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Diuron, Irgarol 1051 and Fenitrothion contamination for a river passing through an agricultural and urban area in Higashi Hiroshima City, Japan

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HIGHLIGHTS

- Diuron, Irgarol 1051 and Fenitrothion were analysed in Kurose River, Japan.
- Izumi site, a high density urban area showed highest concentration.
- Diuron and Fenitrothion detected at all sites, Irgarol 1051 only present at Izumi.
- Diuron and Fenitrothion from agriculture while Irgarol 1051 source is paint.
- Diuron and Fenitrothion concentration correlated with utilization data for Hiroshima.

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ABSTRACT

A study was conducted on the pesticides Diuron, Irgarol 1051 and Fenitrothion in Kurose River water, Higashi Hiroshima, Japan for a period of one year to assess the contribution of agriculture and urban activities on pesticide pollution of the river. Samples were analysed by a reverse phase HPLC system. The maximum pesticide concentrations were; 4620 ng/L, 50 ng/L and 370 ng/L for Diuron, Irgarol 1051 and Fenitrothion, respectively. While Diuron and Fenitrothion were detected at all sites, Irgarol 1051 was only present at Izumi, a high density urban and industrial area which also registered the highest concentrations of the pesticides. The pattern showed by Diuron and Fenitrothion was linked to farming activities. Also, Diuron and Fenitrothion concentration correlated with pesticide utilization data for Hiroshima Prefecture. Irgarol 1051 showed a different pattern to that of Diuron and Fenitrothion and its source was attributed to paint. It was noted that 78% and 42% of water samples at Izumi sampling site exceeded the European Union (EU) guidelines for Diuron and Fenitrothion, respectively.

1. Introduction

Pesticides are applied to agricultural crops and amenity land as part of the normal management of those areas for best yield or general maintenance, respectively (Bloomfield et al., 2006). The most heavily used pesticides are frequently detected in streams and groundwater (USGS, United States Geological Surveys, 1999). Agriculture and urban activities can cause significant contamination of pesticides to rivers and lakes if not handled properly (Gerecke et al., 2002) hence it is necessary to have proper management techniques for these processes (Skinner et al., 1997). In Japan, although pesticides are used in various sectors, they are mainly applied to paddy fields to control weeds, insects and fungal pests. Many of these pesticides are thought to be flushed finally into aquatic ecosystems through ditches or other paths causing contamination of river water and benthic animals (Ohyama et al., 1987) which in turn may lead to significant ecological damage (Anderson et al., 2006). This is because even at low concentrations they may cause significant effects (Sakai, 2006). The surface drainage of paddy water containing appreciably high concentrations of pesticides is obviously the main factor responsible for pollution (Watanabe et al., 2007). In rice growing areas, the concentration of pesticides in rivers increase during and after their application (Mitobe et al., 1999). Since pesticides are toxic by design, it is very important that they should be monitored (Lamers et al., 2011) because studies have shown the negative impact of these chemicals resulting from anthropogenic activities like agriculture and urban runoff on river organisms such as bivalves (Pereira et al., 1996).

Diuron (3-[3,4-dichlorophenyl]-1,1-dimethylurea) and Irgarol 1051 (2-[tert-butylamino]-4-[cyclopropylamino]-6-[methylthio]-1,3,5-triazine) are pesticides used for non-agricultural purposes (Azevedo et al., 2000) although the former is also heavily used in agriculture as a herbicide. In urban environments, treated surfaces with herbicides include not only soils but also roads, paths, pavements all composing of impervious surfaces which encourages runoff to surface water bodies (Blanchoud et al., 2007). Diuron and Irgarol 1051 inhibit photosynthesis by preventing oxygen production and blocking the

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electron transfer at the level of photosystem II (PSII) (Kitada et al., 2008) which is a cause for concern since in rivers they could destroy non-target plants. A study by Mohr et al. (2009) showed that Irgarol 1051 is highly toxic to autotrophic organisms and has the potential to accumulate in organic material. Although periphyton is the target group of Irgarol 1051, environmental concentrations found in freshwater are in the range of the effect concentrations for macrophytes. Diuron on the other hand has been found to be highly toxic to plants and algae (Turner, 2003; Schwab et al., 2013). Fenitrothion (O,O-Dimethyl O-(3-methyl-4-nitrophenyl) phosphorothioate) is mostly used as an insecticide. In Japan, it is mainly used to control stem borers in rice. It is an acetyl cholinesterase inhibitor (Escartin and Porte, 1996) hence a threat to both small and large organisms in rivers. Fenitrothion has been shown to be highly toxic to fish and in some species like guppies, *Poecilla reticulate* causes behavioural changes (Sarıkaya et al., 2007).

This study reports about the contribution of agriculture and urban activities to Diuron, Irgarol 1051 and Fenitrothion pollution in Kurose River water, Higashi Hiroshima, Japan. This is important because organic pollutants from land may easily end up in surface water bodies. According to Derbalah et al. (2003), the runoff from agricultural fields and wastewater containing industrial and household pollutants flows into Kurose River. In this study, therefore, seasonal trends of pesticides in Kurose River were examined and compared to agricultural and other catchment uses which are important for future practices as they provide information on the fate and transport of pesticides (House et al., 1997).

