BRAIN STORMING SESSION

ON

USE OF ENDOSULFAN FOR THE CONTROL OF TEA MOSQUITO IN CASHEW

on 16 August 2001

at the
Kerala Agricultural University
Vellanikkara, Trichur

KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA 680 656, TRICHUR

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SUMMARY

The Plantation Corporation of Kerala (PCK) was following aerial spraying of endosulfan during the last two decades in more than 5,000 hectares of cashew plantations spread in different villages of Kasaragod and Kannoor Districts of Kerala for the control of tea-mosquito bug in cashew, which is a major pest of the crop. Recently, reports appeared in the media on the occurrence of abnormalities, mostly related to central nervous system in human beings, in Padira Village of Kasaragod District. Some of the reports implicated the aerial spraying of endosulfan as the suspected cause of the reported health problems (mental retardation, epilepsy, congenital abnormalities, psychosis, cancer, skin diseases, headache, etc.)

Endosulfan is a cyclodiene compound belonging to the family of organo-chlorine pesticide. It is an efficient contact insecticide capable of controlling a variety of insects and pests. It has been used for the control of tea-mosquito bug in cashew since early 1980s. It is relatively harmless to natural enemies as well as beneficial insects and therefore often used as a component in integrated pest management programmes. However, it is highly toxic to fish. As per reports, endosulfan is rapidly degraded mainly into water-soluble compounds and eliminated from the gastrointestinal tract in human beings. It is moderately persistent in soil with a reported average half-life of 50 days.

Inspite of the reported low toxicity of this insecticide to human being at the recommended level of application, the continued appearance of reports on health hazards from Padira Village of Kasaragod District compels the scientific community to examine the possibility of endosulfan as a cause for the alleged health problems. It is also likely that aerial spraying of insecticides in an area where the canopy height is not uniform (as in the case of PCK plantations) and people reside nearby may not be ideal due to the possible drift and consequent contamination of the surroundings. However, it is astonishing to note that the reported abnormalities occurred only in one village while the insecticide spray was being followed in a wide network of plantations situated in many villages.

The Honorable Minister for Agriculture, Govt. of Kerala while addressing the Agricultural Research Organizations of the State during the Subject Committee Meeting held on 16th August 2001 at the Legislative Complex, Trivandrum urged that the scientific community of the State should look into the seriousness of the alleged reports and evolve necessary recommendations in the context of the reports appeared in the media. In this back drop, the Kerala Agricultural University held a brain storming session on the use of endosulfan as an insecticide for the control of tea-mosquito bug in cashew on 16th August 2001 at the Seminar Hall of the Central Library of the University at Vellanikkara, Trichur.

During the seminar, status papers were presented on the chemistry, toxicology, environmental impact and alternatives of endosulfan for the management of the tea-mosquito bug in cashew. The seminar was attended by a total of 31 scientists from the Kerala Agricultural University, National Research Centre on Cashew (ICAR), Central Plantation Crops Research Institute (ICAR), Directorate of Cashewnut and Cocoa Development (GOI) and Spices Board (GOI).

ENDOSULFAN CONTROVERSY, MYTHS AND REALITIES-A STATUS PAPER

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Abstract

An attempt was made to investigate the myths and realities behind the Endosulfan controversy reported from Padre village of Kasaragodu district. The Kerala Agricultural University did two investigations. Aerial spraying with any form of chemical insecticide in this area cannot be justified. Data were insufficient to fix the cause of the problem on Endosulfan. Plantation Corporation of Kerala should rationalize its plant protection operations in cashew plantations on more scientific grounds. There exist unusual health hazards in Padre village and the cause is unknown. A medical team should conduct a detailed health survey in order to enumerate the cases and find out the nature of clinical problems. To identify the cause of the health hazards, a multi disciplinary research group involving medical doctors, agricultural scientists and environmental scientists should launch a detailed study. Levels of pesticide residue on biological and environmental samples, the quality of the drinking waters, possibility of heavy metal contamination (Mercury, Lead, Arsenic and Cadmium) in food chain, fluorine toxicity, background radiation, genome history, nutritional and dietary habits etc., needs investigation.

The author is associated with investigations on the Endosulfan controversy of Kasargodu district, as leader of Kerala Agricultural University (KAU) scientific team twice, and as a member of the Expert team constituted by GOK, to investigate this issue. There exist considerable confusion among the public on various aspects of this issue. In this context, it was felt appropriate to compile and present the information gathered during our investigations for the public. The information gathered so far is grouped under the following headings.

Reported problem
Sensation in the media
About Tea Mosquito Bug
About Endosulfan
About aerial spraying
Investigations done so far on the problem
Suspected causes of the malady
Conclusions

1. Reported problem

Plantation Corporation of Kerala (PCK) was following aerial spraying of Endosulfan, for the last 20 years in their 5200 ha of cashew plantations spread over 20 villages of Kasargodu and Kannur districts.

Wide spread health problems are being reported from Padre village of Kasargodu district, where aerial spraying was followed over years. These health problems (mostly Central Nervous system related) are reportedly due to aerial spraying of Endosulfan. But similar problems are not reported from any other aerial sprayed villages of Kasaragodu district , except Periya. The Health disorders reported from Padre include *Mental retardation, Epilepsy, Deformed births, Cancer, Headaches, Dizziness, Cerebral palsy, Skin lesions, Congenital anomalies etc.*

The composition of the cases reported from Padre village is as follows

Cancer (living)	- 3
Cancer (dead)	- 46
Mental retardation	- 23
Psychic cases	- 43
Epilepsy	- 23
Bone handicapped	- 9
Suicide	-9

2. Sensation in the media

Media has done excellent job to sensationalize this issue in a big way. "Children of Endosulfan" (Down to earth, February 28,2001) , "Spray of misery " (India Today, July 23rd, 2001), Cashews for human life (The Hindu, July 23, 2001), etc. are a few examples. Print and electronic media competed each other, which created panic among the public. It was alleged that Endosulfan is the root cause. Some of the photographs appeared in the print media are shown as Fig. 1 to 3.

3. About Tea Mosquito Bug

Tea mosquito bug (TMB) is one of the most notorious pests of cashew that causes 40 to 80 percent yield reductions (Fig. 4). In severe cases, TMB can cause yield reduction up to 100 percent. To control TMB, Kerala Agricultural University recommends three ground sprayings with Quinalphos 25EC during flushing (Oct – Nov), Endosulfan 35 EC during flowering (Dec-Jan) and Carbaryl 50WP at tender nut formation (Jan-Feb) stages.

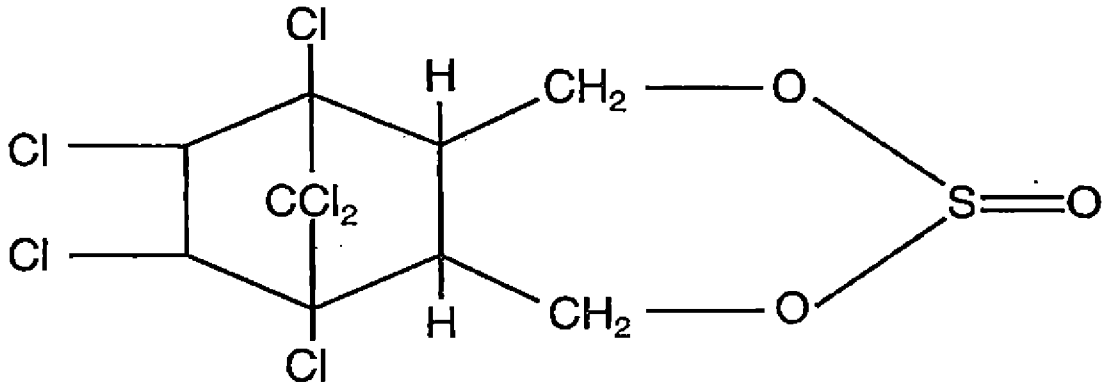
4. About Endosulfan

World Health Organization classified it as **sulfurous** ester of a chloride cyclic diol. Some of the reported chemical properties of Endosulfan are as follows.

Trade name	: Endocel
Common name	: Endosulfan
Chemical name	: 6,7,8,9,10,10- hexachloro-1, 5,5a, 6,9,9a- hexahydro-6,9- methano- 2,4,3- benzodioxathiepin - 3- oxide
Structural formula	: $C_9H_6Cl_6O_3S$
Molar mass	: 406.9
Density	: 1.745 g/ cm^3
Alpha to beta isomer ratio	: 70 to 30
Solubility	: Virtually insoluble in water (0.32 ppm)
Mode of action	: Contact action, stomach action and mild fumigant action
LD50	: oral-110mg/kg body weight and dermal-74-130mg/kg body weight
Half-life	: 50 days

Endosulfan when applied gets adsorbed and retained in soils. Endosulfan is toxic to fish, safe to honey bees and rapidly degrade into water-soluble compounds. It gets eliminated in mammals within few weeks. Photo degradation of Endosulfan is fast (in 4 weeks). In strong alkaline conditions it degrades very fast (1/2 life 1 day)

Endosulfan structure



Reports are available revealing the toxicological danger of Endosulfan. Reports are also available projecting Endosulfan as a safer insecticide. A few reports in this connection are indicated below.

37 people died due to Endosulfan poisoning in Benin. It is further reported that the death is due to eating Maize and Cassava contaminated during pesticide transport, reuse of pesticide cans for packing foods, inhalation during spraying etc. (Pesticide news March 2001 (47) P 12-14).

Endosulfan residues on cowpea reach below the maximum residue limit of 2ppm with in 4 days (*Naseema Beevi et al., 1995*).

Among 8 insecticides field-tested Endosulfan proved to be least disruptive to honey bees (*Rathore et al., 1997*).

Endosulfan can be considered as an environmentally sound insecticide for use under subtropical conditions (*Trilochan, 1997*).

Endosulfan has no carcinogenic potential, the chronic toxicity and carcinogenocity study gave no indication of any oncogenic potential of Endosulfan in rats and mice (*Hack et al., 1995*).

Waiting periods of certain insecticides

Following are the waiting periods reported for Endosulfan and certain other insecticides, for vegetables.

Endosulfan	: 7 days
Monocrotophos	: 15 days
Carbaryl	: 12 days
Quinalphos	: 15 days

Countries in which Endosulfan is in use

60 countries including USA, Australia, Japan, France, Israel, Korea, China and Thailand use Endosulfan as a pesticide in Agriculture. It is reported that the global consumption of Endosulfan is in the order of 50 million litters and India consumes about 10 million litters.

