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INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

PROCEEDINGS

1. Background information
2. Tribute to Dr. Ton That Tung
3. Symposium governance
4. Overall summary report
5. Summary reports of the working groups
   - E1. Terrestrial plant ecology and forestry
   - E2. Terrestrial animal ecology
   - E3. Soil ecology
   - E4. Coastal, aquatic, and marine ecology
   - P1. Cancer and clinical epidemiology
   - P2. Reproductive epidemiology
   - P3. Experimental toxicology and cytogenetics
   - P4. Dioxin and related chemistry
6. Attendance
   - a. Participants
   - b. Observers

N.B.: The attached documents, which comprise the initial Symposium Proceedings, have all been lightly edited in the interest of clarity, brevity, and internal consistency and also to limit the material presented to the scientific matters under direct consideration. Please be sure to bring any errors of commission or omission to the attention of Prof. Arthur H. Westing (SIPRI, Bergshamra, S-171 73 Solna, Sweden; telephone 8/55 97 00) as soon as possible so that any necessary corrections can be incorporated into the final published Proceedings.

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

BACKGROUND INFORMATION

The Second Indochina War of 1961-1975 is, among other things, notable for the massive employment of anti-plant chemical warfare agents (herbicides or plant defoliating and killing chemicals). Primarily during the mid to late 1960s the USA sprayed approximately 72 million liters (91 million kilograms) of these herbicides onto some 1.7 million hectares of rural South Viet Nam, that is, onto about one hectare out of every ten. At least 12% of the inland forests and 40% of the coastal mangrove forests were sprayed one or more times as were 5% or more of the agricultural lands.

The three major chemical warfare agents employed in this anti-environmental program (referred to as Operation Ranch Hand by the U.S. Air Force) were:

1. Agent Orange, a mixture of 2,4-D (2,4-dichlorophenoxyacetic acid and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), the latter also containing traces of dioxin (TCDD; 2,3,7,8-tetrachlorodibenzo-para-dioxin) as an inadvertent impurity. A total of 44 million liters (57 million kilograms) of Agent Orange was expended containing 22 million kilograms of 2,4-D, 24 million kilograms of 2,4,5-T, and at least 170 kilograms of dioxin;

2. Agent White, a mixture of 2,4-D and picloram (4-amino-3,5,6-trichloropicolinic acid). A total of 20 million liters (23 million kilograms) of Agent White was expended containing 5 million kilograms of 2,4-D and 1 million kilograms of picloram; and

3. Agent Blue, a formulation of cacodylic acid (dimethyl arsinic acid). A total of 8 million liters (11 million kilograms) of Agent Blue was expended containing 3 million kilograms of cacodylic acid (of which almost 2 million kilograms was elemental arsenic).

Agents Orange and White were the agents of choice for forest destruction, whereas Agent Blue, and to a lesser extent Agent Orange, were used in the crop destruction missions.

It is the Agent Orange that has caused the greatest level of continuing medical concern because of its dioxin contaminant. Dioxin is an extraordinarily toxic animal poison, lethal in minute doses. Moreover, when administered to experimental animals in sublethal quantities it can be teratogenic (result in birth defects), mutagenic (cause genetic damage), and carcinogenic (instigate cancers).

The present Symposium (the planning for which began in 1979) has been convened in order to examine the aftermath of this chemical assault on South

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Viet Nam, now that about a decade has elapsed since the spraying. Thus, more than 70 ecological and physiological (medical) scientists from some 20 countries, both East and West, are coming together informally and in their private capacities (about 30 ecological and 40 physiological) in order to meet with almost an equal number of their Vietnamese counterparts. The international participants include some of the top experts in the world in their respective fields of science.

The three primary aims of the Symposium are:

1. To evaluate the existing scientific information on the long-term ecological and physiological consequences of the massive employment of anti-plant chemical warfare agents;

2. To identify and foster needed research in these areas with a view to continued restoration and rehabilitation; and

3. To promote international scientific cooperation. It is a strictly working conference, open only to qualified scientists.

During the course of the Symposium the participating scientists will be meeting not only in plenary sessions, but--more importantly--in one of the following eight working groups: E1, Terrestrial plant ecology and forestry; E2, Terrestrial animal ecology; E3, Soil ecology; E4, Coastal, aquatic, and marine ecology; P1, Cancer and clinical epidemiology; P2, Reproductive epidemiology; P3, Experimental toxicology and cytogenetics; and P4, Dioxin and related chemistry.* The international and Vietnamese scientists within each of these working groups will be preparing a working group summary report during the course of the Symposium.

The participants are being welcomed to Viet Nam by Mr. Mai Chi Tho, President of the People's Committee of Ho Chi Minh City, and the Symposium will be formally opened by Prof. Dr. Hoang Đinh Cau, Vice Minister of Health of Viet Nam and Chairman of the Symposium. This is being followed by a tribute to the internationally renowned late Dr. Ton That Tung whose pioneering researches into the subject of the Symposium provide its very foundation and through whose efforts the Symposium was initiated. The tribute will be presented by Dr. John D. Constable of Massachusetts General Hospital and Harvard University. Mrs. Vi Nguyet Ho, Dr. Tung's widow, is making a response. The opening ceremony is being concluded with brief statements by Dr. Reynaldo M. Lesaca, Director, Regional Office for Asia and the Pacific, United Nations Environment Programme (UNEP); and by Dr. John R.E. Harger, Regional Officer for Science and Technology for Southeast Asia, United Nations Educational, Scientific, and Cultural Organization (UNESCO). Mr. Mohamed S. Boulecane, Representative for Viet Nam, Food and Agriculture Organization of the United Nations (FAO) will be representing that Organization.

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* During the course of the Symposium Working Groups P3 and P4 were combined in a formal sense, but functioned largely as two de facto groups.

The Organizing Committee of the Symposium consisted of Dr. Ton That Tung, Director, Viet Duc Hospital, Hanoi, and Prof. Arthur H. Westing, Hampshire College, Amherst, USA, from 1979 to May 1982; after his death in May 1982, Dr. Tung was replaced by Prof. Dr. Hoang Đinh Cau, Vice Minister of Health, Hanoi.

The Symposium Presidium consists of the following five members: 1. Prof. Dr. Hoang Đinh Cau; 2. Acad. Alexander V. Fokin, Secretary-General of the Soviet Academy of Sciences, Moscow; 3. Acad. Vladimír Landa, Czechoslovak Academy of Sciences, Prague; 4. Prof. Paul W. Richards, Cambridge, England; and 4. Prof. Arthur H. Westing.

In order to help insure the strictly scientific nature of the Symposium, journalists are not being permitted to participate in the substantive portions of the Symposium. However, Vietnamese and foreign press present in Ho Chi Minh City are most welcome to attend the opening ceremonial and closing ceremonial plenary sessions. The final working group summary reports will be available for distribution shortly after the conclusion of the Symposium, and there will also be a press conference following the conclusion of the Symposium.

The initial Proceedings of the Symposium are to consist of the summary reports of the eight working groups as well as an overall summary statement. Added to these nine documents will be the present Background Information statement, a governance list, an attendance list, and the tribute to Dr. Ton That Tung. Ultimately, these materials are to be enhanced by several of the individual papers presented at the Symposium, by lengthier reviews from the eight working group rapporteurs, and by a bibliography.

The Organizing Committee is pleased to acknowledge financial support from the Christopher Reynolds Foundation (New York), Samuel Rubin Foundation (New York), Foundation for Scientific Cooperation with Vietnam (Fullerton, California), Hampshire College (Amherst, Massachusetts), and several private donors.

(Prepared by the Organizing Committee on 13 January 1983; revised 20 January 1983.)

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

A TRIBUTE TO DR. TON THAT TUNG

Distinguished representatives of the Ministry of Health of Viet Nam, co-workers in the search for truth who have come together from all over the world for this Symposium, colleagues and friends: I am deeply touched by the signal honor that has been accorded me by Madame Vi Nguyet Ho, the widow of Dr. Ton That Tung, and by the Organizing Committee of this Symposium in allowing me to speak a few words in honor of the memory of the late Professor Dr. Ton That Tung without whose splendid leadership we would not be gathered together today.

Although many aspects of the professional history of Dr. Tung are well known to us, I shall nonetheless briefly review some of the major highlights of his life and then conclude with a more personal reminiscence of Ton That Tung, the person, as I knew him in his last years.

Dr. Tung was born into an aristocratic family at Ton Hua on 10 May 1912, and died in Hanoi of a massive coronary thrombosis on 7 May 1982, just three days before his 70th birthday. His father having died within a few months of Tung's birth, the family soon moved to a house on the banks of the Perfume River in Hue. Following graduation from the Lycee du Protectorat, Ton That Tung entered the faculty of medicine. By dint of heroic and persistent effort in the face of severe and unrelenting opposition from the French Colonial Government, he eventually became an extern at the hospitals of Hanoi in 1936, intern in 1938, resident surgeon also in 1938, and then assistant and finally chief surgeon at the Viet Đuc Huu Nghi Hospital.

