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Risk assessment of pesticides used in rice-prawn concurrent systems in Bangladesh

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HIGHLIGHTS

- Eleven synthetic insecticides and one fungicide were recorded in Khulna region.
- Symptoms after pesticide application were vomiting, headache, eye irritation.
- TOXSWA indicates pesticides pose higher risk for invertebrates than fish and algae.
- PERPEST confirms higher risks for insects than other ecological endpoints.

GRAPHICAL ABSTRACT

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ABSTRACT

The objectives of the current study were to determine the occupational health hazards posed by the application of pesticides in rice-prawn concurrent systems of south-west Bangladesh and to assess their potential risks for the aquatic ecosystems that support the culture of freshwater prawns (*Macrobrachium rosenbergii*). Information on pesticide use in rice-prawn farming was collected through structured interviews with 38 farm owners held between January and May of 2012. The risks of the pesticide use to human health were assessed through structured interviews. The TOXSWA model was used to calculate pesticide exposure (peak and time-weighted average concentrations) in surface waters of rice-prawn systems for different spray drift scenarios and a simple first tier risk assessment based on threshold concentrations derived from single species toxicity tests were used to assess the ecological risk in the form of risk quotients. The PERPEST model was used to refine the ecological risks when the first tier assessment indicated a possible risk. Eleven synthetic insecticides and one fungicide (sulphur) were recorded as part of this investigation. The most commonly reported pesticide was sulphur (used by 29% of the interviewed farmers), followed by thiamethoxam, chlorantraniliprole, and phenthoate (21%). A large portion of the interviewed farmers described negative health symptoms after pesticide applications, including vomiting (51%), headache (18%) and eye irritation (12%). The results of the first tier risk assessment indicated that

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chlorpyrifos, cypermethrin, alpha-cypermethrin, and malathion may pose a high to moderate acute and chronic risks for invertebrates and fish in all evaluated spray drift scenarios. The higher tier assessment using the PERPEST model confirmed the high risk of cypermethrin, alpha-cypermethrin, and chlorpyrifos for insects and macro- and micro-crustaceans thus indicating that these pesticides may have severe adverse consequences for the prawn production yields.

1. Introduction

The cultivation of the freshwater prawn or giant river prawn (*Macrobrachium rosenbergii*), in combination with rice (*Oryza sativa*) occupies more than 0.2 million hectare in the southwest coastal area of Bangladesh (DoF, 2013) and constitutes the main livelihood for poor people in the region (Ahmed et al., 2013). Rice-prawn farming is practiced in modified rice fields locally known as 'gher' (Chapman and Abedin, 2002; Ito, 2004). The Bengali term 'gher', meaning 'perimeter', is an enclosure made for fish and prawn cultivation by modifying rice fields through building higher dikes around the field and excavating a canal several feet deep inside the periphery to retain water during the dry season (Ahmed and Garnett, 2010; Fig. 1). Rice-prawn farming is considered as an effective method of integrated agriculture-aquaculture (Ahmed et al., 2008) which maximizes land and water utilization, while providing excellent opportunities for nutrient re-utilization within the system (Kunda et al., 2008). In rice-prawn concurrent systems, the rice crop attracts a series of insect species that constitute the natural food source for the cultured fish and prawns, while the nutrient-rich waste released from the cultivated aquatic animals can be effectively used as fertilizer for rice farming (Huy Giap et al., 2005).

Rice-prawn farming offers a source of staple food (rice) and animal protein (fish) for the people of Bangladesh, while prawns are used as a cash crop to sustain the economy of the rural population (Ahmed and Garnett, 2010). The expansion of rice-prawn farming in Bangladesh has been noticeable over the last two decades, and prawn production has drawn a noteworthy attention due to its export potential to international markets (Ahmed et al., 2008; Mirhaj et al., 2013) such as USA, Europe, and Japan (Ahamed et al., 2014; Ahmed and Garnett, 2010). Between 2011 and 2012, Bangladesh exported 7060 tons of freshwater prawn, with a market value of 108 million US$ (DoF, 2013).