Certain countries have banned the use of Endosulfan due to health reasons. It is argued tha there is no insecticide, which is universally accepted for use.

Endosulfan use is largely confined to field crops like cotton, vegetables, pulses and plantation crops like tea, cashew etc.

Following are certain crops recommended with Endosulfan for pest control.

Cashew	:0. 05%
Cotton	: 0.07%
Coconut	:0.05%
Oil palm	:0.20%
Cardamom	:0.10%
Pepper	:0.05%
Tamarind	:0.20%
Cocoa	:0.05%
Tobacco	:0.05%
Coffee	: 1.7 ml/ litre
Tea	
Rice	
Colocasia	

5. About aerial spraying

Kerala Agricultural University so far has not recommended aerial spraying for any crops in the state. But it is understood that PCK adopts aerial spraying in cashew as detailed below.

For 1 ha : 750 ml of Endosulfan + 23 liters of water (aerial spray)

Precautions necessary during aerial spraying

- Regulate height of helicopter 2 - 3 m from the canopy to avoid drifts
- Stop spraying 10 m ahead of border
- Cover water bodies
- Spray in the morning or evening to minimize drift.

6. Investigations done so far on the problem

Various Government organizations and Non Governmental Organizations (NGO) have done preliminary studies on this issue and came out with conflicting reports. A few such organizations are

a. Centre for Science and Environment (CSE), New Delhi (NGO)
b. Kerala Agricultural University (Autonomous)
c. Plantation Corporation of Kerala (Autonomous), with the help of Fredrick Institute of Plant Protection and Toxicology (FIPPAT), Chennai

a. Results of CSE study

CSE report appeared in the magazine *'Down to Earth'*, 28 February 2001, created considerable sensation, as the residues of Endosulfan reported in water, human blood and other environmental samples were very high (Table1). The validity of the report is questioned by many on technical grounds.

Dr. H.K. Handa an eminent scientist questioned the report. He states that The Procedure looks biased and Values look unbelievable (Agriculture today June 2001 P 6-7). Dr. Handa further states that *the study is contradictory in itself and the results obtained are highly questionable. The CSE approach is to present the situation in Kerala in a pseudo – scientific way with motive to get the product banned in the country*

Dr. EVV. Bhaskara Rao, Director, National Research Center for Cashew (ICAR), Puttur writes regarding the Endosulfan theory as follows.

In his paper entitled *First convict the suspect and later conduct the trial*, Dr. Rao states that *There is no way to justify the CSE conclusions that only Endosulfan spray is responsible for the deformity reported. There should be more intensive research to find out the cause of the malady in Padre village. May someone help us to understand the phenomenon and motives behind the publicity.*

b. K A U study

Kerala Agricultural University conducted a preliminary study during February 2001. Two teams, involving scientists from different disciplines of the university were sent by Kerala Agricultural University, first during February 2001 and second during August 2001, with the following scientists, to investigate on the problem.

Dr. M. Abdul Salam, Associate Professor & Head, Cashew Research Station Madakkathara (Team leader)

Dr. Samuel Mathew, Associate Professor, Chemist i/c of Analytical Lab, Aromatic and Medicinal Plants Research Station, Odakkali, Ernakulam District

Dr. Naseema Beevi, Associate Professor (Entomology) and Head, AICRP on Pesticide Residues, College of Agriculture, Vellayani, Trivandrum

Dr. Susannamma Kurien, Associate Professor (Entomology), Cashew Research Station, Madakkathara

Dr. Gopakumar, Associate Professor (Pharmacology), College of Veterinary and Animal Sciences, Mannuthy

Dr. Ranjith, Associate Professor (Entomology), College of Horticulture, Vellanikkara

Dr. Sreekumar, Assistant Professor (Entomology), College of Agriculture, Padannekkad

Dr. Thomas Biju Mathew, Associate Professor (Entomology), AICRP on Pesticide Residues, College of Agriculture, Vellayani, Trivandrum

Dr. Maicy Kutty, Associate Professor (Entomology), College of Horticulture, Vellanikkara

The team visited the area, met the persons reported to be affected due to aerial spray, collected and analyzed few environmental samples and submitted reports.

The problems faced during the study are

- Panic stricken people
- Continuous sensation by media
- Over action and enthusiasm by environmentalists
- Non availability of quick method to assess residues
- Involvement of too many organizations
- Incidence of a number of health hazards
- Absence of scientific health survey
- Probable damage to export prospects of cashew

Opinion differed among villagers on the cause. Two types of arguments exist; One group believed that this malady is due to Endosulfan. Another group believed otherwise. The affected persons are mostly economically backward. The health problems are less/ absent, in the affluent group.

KAU team during the first visit collected 15 environmental samples (Soil, Plant, Well water, Rivulet water, Black pepper, Betel leaf and Butter) and subjected to residue analysis following standard procedures.

Residue level in environmental samples (K A U 2001)

	Samples	Residue
Water	: 5	Nil
Pepper berries	: 1	Nil
Betel leaf	: 1	Nil
Soil	: 5	0.05 – 3.8ppm
Cashew leaves	: 3	0.5 0– 0.8 ppm

Results: No evidence was obtained to relate Endosulfan from the 15 samples. But Kerala Agricultural University did not draw definite conclusions based on the results

K AU recommendations

From the preliminary studies conducted (after analyzing the samples, studying all possible aspects and having discussed with the villagers, Government officials and others concerned), the following recommendations were made.

1. *It is difficult to make any conclusion either in favour of or against the argument that Endosulfan causes health problems. It is essential that a multi disciplinary expert group (medical, agricultural and environmental scientists) investigate on the various aspects.*

2. *In view of the topographical disadvantages, more number of water bodies and high degree of inhabitation in the adjoining areas of the cashew plantation, it is necessary to stop aerial spraying.*

3. *The PCK should rationalize the PP operations in cashew in a more scientific manner.*

Subsequently, at the instance of the Minister of Local Administration, GOK, an 8 member Kerala Agricultural University team visited the area during August 2001, to assess the situation. The recommendations of the second team are as follows.

a. *It is evident that there exist some unusual human health hazards in the Padre village. But the cause effect relationship is yet to be established.*

b. *The Director of Health services may conduct a detailed health survey immediately in this area, in order to enumerate the cases and to find out the nature of clinical problems.*

c. *Most of the sufferers are economically backward persons. Therefore, it is quite justifiable that the Government provides free medicines and special medical care to these innocent people.*

d. *Since the cause of the problem could not be established, it is necessary to conduct a more detailed study involving scientists from different disciplines and organizations in order to identify the factors responsible for the maladies in this area. For this purpose a pilot project proposal entitled* ***Cause analysis of Human Health Hazards in Padre Village of Kasaragodu district.***

c. PCK studies (FIPPAT)

PCK sponsored a study, with the help of FIPPAT to know the insecticide residue levels in the human and environment samples, in the context of CSE report. Unfortunately, when the researchers approached the people of Padre village for samples, the members of the Endosulfan spray Protest Action Committee (ESPAC) prevented them from drawing samples. They collected samples of water, fish, milk, human blood, soil and cashew leaves from the other aerial sprayed villages and subjected them to residue study. Human blood samples from control area was also collected for comparison. The results of the PCK study are given below.

Residue level in biological and environmental samples.

	Samples	Residue
Water	: 36	Nil
Fish	: 1	Nil
Milk	: 1	Nil
H Blood	: 106	Nil
H Blood (C)	: 6	Nil
Soil	: 29	0.001 –0.012ppm
Cashew leaves	: 28	0.04– 2.863 ppm
	207	

Result: Endosulfan is not present in human blood, water, fish and milk samples. However, residues were noticed in soil samples and cashew leaves.

From the studies conducted so far, it is clear that there exist some unusual human health problem. But the cause effect relationship is yet to be established. The following aspects need detailed examination to draw meaningful conclusions.

Contradictions and non reliability of CSE data
Non occurrence of problem in the other sprayed areas of PCK plantations
Problem restricted to poor people.
Difference of opinion among villagers
Problem associated to persons using SURANGA waters
Suspicion on quality of SURANGA waters
Experience with Endosulfan in other crops including vegetables
Probability of heavy metal toxicity through food chain, particularly water
Possibilities of Background radiation (Ullal, a nearby place is radiation prone)

The data generated so far suggests that more intensive study is necessary either to support or to dispute the Endosulfan theory. It is essential that the cause of the health hazards is identified.

The questions that remain unanswered are-

What are the motives behind the sensation in the media?. Will the present level of sensation help to minimize the pains of the innocent victims?. Will it not seriously affect the export prospects of our precious agricultural commodities like cashew and spices?. What is needed now is to identify the cause of the problem using science and technology.

THE TRUTH

The poor people of padre village are innocent
The cashew as well
The health problem is real
The cause is unknown

7. Suspected causes of the malady

SUSPECTED CAUSES	
Endosulfan	????????????
Suranga waters .	????????????
Heavy metal contamination in food chain (lead, Mercury, Arsenic, and Cadmium.)	????????????
Fluorine toxicity	????????????
Background radiation	????????????
Microbial contamination in water	????????????
Poor nutritional status and dietary habits	????????????
Genome history (inbreeding effects	????????????
Others if any	????????????

8. **Conclusions:** May someone help us to understand the causes of the problem?