At the time of his internship Dr. Tung began his special interest in liver diseases, especially those precipitated by the ascaris infections which were, and are, particularly prevalent in Southeast Asia. In a serendipitous way the filling of bile ducts with ascaris worms enabled him to dissect out the inner anatomy of the liver better than had been done previously; and this, in turn, led to the development of major liver resections by the so-called finger fracture technique, in which the organ can be broken with minimal loss, and which led to his world renown.

During the period of 1946 to 1954 Dr. Tung's surgical work in Hanoi was interrupted by his active service in the resistance. During this period he travelled extensively all over the northern part of the country, often accompanied by his wife and small son, Ton That Bach, by all manner of different conveyances. In 1948 he became Vice Minister of Health in the Provisional Government established by Ho Chi Minh, and subsequently Chief Physician of the Army of the Resistance. The period of his military commitment culminated in his close involvement in the siege and capture of Dien Bien Phu, during the course of which he carried out a remarkable number of sophisticated surgical

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procedures in shallow bunkers or in underground passages. At this time he received from the hands of Vice President Ton Duc Thong--and in the presence of President Ho Chi Minh--the Resistance Medal Third Class, which he always considered his most precious award, although he later received many other decorations including that of a Heros du Travail Socialist de RDVN and, posthumously, the Order of Ho Chi Minh.

After Dien Bien Phu, Dr. Tung returned to Hanoi as director of the Viet Duc Hospital and head of the surgical faculty of the Hanoi Medical College, although he also remained Vice Minister of Health until 1962. During the latter period of his life, and continuing to the time of his death, Dr. Tung devoted himself to extensive research in liver surgery which won him international fame; to the development of his staff; to the training of his students; and, towards the end of his career, to an intensive involvement with herbicides. He succeeded in creating an extensive teaching program. He was always encouraging the use of new surgical methods, and, in spite of many technical difficulties, was doing heart surgery by 1958 and using a heart-lung machine by 1965--both truly formidable achievements.

Dr. Tung's interest in primary liver tumors led to his recognition of their increased frequency during the Second Indochina War and this, as well as his political awareness, led to his early interest in the possible deleterious health effects of herbicides and especially of dioxin which his studies convinced him was the probable cause of the increased rate of liver carcinoma. He also pointed to the possible connection of herbicides to an increased rate of cellular chromosomal abnormalities and to an unusually high rate of congenital anomalies in the children of herbicide-exposed fathers. All of these subjects of research are among those that we will explore together in the next few days. Even at the height of the Second Indochina War Dr. Tung had the foresight to urge the importance of careful scientific studies on the long-term effects of herbicides.

It is of personal significance to me that at the time I was in South Viet Nam in 1970 for the Herbicide Assessment Commission of the American Association for the Advancement of Science under the aegis of Professor Matthew S. Meselson we were able to be in touch with Dr. Tung in Hanoi and were offered any assistance he could provide in our studies, although, unfortunately, it was help of which we could not take advantage at the time. His interest and enthusiasm in the problem of herbicides make him truly the father of this Symposium.

Dr. Tung was widely honored for his medical work, being a member of many learned societies and the recipient of a number of prestigious awards. He also remained active in politics as Deputy in the National Assembly and as member of the Presidium of the Central Committee of the Vietnamese Fatherland Front.

I was fortunate to have known something of Dr. Ton That Tung, the person, during the last two years of his life, he having honored my house with his presence when touring the USA, and I having visited him in Hanoi. Here was

truly a remarkable person.

Dr. Tung was a supurb technical surgeon: I remember his carrying out a 70% hepatectomy for a massive tumor in a total time of no more than two hours, skin to skin, and with a blood loss of no more than 250 milliliters. On the third day I found the patient missing from his usual ward. I somewhat feared the worst, but he had, in fact, been transferred to an ambulatory ward since he was up and around and no longer in need of intravenous treatment.

Dr. Tung was a great hospital administrator: I remember his pride in the amazing conglomeration of equipment from all over the world and gathered under many different circumstances, that was somehow put together to keep his hospital at the very front of Vietnamese surgery. But, even though he made use of much advanced equipment, he never forgot the days of his surgery 'dans la forêt', and he scorned the use of air conditioning, which seemed always subject to failure, in his operating rooms.

Dr. Tung was a great teacher: This was shown by the extraordinary staff that he gathered around him and trained at his Viet Đuc Hospital.

Dr. Tung was a Francophile bon viveur: I remember an admirable goose, Vietnamese style, which we ate at his house in Hanoi, surrounded by his delightful family, as we talked of subjects of great variety. He was a man deeply read, interested not only in medicine and politics, but also in natural history, literature, ideas of all kinds, and even soccer.

Dr. Tung was a philosophical fighter for political and academic freedom who showed in his life how major a contribution one single person can make to a cause.

Above all, I found Ton That Tung a friend with whom, even if one had, in fact, only known him for a short time, one felt the security and intimacy of a lifetime association. My friends, I ask you once again to join me in a tribute to the founder and leading light of our Symposium, a man I am proud to call a dear friend, Monsieur le Docteur Professeur Ton That Tung!

(Presented by Dr. John D. Constable at the opening plenary session on 14 January 1983.)

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

SYMPOSIUM GOVERNANCE

1. Organizing Committee
   a. Prof. Dr. Ton That Tung (until May 1982)
   b. Prof. Dr. Hoàng Đinh Cầu (after May 1982)
   c. Prof. Arthur H. Westing

2. Presidium
   a. Prof. Dr. Hoàng Đinh Cầu (Chairman)
   b. Acad. Alexander V. Fokin
   c. Acad. Vladimír Landa
   d. Prof. Paul W. Richards
   e. Prof. Arthur H. Westing

3. Secretariat
   a. Prof. Dr. Hoàng Đinh Cầu (Chairman)
   b. Prof. Đoan Xuan Muou (Scientific Secretary)
   c. Dr. Trinh Van Khiem (Administrator)
   d. Ms. Nguyen Ky Minh Phuong (Assistant Administrator)
   e. Prof. Arthur H. Westing (Coordinator)
   f. Ms. Carol E. Westing (Assistant Coordinator)

4. Working Group governance
   E1. Terrestrial plant ecology and forestry
   Prof. Dr. Thái Văn Trùng (Chairman); Prof. Arthur W. Galston (Rapporteur)
   E2. Terrestrial animal ecology
   Dr. Vo Quy (Chairman); Prof. Mark Leighton (Rapporteur)
   E3. Soil ecology
   Cand. Hoàng Văn Huấy (Chairman); Prof. Paul J. Zinke (Rapporteur)
   E4. Coastal, aquatic, and marine ecology
   Dr. Mai Đinh Yen (Chairman); Prof. Samuel C. Snedaker (Rapporteur)

   P1. Cancer and clinical epidemiology
   Dr. Luong Tan Truong (Chairman); Prof. Samuel S. Epstein (Rapporteur)
   P2. Reproductive epidemiology
   Prof. Dr. Nguyễn Cân (Chairman); Dr. John D. Constable (Rapporteur)
   P3. Experimental toxicology and cytogenetics
   Dr. Cung Bính Trung (Chairman); Dr. Alastair Hay (Rapporteur)
   P4. Dioxin and related chemistry
   Cand. Tran Xuan Thu (Chairman); Prof. Christoffer Rappe (Rapporteur)

(Prepared by the Organizing Committee on 13 January 1983; revised 20 January 1983.)

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
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OVERALL SUMMARY REPORT

The International Symposium on Herbicides and Defoliants in War: the Long-term Effects on Man and Nature was held in Ho Chi Minh City from 13 to 20 January 1983. Attending the Symposium were almost 130 scientists from 21 countries as well as more than a dozen scientific or technical observers, including observers from the United Nations Environment Programme (UNEP), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and the Food and Agriculture Organization of the United Nations (FAO). The Symposium was devoted to the long-term effects of the herbicides and defoliants employed by the U.S. armed forces, with the agreement of the Saigon administration, during the Second Indochina War of 1961-1975.

At the plenary sessions and in the working groups the scientists presented and discussed some 60 scientific papers dealing with the following four general topics or problems:

1. The scope and nature of the anti-plant chemical warfare program conducted by the USA primarily in South Viet Nam from 1961 to 1971, so-called Operation Ranch Hand;

2. The long-term effects of the military herbicides and defoliants on man (about 35 reports) and on nature (about 25 reports);

3. The results of experimental studies on herbicides and defoliants in the laboratory or, on a small scale, in the field; and

4. The results of studies on the consequences of herbicides or related substances from accidents occurring in factories producing them, or else their effects on groups of workers dealing with these chemicals in agriculture or elsewhere.

The scientists present exchanged views and evaluated the results of studies in the laboratory or of field experiments. They discussed the research work to be conducted in the near future aimed at eliminating the consequences of the indiscriminate use of herbicides and defoliants on a large scale. They also discussed the possibilities of international cooperation in the field of scientific research.

During the time the Symposium was held the scientists visited an exhibition displaying the various kinds of chemical weapons used during the war and the effects of the herbicides and defoliants on man and nature.

