APPLICATION SPACE SIMULATION MODEL OF RESIDUAL DIOXIN SPRAYED BY THE VIETNAM WAR IN THE CONSERVATION MA DA, VIETNAM

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Introduction

In 1962, the US military initiated use of herbicides in Viet Nam for general defoliation and crop destruction through a program code named Operation Ranch Hand (IOM, 2001). Application of herbicides was primarily through cargo aircraft (C-123s), and ground mechanisms (i.e. trucks, backpack sprayers and riverboats); helicopters were also used in certain areas of the country. Over 72 million liters of herbicide were applied over southern Viet Nam (Westing, 1984; IOM, 1994). Herbicide applications ceased in 1971. Ma Da area includes 6 provinces: Dong Nai, Lam Dong, Binh Phuoc, Binh Duong belonging in Tri An lake – being extensively herbicides sprayed in Vietnam. Because of Dioxin characteristics and nature, it is difficult to destroy. Besides the distribution of Dioxin in environment, it is also moved to other places throughout soil erosion, flooding and human activities- this is seriously problem (Mai Van Trinh et al., 2009). Thus, to not only determine the new points accumulated of dioxin to overcome the consequence of dioxin after the war but also save time, properties and labor, the application of GIS to calculate the spread of dioxin and to determine new points accumulated is modern and effective method.

