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Erratum

# Erratum to "Impact of uncertainty in soil, climatic, and chemical information in a pesticide leaching assessment"

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## ABSTRACT

A simple mobility index, when combined with a geographic information system, can be used to generate rating maps which indicate qualitatively the potential for various organic chemicals to leach to groundwater. In this paper we investigate the magnitude of uncertainty associated with pesticide mobility estimates as a result of data uncertainties. Our example is for the Pearl Harbor Basin, Oahu, Hawaii. The two pesticides included in our analysis are atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) and diuron [3-(3,4-dichlorophenyl)-1,1-dimethylarea]. The mobility index used here is known as the Attenuation Factor (*AF*); it requires soil, hydrogeologic, climatic, and chemical information as input data. We employ first-order uncertainty analysis to characterize the uncertainty in estimates of *AF* resulting from uncertainties in the various input data. Soils in the Pearl Harbor Basin are delineated at the order taxonomic category for this study. Our results show that there can be a significant amount of uncertainty in estimates of pesticide mobility for the Pearl Harbor Basin. This information needs to be considered if future decisions concerning chemical regulation are to be based on estimates of pesticide mobility determined from simple indices.

## 1. Introduction

The Pearl Harbor Basin (Fig. 1) is of great interest in Hawaii as it recharges the Pearl Harbor Aquifer, the most important source of freshwater on the island of Oahu. Trace amounts of organic chemicals have recently been discovered in the Pearl Harbor Aquifer (Oki and Giambelluca, 1987). Some of this pollution is thought to be the result of pesticides used by the pineapple industry over the past 30 years to control nematodes. The fumigants which have been detected in groundwater (e.g., DBCP, EDB) are now banned in Hawaii just as they are in many mainland states (e.g., California, Florida).

Intuitive evaluations of potential pesticide leaching failed to predict their occurrence in Hawaiian groundwater before their discovery. The assumptions leading to faulty conclusions about the likelihood of fumigants reaching groundwater were that volatile and degradable chemicals would not be leached to groundwater with the relatively low recharge rates common to pineapple areas where water table depths exceed 100 m. Several authors (e.g., Rao et al., 1974) have suggested that near-surface solute transport in Hawaii is via preferential pathways in highly structured soils perhaps explaining the early appearance of some of the problem chemicals in groundwater. The majority of the vadose zone in Hawaii is made up of very permeable fractured basalt and some saprolite which is conducive to preferential flow and, therefore, rapid solute transport.

The pressing question today is whether or not the chemicals currently used in Hawaii will leach to groundwater. Various mathematical models have been suggested (e.g., Oki, 1987; Or, 1987) for assessment of pesticide leaching. These models range from simple correlation procedures through comprehensive physics-based simulation algorithms. Analysis of the leaching problem with statistical correlation of soil properties with the incidence of groundwater contamination (e.g., Teso et al.,

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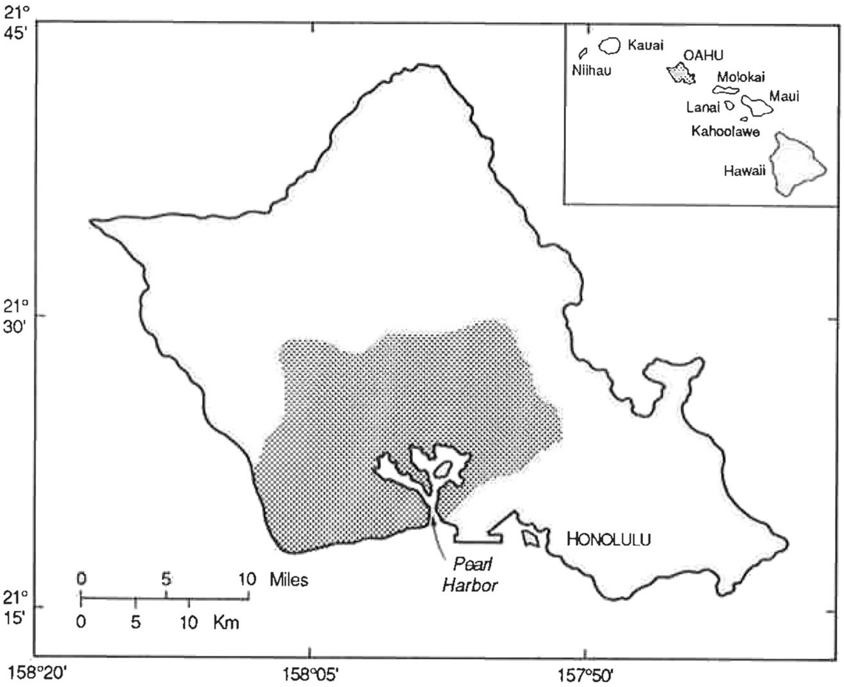