Participants of the Symposium also visited the inland (upland) forest in the Ma Đa area of Đong Nai province (in the former Long Khanh province, Military

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Region III, War Zone D). Here wartime destruction inflicted upon nature remains very apparent. The Ma Đa forest can in effect be considered as one model for experimental field studies as regards the direct and indirect effects of herbicides and defoliants on tropical inland forests, the latter including fire. The visit to the Ma Đa forest gave participants a clear idea of the lengthy duration of effects of herbicidal disturbance on the natural restoration of tropical inland forests.

During the Symposium the scientists were engaged in active work in a friendly atmosphere. Although most of the scientists met one another for the first time, their discussions and exchanges of views were conducted in an open, straightforward, and frank way; and they worked in their private capacities. These factors together helped insure good results for the Symposium.

The majority of the participants reached agreement on the following ten subject areas:

First, Operation Ranch Hand was chemical warfare conducted with herbicides on a large scale in space and time, the first such massive employment in mankind's history of war. It differed completely from failures or explosion accidents in chemical factories. It also differed from the much smaller scale field experiments in other countries or from laboratory experiments. The results of these other occurrences and studies are only of partial usefulness in evaluating what happened to tropical South Viet Nam and to the Vietnamese people during Operation Ranch Hand.

The herbicides and defoliants employed in Operation Ranch Hand included primarily the following four substances:

1. 2,4-D (2,4-dichlorophenoxyacetic acid), a total of 26 million kilograms;

2. 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), a total of 24 million kilograms; containing dioxin (TCDD; 2,3,7,8-tetrachlorodibenzo-para-dioxin) as a contaminant in largely unknown amounts, although conservatively estimated to total no less than 170 kilograms;

3. Picloram (4-amino-3,5,6-trichloropicolinic acid), a total of 1 million kilograms; and

4. Cacodylic acid (dimethyl arsinic acid), a total of 3 million kilograms (of which almost 2 million kilograms was elemental arsenic).

It must be noted that the presented amounts of chemicals expended, as of the amount of the dioxin contaminant, are derived from official U.S. sources for which there is no independent source of verification.

These four chemicals were applied primarily in the following three mixtures:

1. Agent Orange, a mixture of 2,4-D and 2,4,5-T (and thus containing a trace of dioxin);

2. Agent White, a mixture of 2,4-D and picloram; and

3. Agent Blue, cacodylic acid.

Second, over the last twenty odd years, many experimental studies on herbicides and defoliants have been conducted in the research facilities of many countries. No full agreement has yet been reached on the results and conclusions regarding the effects of these chemicals on experimental animals. However, through many years of research with admirable patience and increasingly precise methods, the majority of scientists recognize that phenoxy and certain other herbicides and defoliants used at a high dose or at a low dose for a long period of time will affect animals adversely. They may be variously mutagenic (cause genetic damage), carcinogenic (instigate cancers), or teratogenic (result in birth defects).

Third, studies on workers in factories producing herbicides and defoliants have also been conducted over the last few years. Those studies confirm the toxicity of herbicides and defoliants, especially of 2,4,5-T and dioxin. The signs of immediate and long-term poisoning due to chlorophenoxy-acetic substances have been described in the medical literature. The manifestations considered as characterizing such poisoning are: chloracne; porphyria cutanea tarda; asthenia; etc. The reactions to these pathogenic agents differ from one individual to another, as do the manifestations of these reactions,which renders statistical analysis or other evaluation difficult.

Fourth, the Symposium reserved most of its time for the evaluation of the long-term effects of chemical warfare with herbicides and defoliants in South Viet Nam. Foreign scientists attending the Symposium highly valued the contributions made by Vietnamese scientists who, despite the limited facilities and other difficulties during and after the war, were able to largely overcome these problems and make valuable research contributions. Indeed, the reports and suggestions made by Vietnamese scientists at the Symposium provided the crucial basis for discussion at the plenary sessions and in the working groups. The large-scale field studies carried out by Vietnamese scientists in various localities in both southern and northern Viet Nam have provided much information of scientific value not previously available from other countries.

Fifth, nature and natural resources in Viet Nam have been substantially damaged. This destruction has been the result of a complexity of reasons. However, the participants agreed that the most important cause of this extensive damage to nature was the large-scale use of herbicides and defoliants. Immediately after the spraying, the toxic substances exerted their direct destructive effects on the vegetation and, to some extent, on the animals living in the inland, coastal, aquatic, and marine habitats. The direct and indirect repercussions of these immediate effects have lasted to this day. Time has only slowly helped to reduce the severity of the deleterious effects.

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Restoration can only be a slow process, occurring most readily on very small areas. Photographs taken from the air or space have helped to reflect the true state of the damage that still remains in the sprayed tropical forests.

Sixth, the herbicides and defoliants, sprayed on a large scale, at a high concentration, and in large amount, have changed the composition of some soils, destroyed useful microorganisms, and, in some instances, caused the soil to lose fertility and to deteriorate in other ways. Many areas which had been covered with trees and other woody plants have become savannas of low productivity. They contain only wild grasses or a number of secondary successional plants having little economic value, and support rodents which are disease carriers. Evidence from aerial photography and other sources indicates that some of these savannas are continuing to expand in size. Some species of valuable tropical wood are facing the danger of extermination, as are some precious terrestrial and aquatic animals. Transforming these savannas back to forest or building them into new economic zones for agriculture presents difficult problems, the solutions of which are often far beyond the present abilities of the Vietnamese people. The various impacts on nature have in many instances undermined the whole rural human life support system.

Seventh, the herbicides and defoliants sprayed on the land were washed away to lowland areas, often far from the sprayed areas, and decomposed over varying periods of time. The most dangerous among them was Agent Orange, which was widely used from 1961 to 1970. As noted earlier, Agent Orange contains the impurity dioxin, an extraordinarily toxic and very resistant substance that persists for a long time in nature. According to official (unverifiable) U.S. sources, some 72 million liters (91 million kilograms) of the various herbicides and defoliants were sprayed, of which Agent Orange accounted for 44 million liters (57 million kilograms) containing 24 million kilograms of 2,4,5-T. At this time, the most important thing to determine is whether there still exists dioxin in nature in Viet Nam. To this end, analyses were made in 1981 of seven soil samples taken in a rural area within the administrative unit of Ho Chi Minh City, at different depth levels. In one sample, taken at a depth of 1 meter, there was a trace of dioxin, i.e., a concentration below 5 nanograms per kilogram (ppt) of soil. In another, taken at the soil surface, the concentration was found to be 14 ppt.

Eighth, there are not as yet many scientific studies identifying the biological (ecological) cycle of dioxin from the soil into plant species, into animal species, into food, and into people. Dioxin and the decomposition products of the herbicides and defoliants sprayed have probably been carried to lowland areas in Viet Nam and neighboring countries and surrounding seas. Where will these substances end up? How will they be decomposed? What dangers will they present? How soon will the dioxin be decomposed to insignificance? These points could not yet be established. The opinions put forth at the Symposium were only estimates which must be improved upon and verified over a long period of time.

Ninth, the evaluation of the long-term effects of herbicides and defoliants is a most difficult and complex task. It is therefore difficult to reach full

agreement, since the conditions under which scientists work differ from one country to another. However, most of the conclusions drawn by Vietnamese scientists have corroborated the results of experiments conducted by many scientists elsewhere in the world. Reports by Vietnamese scientists have suggested that herbicides and defoliants affected chromosomes and that they caused congenital abnormalities, molar pregnancies, and chorio epithelioma. Vietnamese veterans of the war exposed to the toxic chemicals for a long time during the war years may pass on such abnormalites to their offspring. The rate of monsters born to families of Vietnamese veterans of the war seems to be higher than in normal families. The Vietnamese studies also provide some data on how these chemicals affect man's health and how they cause cancer. Herbicides and defoliants penetrating into human bodies may cause long-term effects even though the victims have already left the contaminated areas.

Many of the preliminary conclusions of the Vietnamese scientists are new points. They were observed in the Vietnamese society and have never been dealt with, or else only inadequately so, in foreign research works.

Tenth, during the Symposium scientists also agreed upon the following final three points:

a. Further studies should be continued for many years on the long-term effects of herbicides and defoliants used in the war on man and nature in Viet Nam;

b. International cooperation between Vietnamese scientists and their foreign colleagues is necessary to promote study and to determine the effects of herbicides and defoliants, and to find measures to cope with them, both in the interest of the Vietnamese people and of other peoples elsewhere in the world. Thus this Symposium has had a humanitarian aspect, serving the interests of all people; and

c. Measures to cope with the effects of herbicides and defoliants are complicated and difficult. They involve many fields of science, technology, economics, management, and culture; and they call for appropriate government policies. Clearly, they require a high level of science divorced from politics, the cooperation and commitment of the entire population, and substantial investments of money and matériel. Unrestricted assistance from the international community in all fields related to this endeavor is an urgent necessity.