Materials and methods

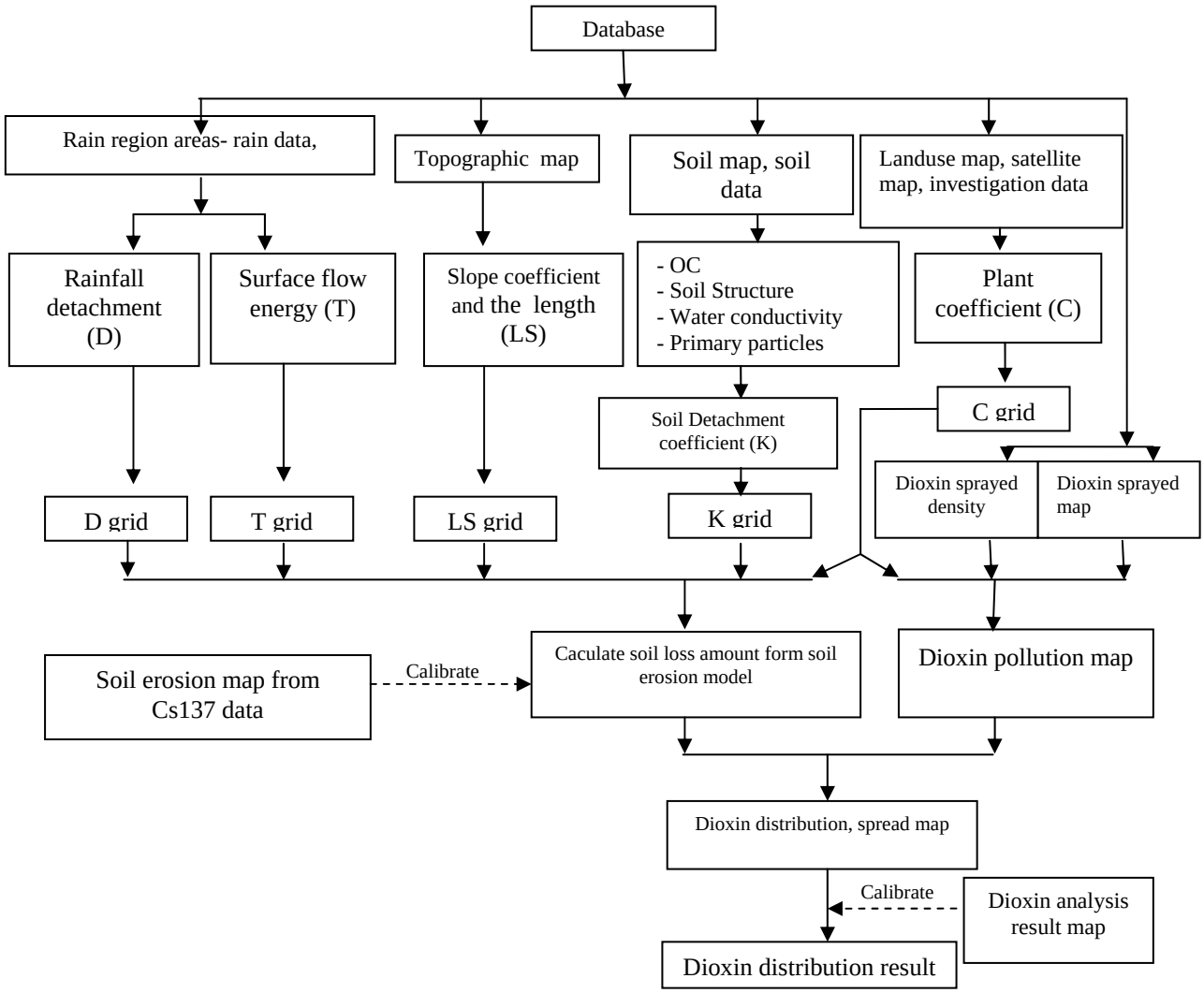

Figure1: Layout of developing dioxin distribution model

The study was conducted in 18 districts of 6 provinces including Dak Nong, Lam Dong, Binh Phuoc, Binh Duong, Binh Thuan, Dong Nai.

Model was developed integrated from several modules, they are: Soil erosion module using SILSOE soil erosion model (Morgan et al, 1982), Soilloss = MIN (D, T) , where: D soil detachment, T is transportation; Leaching model simulated based on monitoring data from 1995 to 1999 (Vo Quy et al, 2007), the leaching module is described by the equation Y (h, t) = 0.1 * Y (h-1, t-1), where: h = soil layer, t = time step; decomposition module was developed based on the results of research of Nguyen Xuan Net (2009), Victory Dance (2011), (Office 33, 2011) with a decomposition equation of

$Y = Yo*e^{-0.02t}$ where Yo is initial diocin concentration and t is decay time (year)

Combining the decomposition, soil erosion, runoff and leaching processes the amount of dioxin in a single cell is calculated as follows:

Dioxin_D(t) = Dioxin_D(t-1) + Soilloss_A(t) * Cdioxin_A(t) + Soilloss_B(t) * Cdioxin_B(t) + Soilloss_C(t) * Cdioxin_C(t) - Soilloss_D(t) * Cdioxin_D(t) – Dioxin_D(Decom,t) – Dioxin_D(Leach,t).

Where: Dioxin_D (t) is the amount of dioxin in cell D at time t; Soillos_A (t) is the amount of soil lost by erosion from A to D; Cdioxin_D (t) is the concentration of dioxin in soil at point D at time t; Dioxin_D (Decom, t) is the amount of dioxin in cell D is decomposed at time t; Dioxin_D (Leach, t) is the amount of dioxin being washed off the surface of the cell D at time t.

The model is develop in GIS base environment of (Figure 2) being an integrated of individual modules like module of satellite image processing to compute plant cover factor, soil indices, rain energy, flow direction and, soil erosion and dioxin dynamics.

Results and discussion

Study area

Study area is located around Tri An lake, coordinated from 106°33’ E to 107°54’ E, from 10°55’to 12°20’ N covering to 6 provinces. Total area of study area is 1,581,000ha with 3,633 million people. The area is divided to 11 sub-watersheds; the smallest one has an area of 11,014 ha while the largest one with area of 535,753 ha.

Dioxin distribution map

Initially, after spraying, dioxin existanced on different surfaces such as trees, bare lands, lakes, fields, rivers ... On flat areas with a little impact, dioxin laid in the soil, through the years they are leached into the deeper soil layers.Their level are relatively stable depending on the rate of decay of themselves and the impact of climatic conditions. At the slopes faces, due to the strong impact of the terrain, weather and climate, occurring runoff , dioxin is not only decomposed but also moved downwards following flow direction and slot terrain, geomorphology though canals, rivers, lakes and oceans. Transportation rate of dioxin depends on leaching rate, soil erosion and also strongly depends on vegetation cover, land surface disturbance from human activities.

The transportation of Dioxin due to soil erosion

The transportation of dioxin associated with runoff erosion by the factors of rain, slope steepless, land cover changes, human farming activities. Dioxin loss due to soil erosion was based on SILSOE soil erosion model (Morgan et al, 1982). Soil erosion is governed by two main processes, which are soil detachment by rain water and transport process. The model shows that study area topography is mainly low hills, land cover is mainly forests of Cat Tien, Da Ma sanctuary. Cultivated the area covered mainly by perennial crops, fruit trees, therefore soil erosion in the study weakly. Calculation results of dioxin lost due to erosion from 1968 to 2010 (42 years) in the Ma Da range from 0 - 7944.203 ppt (Figure 2a).