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Figure 1

Narayan Naik (20) Growth retarded 3 feet height , Skin disorders

Shruthi (7) born with 3 deformed limbs

Figure 2

Avinash is also ca
cerebral palsy, as
neighbouring tar
Combined monit
walk at the age
began having e
Karnataka. It d
We can't buy
his condition

A day later, they were terribly excited. The health effects of endosulfan

Avinash (10) Cerebral palsy, asthma,epilepsy

Mathrubhumi,
The National
Daily in
Malayalam

RK

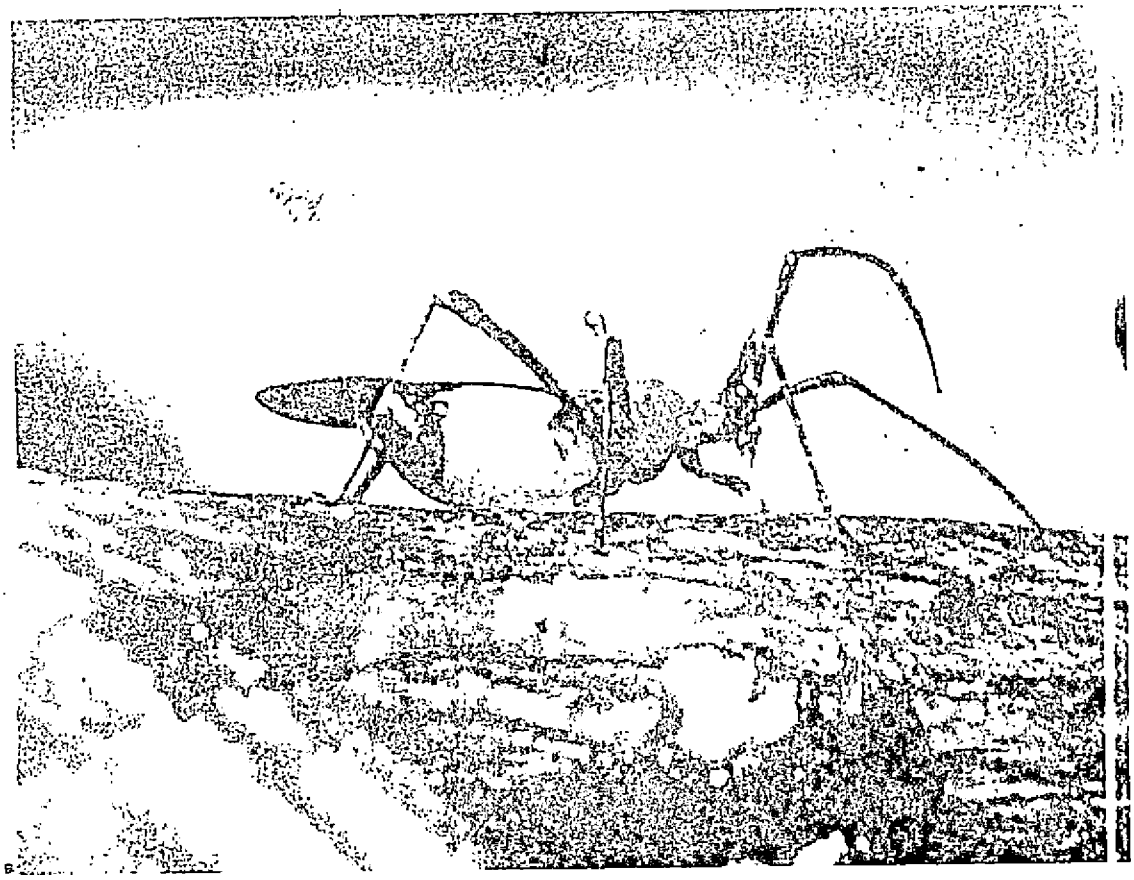
Sainaba (8 m) swollen head

Figure 3

Kittanna (21) cerebral palsy
Sridhar (brother) mental retardation

Cashews for human life?

Figure 4



Tea mosquito bug

Cashew damaged by tea mosquito

Table1

Sample	Detected value of endosulfan	Maximum residue limit (MRL)	Number of times value exceeds MRL
Water	1.18	0.8	7
Water	6.87	0.18*	38
Water	9.19	0.18	51
Butter	14.00	NA	NA
Cow's skin/fat tissue	49.99	0.1	500
Cow's Milk	31.80	0.5	64
Cow's Milk	57.20	0.5	114
Coconut oil	17.00	NA	NA
Cashew	54.11	NA	NA
Vegetables	31.24	0.4-2.0	78-16
Human Milk	22.40	NA	NA
Human Blood	108.90	NA	NA
Human Blood	114.13	NA	NA
Human Blood	115.19	NA	NA
Human Blood	109.50	NA	NA
Human Blood	196.47	NA	NA
Human Blood	176.90	NA	NA
Live Frog	10.35	NA	NA
Cashew	3.74	NA	NA
Spices	212.28	NA	NA
Fish	28.24	NA	NA
Soil	35.16	0.09*	391
Soil	3.17	0.09*	35
Soil	6.40	0.09	71
Cashew leaves	6.52	NA	NA

Note: All figures in parts per million (ppm). ... levels of endosulfan sulphate were

CSE data-Down To Earth,28th February2001

First Convict the Suspect and Later Conduct the Trial

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Director
National Research Centre for Cashew
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India

This title was chosen as it very aptly sums-up the present controversy of endosulfan spraying on cashew plantations in the Padre village in northern Kerala. Since about six months, series of reports have appeared in the print media and also some are floating on Internet on the "devastation and misery" caused on the population in Padre village in northern Kerala by "spraying of endosulfan" to protect cashew plantations from the infestation of a serious pest "Cashew Tea Moquito Bug (TMB)".

All the reports carried photographs of same set of unfortunate children born with physical deformities – "congenital anomalies". McGraw – Hill Encyclopedia of Science and Technology defines congenital anomalies as "Birth defects may be inherited or produced by external factors, however, the CAUSE OF MOST ANOMALIES IS UNKNOWN" (Vo.4 Page 325 6th edition). Further, while dealing with etiology of these anomalies states "some are genetically controlled, some are caused by environmental insults and other reflect interactions of genetic background and external agents. For most human anomalies "it is not possible to identify the causative mechanism". Not so for the anomalies noticed in Padre Village. All the reports unequivocally confirm that the causative agent is "Endosulfan". The very titles of reports – "Children of Endosulfan" (Down to Earth, February 28, 2001), Spray of Misery (India Today, July 23, 2001), Cashews for human life (The Hindu, July 23, 2001) and host of other vernacular reports in Malayalam and Kannada papers substantiate the causative agent as "Endosulfan". Well the suspect is already found and "confirmed"! First sentence it, evidence and proof can be found out later..... appears to be the pulse.

Now let us look on the case details. The research conducted by the plantation crop scientists in early 70's came out with the conclusion that endosulfan is the best insecticide chemical for saving the cashew crop from the dreaded pest TMB. In order to facilitate timely application in

large areas, based on the trials conducted it was found that aerial spraying is the best and economical for large plantations. When the recommendation was given on this aspect for taking up the spraying by Plantation Corporation of Kerala and other corporations like, Karnataka Cashew Development Corporation, Andhra Pradesh Forest Development Corporation, Orissa State Cashew Development Corporation etc. only the Plantation Corporation of Kerala was regular in taking up the aerial spraying while the rest took up aerial spraying on and off.

Recently, a number of media reports appeared implicating that the endosulfan spraying was responsible for the deformed births, epilepsy, cancer, cerebral palsy and host of many other ailments in Padre village and on the manifestation of toxic effects of endosulfan residues. Even the suicides committed in this village were implicated for the spraying. Even before these recent reports, much earlier in 1997, Dr. YS Mohana Kumar, a doctor practicing in the village brought this unusual occurrence of high proportion of congenital deformities in an article in Kerala Medical Journal. He states "I feel the root of the problem lies in the water itself which might contain a mineral or radioactive substance which is harmful to the brain". The recent report in Hindu Magazine mentions that Shree Padre a progressive farmer, way back in 1931 noticed that "something was very wrong in this area". All these cases numbering about 197 are reported to be from 123 houses. Except the report which appeared in Down to Earth, by Centre for Science and Environment (CSE), there are no other reports indicating such high values of endosulfan residues from anywhere.

However, the report published on endosulfan has many contradictions including questionable procedure adopted in conducting these tests. An eminent scientist, Dr. S.K.Handa has published an article "Report on Endosulfan – Deviation from truth" (in Pesticides Agriculture Today, June 2001) wherein he questions the very objective of this study by saying "The study is contradictory in itself and the results obtained are highly questionable. It appears that the CSE approach is to present the situation in Kerala in a peudo-scientific way with a motive to get the product banned in the country".

Now coming to the studies undertaken by Centre for Science and Environment scientists', the procedure adopted certainly looks biased. In any of the studies of this nature, the most logical option would be to collect random samples from the people including both healthy and affected and analyze them after coding the samples and try to correlate the residues with maladies. But residue level reported in water, butter, cow's milk, coconut oil indicate the possibility that almost every person in Padre village should have residues in their blood samples and these are most common item which are consumed by every person. Further it is possible that even persons in neighbouring village who consumed milk from Padre village must have been affected by residues in milk as even the "stall fed cow milk" was

reported to be having the endosulfan residues. Probably this could be the reason for Dr. Handa's comments "it appears CSE approach to the present situation in Kerala in a pseudo-scientific way with a motive to get the product banned in the country". The intention is not to find only faults in the results reported by Centre for Science and Environment. It is very clearly mentioned in one of the earlier communication that "environmental protection and human safety should also receive equal if not more attention over simple economics". Therefore, while the deformities reported are certainly alarming, the conclusion drawn on the effects of endosulfan residues are still to be validated scientifically.

Now let us deliberate on the various implications of the reports and possible surmise one can arrive at. The statistics say that over 1.9% of the population (i.e. 16.5 million people) are handicapped through congenital defects in India. If the endosulfan is the only culprit in inducing congenital deformities which are reported in Padre village and what could be the reason for high proportion of defects in Indian population. There is no way to justify the conclusion that only endosulfan spray is responsible for deformities as reported.

The second aspect which also needs attention is as per the Centre for Science and Environment reports, the samples collected from the village such as cow's milk, coconut oil, vegetables contain residues in a very large proportion. If so, the whole of the village population must have been exposed to these products as it is common to presume that the people would have consumed the milk, vegetables and water. Then, why only few people from 123 houses only were affected while others are free from these ailments. Normally in the food poisoning reports in the media like illicit liquor cases or food poisoning in the functions, almost all the people who have consumed the contaminated materials are reported to be affected.

One important aspect which needs to be looked into is the status and structure of the population in this village. Many of the people who are affected with these maladies are reported to be related to each other, socially backward and economically poor, as per the reports which appeared in the media. The possibility of inbreeding by marriage between close relatives in these families over a period of time also could have contributed to the congenital defects and passed over to present generations. Ms. S. Usha, Research Associate with INTACH who conducted a survey among 250 families in this area may be able to throw more light on the inbreeding aspect which may be responsible for infertility, regular miscarriages and hormonal problems which she noticed in some village families.

The third consideration which also should be looked in to is the possibility of use of prohibited drugs (medicines) during the initial stages of pregnancy which is also reported to result in birth defects. Dr. YS Mohana Kumar who has been practicing in this region for a number of years may be able to enlighten on the medical history of these people.