**Fig. 1.** Pearl Harbor Basin on the Island of Oahu.

1988) requires an extensive data base including both contaminated and uncontaminated wells, and is limited in prediction ability outside the area for which the correlations were derived. On the other hand, rigorous physically based prediction of pesticide leaching is limited both by a lack of accurate input data and by an inadequate representation of reality with existing analytical and numerical models. How then can decision makers regulate chemicals without banning everything? A rational approach is to use relatively simple indices, which describe processes more directly than correlation analysis and are less data-intensive than complex dynamic simulation models. Such indices should suffice to screen and rank the potential mobility of various chemicals. This may be the only level of information needed by a decision maker and, therefore, it can be very useful if the indices and the data are reliable.

In this paper we illustrate how a simple pesticide mobility index, when combined with soil, hydrogeologic, climatic and chemical data, can be used to generate rating maps for various chemicals. Our example is for the Pearl Harbor Basin. The focus of our investigation, however, it not to make rating maps but to investigate the "magnitude of uncertainty" in pesticide mobility estimates resulting from data uncertainties. The two chemicals used in our example are currently employed by the pineapple growers in Hawaii. Both the public and state officials are concerned about the fate of these chemicals in the insular hydrogeologic environment of Hawaii.

### 1.1. AF index of pesticide mobility

A simple index, known as the attenuation factor (*AF*), has been proposed by Rao et al. (1985) to rank pesticides with respect to their potential to leach to groundwater. In essence, *AF* is simply the fraction of the initial mass of an applied pesticide to the mass remaining after a given time. Rao et al. (1985) point out that methods, such as the *AF* index, are needed by regulatory agencies to screen large numbers of pesticides to determine their potential to contaminate groundwater.

The *AF* index is based upon some of the primary processes which control the rate of pesticide leaching. These processes are sorption, advection, and transformation. Sorption is incorporated into *AF* by way of a retardation factor (*RF*) defined as:

$$RF = 1 + \frac{\rho_b f_{oc} K_{oc}}{\theta_{FC}} + \frac{n_a K_H}{\theta_{FC}} \tag{1}$$

where

| | |
|---|---|
| $\rho_b$ | soil bulk density ($M\,L^{-3}$) |
| $f_{oc}$ | soil organic carbon (mass fraction) |
| $K_{oc}$ | pesticide sorption coefficient ($L\,M^{-1}$) |
| $\theta_{FC}$ | soil-water content at field capacity (volume fraction) |
| $n_a$ | soil air-filled porosity (fraction) [$n_a = n - \theta_{FC}$] |
| $n$ | soil porosity (fraction) [$n = 1 - (\rho_b/\rho_p)$] |
| $\rho_p$ | soil particle density ($M\,L^{-3}$) |
| $K_H$ | Henry's constant (dimensionless). |

Advective transport is approximated in *AF* with an estimate of pesticide travel time given by:

$$\tau = \frac{d\,RF\theta_{FC}}{q} \tag{2}$$

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