In closing it should be noted that a brief separate document provides background information on the subject of the Symposium and that the following additonal documents provide official summaries of the eight working groups of the Symposium:

E1. Terrestrial plant ecology and forestry;

E2. Terrestrial animal ecology;

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E3. Soil ecology;

E4. Coastal, aquatic, and marine ecology;

P1. Cancer and clinical epidemiology;

P2. Reproductive epidemiology;

P3. Experimental toxicology and cytogenetics; and

P4. Dioxin and related chemistry.

(Prepared by the Presidium and, following revision, adopted unanimously by the Symposium participants in plenary session on 19 January 1983.)

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

SUMMARY REPORT OF WORKING GROUP E1, TERRESTRIAL PLANT ECOLOGY AND FORESTRY

This summary report examines the long-term effects on inland plant ecology and forestry of the herbicides and defoliants applied to South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement).

The massive use of these chemicals has produced many effects on the agriculture and ecosystems of South Viet Nam, only a small part of which are currently understood. We see the need for a large-scale coordinated program to accomplish the following four objectives:

1. To establish an accurate inventory of the extent and severity of the damage and change caused by the spraying;
2. To estimate the extent of spontaneous regeneration in the sprayed forest and other ecosystems. For such work, the existence or establishment of reliable descriptions of the forests of this region must provide a necessary base of data;
3. To develop policies of land management in order to encourage such regeneration, and, where indicated, agriculture that will minimize the damage and restore the land to maximum stability and productivity; and
4. To devise systems of international cooperation and aid in order to implement those beneficial policies which are beyond the financial and technological means of the Vietnamese nation.

Over the decade starting in late 1961 at least 12% of the inland forests of South Viet Nam were sprayed at least once, and many were sprayed repeatedly. Some Vietnamese estimates set this figure as high as 44%. The extent of permanent damage is correlated with the total herbicide and defoliant dose, as judged by matching aerial photographs with military spray records. The degree of initial damage and the rate of recovery from such damage depend on many factors, including the species involved, the dosage, the total contiguous area sprayed, the terrain, and the weather patterns. Similarly, spontaneous regeneration varies widely in the affected areas; it depends mainly on the species, the size of the area affected, and the weather. The existence of a prolonged dry season in Viet Nam certainly impedes regeneration. In some areas natural regeneration has not occurred, making artificial replanting essential. In one region studied--the inland forest in the Ma Đa area of Đong Nai province (in the former Long Khanh province, Military Region III, War Zone D)--regeneration has proceeded very slowly over the past decade, as judged from satellite photographs and on-the-ground studies.

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Frequently the nearby availability of seeds is the critical factor determining regeneration. The regenerated forest may differ significantly from the original one in terms of economically important species. Inventories must be made of these changes.

Once an area has been sprayed with herbicides and defoliants, it may be prevented from recovering through subsequent human intervention. We note, for example, the repeated burning of the grasses and young woody cover that become established on sprayed areas such as in the Ma Đa forest; and the conversion of some such areas to agriculture. Such conversions, once effected, are difficult to reverse, and such land might best be left to agriculture.

Once policies have been developed to foster recovery, laws and social practices should be developed to minimize the deleterious effects of those practices that prevent recovery.

The ecological damage produced by spraying with herbicides and defoliants may also become spontaneously worse with time. For example, areas denuded of vegetation may suffer erosion or other deleterious transformations; or they may become invaded by noxious plants, such as Imperata, which impede restoration of the original flora. The extent of such transformation, representing possible permanent loss of forest lands, should be accurately estimated.

With regard to agriculture, a substantial area of cultivated or potentially cultivable land may have been lost as a result of the spray operations, partly because of the high concentrations of herbicides and defoliants used. The problems underlying agricultural restoration or establishment in these areas require separate and intensive study in order to determine, for example, possible danger from toxic residues, effects on soil microflora, and the best crops to use.

Making recommendations for vegetational restoration in Viet Nam is difficult because the complexity of the landscape and the variety of local conditions make generalizations impractical and even counterproductive. Each separate area must be given independent analysis. Although ingenious and provocative models have been proposed to estimate productivity and performance in a forest ecosystem, it is premature to expect these models to be usefully employed in the field in Viet Nam. We are impressed by the high quality and prodigious quantity of work accomplished by our Vietnamese colleagues under difficult conditions and with very little support. This encourages us to urge that their research be supported in concrete terms.

Such information as we now have, admittedly fragmentary, permits the conclusion that the combined ecological, economic, and social consequences of the wartime defoliation operation have been vast and will take several generations to reverse.

Recommendation

We believe that a useful approach to restoring the damaged forest resources of southern Viet Nam would be by means of a pilot scheme for a small selected area. This could be started immediately and would provide valuable experience while a large long-term scheme was being organized. The forest at Ma Đa which we visited might be suitable for such an experiment if it were protected from fire. In the Ma Đa area it would be possible to find: 1. Areas of undamaged forest which could serve as a base of reference and as seed sources; 2. Areas of herbicide-damaged forest needing to be restored to full productivity by encouraging natural regeneration or by conversion to plantations of fast-growing trees; and 3. Areas of scrub and grassland which might be reforested.

The cost of our pilot scheme would not be large and could perhaps be met by grants from such agencies as the United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), Food and Agriculture Organization of the United Nations (FAO), or United Nations Educational, Scientific, and Cultural Organization (UNESCO).*

Members of Working Group E1: P.S. Ashton, B.D. Baikov, E.F. Brünig, Chan Tong Yves, Đuong Hong Dat, Vu Van Dung, A.W. Galston (Rapporteur), Tran Đinh Gian, Nguyen Van Hanh, Đinh Hiep, Pham Hoang Ho, Hoang Hoe (Vice-Chairman), I.I. Maradudin, B.A. Molski, Bui Van Ngac, Phung Trung Ngan, Y.G. Puzachenko, Nguyen Huu Quang, P.W. Richards, A.L. Takhtajan, H. Thomasius, Thai Van Trung (Chairman), J.H. Vandermeer, and J.E. Vidal.

(Prepared and adopted by the Working Group on 18 January 1983; and, following minor revision, adopted unanimously by the Symposium participants in plenary session on 19 January 1983.)

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* Additionally Working Group E1 deemed it appropriate, as did the Symposium participants in plenary session, that international agencies adopt steps to condemn herbicidal warfare against the environment and to ban such practices from any future military operations.

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

SUMMARY REPORT OF WORKING GROUP E2, TERRESTRIAL ANIMAL ECOLOGY

This summary report examines the long-term effects on terrestrial animal ecology of the herbicides and defoliants applied to South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement).

These chemicals were sprayed in high concentrations and over large areas of forest, damaging the forest environment and causing the death of countless animals. The working group primarily reviewed two papers reporting the results of two years of study of the effects of massive herbicide spraying in the A Luoi valley in Binh Tri Thien province (in the former Thua Thien province, South Viet Nam, Military Region I). Some 80% of this valley had been covered by tropical forest supporting a rich fauna, but was degraded to grassland as a result of the spraying.

A research team led by Dr. Vo Quy of the University of Hanoi interviewed a cross section of the inhabitants of ten villages in the valley who had witnessed the immediate results of the spraying. These people consistently reported that spraying was followed within a few days by the deaths of large numbers of both wild and domestic birds and mammals. There has been no study investigating the contribution to this mortality from direct toxic effects of the chemicals versus indirect effects such as starvation or disease that would follow the destruction of the forest environment of animals.

An important comparison between A Luoi valley and two control forest areas regarding numbers of bird species (by Vo Quy) and numbers of mammal species (by Đang Huy Huynh) was presented and discussed. Only 24 species of birds and 5 species of mammals were found in A Luoi valley whereas 145 and 170 bird species and 30 and 55 mammal species were censused in the two control forests.

Two additional studies were reported. According to L.W. Medvedev, termite abundances were lower in a sprayed forest site as compared with an unsprayed forest site of similar vegetational structure. According to Tran The Thong, higher incidences of reproductive problems and birth abnormalities were found among domestic pigs in a village that had been subjected to chemical spraying as compared with a similar unsprayed village.

Visits to defoliated forests and examination of aerial photographs of sprayed and unsprayed forest have shown that the tropical forest was transformed by the spraying to one of two types of degraded vegetation. First, forest repeatedly or intensely defoliated over large areas was often subsequently burned, leading to the establishment of grassland. Examples are the A Luoi valley mentioned above and the large inland forests in and north of the Ma Đa area of Đong Nai province (in the former Long Khanh province, South Viet Nam,

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Military Region III, War Zone D). Second, over large areas of forest less frequently sprayed, plants of the upper layers (strata) of the forest were killed, resulting in a new forest of low stature relatively poor in animal species.

Thus in defoliated areas, tropical forest supporting a rich fauna of invertebrates and vertebrates has been destroyed, together with the animals dependent upon the microclimatic conditions, food resources, and physical structure of the forest. Populations of animals requiring forest of well developed structure and high plant species diversity have been reduced and subdivided into isolated areas. These species are now more susceptible to local extirpation as a result of the reduction and division of their forest habitat. This phenomenon was specifically investigated by Vo Quy and colleagues in seven forest areas of South Viet Nam during surveys of endangered species such as Rhinoceros sondaicus, Bos sauveli, Pygathrix nemaeus, and Lophura edwardsi, and of other economically important vertebrates.