The scientific reports available on residues of endosulfan are reproduced below:

I. "endolsulfan residues on cowpea reach below the maximum residue limit of 2 ppm within 4 days" (Naseemia Beevi and others 1995)

II. "endosulfan can be considered as an environmentally sound insecticide for use under subtropical conditions" (Trilochan 1997)

III. "Among eight insecticides field tested endosulfan proved to be least disruptive to honey bee (Rathore and other 1997)

IV. "endosulfan has no carcinogenic potential, the chronic toxicity and carcinogenicity study gave no indication of any oncogenic potential of endosulfan in rats and mice (Hack and others 1995).

V. Endosulfan is not highly persistent in the environment. For most of the fruits and vegetables 50% of the residues are lost within 2-7 days. In animals endosulfan is metabolized and excreted in urine and does not accumulate in milk, fat or muscle (Kidds and James, the Agrochemical hand book 1991).

VI. "No genotoxic activity was observed in an adequate series of tests for mutagenecity and clastogenecity in vitro and in vivo (Pesticide Residues in Food - Report of the 1998 joint FAO/ WHO meeting of experts)

Well how do we conclude now in the light of above reports. Can we out- rightly reject either the reports appeared on endosulfan in our media or the above listed reports. The logical synthesis will indicate that there should be more intensive scientific enquiry in what actually is the cause for maladies in Padre village. Drawing conclusions on premises and presumption can only create controversy and but not give a solution. Some of the catching captions can even cause considerable damage also. For example the report in The Hindu "Cashew for Human Life" can scare away the importers from Indian cashews for no fault of cashew. None of the reports from experts on pesticides residues contain any reference to presence of endosulfan residues in cashew kernels. As mentioned in the beginning the etiology of congenital defects is still to be understood properly. Let us understand clearly the problem first. The deformities in Padre village is a fact which every one should accept but "cashew causing misery", "children of endosulfan" "spray of misery" are fantacies of individuals which in no way would help poor handicapped children of Padre except to parade them naked in print and visual media before the world.

Before,we sign off one nagging thought remains unanswered. Reports indicate that abnormalities were noticed first in 1981, in 1997 report of possible effect of radiation was aired but in both the instances very little publicity was given for these reports. Surprisingly, in 2001 there is a blitz in the media. May someone help us to understand the phenomena and the motive behind the wide publicity that has gained.

REPORTS ON ENDOSULFAN

Deviation from truth

The findings of the New Delhi-based NGO—the Centre for Science and Environment—of highly toxic levels of endosulfan in the blood samples of the people of Padre village, Kasargod district in Kerala have been challenged here by the author. He opines that the findings figuring in the media reports are spawning unfounded fears about the use of pesticides in agriculture.

There have been several reports in the media lately coming from Kerala linking endosulfan, an insecticide, to a variety of health problems. As one who has been involved for over three decades as a scientist in the field of the environmental impact of pesticides and residues, I cannot but regard the coverages on the pesticide with shock, as they would make the general public dread the use of pesticides in agriculture. The articles appearing in magazines and newspapers and reports of various seminars held by environmentalist groups and NGOs have become quite vociferous and critical on use of pesticides. It seems that often the informations they carry ignore the well-founded facts and draw erroneous conclusions while generating irrational fears in the minds of readers. This article is being written in the interest of propagation of authenticated informations that should help replace distorted or misleading informations.

Recently, in an emotive report released by a New Delhi based NGO, the Centre for Science and Environment, under the title of "The Children of Endosulfan", much information has appeared that is inaccurate and misleading.

Endosulfan has been registered for more than 45 years and is used in over 60 countries, including the USA, France, Japan, China, Australia, Korea and Israel which have highly sophisticated regulatory and re-registration procedures. In India, Endosulfan was registered by the Registration Committee after considering the data on biological efficacy, bioefficacy, residues on crops, metabolism and toxicity studies including carcinogenicity, mutagenicity, primary skin irritation, teratogenicity, toxicity to birds, honey bees, fish and to livestock when applied to a wide range of crops including rice, wheat, jowar, pulses, sugarcane, cotton, jute, maize, vegetables, coffee and cashew. The Pesticides Residue Sub Committee of Food Standards, Ministry of Health, has fixed maximum residue limits on fruits, vegetables, cotton and cottonseed oil. Entomologists regard endosulfan as an extremely useful product for its unique role in integrated pest management programme (IPM). IPM uses a range of tools, including the judicious use of crop protection products, to manage pests. A recent report from Australia says "Endosulfan is an insecticide which has been widely used for over 30 years. The agriculture industry and State Agricultural Authorities advise that endosulfan is extremely important to Australian Agriculture".

Endosulfan has been registered for more than 45 years and is used in over 60 countries. A recent report from Australia says "Endosulfan is an insecticide which has been widely used for over 30 years. The agriculture industry and State Agricultural Authorities advise that endosulfan is extremely important to Australian Agriculture".

ALLEGATIONS

The scientists working at the Centre for Science and Environment(CSE) have analysed the samples of soil, water, bovine milk, blood, butter, coconut oil, vegetables, fish and human milk collected from Padre village, Kasargod district in Kerala. Based on results on residues of endosulfan, they have made certain comments on the use of the product. However, I am afraid that the basic analytical method used by scientists of the CSE, for estimation of endosulfan, was not correct and properly standardised. Pesticides residue estimation consists of sampling, extraction, clean-up and estimation. The scientists after collection of samples and extraction treated the residues of endosulfan with concentrated sulphuric acid. It is a well known fact, referred to in literature, that endosulfan when treated with sulphuric acid,

gives diol and other secondary metabolites. So the scientists have not estimated the residues of endosulfan and consequently the results reported by CSE should be verified by an independent residue expert. The study is contradictory in itself and the results obtained are highly questionable. It appears that the CSE approach is to present the situation in Kerala in a pseudo-scientific way with a motive to get the product banned in the country.

Pesticides residue analysis is a complex and sophisticated job as they are to be detected at the nanogram and picogram levels. The presence of pesticides residues in food may have both important legal and commercial implications and, therefore, reproducibility, reliability and integrity of analytical data is of utmost importance. Normally, confirmatory tests are necessary before reporting adversely on samples containing residues of pesticides not normally associated with that commodity or where minimum residue limit (MRL) appear to have exceeded. In the report of the CSE, no confirmatory analyses have been published. I understand that the Centre for Science and Environment has started pesticide residues analysis very recently. The scientists working in the field of pesticides residues should be fully trained in modern methods of residue analysis at some good research institute having the capability of conducting modern analytical techniques.

Besides alleging presence of endosulfan residues in most environmental samples, the CSE report blames endosulfan for a number of health problems such as cancer, epilepsy and mental retardation. As recently as 1998, the FAO extensively reviewed the toxicological and epidemiological data of endosulfan and concluded that it is neither carcinogenic nor mutagenic and it does not cause allergies.

The Ministry of Agriculture, Department of Agriculture and Cooperation, Govt. of India constituted a high-power committee under the chairmanship of Dr. S.N. Banerjee, Ex. Plant Protection Advisor to Govt. of India, with 22 experts from different disciplines for reviewing the use of endosulfan in this country. All the scientific data on chemistry, bioefficacy, carcinogenicity, mutagenicity, teratogenicity, neurotoxicity, epidemiological studies, foreign reports from WHO/FAO, environmental impact, persistence in soil, water, crops, toxicity to birds, fish and honeybees, status of registration abroad and restrictions were studied. The Committee recommended the continued use of endosulfan in the country.

The residues of endosulfan and consequently the results reported by CSE should be verified by an independent residue expert. The study is contradictory in itself and the results obtained are highly questionable. It appears that the CSE approach is to present the situation in Kerala in a pseudo-scientific way with a motive to get the product banned in the country.

The All India Coordinated Research Project on Pesticide Residues, being conducted in 17 research centres in the country, has generated residue data on endosulfan by carrying out multilocational supervised trials under "Good Agricultural Practice" on cereal crops, pulses, oilseed, cash crops, vegetables and food crops. The waiting period between spraying and harvesting of endosulfan on vegetables is between 3-7 days and no detectable residues were found in the pulses, cereals and oilseeds at harvest. The project has also generated data on monitoring of endosulfan in soil, water, fish, honey, vegetables, fruits, milk and milk products. In most of the samples, no detectable residues of endosulfan were reported and in samples where endosulfan was detected, the residues were below the maximum residue limits. Recently, Nath et. al have reported that endosulfan residues were not detected in milk of cattle when cattle were fed with feed mixed with endosulfan for 4 weeks at a high rate of 50 mg per day. This observation explains why the samples of milk, collected from the farm, are free of endosulfan residues; (Nath et al 2000, A study on the transfer of organochlorine persistence from feed of cattle into their milk, Pesticides Research Journal, Vol. 12 (2), 68-73).

The residue data of endosulfan on soil, water, vegetables, bovine milk, butter, fish, blood and human milk, generated by the scientists of CSE, is not scientifically correct and sound because of the wrong methodology used for estmation of endosulfan. If the problem at Padre village in Kasargod district is serious, it is suggested that the basic endosulfan manufacturers in the country should sponsor a research project at Kerala Agricultural University, Centre of All India Coordinated Research Project on Pesticides Residues which has the expertise and instruments for studying the persistence of endosulfan at Padre village, so that actual status of environmental pollution, if any, due to endosulfan may be revealed to the public.

The pesticides residue data has great implications on the environment, human health and international trade. It is suggested, therefore, that the legal authorities should accept the residue data generated by Govt. laboratories, agricultural universities and private laboratories having Department of Science and Technology (DST) recognition or having good laboratory practice certification in the country.

