

A REVIEW: DIOXIN FROM AGENT ORANGE IN VIET NAM AFTER FOUR DECADES

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From 1962 to 1971, 72 million liters of herbicides were sprayed on Southern Viet Nam. Analyses of soil samples collected from 11 sprayed provinces in Southern Viet Nam showed that three to four decades after spraying 2,3,7,8-TCDD levels were quite low almost everywhere¹⁻⁵.

Levels of 2,3,7,8-TCDD detected in 14 of 54 samples from Tay Ninh province ranged 1.2 - 38.5 ppt (mean value 14 ppt). The values in other sites were as follows: 4 of 6 from Thua Thien-Hue 4.4 - 17 ppt (mean value 8.6 ppt), 1 of 11 from Binh Duong (6ppt), 2 of 9 from Ho Chi Minh city 3 -59 ppt (mean value 31 ppt). Dioxin from samples from other areas was below detection limits⁵.

These results show that 2,3,7,8-TCDD from Agent Orange after landing on the ground following spraying was moved by rain and floods elsewhere. That is why 2,3,7,8-TCDD was sometimes found in non sprayed area: For example, 1 of 3 silt samples taken in Thi Nghe canal running in the center of Ho Chi Minh city - a non sprayed area - had a level of 190 ppt⁵.

However, in a few locations 2,3,7,8-TCDD levels were elevated, contrary to initial expectations. For example, at Bien Hoa airbase in Bien Hoa city near Ho Chi Minh City, while most samples were below detection limits for TCDD, there were findings as high as 1,100,000 ppt, 860,000 ppt, 177 ppt, 114 ppt, and 98 ppt^{6,7}. At the A So airbase in A Luoi, TCDD was found at levels as high as 897 ppt and 110 ppt^{8,9}.

One cause may be that during the war, in order to protect their military bases, commanders sprayed as much Agent Orange defoliant as possible around base perimeters by backpacks or other means of ground spraying. Even more important an explanation for the elevated 2,3,7,8-TCDD in these areas, we believe, is that spills of large amounts of Agent Orange occurred at these locations.

Dioxin, including 2,3,7,8-TCDD, persists for a long time in soil where there is much shade, as in jungles, and also in sediment or silt. An example of this can be found in analyses of 2 soil samples collected in the same site (Tabat - A Luoi) in 1990 and 1999 (4.3) has shown that the dioxin levels appeared to be constant: 12.8 ppt (range 8.5 - 17 ppt, n=2) and 11.9 ppt (range 4.3 - 35 ppt, n=10).

On the other hand, in soil repeatedly ploughed and exposed to the sunlight, dioxin can sometimes, at least in theory, be destroyed. For example, in A Luoi 2,3,7,8-TCDD was found in forest soil at 147 ppt, in a ploughed field the level was 4.2 ppt^{8,9}. The rate has fallen by 94 %. 2,3,7,8-TCDD is often situated at the upper 10 cm of soil¹⁰. A ploughshare can easily bring it to the soil's surface. Once exposed to the sunlight, it can, in theory at least, be destroyed, although we are unaware of any

studies at this time documenting the practical efficacy of this theoretical means of decontamination of TCDD in soil.

2,3,7,8-TCDD moving in water can bind to silt in the bottoms of ponds and marshes. In A Luoi in 1990 the farmers dug fishponds. Nine years after the accumulation of 2,3,7,8-TCDD in silt a level of 5.6 ppt was found (range 1.8-8.5 ppt n=5)^{8,9}. Of the six highest values of 2,3,7,8-TCDD found in the western areas of Southern Viet Nam, all were located along the great rivers: Hau Giang river, Tien Giang river and Vam Co river^{11,12}.

In animals, 2,3,7,8-TCDD levels have usually been relatively low¹³. The levels of 2,3,7,8-TCDD in animals from Binh Duong province were: fish 0.6, chicken 4.1, egg 0.16; in Ho Chi Minh city: pig 2.08 ppt (range 0.77-3.4, n=2) egg 0.2 ppt TCDD (n=1)¹⁴.