Recommendations

We suggest the following objectives for further research on the ecological impact of chemical warfare with herbicides on forest animals. First, thorough ecological and zoological studies are necessary, especially in order to quantitatively document differences in animal species richness and abundance in sprayed and unsprayed areas for different forest types. Second, ecological field studies should be combined with laboratory investigations of particular animal taxa in order to discover species useful as bio-indicators of herbicidal impact. Similar studies should be used to investigate whether long-term reproductive problems have resulted from genetic damage to wild and domestic animals surviving chemical poisoning. Third, the distribution of any residual chemicals in the ecosystem should be assessed. Fourth, long-term research plots in forest areas recovering from chemical spraying should be established in order to monitor changes in their animal communities. Fifth, more surveys should be conducted in order to identify and categorize the remaining forests of southern Viet Nam and their animal components.

We stress that recommendations from animal ecologists for forest rehabilitation must be integrated with economic studies of how best to utilize these altered lands for the economic and social needs of the people. We have two immediate recommendations to offer. First, we suggest establishing a system of national biological reserves in order to protect and manage what remains of the rich diversity of animal life in the forests of southern Viet Nam. Second, we are especially concerned about further reductions in forest cover caused by the spread of grasslands, this process having been set in motion by the herbicidal attacks. We thus suggest that efforts be devoted to reforesting grassland in order to rejoin small patches of forest that are now isolated from one another, a situation which prevents animal dispersal.

Finally, we suggest that biological institutions within Viet Nam seek expert assistance and funds from international agencies such as the Food and Agriculture Organization of the United Nations (FAO), the United Nations

Development Programme (UNDP), the United Nations Environment Programme (UNEP), the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and especially its Man and the Biosphere Programme (MAB), the International Union for Conservation of Nature and Natural Resources (IUCN), and the World Wildlife Fund (WWF).

In closing, our working group wishes to emphasize that the complexity of and interrelationships among the ecological problems we have identified require cooperation among botanists, zoologists, soil scientists, and aquatic biologists in order to achieve the rehabilitation of the devastated forest fauna.

Members of Working Group E2: Đang Huy Huynh (Vice-Chairman), V. Landa, M. Leighton (Rapporteur), L.W. Medvedev, I. Mototani, E.W. Pfeiffer, Vo Quy (Chairman), V.E. Sokolov, and Tran The Thong.

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INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

SUMMARY REPORT OF WORKING GROUP E3, SOIL ECOLOGY

This summary report examines the long-term effects on soil ecology (including the physical, chemical, and biological properties of soil) of the herbicides and defoliants applied to South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement).

The use of these chemicals caused heavy damage and long-term effects on soil ecosystems. In turn, these consequences could affect agricultural and forest production and, ultimately, man's health. The effects of herbicides and defoliants on soil may be direct or indirect. Their direct effects occur when they enter the soil and influence soil organic matter degradation processes or the soil microbiology. Their indirect effects occur through changing the vegetation and through their influence upon soil properties. The magnitude of changes in soil properties will vary depending upon other factors which influence the soil ecosystem, for example, the geological conditions, the topography, and the degree of development of the soil.

Our working group heard and discussed papers which dealt with the following three main soil topics: 1. The changes in soil properties that have occurred since the wartime spraying; 2. The effect of the herbicides and defoliants on the ecosystem of soil microorganisms; and 3. The fate of herbicides and defoliants entering the soil, including the processes and products of their degradation. The five major points made in these reports follow:

First, a large proportion of the elements of site fertility in undisturbed tropical forests is contained in the trees relative to the soil. Herbicides bring about a sudden return to the soil of the foliage of vegetation with its elemental content. Rapid decay of this detritus brings a flush of organic matter, nitrogen compounds, and associated mineral elements to the soil. The increase in these materials changes the soil properties. The changes may be temporary or long lasting depending upon many factors, such as rate of recovery of original vegetation, amount of conversion to other types of vegetation, nature of the geologic substrate, the topography, and the degree of erosion.

Second, loss of soil fertility elements may occur depending upon the intensity and duration of vegetational change induced by the herbicides. Repeated herbicide applications resulted in greater opening of the forest and conversion to other types of land occupance or use. The fertility content of the site (in both soil and vegetation) became less with the sequence from forest to grassland or bamboo. The soil fertility elements most susceptible

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to loss are potassium and nitrogen; a drop in available phosphorus also occurs owing to incorporation into insoluble substances.

Third, a study made in the A Luoi valley in Binh Tri Thien province (in the former Thua Thien province, South Viet Nam, Military Region I) reported on changes in soils that had been collected from areas 12 years after they had been converted from tropical inland forest to Imperata grassland through spraying. The Imperata cover had been maintained during this period through the influence of periodic fires of anthropogenic origin. Where the topography was steep, the changes in soil properties included lower organic matter content, lower nitrogen content, less available phosphorus, and lower calcium, magnesium, and iron in the soil's cation exchange complex; they further included increases in acidity and aluminum content. On the other hand, where the topography was flat, as in the valley bottoms with alluvial soils, there were increases in the soil organic matter and nitrogen contents.

A study made of mangrove forest soils on the Ca Mau peninsula in Nam Can district of Minh Hai province (in the former An Xuyen province, South Viet Nam, Military Region IV) reported on long-term changes in areas which had been cleared of mangroves by the wartime spraying. These soils were reported to have increased carbon and nitrogen contents, a greater acidity, less available phosphorus, and lower potassium in comparison with uncleared mangrove forest. Where cleared soils were being used for agriculture, there was a drop in nitrogen content, but organic matter remained high. Soil deterioration has occurred in some of these areas owing to acid sulfate formation.

Fourth, herbicides and defoliants can enter the soil directly or can be transmitted through sprayed plants via root exudates. In either case they may affect the species composition of the soil microorganisms. There may be a selection in favor of those species which can decompose the compounds applied. These organisms will aid in the decomposition of the herbicides and defoliants, but the possibility exists that the degradation compounds formed will be toxic.

Fifth, with the appropriate combination of soil microflora present (usually the case), both 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) are fairly quickly degraded to nontoxic products. However, picloram (4-amino-3,5,6-trichloropicolinic acid) is more stable in soil, being detectable for up to about three years. The arsenic from cacodylic acid (dimethylarsinic acid) may remain in soil in a fixed condition. Decomposition rates of herbicides and defoliants in soil will vary depending upon the physical properties of the soil, its acidity, its microfloral composition, and its clay content (to which the chemicals could adhere). One study which has reported lengthy persistence is perhaps explicable on the basis of such fixation to the clay fraction of the soil.

Recommendations

Our working group makes the following seven proposals for the benefit

of scientists interested in long-term international cooperation:

First, total ecosystem studies are needed to understand the role of herbicides (as of other xenobiotics)in biogeochemical cycling and their effects upon soil fertility.

Second, a survey should be made of land use in areas subjected to the wartime spraying and of the resulting sequence of vegetational change. Such a survey should include areas of intense land deterioration owing to erosion.

Third, techniques of restoration of soils deteriorated by adverse aspects of herbicide use and of subsequent land use should be developed and applied. Special attention is needed for acid sulfate soil reclamation.

Fourth, studies are needed on the persistence of herbicides in soils and on the processes of their degradation. The role of microorganisms in the decomposition and degradation of herbicide materials needs further study. Studies of effects on microfloral composition are needed as are studies on selected indices of herbicide presence such as nitrogen fixers, cellulose decomposers, and mycorrhizal and similar microfloral/plant-root associations.

Fifth, studies on special soil topics related to herbicide use are needed, for example, the possible catalytic effect of clay minerals on the photo-oxidation or other degradation of herbicides, and the effects of herbicides and defoliants on processes of soil laterization.

Sixth, studies should be made on persistence of dioxin (2,3,7,8-tetrachlorodibenzo-para-dioxin) contaminants of herbicides in soil and their possible movement in the food chain to man.

Seventh, we recommend that international agencies such as the United Nations Educational, Scientific, and Cultural Organization (UNESCO), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), and Food and Agriculture Organization of the United Nations (FAO) and the international scientific community collaborate with Vietnamese scientists on studies of the problems associated with the wartime use of herbicides and defoliants.*

Members of Working Group E3: V.A. Bolshakov, Le Van Can, Le Trong Cuc, (Vice-Chairman), H.B. Gunner, Hoang Van Huay (Chairman), C.F. Jordan, S.K. Mukherjee, V.V. Nazarov, Nguyen Hung Phuc, J. Pospisil, Pham Van Ty, and P.J. Zinke (Rapporteur).

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* Additionally Working Group E3 recognized, as did the Symposium participants in plenary session, that there are far broader aspects of herbicide use in a global context than the effects of herbicide use during wartime in Viet Nam on soil conditions. Its response of outrage to large-scale wartime use of herbicides for crop destruction and forest defoliation should not deny the benefits of their use to farmers and workers in the forest during times of peace.