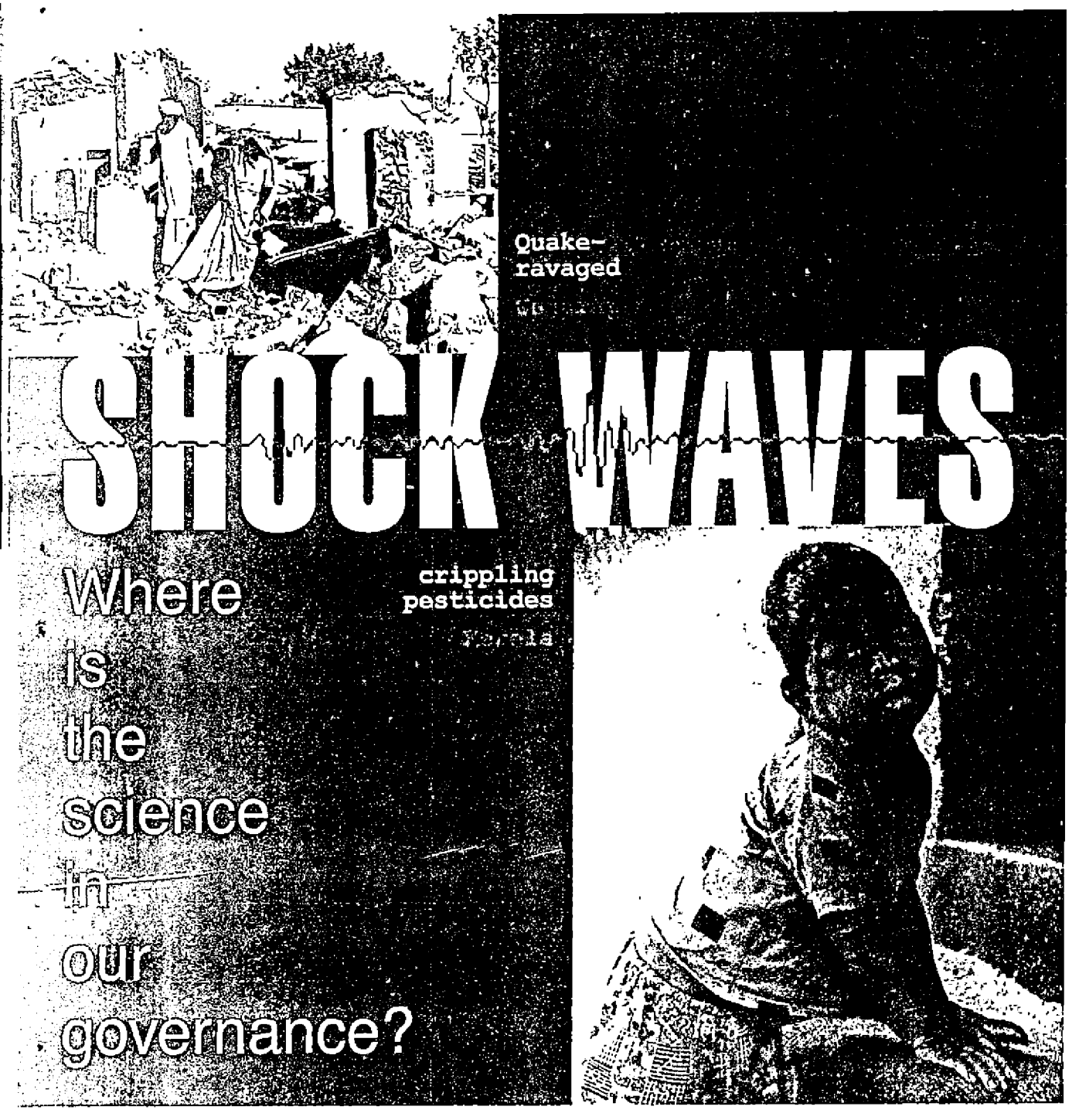
By DR. S.K. HANDA

SCIENCE AND ENVIRONMENT FORTNIGHTLY

Down To Earth

Rs 20.00

FEBRUARY 28, 2001



Future shock: more of drought and floods

No headway on setting fuel standards

Science of sinks gets trapped in a bog

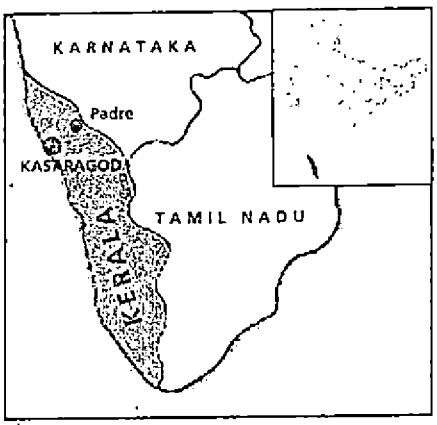
Children of endosulfan

SHRUTI, 7, lives in Vaninagar area of Padre village. The school is barely 100 metres from her house. She desperately wants to go there. But the hilly terrain of the Western Ghats and her physical handicap won't let her. She was born with three deformed limbs — a congenital anomaly. She hops around on one leg. Her mother died of cancer. Her father is an agricultural labourer.

Several unusual diseases afflict a Kerala village. Residents blame aerial spraying of the pesticide endosulfan by the Plantation Corporation of Kerala. SOPAN JOSHI listens

Most of them have been putting it down to a supernatural curse. Jatadhari, the guardian spirit (*theyyam*) of the area, is angry, believe several people of Padre village of Enmakaje Gram Panchayat (village council) in Kasaragod district of Kerala. Family after family has people suffering from diseases that were never noticed in the area in the past. The worst hit is an area of about four sq km in the sixth and seventh wards of the *panchayat*. Here, if you walk along the Kodenkiri *todu* (stream), you'll realise that hardly any family has escaped the curse. Several smaller streams, flowing down the surrounding Western Ghat hills, join the Kodenkiri. The Plantation Corporation of Kerala (PCK), run by the state government, has its cashew plantations on the upper reaches of these hills.

Mohana Kumar Y S, a doctor who has practised medicine in the area since 1982, has been perplexed for the past 10 years. "Disorders of the central nervous system are very common among the children of the area — cerebral palsy, retardation of mental and/or physical growth, epilepsy and congenital anomalies like stag horn limbs. There are too many cases of cancer of the liver and blood; infertility and undescended testis among men; miscarriages and hormonal irregularities among women; skin disorders; and asthma, to name a few. Psychiatric problems and suicidal tendencies have also been rising. Surprisingly, almost all the ailments are restricted to people under 25 years of age," the doctor points out. "There is no source of pollution in the area, no industries. I just couldn't fathom the cause of these diseases. But I was sure about one thing: they are all very difficult to cure," Kumar points out (*see interview*).



In 1996, he wrote to some big names in psychiatry in the region, drawing their attention to the mysterious nature of the problem. There was no response. In December of 1996, he wrote to the *Kerala Medical Journal*, soliciting researchers' attention. Again no response. If you check the February 1997 issue of the journal, you'll chance upon the appeal: "I feel the root of the problem lies in the water itself which might contain a mineral or radioactive substance which is harmful to the brain," the letter says, referring to the Kodenkiri stream. Narayan G, teacher at the Government Higher Secondary School in Vaninagar area of Padre, says, "For the past 10 years, teachers have felt that the children coming from the backside of the school, which is adjacent to the Kodenkiri stream, are below the average intelligence level. Of the 40 children who come from that area, nine are mentally retarded. It cannot be malnutrition. Even the poorest of the poor in this village have at least two square meals a day." But let's briefly leave the doctor and the teacher in their bewilderment and go to a somewhat older story.

Each year 3,000,000 cases of pesticide poisoning occur worldwide, including 220,000 deaths, WHO estimated in 1995. Its 1991 estimates said 25,000,000 farm workers in South are likely to suffer pesticide poisoning each year

AN UPDATE

Around 1963-64, the agriculture department began planting cashew trees on the hills around Padre. The valleys below house villages like Padre. In 1978, PCK took over the plantations. Today, the area under PCK's Kasaragod Estate stands at 2,209 hectares.

Insecticide sprays were taken up to counter the tea mosquito, a major pest that affects yields. To begin with, it was a pesticide called endrin. Later, PCK began spraying endosulfan, an organochlorine pesticide (see box: *Endosulfan: a profile*). Aerial spraying of endosulfan began sometime around 1976, say Padre residents. Bala Kurup, manager of PCK's Kasaragod Estate, says aerial spraying began only 15 years ago (*see interview*). *The Evidence Weekly* magazine published a report on cows giving birth to calves with deformed limbs after aerial sprays of endosulfan in Enmakaje Gram Panchayat as far back December 25, 1981. The author was Srikrishna "Shree" Padre, a farmer and journalist who takes keen interest in agriculture, the environment and matters of public interest (*see interview*).

Protests against aerial spraying began about two decades ago. The *panchayat* complained to the district collector, seeking a thorough probe. Sporadic protests continued. Residents saw bees, frogs and fish disappear from the area. Farmers producing honey to supplement their income have continually opposed aerial spraying. But it took 18 years for the matter to come to a head. On December 25, 2000, PCK announced that it would carry out aerial spraying the next day.

DECEMBER 26, 2000

The next day some young men of Padre gathered around the temporary helipad. Two schoolteachers, Aravinda Yedamale and Nagaraj Balike, led the protest. They asked PCK officials to desist from aerial spraying. Bala Kurup would have none of it. When the crowd became agitated, he called in the police. Aerial spraying was carried out. The unrest brought together several residents. The Endosulfan Spray Protest Action Committee was formed with Aravinda Yedamale as the chairperson. Shree Padre was also there. He exchanged notes with Mohana Kumar about the episode. For the first time, the doctor shared his suspicion that endosulfan had something to do with the unusual maladies he has noticed. Shree Padre saw sense in this. He encouraged Kumar to probe further. The doctor went back to his tattered, dog-cared toxicology textbooks. The scribe started searching the internet.

Avinash is also called Udaya. The 10-year-old resident of Vanipagar has cerebral palsy, asthma and epilepsy. Father P Sunder Shetty works the neighbouring farms. Mother Shaileja rolls *bidis* for additional income. Combined monthly income: Rs 2,000-3,000. When Udava wasn't able to walk at the age of one, his parents realised his disability. At age two, he began having epileptic fits. They took him to a hospital in Mangalore, Karnataka. It didn't help too much. They can't afford medical care now. "We can't buy medicines all the time. We purchase some tablets when his condition deteriorates."

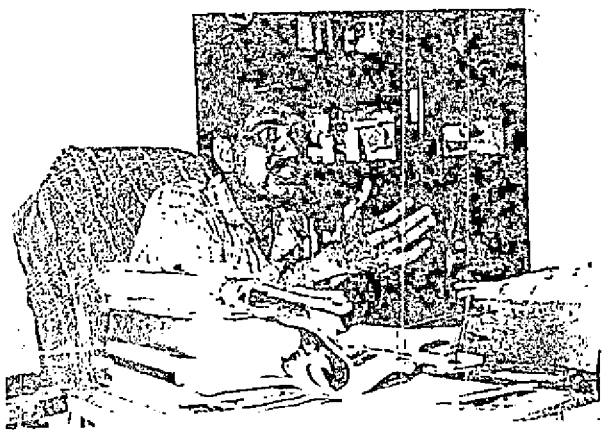
A day later, they were terribly excited. The health effects of endosulfan poisoning were similar to the maladies Kumar had noticed. But saying that a public sector company was indulging in mass homicide was a bit too much. The evidence Kumar and Padre had was too circumstantial. But their sense of moral outrage at the arrogance of PCK officials like Bala Kurup made them persist. The doctor began to dig up medical records. Shree Padre, who keeps in touch with the civil society right across the country, began sending emails to anybody who could provide him further information. Both came up with some truly shocking findings. Almost all the symptoms noticed in the area were listed under the health effects of endosulfan. The pieces of the puzzle were coming together.