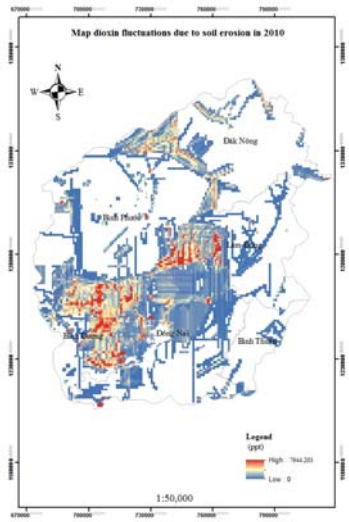

Figure 2a

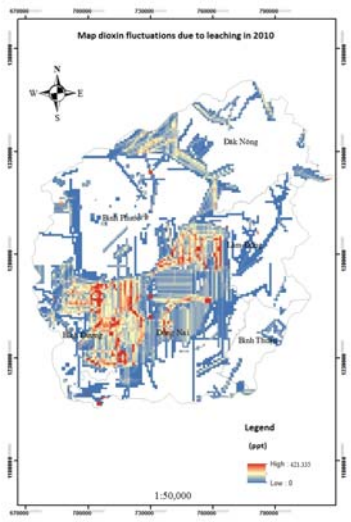

Figure 2b

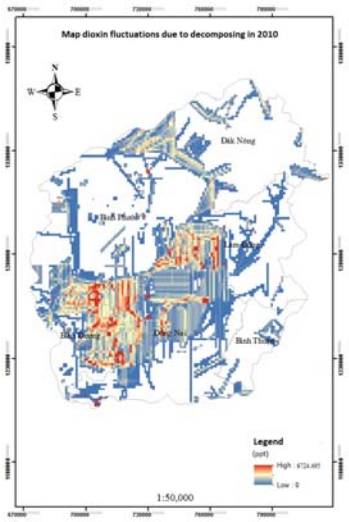

Figure 2c

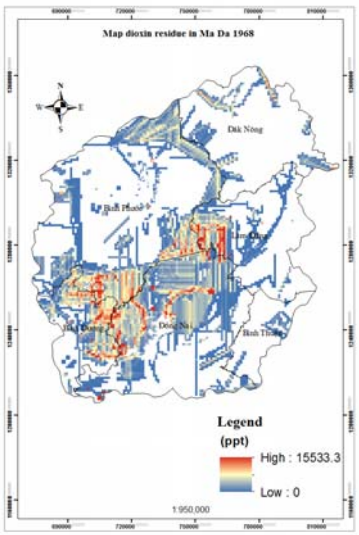

Figure 2d

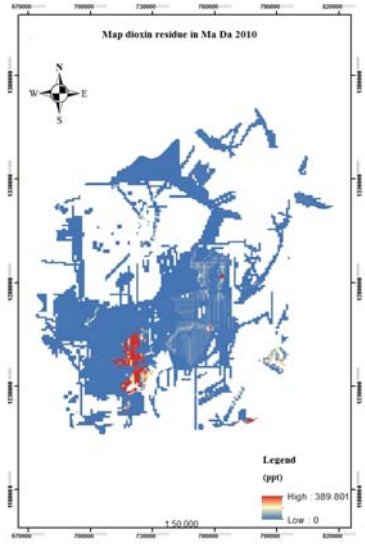

Figure 2e

Figure 2: Initial dioxin distribution map, some result maps and accumulation points

Leaching of dioxin

In addition to the movement of dioxin according to soil erosion, the dioxin was leached to the deeper layers. The leaching rate depends on soil properties. For high porosity soil when rain or shine they can be cracks to facilitate for apperance of dioxin flow and brought dioxin down into the soil's depth, For heavy soil structure, the dioxin would be difficult to move deeper. Calculation results showed that dioxin was moved into the soil depth until 2010 ranges from 0 - 421.335 ppt (Figure 2b)

Dioxin decomposition

Half-time of dioxin decomposition is a key parameter to assess the robustness of dioxin in different subjects. According to Paustenbach (1992), the half-life of dioxin decomposition is 9-12 years with dioxin in surface layer 0.1cm, in the deeper soil layers being 25-100 years. In the model calculations of dioxin

decomposition, stimulating the average half-life time of the dioxin was 50 years (reference from research results of Nguyen Xuan Net, 2009, Office 33, 2011). Results showed that dioxin lost due to decomposition until 2010 range from 0 - 6724.495 ppt (Figure 2c).