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

SUMMARY REPORT OF WORKING GROUP E4, COASTAL, AQUATIC, AND MARINE ECOLOGY

This summary report examines the long-term effects on coastal mangrove, inland (freshwater) aquatic, and marine ecology of the herbicides and defoliants applied to South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement).

Mangrove forests were frequently defoliated during the period of years between 1962 and 1971 and this resulted in the complete destruction of a significant percentage of these coastal forests from the Rung Sat area southeast of Ho Chi Minh City (Saigon) to the Ca Mau peninsula at the southern tip of the country (i.e., much of the eastern fringe of the former Military Region IV). A U.S. National Academy of Sciences study team concluded in 1974 that the affected mangrove areas were so intensively damaged that natural recovery might take as long as 100 years, owing in part to the extensive loss of seed sources.

The destruction of the coastal mangrove forests resulted in a significant potential loss of timber, firewood, wood for charcoal, tannin, and other forest products. It also presumably led to a decrease in estuarine and nearshore fishery yields. In essence, a substantial proportion of the mangrove ecosystem, including its associated estuarine flora and fauna, experienced a significant productive loss.

The use of herbicides and defoliants in the inland (upland) areas of South Viet Nam was more extensive than in the coastal mangrove areas, but the subsequent damage was more variable in the inland areas than in the coastal areas. Disturbance to the inland watersheds and the introduction of herbicides and defoliants into inland aquatic ecosystems have been associated with aquatic biological changes that are considered to be serious.

This working group has reviewed the available information and data and recommends that countries and international organizations supporting the development of Viet Nam provide assistance in the following two areas: 1. For the assessment and monitoring of any possible chronic effects from residual herbicides and defoliants during the process of ecosystem recovery; and 2. For the evaluation of productive alternatives of economic and social benefit for the utilization of the altered habitats.

Coastal mangrove ecosystems

The data and information available for the mangrove ecosystem indicate that the effects of spraying are widespread, long-lasting, and severe within the affected areas. The relatively good quality of the available information

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makes it suitable for the definition of the basic research programs required to assist in the restoration of the habitat, including its flora and fauna, and for the directions that should be taken in developing new economic opportunities. Trial plantations of a high-value species of mangrove (Rhizophora apiculata) in its former habitat could accelerate the recovery of the mangrove ecosystem. However, degraded and otherwise unsuitable habitats will require the evaluation and selection of alternative economic uses.

Whereas it is doubtful that toxic residues of the herbicides and defoliants persist in significant concentrations, there is a reasonable probability that the defoliated and altered inland watersheds continue to have an impact on the downstream coastal mangrove forests. Altered hydroperiods, excessive erosion and deposition, and introductions of deleterious materials could have a significant effect on the fauna and flora of the mangrove ecosystem and associated estuarine areas. Insufficient quatitative data exist as yet to assist in evaluating these possible impacts.

Inland aquatic ecosystems

Compared to the existing knowledge of the mangrove ecosystem, the potential effects on the inland aquatic ecosystems have been much less well described in the literature. However, some relevant data and information have been assembled by qualified Vietnamese scientists. These suggest the existence of spray-induced adverse effects, including the loss of freshwater vertebrate and invertebrate species and anomalous deformations among species of the local freshwater algae. Because many questions remain to be answered concerning this topic, a statistically valid assessment study is warranted that would determine the characteristics of the altered freshwater habitats and their biotic components, particularly those that have economic importance.

Marine ecosystems

Vietnamese scientists have confirmed earlier reports of declining marine fishery stocks and of the disappearance of certain species. Although similar problems are being reported in other countries of the region, the Vietnamese situation cannot be attributed to overfishing and related exploitative fishing practices. It is therefore urgent that fishery stock assessments be undertaken and that local training be provided in fishery management and capture techniques.

Recommendations

Owing to the ecological and economic values of Viet Nam's coastal, inland aquatic, and marine ecosystems and because Viet Nam's opportunities for natural resource development are limited, this working group makes the following six recommendations:

First, it is suggested that Viet Nam participate in the Regional Coastal and Marine Programme of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). To this end, Viet Nam must create a

coordinating National Mangrove Committee and should send members of this Committee to the UNESCO Programme in Bangkok for training in mangrove biology and management. The National Committee should also serve as an ad hoc advisory body to monitor the reclamation and restoration of the altered ecosystems.

Second, Viet Nam should solicit cooperation from the Czechoslovak Academy of Sciences concerning the use of insect indicator species in monitoring the recovery of inland aquatic ecosystems.

Third, Vietnamese scientists and natural resource managers should actively solicit library materials, methodological handbooks, and training aids on relevant scientific and management studies.

Fourth, Viet Nam should undertake statistically controlled studies of each altered ecosystem for the purpose of explaining why certain ecosystems appear to be slow in recovering, doing so in order to lay a scientific basis for accelerating the recovery processes.

Fifth, Viet Nam should evaluate all alternative potential uses of altered ecosystems, with emphases on aquaculture and on the harvesting of species not previously utilized in the country.

Sixth, Viet Nam should incorporate socio-economic considerations into its natural resource development plans in order to insure that maximum human benefits are achieved.

In closing, the working group considers international cooperation with Vietnamese scientists a necessity in overcoming the adverse effects of the war.

Members of Working Group E4: Vo Tri Chung, D.F. Dunn, Phan Nguyen Hong, Bui Thi Lang (Vice-Chairwoman), Nguyen Duy Minh, S.C. Snedaker (Rapporteur), S. Sokolova, Nguyen Van Tuyen, and Mai Đinh Yen (Chairman).

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INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

SUMMARY REPORT OF WORKING GROUP P1, CANCER AND CLINICAL EPIDEMIOLOGY

This summary report examines epidemiologically the long-term effects on human cancer and other clinical sequelae of the herbicides and defoliants applied in South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement). Of particular concern here is the dioxin (TCDD; 2,3,7,8-tetrachlorodibenzo-para-dioxin) contaminant of Agent Orange, the major herbicide that was employed.

Dioxin is one of the most toxic organic compounds known, producing a wide range of organ and metabolic dysfunctions, fetotoxicity, teratogenicity, and carcinogenicity at the nanogram per kilogram to microgram per kilogram (ppt to ppb) range. There is a general consistency between the pattern of chronic toxicity induced in animals by dioxin and dioxin-contaminated chlorophenolic compounds and those observed in exposed human populations. Such toxicity includes: 1. chronic hepatitis; 2. disturbances in immune function; 3. disturbances in lipid and porphyrin metabolism; and 4. neurological abnormalities, sometimes associated with a toxic neurasthenic syndrome. Studies by Dr. Ton That Tung on Vietnamese populations exposed to herbicides and defoliants during the Second Indochina War have produced suggestive evidence of an excess of primary liver cancers and other evidence of chronic toxicity. A series of Swedish epidemiological studies, confirmed by more recent U.S. mortality studies, have demonstrated an excess of soft-tissue sarcomas (malignant growths) in groups occupationally exposed to chlorophenoxy herbicides and chlorophenolic compounds. Chloracne is not an obligate effect of dioxin exposure in either sensitive animal species or humans.

Vietnamese studies

Morbidity studies in civilians in Tay Ninh province (in the former Military Region III, War Zone C) and in Ben Tre province (in the former Kien Hoa province, Military Region IV) as well as in Vietnamese veterans in the North have demonstrated consistent and strong associations between wartime herbicide exposure and chronic neurasthenic symptoms. Two preliminary case-control studies of primary liver cancer were reported. A case-control study of primary liver cancer in Hanoi demonstrated a strong association with herbicide exposure. Another similar study at Cho Ray Hospital in Ho Chi Minh City (Saigon) with a limited number of cases gave evidence of a slight excess of risk of liver cancer in exposed persons, but this association was not large enough to achieve statistical significance.

These Vietnamese studies have established suggestive evidence of an association between wartime herbicide exposure and chronic toxic effects, including neurasthenic symptoms and primary liver cancer. It is planned to

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expand these studies with particular reference to the following four points: 1. definition of past and present exposure to toxic herbicides and defoliants, including dioxin levels, from direct and indirect sources; 2. methodological considerations, including the need for larger sample sizes, random sampling, the use of multiple controls, and avoidance of reporting bias; 3. incorporation of objective clinical and laboratory studies, such as associations between chronic neurasthenic symptoms and disturbances in nerve conduction velocity and in lipid metabolism and porphyrin metabolism; and 4. study of the role of Hepatitis-B in studies of the association between primary liver cancer and exposure to toxic herbicides.

The working group recognizes the major problems in conducting complex epidemiological studies of this type, even under ideal conditions, and congratulates its Vietnamese colleagues for their scientific contributions under difficult conditions.

Recommendations

Although primary consideration here has been directed toward Viet Nam, the working group recognizes the existence of similar problems and needs in Laos and Kampuchea as a result of the Second Indochina War. Greatly expanded initiatives should be developed in the following five general areas: 1. collaborative programs that are based jointly in Vietnamese and foreign laboratories; 2. visiting consultant programs that involve foreign scientists with work in Viet Nam; 3. scholarship programs that allow young Vietnamese scientists to receive specialized training in foreign countries; 4. the development of standardized protocols for epidemiological, clinical, and laboratory studies; and 5. foreign reference centers for specialized purposes such as dioxin analysis and histopathology review.