The doctor began holding public meetings to explain his findings to the villagers. Shree Padre began contacting journalists. In no time, the local press and television picked up the issue. They faced one major limitation: lack of hard scientific evidence. What ensued was a media war. PCK began issuing press releases, absolving itself of any blame. But the local media has been more appreciative of their struggle.

One case that has really caught the attention of the media is that of Kittanna, who has cerebral palsy. "After the popular daily *Malayala Manorama* carried Kittanna's picture on page one, Bala Kurup visited his father Shinappa Shetty. He asked Shetty to give a written statement that endosulfan spraying had nothing to do with his son's illness. Shetty signed a statement saying he couldn't say whether Kittanna's disability

MOHANA KUMAR Y S

doctor practising in Padre and neighbouring villages for 19 years



After a friend developed psychiatric problems in 1990, I started probing further. I noted a large number of disorders related to the central nervous system in Padre. All my efforts to find a probable cause drew a blank for 10 years. All calls for assistance from medical experts proved futile. On December 31, after realising the similarity in the textbook descriptions of health effects of endosulfan poisoning and the cases I was seeing, I started compiling the medical records of the cases that had come to me from the sixth and seventh wards of Enmakaje Gram Panchayat (which has a population of about 6,000 according to a member from the sixth ward in the *panchayat*). By January 5, 2001, when I stopped the exhaustive exercise midway, I had 156 documented cases (see *table below*). By January 26, the figure has risen to 197 cases from only 123 houses. I haven't worked out the break-up.

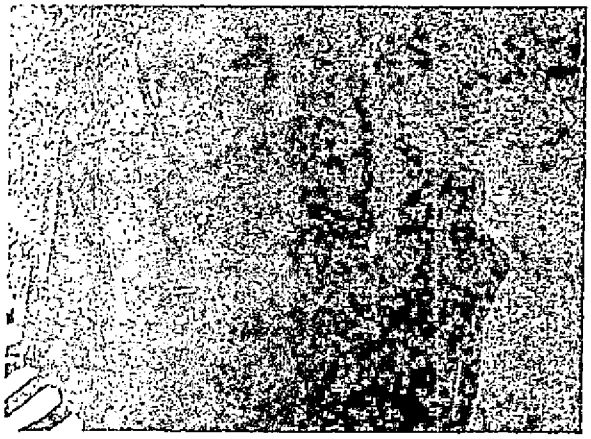
I have records of only those who consulted me. That doesn't include suspected cases or those who went to other doctors. I haven't included asthma, hormonal complications, infertility, miscarriages, and skin disorders and allergies in this list. Even if the cause of these diseases is not aerial spraying of endosulfan, this ought to be stopped on the basis of the precautionary principle. Even if the pesticide is not the direct cause, it might aggravate the cases.

THE INCOMPLETE LIST OF CONFIRMED CASES

Cancer	49
Mental retardation	23
Congenital anomalies	9
Psychiatric cases	43
Epilepsy	23
Suicide	9
Total*	**156**
Total (by January 26)**	**197**

NOTE * - cases counted by January 5, 2001
** - break-up not available

SHREE PADRE



The Insecticides Rules of 1971 stipulates that before aerial spraying is undertaken, all waterbodies should be covered. After people began protesting, the Plantation Corporation of Kerala (PCK) has begun to provide dried tree leaves and stitched up fertiliser bags made of plastic to cover the wells. But people of this area rely on streams running down the mountains for drinking water. Can PCK cover the streams? Moreover, the Act says it is the responsibility of the agency conducting aerial spraying to inform the people of their rights. We didn't know that the law says that if a domestic animal dies after spraying, a post mortem has to be conducted at PCK's cost. If the cause of death is established as pesticide poisoning, the corporation should pay compensation. Cattle deaths have occurred after aerial spraying in this area. Obviously, PCK has violated norms. But the district administration has done nothing despite our pleas.

had anything to do with the pesticide," points out Shree Padre. Both Shetty and Bala Kurup corroborate this. After obtaining the statement, the PCK official went to the doctor to ask for the addresses of other patients in his list. "I refused to give him the addresses of my patients. His motive was obviously not to help them. He probably wanted more signed statements. How can a villager establish the cause of disease?" asks Kumar. The residents saw this move as a sure sign of misconduct. They mobilised themselves under the action committee and sent a complaint to the district administration.

At least 37 people died over the 1999-2000 season in the northern Borgou province of the African Republic of Benin due to endosulfan poisoning. Another 36 people experienced serious illnesses due to the pesticide

THE DISTRICT ADMINISTRATION: NO COMMENTS

The district collector grants permission for aerial spraying. When *Down To Earth* met the district collector of Kasaragod, P C John, he refused to comment. He said ministers and elected representatives were discussing the matter and it wasn't proper for him to say anything. In an interview with the television channel *Star News*, John had earlier said: "How to stop it [aerial spraying]? Why should I stop it? Those are the questions. Because I am giving consent as per rule."

Till the time of this story going to press, no ministers or administrative officials had visited the village, although elections to the legislative assembly are due in three months. Cherkalam Abdullah, the local representative to the assembly, visited three victims' families on February 3, 2001. The village leaders say the administration's apathy is hardly surprising as the village is up against a public sector corporation, and hence the whole state machinery. No political party took a stand on the matter initially. The first was the Communist Party of India (CPI), a part of the leftist coalition that is in power in Kerala. The vice-president of the Enmakaje Panchayat is from the CPI, and is busy organising public opinion against the spraying. The Bharatiya Janata Party has also decided to take up the matter and join the protest. "Everything becomes a political issue given the polarisation of Kerala's polity. We don't wish to become pawns in a political game. We only want an end to this tragedy. If political parties can sense our misfortune, they are welcome join us." Having lost their faith in the administrative set-up and the political parties, Padre village has taken recourse to the court. The response has been favourable thus far.

NARAYAN NAIK's mental and physical growth is retarded. At the age of 20 he stands at about three feet. He has skin disorders, too. Father Devappa Naik labours in the neighbouring farms. Narayan can make conversation on rudimentary matters. He can point out the direction from where the helicopter comes, though he knows little about the endosulfan that it sprays. His younger sisters, Jaya, 18, and Revathi, 14, could both pass for his aunts. They play with him, indulge him. Revathi has epilepsy.

KITTANNA, 21, has cerebral palsy. Brother SRIDHAR's (far left) mental growth is retarded. The Kodenkiri stream flows next to their house. Across the stream lives S Narayan Bhat, with his two nephews suffering mental retardation and a 35-year-old sister who has epilepsy. Kittanna's father Shinappa Shetty looks after the arecanut trees in less than half a hectare of their land that is irrigated. Mother Muthakka, 50 (right), manages the household, helps her husband in the field, and takes care of her two handicapped sons — Kittanna can't eat or walk without help. There is nobody else in the house. Bala Kurup, estate manager of Plantation Corporation of Kerala, came to this house on January 24 to get a signed statement saying Kittanna's illness has nothing to do with the spraying of endosulfan. Kittanna, unaware, just sits and stares all day.

IN COURT

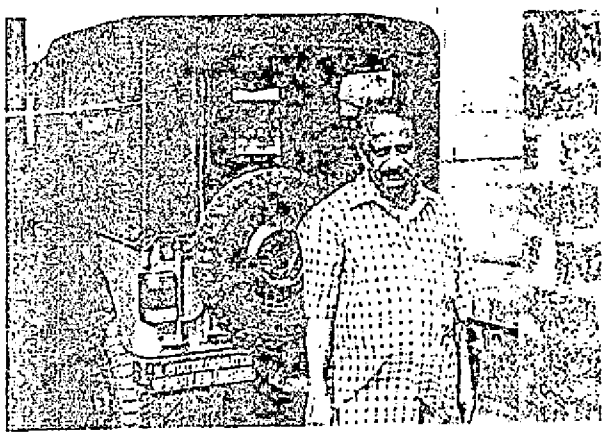
On January 24 some residents of Padre petitioned the Court of the Munsiff of Kasaragod. Mohana Kumar filed an affidavit explaining the reasons for his concern. They obtained an *ad interim* stay till February 8, restricting PCK from spraying of endosulfan by helicopters or any other means. The court order states that the petitioners have established a *prima facie* case through the documents presented. On February 8, the stay was extended till February 16.

But a woman from Kajampady area of Padre, who works in the PCK plantations, informed *Down To Earth* that spraying was going on through manual pumps in some parts of the plantations. The village is contemplating contempt of court proceedings. But the leaders of the campaign aren't content with waiting for the court ruling. Every other day, Kumar, Shree Padre and Shripati Kajampady, a doctor who runs a nursing home in the nearby Perla village, as well as other known people hold public meetings. They brief the residents of all the latest information available. If some agitated people want to take up violent measures to put an end to the endosulfan menace, they try to calm them down. They want to ensure that all protest is non-violent and democratic.

They are trying to build support for their cause in the civil society, constantly seeking guidance and support from scientists, social leaders, environmental campaigners and journalists. They are also reaching out to other villages that have complaints similar to theirs. Periya and Pullur, two neighbouring villages 25 km south of the district headquarters.

BALA KURUP

Estate Mgr, Kasaragod Estate, Plantation Corporation of Kerala



SOPAN JOSHI / CSE

In this area all these complaints have come up in recent times. They are not at all productive. We are spraying endosulfan in so many other places like Cheemeni and Rajapuram. We have been spraying for so many years. There have been no complaints in the past. Endosulfan is not banned in India and we use recommended concentrations. It is a contact poison, not at all harmful to humans. I think some experienced people like doctors should do a study. Endosulfan is used for so many other crops like paddy, cotton, sugarcane and arecanut. If it is harmful the government should ban it. We follow all the norms. We make mike announcements in advance. We notify people through advertisements in newspapers. We cover the waterbodies. After complaints, the Kerala State Pollution Control Board has taken well water samples and there is not at all any contamination in the waterbodies (in Periya). The stream in Padre (from where these complaints are coming) is one and a half km away from the plantations. We don't spray close to the human habitations. I think there are some interests behind all these (complaints). They are purposefully done. I don't know the reason behind them. I think what they say is not true. We are taking all precautions as per the directions of the district collector. And the district collector is giving permission after recommendations of the medical officer. If we don't spray the entire plantation will be gone. We'll lose Rs two crore in Kasaragod; 85 per cent of the crop will be gone. It is government money. I have seen one or two cases in Padre. Their relatives are saying they don't know (whether this is due to endosulfan). We don't want to make problems for the local people. But if we don't spray the government will lose a lot of money. We are already having a financial crisis.

of Kasaragod. Some residents here have obtained a stay order from the courts against aerial spraying by PCK. Here, several families stay right inside the plantations. They don't talk readily, living as they are right under PCK's nose. But there are several stories of illnesses here, especially among women and children.

