the Mehlich3 extraction method (*Mehlich*, 1984). The total content of elements was determined according to the acids (HF + HNO_3 + HCl) digestion method, as described in *USDA-NRCS* (2004).

In the stream water filtrate (< 0.45 µm), the dissolved species of Al, Fe, Mn, Cu, and Zn were determined by the Inductively Coupled Plasma-Mass Spectrometry. The dissolved anions in filtrate were determined by the high-pressure ion chromatography.

RESULTS

The annual water flow into the Salt creek was 10.1 million m^3 for the dry year and 46.1 million m^3 for the wet year. For the dry 2009 year, the weekly sediment loading into Salt Creek ranged from 0.01 to 729 metric tons, with an annual average of 47.9 metric tons/week. The wet year values gave an annual loading of 8933 metric tons which was more than five times the amount of sediment measured during the dry year. Dissolved and sediment-associated forms of the five elements were measured weekly (kg) in Salt Creek at the Roca monitoring station during the dry and wet years. In general, both dissolved and sediment-associated element forms were greater for the wet than the dry year. Also, most of elements were found in water during and after storm events. *Hubbard et al.* (1982) reported that most of elements loss in runoff occurs from a few high-intensity rainstorms, and the concentrations of chemicals in runoff can be high during those events. The total bioactive element concentration in Salt Creek during the dry year was 424, 349, 387, 5.21, and 26.8 µg/L, for Al, Fe, Mn, Cu, and Zn, respectively. The corresponding total bioactive element concentration for the wet year was 622, 479, 114, 3.68, and 19.8 µg/L, respectively.

The bioactive Cu and Zn concentrations found in Salt Creek for both the dry and wet years were lower than the value of Cu (15 µg/L) and Zn (64 µg/L) concentrations in natural surface waters of the USA (*Manahan*, 1991). The maximum permissible limit for Fe, Mn, Cu, and Zn in U.S. drinking water is 300, 50, 1300, and 7,400 µg/L, respectively while no limit has been recommended for Al (*USEPA*, 2002). The bioactive element concentrations found in Salt Creek were much lower than the maximum permissible value for Cu and Zn in U.S. drinking water. However, it appears that both bioactive Fe and Mn concentrations in Salt Creek have exceeded the permissible limit for U.S. drinking water during the two years.

CONCLUSION

The concentration and species of dissolved Al, Cu, and Zn measured in the Salt Creek stream water are not expected to have any adverse effect on human and animal health. However, the relatively high concentration of Fe and Mn in stream water has exceeded the permissible limit for U.S. drinking water. Further, the Al concentrations determined in water (424 to 622 µg/L) suggests that aquatic life in Salt Creek could be harmed from long term exposure. On the other hand, none of the other four elements investigated (Fe, Mn, Cu, and Zn) have exceeded the recommended USEPA criteria for surface freshwater. In general, both the amount of elements in dissolved form and those associated with suspended sediments in runoff were greater for the wet year than the dry year. We conclude that greater precipitation during the wet year increased the five metal element loadings into salt Creek and the negative impact of runoff from agricultural land on surface water quality.

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