Attempts should be made to integrate such initiatives with worldwide studies on groups occupationally exposed to dioxin and dioxin-contaminated chlorophenoxy compounds, including foreign veterans of the Second Indochina War. Such initiatives should be developed in parallel with programs to improve the overall public health and nutritional status of the Vietnamese population. Specific recommendations for collaborative programs include the following five areas: 1. expanded case-control studies designed to investigate the relationship in standardized populations between past exposure to the toxic herbicides and present disease; 2. the same studies designed to also investigate associations between subjective disease and objective clinical and laboratory findings; 3. the same studies additionally designed to investigate the relation between such associations and present levels of dioxin in soil, water, and vegetation in areas that had been subjected to wartime spraying; 4. retrospective case-control studies on soft-tissue sarcomas; and 5. subject to available resources, long-term prospective epidemiological studies on exposed Vietnamese populations.

The working group recognizes that all recommendations are meaningless in the absence of a workable plan for implementation. The following five recommendations for practical action are therefore proposed:

1. Funding should be sought to support further research, diagnosis, and treatment of the effects of the wartime exposure to herbicides and defoliants in Viet Nam, Laos, and Kampuchea;
2. Practical mechanisms for scientific collaboration should be immediately established by us. In particular, these mechanisms should include international scientific commissions or committees for collaborative research;
3. Every effort should be made by the participants in this Symposium to increase the availability of medical supplies to Vietnamese, Laotian, and Kampuchean researchers. Similar efforts should be made with respect to scientific journals, laboratory reagents, and laboratory equipment;
4. Research concerning the treatment of exposed persons should be part of the overall research program; and
5. The World Health Organization (WHO) should be approached concerning the expansion of the dioxin project of its International Agency for Research on Cancer (IARC) in order to incorporate and support research on the effects of herbicides in Indochina.

Members of Working Group P1: N.S. Antonov, Đoan Thuy Ba, Ton That Bach, H. Carpentier, Nguyen Đinh Đich, Z. Dienstbier, J.H Dwyer, S.S. Epstein (Rapporteur), K.-R. Fabig, R.R. Gavalda, C.R. Jerusalem, Pham Duy Linh, My Samedy, Pham Hoang Phiet, N.S. Scharager, Pham Bieu Tam, C. Thammavong, C.J.M. van Tiggelen, Đo Thuc Trinh, Le The Trung, Luong Tan Truong (Chairman), Nguyen Anh Tuong, Đo Đuc Van (Vice-Chairman), and Nguyen Van Van.

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INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

SUMMARY REPORT OF WORKING GROUP P2, REPRODUCTIVE EPIDEMIOLOGY

This summary report examines epidemiologically the long-term effects on human reproduction of the herbicides and defoliants applied in South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement). Of particular concern here is the dioxin (TCDD; 2,3,7,8-tetrachlorodibenzo-para-dioxin) contaminant of Agent Orange, the major herbicide that was employed.

The working group accepts without dissent the animal evidence proving the teratogenicity of dioxin when administered to females, but remains unaware of any acceptable evidence of the transmission of this toxicity through the male.

Although there have been many studies of the medical effects of Agent Orange and related compounds, together with their contaminants, these studies have been inconclusive as regards reproductive effects. It is therefore that the study of these effects in Viet Nam, where there has been such extensive exposure, seems to be of the greatest interest and importance, not only to Viet Nam but also to the rest of the world.

Recognizing--and, indeed, deeply cognizant of--the extraordinary difficulties necessarily associated with any such retrospective study, especially when it is being carried out some 15 years after the time of exposure, we have been very much impressed by the seven Vietnamese studies that have been reported to us. These Vietnamese evaluations of the possible teratogenic and/or mutagenic effects of herbicide exposure are being made in the following three major ways:

1. Changes in the frequency of miscarriages and stillbirths relative to normal deliveries;
2. Changes in the frequency of congenital malformations; and
3. Changes in the rate of occurrence of hydatidiform moles.

Changes in miscarriages, stillbirths, and congenital anomalies have been studied not only among exposed women (necessarily in southern Viet Nam), but also in the children of <u>un</u>exposed women whose husbands have been exposed.

The authors of all these investigations, well aware of the many obstacles to a completely satisfactory study, have proffered them as preliminary reports even when they already include an immense amount of laboriously acquired information.

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The most complete, and perhaps consequently the most impressive and persuasive, studies relate to an increase in the unfavorable outcomes of pregnancy in North Vietnamese women whose husbands served in the South during the war, and were therefore at least potentially exposed to herbicides and defoliants, as compared to fellow villagers whose husbands had remained in the North. Providing that the following criteria have, indeed, been met--a properly carried out blind study; an absence of bias, especially in selection; maximum validation of data other than by self-reporting; and strict adherence to a properly prepared protocol--and we have no specific reason to doubt any of them--then a statistically valid increase in these unfavorable outcomes has been shown for the unexposed wives of exposed fathers in one study; and is strongly suggested in another, which additionally indicates a reversal of the usual increase in the frequency of such disasters with progressive pregnancies.

However, it is agreed by all that in such investigations--especially when they show results contrary to previous experimental evidence--one, or even two or three, congruent investigations are not enough to provide complete proof of their conclusions, and further similar work is needed.

As regards congenital anomalies, there are several studies apparently indicative of a generally higher rate of their frequency amongst exposed women, but these changes are often hard to prove beyond any doubt. The absolute rate of reported congenital anomalies in Viet Nam seems generally very low. Although the reasons for this are not fully understood, they may include the low sensitivity of the information system, a reduced exposure to toxic chemicals, and inherent ethnic differences.

We are much impressed by the large numbers of reported cases of the following five categories of congenital anomalies:

1. Anencephaly and other neural tube defects, which here are associated with a remarkably low incidence of spina bifida;
2. Deformities of the sensory organs, such as anopthalmia;
3. Deformities of the limbs, including phocomelia;
4. Conjoined twins; and
5. Orofacial cleft defects.

In most other countries these malformations are either not very common (anencephaly, orofacial clefts) or even rare (deformities of the limbs, deformities of the sensory organs, conjoined twins).

In order to appropriately further pursue this important field of inquiry, at least the following two things are essential: 1. a more precise identification and classification of reported anomalies; and 2. a determination of the expected rate of such deformities in Viet Nam. The latter can be accomplished in one of three ways: 1. best, by the recovery of accurate pre-spray figures; 2. second best, by the use of data from more or less closely related populations, available through the World Health Organization (WHO) for the years 1962-1963

for India, Hong Kong, Malaysia, and Singapore; or 3. minimally desirable, by determination of the worldwide reported ranges of frequency.

Hydatidiform moles seem to show an increase in frequency in herbicide exposed women, but more work is needed if this is to be proved. Recognizing the relatively high frequency of this lesion in Southeast Asia, information should be obtained as to any recent changes reported for elsewhere in the area.

We feel that the general design of the studies reported is excellent, but that additional numbers are needed, that controls be made somewhat stricter, that possible variables be carefully scrutinized, and that the protocols be rigidly adhered to. Until now, exposure index has rarely been included and no sort of dose-response curve has been constructed. Consideration should be given to comparing the possible results of direct exposure compared to exposure via the diet. A search should perhaps be made for other possible toxins such as heavy metals or DDT.

Finally we would point out that even if all of these studies, as designed, were to yield unequivocally positive results, then only the increased defects resulting from exposure would have been proved, not a specific association with dioxin. The latter would remain presumptive until the causal relationship was confirmed by separate investigations. These would be made easier if the newest methods of chemical analysis can, indeed, still demonstrate residual dioxin at variable levels in human tissue.

The working group agrees that the remaining problems of the possible teratogenesis of herbicides and defoliants require extensive continued study by the scientists of Viet Nam in which they could be appropriately aided by the international scientific community, especially with respect to experimental laboratory investigations.

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INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR
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HO CHI MINH CITY, 13-20 JANUARY 1983

SUMMARY OF WORKING GROUP P3, EXPERIMENTAL TOXICOLOGY AND CYTOGENETICS*

This summary report examines those aspects of experimental toxicology and cytogenetics relative to the long-term effects on human health of the herbicides and defoliants applied in South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement). Of particular concern here is the dioxin (TCDD; 2,3,7,8-tetrachlorodibenzo-para-dioxin) contaminant of Agent Orange, the major herbicide that was employed.

Cytogenetics

Vietnamese scientists, using standard non-banding cytogenetic techniques and sister chromatid exchange methods for investigations on chromosome aberrations, have reported an increase in chromosome aberrations and sister chromatid exchanges in adults directly exposed to herbicides and defoliants during the war in South Viet Nam as well as in their children. These people are still living in the sprayed area. A control group was selected from South Viet Nam. The research was performed on the peripheral blood.

