EFFECTS OF HERBICIDES USED IN THE WAR INTO NATURAL ECOSYSTEMS AND BIODIVERSITY IN VIETNAM

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Introduction

During the war time in Vietnam, approximately 80 million liters of herbicides were sprayed over 10-14% area of South Vietnam. Many kinds of herbicides in which most frequent formulation containing 50/50 mixture of 2,4,5-T and 2,4-D known as Agent Orange were sprayed and 86% spray mission targeted against forest and remainder against cropland (Westing, 1984)[1]. Many studies on impact of herbicides on environment and human health had been conducted by both Vietnamese and international scientists since 1980. Results from 1981-1984 period showed immediate impacts of herbicides on natural ecosystems and biodiversity of sprayed areas. It was reported that AO/dioxin sprayed had immediately destroyed natural ecosystems by breaking ecological structure and nutrient web, resulting in pollution of environment and deteriorations of habitats and declination of biodiversity. In next period from 1994-now, in the cooperation with Hatfield Ltd. (Canada), Vietnam Committee 10-80, Vietnamese scientists have carried out assessment of herbicides on environment and human health which focused on long term effects of herbicides on biodiversity and ecosystems. These researches presented that the long-term effects of herbicides on ecosystems and biodiversity are difficult problems need further investigations, positive cooperation in both domestically and internationally.

Materials and Methods

Studying methods were base on overall approaches to research targets:

- Overview information and documents previously accumulated, specially research data published from 1980s
- Based on spraying maps of international scientists in order to determine number of sprays, focal area of spraying missions.
- Organized field trips to sprayed and unsprayed areas for collecting information, taking samples of plants and animals and analysis in the laboratories.
- Actual assessment of comprehensive approaches to focal areas.
- Gathering, evaluating and analyzing data and information obtained.

Results and Discussions

Direct effects of the herbicides onto ecosystems and biodiversity in Vietnam

Studies on impact of herbicide on environment and human health used by American army in the war in Vietnam have mainly conducted from beginning 1970s by foreign scientists. The research results show that the most extensively herbicide sprayed type of vegetation was forest, an ecosystem that covered more than 10 millions ha in South Vietnam, comprising about 60% of the land surface (Westing, 1971; 1976).

In 1969, a group of biologists organized a trip to survey the effects of defoliants (Orians and Pfeiffer 1970; Neilands *et al.* 1972). One of their field trips, for example, was to Rung Sat near Ho Chi Minh City. They concluded that the Rung Sat mangroves were "extremely susceptible" to defoliants. Only one application was apparently necessary to "kill most trees". Most of the areas they visited remained "completely barren" although they had been sprayed several years earlier.

Studies in the period of 1981-1984 are carried out by Vietnamese and foreigners in Aluoi (Thua Thien-Hue), Sa Thay (Kon Tum), Ma Da (Dong Nai) and mangrove forest in Ho Chi Minh city and Ca Mau peninsula. Almost research results of this period show that immediate impacts of herbicides onto natural ecosystems and biodiversity of sprayed areas.

As a result, many animals, including mammals and birds, were killed directly or indirectly during the war. The most serious impact, however, was the destruction of ecosystems that had provided habitat for forest animals. Mangrove forest is especially sensitive to herbicide. About 110,000 ha of coastal mangrove were sprayed at least once, or about 36% of the area of that type of forest (NAS, 1974). Spraying devastated the mangrove ecosystem, and created a large area of poorly vegetated or unvegetated coastal barrens (Orians and Pfeiffer, 1970; Westing , 1971, 1976, 1984b, c; NAS, 1974; Hiep, 1984; Snedaker, 1984).

Effects of herbicides were also severe in the much more species-rich inland forests including rain forest with a total area of 10.5 million ha. Mature forest of this type has many angiosperm species, especially of the families Dipterocaceae and Leguminoseae. The tree height is up to 40m or taller, and diameter at breast height is up to 2m (NAS, 1974; Galston and Richards, 1984). Studies conducted in Aluoi valley show that had been changed by herbiciding from a continuous upland tropical forest to an 80% cover of grassland found only 24 birds and 5 mammal species, compared with 145-170 bird and 30-55 mammal species in two unsprayed reference areas (Quy et al,. 1984).

Reports from freshwater ecosystems in the Aluoi Valley, cited by Snedaker (1984), revealed a correlation between spraying and decreased overall species diversity and morphological abnormalities in freshwater algae. There is no evidence that these were attributable to persisting toxicity of herbicides or their residues because of the variety and magnitude of other coincident environmental abuses during the war such as bombing (Snedaker 1984), and post-war from agricultural practices and population growth.