2. Materials and methods

2.1. Study area

Samples were collected from Kurose River which is located in Higashi-Hiroshima City, Hiroshima Prefecture, Japan (Fig. 1). Out of 86 cities, towns and villages in Hiroshima Prefecture, Higashi-Hiroshima city has the largest rice production (Hiroshima Prefecture Office, 2002). Kurose River is 50.6 km long with a catchment area of 238.8 km^2 and flows southward into the Seto Inland Sea (Ogura et al., 2009). A total of 6 sites, Namitakiji (K1), Tokumasa (K2), Izumi (K3), Ochiai (K4), Hinotsume (K5) and Kurose Bunka Centre (K6) were sampled for a period of one year (January to December, 2013). Tokumasa, Ochiai and Hinotsume sites are located near agricultural areas, mostly rice fields and low population density areas. Ochiai site is also located next to a wastewater treatment facility while the Izumi site is situated

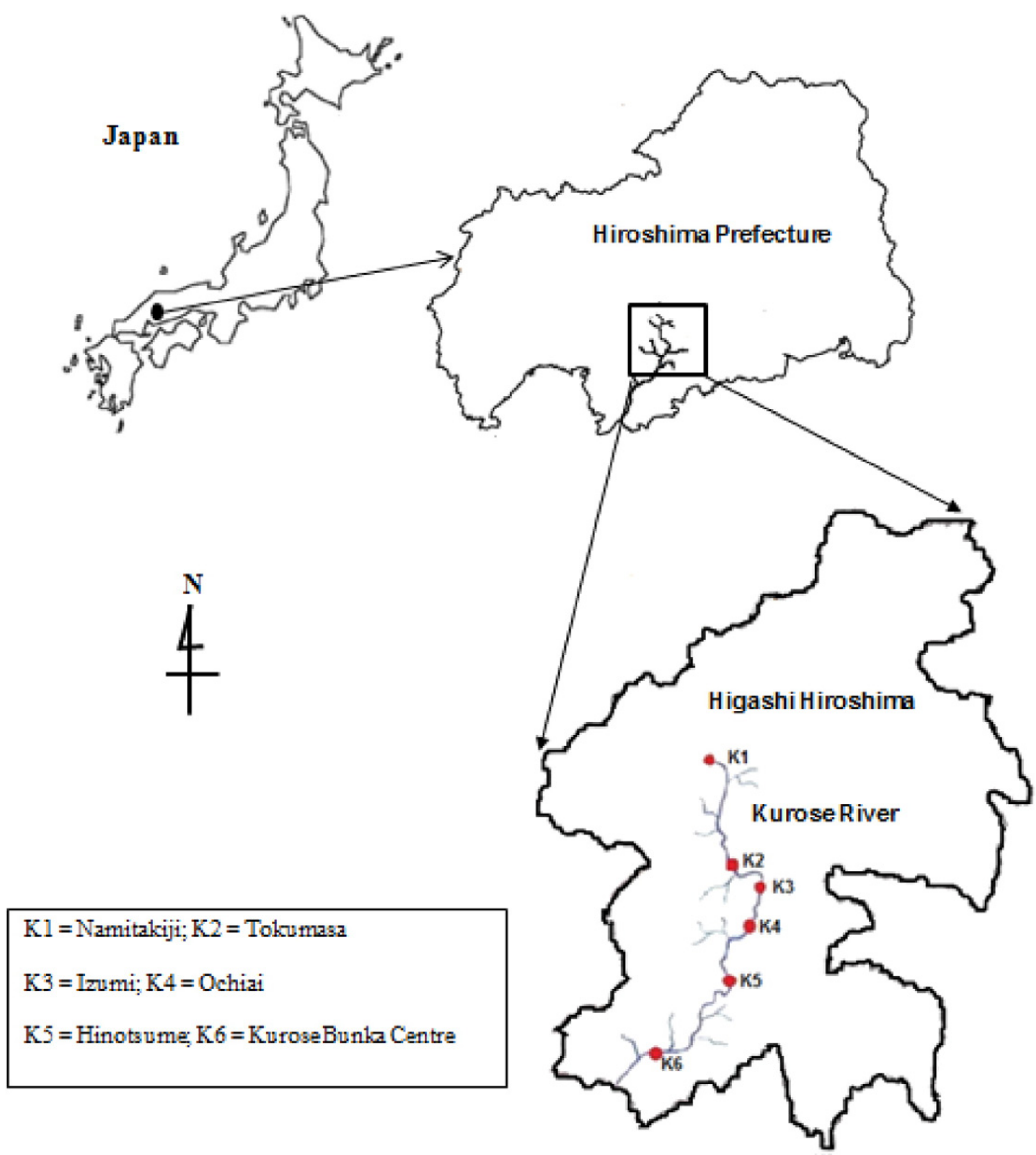

Fig. 1. Map of sampling area.