The abnormalities reported include chromatid breaks, chromosome breaks, translocations, and polyploid cells. Some of these are rarely seen in human beings, especially the ring chromosomes, translocations with quadriradial figures, and endoreduplications. These aberrations have been found many years after the chemicals had been sprayed. According to the Vietnamese scientists, aberrations similar to those they described have also been reported for victims of radiation exposure in Japan following the dropping of the two atomic bombs. And the Vietnamese scientists believe that their findings indicate that there has been a long-term health effect on the victims of the wartime herbicide exposure.

The above information has been extended by other Vietnamese scientists who reported an increase in chromosome aberrations in spermatogonia and primary spermatocytes caused by 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) in *in vivo* tests on white mice (*Mus musculus*).

Members of the working group discussed papers on dioxin that indicate a lack of mutagenicity in fruit flies (*Drosophila melanogaster*) and, using the Ames test, in bacteria; but the presence of mutations when the dioxin was tested in a mammalian cell transformation assay.

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* During the course of the Symposium Working Groups P3 and P4 were combined in a formal sense, but functioned largely as two *de facto* groups.

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In the opinion of the working group, the cytogenetic investigations reported by the Vietnamese scientists are certainly interesting, but because of the controversial nature of the published literature on the subject further studies by additional laboratories are needed.

Toxicology

A member of the working group presented evidence on the carcinogenicity of dioxin in rodents. This study, considered alongside the five or so already published in the scientific literature, indicates that there is now sufficient evidence to class dioxin as a carcinogen in a number of animal species. It is not yet clear, on the other hand, whether dioxin acts directly or indirectly to cause cancer. However, the information presented here on the mutagenicity of dioxin in a cell transformation assay suggests that this chemical is an initiator and can cause cancer. Evidence was also presented for the carcinogenicity of the herbicide 2,4,5-trichlorophenoxyethanol in rodents.

A member of the working group presented evidence for the toxicity of herbicides in fruit flies. 2,4-D (2,4-dichlorophenoxyacetic acid) was toxic at a level of 1000 milligrams per kilogram (ppm) whereas 2,4,5-T was toxic at a level of 300 ppm. The toxic effects included total failure of the life cycle of the fly at these doses; and a proportionate survival at lower doses, with a developmental delay which was not teratogenic, but which caused changes in the duration of the life cycle, the sex ratio of the emergent population, and the time of maturation. They also included behavioral modifications in the choice of media for egg laying. Media free of herbicides were preferred for egg laying over those containing 2,4-D, 2,4,5-T, or a mixture of the two. The dioxin content of the 2,4,5-T employed in these studies was not known.

The mode of action of the chlorinated pesticides, polychlorinated dibenzofurans, and dioxins was discussed with reference to their action in the liver. Chemical warfare agents in general were reported to have delayed toxic effects in humans and it was suggested that a considerable research effort was required to find out more about this problem. In particular, it was suggested that workers employed in the manufacture of chemcial weapons be studied for any long-term health problems.

Recommendations

The working group would like to see: 1. more *in vitro* studies using eukaryotic organisms with different doses of herbicides in order to determine different frequencies of chromosome aberrations and gene mutations; 2. continued monitoring of the Vietnamese population exposed to the wartime herbicides in order to detect any mutagenic or carcinogenic effects in this and and subsequent generations; and 3. cooperation among laboratories on an international basis in order to facilitate this work.

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SUMMARY REPORT OF WORKING GROUP P4, DIOXIN AND RELATED CHEMISTRY*

This summary report examines those aspects of the chemistry of dioxin (TCDD; 2,3,7,8-tetrachlorodibenzo-para-dioxin) and closely related compounds relative to the long-term effects on human health of the herbicides and defoliants applied in South Viet Nam during the Second Indochina War of 1961-1975 (the details of which are summarized in the accompanying Background Information statement). The dioxin was a contaminant of Agent Orange, the major herbicide that was employed.

According to official U.S. figures, 44 million liters (57 million kilograms) of Agent Orange were expended containing 22 million kilograms of 2,4-D (2,4-dichlorophenoxyacetic acid) and 24 million kilograms of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid); 20 million liters (25 million kilograms) of Agent White were expended containing 5 million kilograms of 2,4-D and 1 million kilograms of picloram (4-amino-3,5,6-trichloropicolinic acid); and 8 million liters (11 million kilograms) of Agent Blue were expended containing 3 million kilograms of cacodylic acid (dimethylarsinic acid; of which almost 2 million kilograms was elemental arsenic). In addition to these herbicides and defoliants, the U.S. also expended some 9 million kilograms of the harassing agent CS (ortho-chlorobenzalmalononitrile). These amounts cannot be independently verified and some believe that they may be higher.

The herbicides and defoliants were sprayed onto at least 1.7 million hectares (and the harassing agent over perhaps an additional 3 million hectares). The concentration of herbicides and defoliants used varied from 15 or 20 kilograms per hectare up to 300 kilograms per hectare in unusual circumstances (with the average being about 30 kilograms per hectare).

Derived from information released by the USA, the Agent Orange and its analogs contained about 170 kilograms of dioxin. Some participants in the working group agreed that this amount of dioxin was approximately correct. Based on analytical data from samples left over from the spraying program in South Viet Nam and the amounts of 2,4,5-T produced in different factories in different years and subsequently sprayed, they also arrived at a total figure of about 170 kilograms. However, a majority of the working group came to the conclusion, based on some published data, that the total amount of dioxin was greater than 500 kilograms.

The working group suggested that owing to the high toxicity of the 2,3,7,8-TCDD isomer of the dioxin group and the large variation in toxicity

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among the different dioxin isomers, the analytical method used in dioxin analyses should have: 1. good reproducibility; very high sensitivity (in the 10^{-12} gram range); and 3. the ability to allow the quantification of specific isomers, especially of the 2,3,7,8-TCDD isomer.

To date, 2,3,7,8-TCDD has been found in several different types of samples, such as soil, sediment, vegetation, fish tissue, mammalian tissue, and bovine milk; and also in human milk, blood, liver, kidney, and adipose samples.

Although 2,3,7,8-TCDD is the major impurity found in Agent Orange, it should be pointed out that other dioxins such as 1,3,7,8-TCDD, 1,3,6,8-TCDD, 1,3,7-tri-CDD, 2,7-di-CDD, and 2,8-di-CDD have also been reported, together with a series of dibenzofurans.

Dioxins have also been found in other technical products. Of special interest is the existence of 1000 milligrams per kilogram (ppm) of TCDD isomers in diphenyl-ether herbicides used in rice fields. The major isomers here are 1,3,6,8-TCDD and 1,3,7,9-TCDD, but other isomers have also been identified. On the other hand, the 2,3,7,8-TCDD isomer has not been found here.

The working group discussed the matter of secondary formation of dioxin after phenoxy herbicide spraying via photochemical or pyrolytic reactions. The environmental situation is very complex. However, experimental data do not indicate any extensive secondary formation of dioxin as it relates to the Viet Nam situation. Although the burning of 2,4,5-T salts results in the formation of some TCDD, the 2,4,5-T in Agent Orange was a butyl ester formulation.

A series of experiments has demonstrated the bio-availability of dioxin in soil and sediments. It is therefore recommended that tissue samples from both terrestrial and aquatic animals be analyzed for dioxin.

The degradation of dioxin in soil is very slow. A half-life in soil of greater than 10 years has been reported.

The metabolism and/or excretion of dioxin in primates seems to be quite slow. The half-life in primates appears to be about 1 year. However, in small rodents the degradation is reported to be much faster.

Analysis for the dioxin content of the parent phenoxy herbicide can be carried out by standard methods of high-resolution gas chromatography (HRGC). However, the presence of trace levels should be confirmed by an additional technique such as mass spectroscopy.

Regarding Agent Blue, the working group noted that for the analysis of arsenic, atomic absorption and X-ray spectroscopy are the methods with the best sensitivity and reproducibility.

Recommendation

The working group is aware of only two analytical dioxin studies of samples from Viet Nam. In the first, fish and crustacean samples collected in South Viet Nam in 1970 were found by R. Baughman & M. Meselson (1973) to contain up to about 800 nanograms per kilogram (ppt) of dioxin. In the second, a recent study by K. Olie, small amounts of dioxin (up to 30 ppt) were identified in soil and sediment samples collected not long ago in South Viet Nam. The working group recommends further analyses of critical samples of soil, sediments, fish and other aquatic animals, human milk, and human tissue samples. The first phase of such a project should include a brief screening of "grab samples", followed by systematic sampling under the aegis of an international organization such as the United Nations Educational, Scientific, and Cultural Organization (UNESCO), United Nations Environment Programme (UNEP), or World Health Organization (WHO). After coding, the test samples, together with control samples, should be sent in a "round robin" study to a number of different analytical laboratories in, for example, Amsterdam, Hanoi, Ho Chi Minh City, Lincoln (Nebraska, USA), and Umeå (Sweden).

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N.B.: Please be sure to bring any errors in this list to the attention of Prof. Arthur H. Westing (SIPRI, Bergshamra, S-171 73 Solna, Sweden; telephone 8/55 97 00) as soon as possible.

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THE LONG-TERM EFFECTS ON MAN AND NATURE
HO CHI MINH CITY, 13-20 JANUARY 1983

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