Research results on impact of orange/dioxin into mammal diversity in Ma Da forest (Dong Nai province), cited by Huynh et al., (1994), after spraying, number of mammal genera clearly decreased, only found 29 genera and 38 species, compared with 39 genera and 52 species, which were recorded before spraying. Orange/Dioxin destroyed forest ecosystems, and lost their habitats and food sources as well. Many mammal species had removed from here to other areas.

Long-term effects of the herbicides onto ecosystems and biodiversity in Vietnam

In the stage from 2000 till now, many research projects (under steering of the National Program for researching effects of herbicides on environment and human health called CT. 33) are conducted mainly by Vietnamese scientists in some typically sprayed areas in south Vietnam. One of these projects focused on long term effects of herbicide used in the war onto biodiversity and ecosystems and propose measures for improvement of degradation ecosystems. Research results of a project on effects of orange/dioxin into biodiversity in Aluoi district (Thua Thien-Hue province)(Huynh et al., 2003), conducted in 2000-2002 are summarized as follows:

- Toxic chemical compounds (dioxin/orange) that were used in the war by the American army immediately destroyed natural ecosystems by breaking the fragile ecological structure and nutrient web; resulting in pollution of environment and deterioration of habitats which strongly led to the decline of biodiversity in this area.
- Up to now, more than 30 years after the end of the war, dioxin/orange still has caused long term impacts into the fauna and flora of various ecosystems in this area. The natural vegetation in Dong Son commune before spraying is primary forest, with abundant and storied forest but can not rehabilitated, and now only grasses, bushes occurred.
- Species composition and quantity of mammal, bird, reptile, amphibian, soil animal, and soil microorganism is lower than unsprayed other area with the same landscape. Many wild species, which habited here before

spraying but not returned yet nowadays. An example as follows: before spraying 46 species of mammal were recorded, but only 27 species were found in 2001. There are 65 species of bird found in Dong Son commune (strongly sprayed area) to be lower than 115 species of bird recorded from Pe Ke (unsprayed area). 23 species of termite found in Dong Son to be lower than 37 species in Pe Ke. Quantity of musty species in Dong Son only equal 35-50 percent of musty species amount in unsprayed area.

- There are morphological abnormalities in some species of fish, soil worm and spring tail. However, studies on reasons of these abnormalities need to be studied continuously in future in order to receive of reliable scientific data. By electrophoresis carried out on fishes of Snake head (*Channa striata*) and Goldfish (*Carassius auratus)*, there exists a difference on size of AND polymorphic stretch and genome AND sequence between individuals collected from sprayed and unsprayed areas.
- However, research results also indicated that in Aluoi district, some aquatic ecosystems such as stream, pond, have been gradually rehabilitated. Communities of algae, periphyton, weed, macrophyte, zooplankton, and benthos recovered not only in species composition but also in quantity.

In 2002-2004, another research project of the project conducted in Ma Da (Dong Nai province) (Nguyen Xuan Quynh et al., 2005). The research results show that

- The vegetation located in northern area of Ma Da river is destructed tracks by herbicides. Average number of plant species of area with strong spraying to be 73.2 is lower than 81 species in unsprayed areas.
- Number of animal species including invertebrates and vertebrates in Ma Da area is considerably lower than number species in Cat Tien (reference area).
- Diversity index (H') of aquatic invertebrate in Ma Da area determined 0.918 is lower than 3.408 in Cat Tien area. Especially, algae species belonging to genus *Staurastrum* Such as *Staurastrum sp4., sp5., sp6., sp7*., have morphological abnormalities (about 20 lobes). These can be endemic species narrowly distributed in this area but they can be changed in morphology by herbicides.
- There are differences on DNA, protein and enzyme structure of some species of plant and animal between Ma Da and Cat Tien area. It is necessary to study more detail in order to determine reasons of these abnormal changes.

General conclusions

Based on the recombination of research results on ecological impact of herbicides used by American army in the war of Vietnam, there exists some remarks as follows:

1. Up to now, more 30 years ago after the end of the war in Vietnam, toxic chemicals as herbicides used by American army still have long-term effects to ecosystems and biodiversity of several hot spots to be strongly sprayed such as Aluoi (Thua Thien Hue, Mada, Bienhoa (Dongnai). These are expressed through analysis mentioned above.
2. Although there exists some remarks of rehabilitation of aquatic ecosystem but forests in Aluoi formerly rich and large canopy can not rehabilitated and nowadays only grasses, bushes covered. Especially, unexplained morphological abnormalities of some invertebrates and algae species which show that it necessary continuously study in more detail to determination of exact reasons of this phenomenon.
3. Study on long-term effects of herbicides used by American army in the war into ecosystems and biodiversity is a difficult problem. Therefore, it need the cooperation and support of international organizations and foreign specialists participating in next stages.

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