IS IT TOO LATE?

This is just the first phase of Padre's struggle. "Our *gyanodaya* (awakening) happened only one month ago. We have got our hands on some scientific information and mobilise some social support based on that. We are yet to understand the magnitude of the problem," says Shree Padre. One walk through the village is enough to send a chill down the spine. Several families live right at the edge of the forest. Their trees, water, crops, land, their very bodies have absorbed endosulfan for more than two decades. The effect is anybody's guess till a thorough scientific probe is conducted. Till then, all that there is to go by are the observations of the residents, particularly the elders who have witnessed the change in local ecology.

"I don't see jackals in this area now," says Kajampady Subramanya Bhat, 75, whose family has lived in Padre since he doesn't know when. "In 1962-63, when the plantation started, they used to put groundnut cakes in the pits. A worker told me they were mixing pesticides in the cakes to prevent jackals from eating them. I don't see any jackals now, nor too many frogs, fish or crows. Rat snake, a farmer's friend as it checks the rodent population, has disappeared. There are no fireflies. I used to have 22 beehives. Now I have none."

There are several similar tales of ecological destruction. Even if the village manages to stop endosulfan spraying for all times to come, the people here fear a poisoned future. They don't know what other nightmares are in store. If their problems are due to endosulfan then the issue of compensation is bound to come up. But India's record in compensating victims of environmental pollution is abysmal (see 'The red triangle', *Down To Earth*, January 15, 1998). There can be hardly any hope when the culprit is a government corporation. If the cause of their maladies is not the pesticide, it might be an even longer wait till some scientist somewhere decides otherwise. ■

ENDOSULFAN: A PROFILE

An organochlorine insecticide. Effective against a wide range of pests of crops including cereals, coffee, cotton, fruit, oilseeds, potato, tea and vegetables. **HIGHLY TOXIC SUBSTANCE.**

The US Environmental Protection Agency classifies it as a Category 1b **(highly hazardous). Easily absorbed by the stomach, lungs and through the skin. All routes of exposure can pose a hazard**

Exposure may result from:

- breathing air near where it has been sprayed;
- drinking water contaminated with it;
- eating contaminated food;
- touching contaminated soil;
- smoking cigarettes made from tobacco with endosulfan residues;
- working in an industry where it is used.

ACUTE TOXICITY

Stimulation of the central nervous system is the main characteristic of endosulfan poisoning. Acute exposure leads to: hyperactivity, tremors, decreased respiration, salivation, anaemia, lack of coordination, loss of ability to stand, gagging, vomiting, diarrhoea, agitation, convulsions and loss of consciousness. **Blindness** has been observed in animals that grazed in sprayed fields. **People with diets low in protein may be more sensitive.**

CHRONIC EFFECTS

Studies on animals show that **long-term exposure to low levels of endosulfan affects the kidneys, the developing foetus, and the liver.** The ability to fight infections ebbs away. Organochlorine compounds are suspected to play a part in the **decrease in the quality of semen, in the increase in testicular and prostate cancer, an increase in the defects in male sex organs, and increased incidence of breast cancer. Endosulfan can cause mutations. It has been shown to be toxic to genes in human cells.***

ENVIRONMENTAL FATE

Highly toxic to fish, birds, fowl, bees and wildlife. Breaks down faster than the other organochlorines, leaving the body fairly quickly. Despite rapid degradation in water, it can **bind to soil particles and persist for a relatively long period.** Doesn't leach into groundwater, but is particularly prone to runoff immediately after spraying. Its half-life (the time it takes to dissolve into the body or the environment, becoming half the original mass) in water and in most fruits/vegetables is three to seven days. In sandy loam, **its half-life is 60-800 days.** Endosulfan in soil **inhibits the degradation of other organochlorines.**

BREAKDOWN PRODUCT

Endosulfan sulphate **is more persistent than its parent compound** accounting for 90 per cent of the residue in 11 weeks. **Sulphate formation increases with rise in temperatures.**

REGULATORY STATUS

A lot of countries have regulations against endosulfan or have severely restricted its use. Those who have banned it include: **Denmark, Germany, the Netherlands, Sweden, Belize, Singapore,** and the Brazilian state of **Rondonia. Colombia and Indonesia** have been preparing for a ban. Its use is disallowed in rice fields in: **Bangladesh, Indonesia, Korea** and **Thailand.** Use is restricted or severely restricted in: **Canada, Finland, Great Britain, Kuwait, the Philippines, Russia, Sri Lanka, Thailand** and **Madagascar.** Campaigns have been going on worldwide for several years to ban endosulfan.

Source: Anon 2000, Endosulfan — Fact Sheet, in *Pesticide News*, Pesticide Action Network UK London, No 47, March, pp 20-21

* — Yuquan Lu et al 2000, Genotoxic Effects of a-Endosulfan and b-Endosulfan on Human HepG2 Cells, in *Environment Health Perspectives*, Public Health Service, US Department of Health and Human Services, North Carolina, Vol 108, No 6, pp 559-561

OMNIPRESENT POISON

The maximum residue limits for the pesticide endosulfan in soil, water and vegetables from Padre have been breached several times over. But human blood! We couldn't find any maximum residue limit for that. The tests conducted at the CSE laboratory show that each resident of Padre whose blood sample was tested has endosulfan residues several hundred times the residue limit for water

Sample	Detected value of endosulfan	Maximum residue limit (MRL)	Number of times value exceeds MRL	Site/source of sample
Water	1.18	0.18*	7	Small stream in Kumbdaje village near Padre
Water	6.87	0.18*	38	Tank near the cashew plantation, Kajampady, Padre
Water	9.19	0.18*	51	The Kodenkiri stream near Vanlnagar, Padre
Butter	14.00	NA	NA	From the milk of a cow of Saletadka, Padre
Cow's skin/fat tissue	49.99	0.1	500	From the abdominal region of a cow from Padre
Cow's Milk	31.80	0.5	64	From a cow that grazes around Kajampady, Padre
Cow's Milk	57.20	0.5	114	From a stall-fed cow in Kumbdaje village
Coconut oil	17.00	NA	NA	Extracted from produce of trees in Vanlnagar, Padre
Cashew	54.11	NA	NA	From a tree in the plantation near Kumbdaje village
Vegetables	31.24	0.4-2.0	78-16	*Basale*, leafy, spinach-like vegetable, from Kajampady
Human Milk	22.40	NA	NA	Lalitha, 35, resident of Kumbdaje village
Human Blood	108.90	NA	NA	Vishnu Kulkarni, 10; has epilepsy & mental retardation
Human Blood	114.13	NA	NA	Prabhawati Shastri, 35; has asthma & skin allergies
Human Blood	115.19	NA	NA	Mohana Kumar, 40; has chronic throat infection
Human Blood	109.50	NA	NA	Kittanna Shetty, 21; has cerebral palsy
Human Blood	196.47	NA	NA	Muthakka Shetty, 50; Kittanna Shetty's mother
Human Blood	176.90	NA	NA	Lalitha, 35, resident of Kumbdaje village
Live Frog	10.35	NA	NA	From a small stream in Kumbdaje village
Cashew	3.74	NA	NA	From the plantation near Kalamboady, Padre
Spices	212.28	NA	NA	Pepper bunch from Kajampady, Padre
Fish	28.24	NA	NA	From a tank in Kajampady, Padre
Soil	35.16	0.09*	391	From Lalitha's house in Kumbdaje village
Soil	3.17	0.09*	35	From a few metres inside the plantation at Kalampady
Soil	6.40	0.09*	71	From plantation area on a hilltop in Perival, Padre
Cashew leaves	6.52	NA	NA	From the heart of the plantation at Periyal, Padre

Note: *All figures in parts per million (ppm).*

* *Values are the sum of α-endosulfan and β-endosulfan residues. Levels of endosulfan sulphate were not measured. Had this been done, the figures would have been higher.*

† *The MRLs are for the sum total of α-endosulfan, β-endosulfan and endosulfan sulphate residues. Calculated from documents of the US Environmental Protection Agency*

‡ *The MRLs for water and soil are the sum total of α-endosulfan and β-endosulfan residues, and do not include the MRL for endosulfan sulphate.*

§ *MRLs not available (NA)*

SCIENCE FOR ECOLOGICAL SECURITY

The Centre for Science and Environment (CSE), New Delhi, has recently set up a laboratory to monitor pollution. Its aim is to conduct scientific studies and generate public awareness about pesticides and heavy metal contamination of food, water and soil. It provides scientific services at affordable prices to communities that do not have access to obtain scientific evidence of pollution. This is crucial in, say, a court case that a rural community might be fighting against a polluter. Given the state of scientific research in India — most of it is restricted to national defence and food security — this is an effort to use science to achieve ecological security. The laboratory provides paid services for financially self-sufficiency. The Deutsche Gesellschaft fur Technische Zusammenaabeit (GTZ) Gmbh, based in Bonn, and the European Union have provided the funds for setting up the laboratory.

After receiving reports of unusual diseases from Padre village in Kasaragod district of Kerala, where endosulfan is sprayed on the cashew plantations of the Plantation Corporation of Kerala, CSE offered to conduct laboratory tests on samples collected from the village free of cost. The task was planned under the guidance of **Padma S Vankar**, in charge of the Facility for Ecological and Analytical Testing at the Indian Institute of Technology, Kanpur. A CSE researcher went to Padre to organise the collection of samples. Technical guidance on collection and storage of samples came from **M K Prasad**, coordinator of the Environment Centre of the Kerala Sashtra Sahitya Parishad in Kochchi, Kerala, and **V R Raghunandanan**, associate professor and veterinary toxicologist with the Integrated Rural Technology Centre, Palakkad. **Sripati Kajampady**, a doctor who runs a nursing home in the neighbouring Perla village, helped in collecting samples. After the samples were transported to Delhi, Vankar, along with CSE scientists **Rashmi Mishra** and **Sapna Johnson**, began extracting samples for analysis. The process followed for analysis of endosulfan residues — called GC-ECD — is a well documented procedure developed by the US Environmental Protection Agency (EPA). Vankar was shocked at the extremely high levels of pesticide residues in all the samples. "The values were alarming, especially for human blood, fruits and animal tissue. It can hardly be doubted that this has something to do with the high incidence of disorders of the central nervous system in the village," she exclaimed.