In locations with higher 2,3,7,8-TCDD levels in soil some samples in animals had higher 2,3,7,8-TCDD level. For example, in A Luoi: Fish *fat* 17.1 ppt (range 1.9-51 ppt, n=7) *muscle* 0.4 ppt, *liver* 1.1 ppt. Duck *fat* 67 ppt (range 52-82 ppt, n=2) *liver* 1.4 ppt^{8,9}. Bien Hoa: Snakehead fish 65 ppt. Ducks as high as 331 ppt and 276 ppt. Chicken 15 ppt. Toad 56 ppt. These animals contain high 2,3,7,8-TCDD levels because they are species that the farmers leave free ranging in TCDD contaminated areas. They often search for food in ponds, channels, or silt. In some instances values as high as 51 ppt for fish and 331 ppt for duck were found recently¹⁵.

2,3,7,8-TCDD concentrations are not equal in all parts of an animal's body^{16,17}. In fat tissue, 2,3,7,8-TCDD was many times higher than in muscle (42.6 times for fish, 47.9 times for duck). If cattle graze under control and are not free ranging in the fields, and also pigs and chickens are raised in pigsties and chicken cages, respectively, they will be less exposed to TCDD. In one instance, we noted a fish/silt bioaccumulation factor for 2,3,7,8-TCDD to be $17.05/5.6 = 3.04$

In turn, humans are contaminated by eating contaminated food from animals^{16,17}: During the Ranch Hand spraying between 1962-1971 three women from Ho Chi Minh city who lived all their lives in the center of Ho Chi Minh City (which was not sprayed) had TCDD tissue measurements made. These women were never exposed directly to Agent Orange from spraying. However 2,3,7,8-TCDD levels in their fat tissues were 10 ppt, 5.2 ppt, and 4.2 ppt whereas uncontaminated persons had less than 2 ppt TCDD. It very strongly suggests that they were contaminated through food¹⁴.

People who were born after Agent Orange spraying ended in 1971, and who lived for 15-25 years in A Luoi, an Agent Orange sprayed area, had a mean value 8.55 ppt 2,3,7,8-TCDD in blood serum which again to us appears to be from contamination by food which occurred after the spraying ended^{8,9}. The same was found in Bien Hoa City with extremely elevated 2,3,7,8-TCDD levels in blood, even of those born after spraying ended, and in some food and soil. These two instances reinforce our belief that contaminated food now and in the past was responsible for human contamination with TCDD^{6,7,15,18,19}.

The environmental movement of dioxin is: SOIL and SILT to ANIMALS to HUMANS.

Bioaccumulation plays an important role in contamination: Though 2,3,7,8-TCDD is usually found at low levels in soil, it exists everywhere. So animals have a great chance to continuously consume it. After 8 months contamination in fish can be 2.5 ppt (sometimes 65 ppt), in duck can be 2.97 ppt (and has recently been found to be as high as 331 ppt). After decades, contamination by

2,3,7,8-TCDD through food in humans has recently been found to be as high as 413 ppt in Bien Hoa City^{6,7}.

We found also that in certain sprayed areas, where there also were spills of Agent Orange, there are locations with high levels of 2,3,7,8-TCDD in soil, in animals, and in humans. They are A Luoi in TTHue province, and Bien Hoa airbase in Bien Hoa City. These locations are called dioxin 'hot spots'. In 'hot spots' soil is considered as a source binding and releasing, a little at a time, 2,3,7,8-TCDD which gets into animals, then from animals into humans where there can be further bioaccumulation. These 'hot spots' in Vietnam are a constant threat to human health.

Ten percent of the surface area of southern Viet Nam was sprayed. The sprayed area is large, and the exposed population is great. Solutions to this problem must be practical. They can include detoxification of soil, avoiding contact of animals, especially those consumed as food, with the contaminated soil, finding appropriate, nutritious and economical food for people living in sprayed areas, especially in 'hot spots'

Possible solutions for remediation of contaminated areas include:

1. Degradation of dioxin by ploughing, digging the soil in the neighbourhood of communes in order to bring the dioxin up to the surface, then exposing it to sunlight for some time before planting.
2. Every year in dry season, drain the ponds, catch fish and leave the silt exposed the pond silt for some time to sunlight.
3. Incineration of contaminated soil.
4. Fencing off contaminated soil preventing animal and human use.
5. Avoid contact of domestic animals with contaminated soil by keeping chickens in cages, breed pigs in pigsties, graze cattle under control. Advise consumers of wild and unleashed animal food to discard fat from these animals before cooking.
6. Encourage the planting of vegetables and fruits (low in dioxins) for human consumption.

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