Distribution and transportation of dioxin map

Initial density dioxin was calculated based on two data fields Orange Agent (O) and Purple Agent (U) in the density maps of toxic chemicals sprayed in Ma Da area, then transferred the unit coefficient according to international conventions into ppt units for reference and calculated in the model. The results of calculation model about the spread and distribution of dioxin from 1978 to 2010 showed that levels of dioxin sprayed initially in 1968 distributed mainly in the area of Phuoc Cat 1, Phuoc Cat 2, Dong Nai town, Nam Ninh, My Lam, Gia Vien, Tu Nghia Commune- Cat Tien district- Lam Dong province, Dang Hai Commune- Bu Dang district- Binh Phuoc province, Tan Uyen and Dong Phu District- Binh Phuoc province , the district of Tan Phu, Dinh Quan and especially Vinh Cuu district- Dong Nai province. Initial dioxin levels ranging from 0 - 15533ppt, initial dioxin levels below 2000 ppt being dominant, initial dioxin levels > 2000 ppt scattered in several locations such as Phuoc Vinh Town - Tan Uyen - Binh Duong province, Tri An and Lac An commune- Vinh Cuu district, Ta Lai commune - Tan Phu district - Dong Nai province and Tu Nghia - Cat Tien district - Lam Dong province (Figure 2e). Dioxin is lost and move from point to point mainly due to decomposition processes and soil erosion, dioxin moved associated with runoff flow and leached into the soil layers in very small amounts. Many places have the high density of dioxin sprayed but to 2010 it almost disappeared, however; there are many points with high level of dioxin concentration. Dioxin was attached to soil particles and moved downward due to soil erosion and flow direction, flow accumulation points is usually the accumulation points of dioxin. Calculation results in 2010, the dioxin levels in soil in the study area being from 0 to 390 ppt and mostly range from 0 – 30 ppt; The high dioxin concentration points (dioxin from 90 – 390 ppt) concentrated in regions Studies in Tri An commune – Vinh Cuu district, Ta Lai Commune - Tan Phu district- Dong Nai, and My Lam, Tu Nghia Commune - Cat Tien - Lam Dong, this points also laid on intensive flight line. However some new points appeared as accumulated by the pathway of basin (Figure 2e).

Verify model residual dioxin

To calibrate and verify model results calculated residual dioxin concentrations Ma Da region, the team scoring on a map persist dioxin and field soil sampling for analyzed dioxin levels in the topsoil. Data analysis dioxin field is used to calibrate the model residual dioxin in soil Ma Da region. Comparison of model results and field analysis results show that there is a farely well correlation between the model results and the field with coefficient $r^2 = 0.715$ (Figure 3).

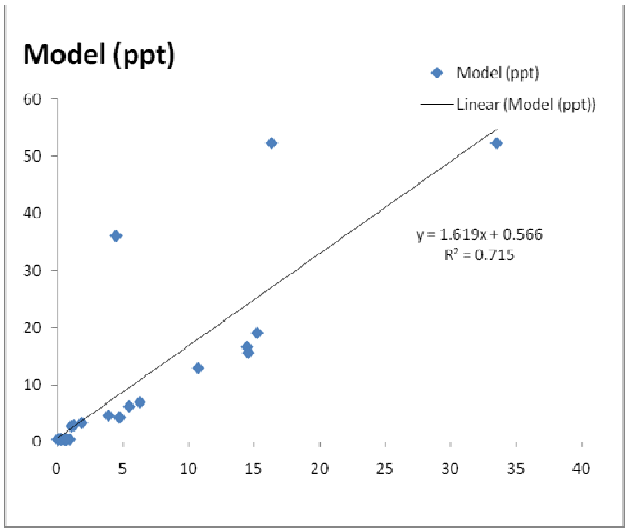

Figure 3: The relationship between dioxin levels in the model calculations and field levels of dioxin

Conclusion

From study results, some conclusions can be drawn as follows:

The current concentration and distribution of dioxin is different from the initial dioxin concentration and distribution. The transported dioxin is mostly accumulated at the points alonging to flow, the valley, the slopes within the basins.

Dioxin stronger transported in the mountainous area with steep slope than in the flat terrain. Also, because of long slopes and meadering terain with many barriers, dioxin exist at relatively high places. The new points located mainly on pathway and before outlets of the water basin.

The model is apowerful tool to support zoning polluted dioxin areas, sampling, and researching to overcome the impact of orange agent basefrom the War.

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