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Vulnerability mapping of agrochemical pollution in regional coastal aquifers in Thailand and Australia

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ABSTRACT: The patterns of agrochemical pollution in two regional coastal aquifers of different hydrological and hydrogeological setting were studied using field investigations and leaching models and upscaled using hydrogeomorphic methods. On the regional scene, nitrate was found to be above the limit in several sites mainly in the horticultural areas of the Gnangara Mound in Australia and in most of the areas of Songkhla Lake Basin in Thailand. On the other hand, the results showed that only a small number of pesticides have the potential to contaminate these aquifers. In both countries, most of the reported incidents of pesticide contamination are attributed to malpractice (i.e. spills, excessive use of pesticides and excessive irrigation).

1 INTRODUCTION

Songkhla Lake Basin in Thailand is predominantly an agricultural region. It is one of the highest growth regions in Thailand and supports a population of 1.25 million engaged in agricultural activities. High levels of fertilizers and a variety of pesticides are used in crop production. The majority of villagers rely on wells dug into the shallow aquifer for drinking water supply and for supplementary irrigation. The Gnangara Mound in Australia is the largest groundwater body in Perth. Groundwater is the main source of irrigation in market gardens as well as supplying more than 50% of the metropolitan water supply. Due to the shallow depth to groundwater, the extensive agricultural and urban activities and the heavy use of nutrients and pesticides, there is high risk of pollution.

2 HYDROGEOMORPHIC SETTING

2.1 *Gnangara Mound, Australia*

The superficial aquifer of the Gnangara Mound in Australia is a coastal aquifer that receives recharge mainly during the winter months of May-Sept each year. Due to the sandy nature of the soils, there is no surface runoff and most of the water that is not lost by evapotransipration is recharged to the aquifer. Groundwater discharge takes place through the series of lakes, which extends in north south line parallel to the ocean and along the ocean in the west and the surface water streams in the north, east and south. The aquifer thickness ranges from 20 to 100 m. and depth to water ranges from few meters near the eastern discharge zone to more than 40 meters in the western coastal areas. The aquifer is characterized by very high hydraulic conductivity (20 to 100 md^{-1}).

2.2 *Songkhla Lake Basin*

The shallow aquifer of Songkhla Lake Basin in southern Thailand is a coastal aquifer which dis-

charge into Songkhla Lake and eventually to the Gulf of Thailand. The superficial aquifer is formed of a shallow sandy clay aquifer and a deeper clayey sand aquifer. The water levels ranges from 1-2 m in the eastern flat areas to 3-6 m in the uplands and slopes. The aquifer is recharged by the rains which falls during most of the year but the main recharge is during the heavy monsoon season, during this period the water levels in most areas comes to near the surface.

3 REGIONAL VULNERABILITY MAPS

Regional groundwater vulnerability maps that indicate the impact of leaching of nutrients under different management scenarios were prepared for both sites using LEACHN model (Hutson and Wagenet, 1992) and upscaled using hydrogeomorphic techniques (Salama et al., 1999). LEACHN model was used to simulate the leaching of N fertilizers as applied to both urban and agricultural areas. The model was also used to simulate several management scenarios of fertilizer and irrigation applications. The results were upscaled using hydrogeomorphic techniques that classify the region into areas that have similar hydrological and hydrogeological characteristics. Regional vulnerability maps for pesticide leaching were prepared using LEACHP model and similar techniques.

4 RESULTS

Nitrate was found to be above the limit in several sites mainly in the horticultural areas of the Gnangara Mound in Australia and in most of the areas of Songkhla Lake Basin in Thailand. Vulnerability for nutrients leaching was highly dependent on the rate of fertilizer application and the amount of irrigation water. The modelling results showed that only a small number of pesticides have the potential to contaminate these aquifers and that with proper management, the risk of contamination could be greatly reduced. Adoption of better irrigation practices, reducing the application rates of pesticides will minimise the contamination potential while increasing the organic matter of the top 10 cm would greatly enhance the filtering capacity of the soils.

5 CONCLUSIONS

Due to the excessive use of organic manure in Thailand and fertilizers in Australia, the groundwater resources of the coastal aquifers are under threat of being heavily polluted by nitrate. Also, a small number of pesticides have the potential to contaminate the aquifers but with proper management the risk can be greatly reduced.

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