Toxicity evaluation of natural samples from the vicinity of rice fields using two trophic levels

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Abstract An ecotoxicological screening of environmental samples collected in the vicinity of rice fields followed a combination of physical and chemical measurements and chronic bioassays with two freshwater trophic levels (microalgae: Pseudokirchneriella subcapitata and Chlorella vulgaris; daphnids: Daphnia longispina and Daphnia magna). As so, water and sediment/soil elutriate samples were obtained from three sites: (1) in a canal reach crossing a protected wetland upstream, (2) in a canal reach surrounded by rice fields and (3) in a rice paddy. The sampling was performed before and during the rice culture. During the rice cropping, the whole system quality decreased comparatively to the situation before that period (e.g. nutrient overload, the presence of pesticides in elutriates from sites L2 and L3). This was reinforced by a significant inhibition of both microalgae growth, especially under elutriates. Contrary, the life-history traits of daphnids were significantly stimulated with increasing concentrations of water and elutriates, for both sampling periods.

Keywords Rice culture · Water and elutriates · Green algae · Daphnids · WET testing · Sub-lethal endpoints

Introduction

The worldwide use of agrochemicals represents a crucial contamination source of freshwater ecosystems. In particular, the rice culture further contributes to such contamination scenarios due to its flooded conditions (Padovani et al. 2006), which favours the entrance of contaminants into adjacent watercourses. Hence, agrochemicals can reach the aquatic environment during or after their application, through the drainage of paddy water to the nearby irrigation/drainage ditches, but also via direct overspray, accidental spills, aerial spray drift and/or run-off (Padovani et al. 2006; Sánchez et al. 2006).

Rice paddy agro-ecosystems are often located nearby natural protected areas and have been recognised as a contribution to biodiversity maintenance, presenting high ecological resources as surrogate habitats for wetland species (MED-Rice 2003; Padovani et al. 2006). However, the exposure to non-point source loads of agrochemical residues during the rice crop may pose a risk to non-target aquatic species. Therefore, it is worthwhile to perform regular surveillance programs for the aquatic system, in the vicinity of
rice fields. Among the requirements established in the European water policy referred as Water Framework Directive (WFD) (EC 2000) is the monitoring of surface water quality status from each river basin, in order to attain “good” chemical and ecological status as protective goals of the receiving environment. Under this scope, a toolbox of existing and emerging screening methods for water quality monitoring in support of the implementation of WFD was developed (Roig et al. 2003). In addition to physical and chemical measurements, one of the biological assessment tools recommended is the use of whole effluent toxicity (WET) bioassays towards the testing of aqueous samples or sediment extracts (Roig et al. 2003).

Though WET tests present limitations they integrate interactions occurring in complex mixtures of chemicals, thereby allowing the prediction of potential hazards in receiving waters (Chapman 2000; Mendonça et al. 2007). This approach has been applied to evaluate different contamination sources affecting water or sediment compartments, through the use of organisms from different trophic levels, such as bacteria, microalgae, cladocerans, macroinvertebrates, sea urchins, bivalves and fish (e.g. Cerejeira et al. 1999; Pereira et al. 2000; Cheung et al. 1997; Mucha et al. 2003; Koukal et al. 2004; Losso et al. 2007). For instance, Sánchez et al. (2006) emphasise that similar approaches are especially suited to discern possible effects derived from paddy water discharges.

Beyond the study of the water compartment, the study of the sediment matrix is also indispensable since it is the sink of toxicants. In turn, they can be resuspended to the water column, through stormwater runoff and water turbulence (Cheung et al. 1997; Viganò et al. 2003), which is likely to occur during the paddy water drainage. In addition, the scrubbing of paddy sediment/soil particles with adsorbed residues into the drainage ditches (Padovani et al. 2006) is especially enhanced when they are characterised by a great percentage of silt/clay and organic content (Kukkonen and Landrum 1996; Lapota et al. 2000; Viganò et al. 2003), hence justifying the need to evaluate the retention function of the paddy sediment/soil. Considering that the water flux in the drainage ditches is residual, it is likely that the suspended particles with associated pesticides settle in the sediment compartment, thereby becoming a source of contaminants (Viganò et al. 2003). Thereby, the paddy sediment/soil as well as the sediment from adjacent waterways impose a threat to the aquatic organisms, being more frequently elicited by sub-lethal impairments (Viganò et al. 2003), in spite of most related studies being generally focused on acute responses of non-target individuals.

In this context, the aim of the present work was to evaluate the toxicity of natural samples collected on a paddy field (in-crop assessment) and in an adjacent aquatic system (off-crop assessment) that was a main canal crossing both a protected area upstream and an extensive agricultural area downstream, which is mainly used for rice cropping. Two assessment periods were selected in order to compare the aquatic system quality before and during the rice culture season. According to Johnson et al. (2004), the assessment of impacts on the receiving water requires a battery of test methods and the inclusion of organisms from different trophic levels evidencing variable sensitivity ranges, as a way to achieve reliable and comprehensive information. Therefore, jointly with the physical and chemical scrutiny, chronic WET assays were performed with organisms belonging to two important levels—producers (green microalgae: *Pseudokirchneriella subcapitata* and *Chlorella vulgaris*) and consumers (cladocerans: *Daphnia longispina* and *Daphnia magna*)—responsible for the energy transfer along the freshwater trophic chains (Lampert 1987; Nyholm and Källqvist 1989). In order to enhance the ecological relevance of the study, the growth and reproductive responses of the autochthonous daphnid, *D. longispina*, and the standard one, *D. magna*, was compared. Overall, the combination of physical and chemical measurements with bioassays was performed to accomplish a holistic overview of potential effects on the aquatic ecosystem, triggered by agrochemical exploitation over the rice fields.