Rice production in Bangladesh has steadily increased, but it is still not sufficient to cover the needs of the ever growing population (Shahid, 2011). The rapid population expansion and food security issues have resulted in a decrease of available arable land and a concomitant intensification of agricultural practices. Nowadays, farmers tend to grow high-yield varieties of rice (e.g. boro rice), which are highly susceptible to infestations with pests and diseases that may produce crop losses of up to 40% (Bagchi et al., 2009; Uddin et al., 2013). As a consequence, pesticides are being used to protect rice crops from pests, herewith improving rice crop yields and the quality of the product (Ansara-Ross et al., 2012; Rahman, 2013). As in many developing countries, the government has promoted the use of pesticides to increase agricultural yields in Bangladesh (Dasgupta et al., 2005). Pesticide consumption in Bangladesh has dramatically increased from 7350 metric tons in 1992 to 45,172 metric tons in 2010 (Hasan et al., 2014).

The application of pesticides in rice production may lead to the contamination of the surrounding aquatic environments by several ways including spray drift, runoff, and leaching (Van den Brink, 2013; Van Wijngaarden et al., 2005; Capri and Karpouzas, 2008). Pesticides applied in rice-prawn concurrent systems may constitute a potential toxicological risk for the aquatic organisms that are cultured in the gher as well as for the maintenance of the aquatic communities that support the aquatic ecosystem of the gher, and herewith can make the whole system less profitable as it may eradicate organisms that are a food source for the cultured prawns (Huy Giap et al., 2005). Furthermore, pesticides applied by farmers with poor education on safe pesticide use practices

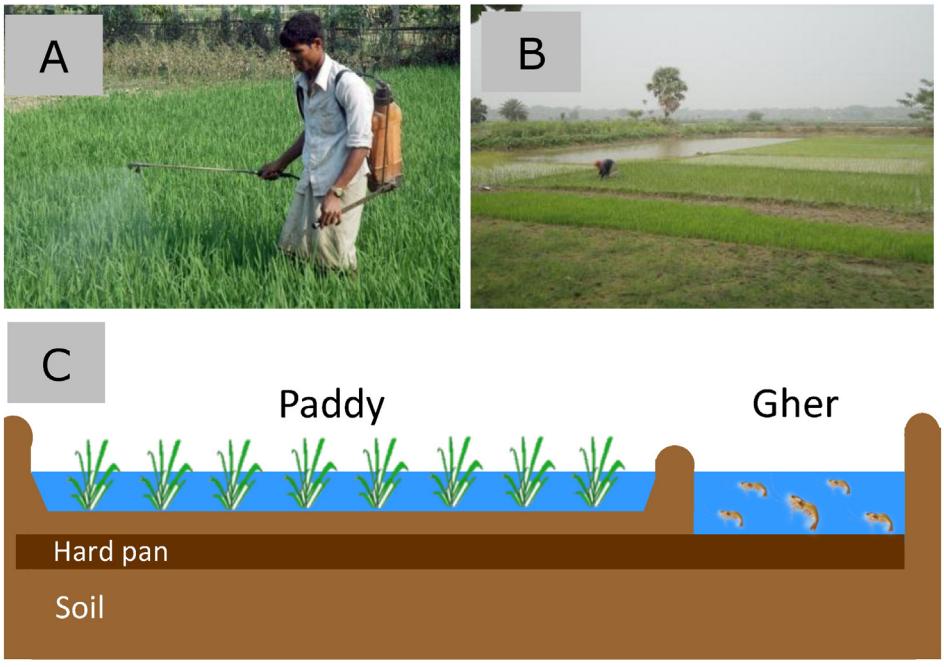

Fig. 1. Pesticide application (A), typical rice-prawn concurrent production system from the Khulna region in Bangladesh (B), and schematic overview of the rice-prawn concurrent system (C).