Knowledge wars and casualties

Endosulfan is **highly hazardous**, says the US Environmental Protection Agency. The pesticide has been in the eye of a storm in developing countries. After the Philippines banned it in 1993, the multinational giant Hoechst, a manufacturer of the pesticide, obtained a court injunction against the Fertiliser and Pesticide Authority of the Philippines. "Several studies and review documents from different sources consistently show that endosulfan is highly poisonous and easily causes death and severe acute and chronic toxicity to various organ systems, including mental and developmental toxicity, liver and kidney damage, cardiac arrest, blood disorder, respiratory depression, skin irritation, and many others," wrote Romeo F Quijano, associate professor in the department of pharmacology and toxicology at the College of Medicine, Manila, in the October/December 2000 issue of the *International Journal of Occupational and Environmental Health*. We present findings of some scientific studies of health effects of endosulfan poisoning.

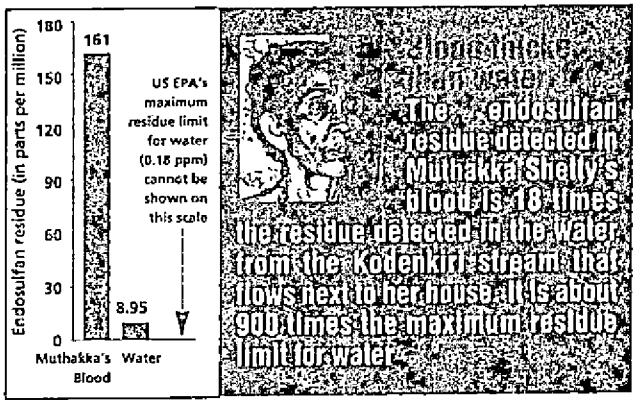
Commercially produced endosulfan usually consists of its two molecular forms (isomers), α-endosulfan and β-endosulfan.

ACUTE TOXICITY: Endosulfan is highly toxic if ingested orally. Its LD50 value (lethal dose at which half the exposed population dies) is 18-160 parts per million (ppm) in rats, 7.36 ppm in mice, and 77 ppm in dogs. It is very toxic when absorbed through skin — LD50 value among rats (when absorbed through skin) is 78-359 ppm. The α-isomer is considered to be more acutely toxic than the β-isomer. Tests on rats show those deprived of protein are twice as susceptible to its toxicity. Stimulation of the central nervous system is the major characteristic of endosulfan poisoning.

CHRONIC TOXICITY: In rats, oral doses of 10 ppm per day caused high rates of mortality within 15 days, but doses of 5 ppm per day caused liver enlargement and some other effects over the same period. Administration of this dose over two years in rats caused **reduced growth and survival, changes in kidney structure, and changes in blood chemistry.** The ability of animals **to fight infection can also become lowered,** a phenomenon called immuno-suppression.

REPRODUCTIVE EFFECTS: Female mice fed 0.1 ppm of the compound every day for 78 weeks at per day suffered **damage to their reproductive organs.** Oral dosage for 15 days at 10 ppm per day in male rats caused damage to the semeniferous tubules (semen-bearing tubes that comprise testicles) and lowered testes weights. Endosulfan is an organochlorine. Organochlorines are suspected of disrupting the endocrine system, resulting in reproductive and developmental defects, among other things.

TERATOGENIC EFFECTS: A teratogen is an agent that causes malformations in foetuses. An oral dose of 2.5 ppm per day resulted in normal reproduction in rats in a three-generational study, but 5 ppm per day and 10 ppm per day resulted in **abnormalities in bone development in the offspring.**



GENOTOXICITY: A substance is genotoxic when it directly affects the functioning of genes, causing changes in their functions. **Both α-endosulfan and β-endosulfan have been shown to be genotoxic to human liver cells.** The β-isomer is a more potent genotoxin.

MUTAGENIC EFFECTS: Mutagenicity refers to the induction of permanent changes in the amount or structure of genetic material of cells or organisms, **which can be transmitted to the coming generations.** Endosulfan has been shown to be mutagenic to bacterial and yeast cells. Endosulfan has also been shown to cause mutagenic effects in mammals. *Evidence suggests that exposure to endosulfan may cause mutagenic effects in humans if exposure is great enough.* Changes induced in cells by a mutagen can cause cancer, while damage to the egg and sperm can cause adverse reproductive and developmental outcomes.

CARCINOGENIC EFFECTS: In a long-term study on mice and rats, the males of both groups experienced such a high mortality rate that no conclusions could be drawn. The females of both species failed to develop any carcinogenic conditions 78 weeks after being fed diets containing up to about 23 ppm per day. Further testing is required to know if endosulfan is carcinogenic or no.

STATUS PAPER

STATUS OF ENDOSULFAN AND ALTERNATIVES FOR THE MANAGEMENT OF TEA MOSQUITO BUG (TMB)IN CASHEW

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The Plantation Corporation of Kerala (PCK) has about 6500 ha. of cashew plantations in the districts of Kasargod and Kannur in Kerala.The estates are not contiguous but consists of small to big estates scattered in the district. One of the major pests infesting cashew has been the tea mosquito bug (TMB). The cyclodiene insecticide Endosulfan has been aerially sprayed since the early eighties to control this pest.

The use of Endosulfan over several years has allegedly resulted in health problems of the public inhabiting close to the sprayed plantations. Congential problems, mental retardation,psychosis, cancer, skin diseases etc have been attributed to the aerial spraying of endosulfan. Medical personnel practising in the area has highlighted these issues. Disorders and deaths among livestock and fishes have also been reported. An analysis of endosulfan residues by an NGO based in New Delhi. viz. Centre for Science and Environment from Padre area during December 2000 to Jan. 2001 has indicated that residues are present in high levels in different materials tested. Their report along with articles on alleged ecosystem pollution and related damage to human life in the electronic and print media has caused a hue and cry among the public in the concerned region. Their demand to discontinue aerial spraying of endosulfan has been taken up seriously by the Government of Kerala.

In this context, it would be worthwhile to examine the use, merits and demerits of endosulfan and to suggest alternate methods for management of TMB. This paper is an attempt to throw more light on the above issues.

Endosulfan

Endosulfan is a cyclodiene compound related to the organochlorines. It was first described by W. Finkerbrink in 1956 and M/s Hoechst.A.G, Germany (presently M/s Aventis Crop Science) manufactured and released the same in 1956. It is a non systemic contact stomach poison with fumigant action. LD50 for rat is Oral -18 to 160 mg / kg. body weight. dermal : 78 to 359 mg/ kg. body weight. It comes under the category II (Highly toxic with yellow triangle). It is used not only in agriculture but also in public health(control of tsetse fly etc). World wide, it is used in pest control of cotton,sugarcane, tea and even on similar, vegetables and oil seed crops. Endosulfan is recommended against chewing moth larvae,beetle grubs,tissue borers, miners, termites, sucking pests ,mites etc.Endosulfan finds use as a wood preservative also.

Some examples of pests controlled in Kerala:-

Crop	Pest
Rice	Army worm
Coconut	Coreid bug
Pepper	Pollu beetle
Cashew	Tea Mosquito Bug (TMB)
Cocoa	TMB

Some of the formulations available as 35 E.C (Emulsifiable concentrate) include:Agrosulfan,Endocel,Endostar,HexaSulfan,Hilden,Thiodan,Thiokill,Thionex, ParrySulfan,GaneshSulfan etc. Other formulations include wettable powder,dusts, granules, Ultra Low Volume liquid (ULV) and smoke tablets

Routes of exposure to endosulfan

Endosulfan contaminates the environment through spray drift,volatilisation and particle transport both aerially and by runoff.

a. Breathing air from the vicinity of the sprayed area is one route. This can happen when endosulfan is applied with air blast equipment resulting in local drift of the pesticide.

b. Contamination of water in streams,rivulets and agricultural run off is another possible route but reports indicate that in ground, endosulfan contamination is not as widespread as in the aquatic environment. However accidental spillage etc. can be a cause.

c. Physical contact with contaminated soil is another possible route. Endosulfan is adsorbed in soil and the major degradation product is endosulfan sulphate. Most of the residue is absorbed in the top10 cm of the soil and about 2 percent has been found in the leachate.(NRA .1998)

d. Another route can be the consumption of contaminated food. In general residues in food are below the MRLs established by the FAO/WHO.

e. Occupational exposure has resulted in some incidents of poisoning where proper safety precautions were not ensured.

MERITS

Endosulfan is a widely used, effective insecticide against an array of pests infesting agriculture crops,garden plants, public health and animal health .

It is readily metabolised, eliminated and does not accumulate in the human body. Endosulfan does not have the same affinity levels for lipids compared to most related chemicals. Thus the likelihood for bio-magnification and accumulation of endosulfan in food chains is less. Organisms like fishes when exposed to endosulfan at below lethal levels, accumulate the compound to a plateau level. Once the source of contamination is removed, they clear the residues quite rapidly. (IPCS, 1984).

Endosulfan is relatively harmless to benficial insects. It has moderate or low levels of toxicity to honey bees. A contact LD_{50} of 7.1 mg/kg body weight and an oral LD_{50} of 6.9 mg/kg body weight was reported by Stevenson *et.al* (1978). Endosulfan application in the field appears to have no significant effect on foraging bees. (NRA, 1998) Endosulfan is comparatively harmless to natural enemies viz. parasites and predators of pests eg: parasitic wasps, ladybird beetles and some mites. When endosulfan is applied on leaf foliage, the natural enemies could be affected. However the toxicity does not persist for more than one day, allowing for repopulation of the natural enemies from unsprayed areas. (NRA, 1998).Laboratory studies have indicated that the toxicity of endosulfan to microorganisms is low. Hence in field conditions, toxicity is not likely to be a problem. (IPCS. 1984)

EFFECTS OF ENDOSULFAN ON HEALTH

Studies have indicated that endosulfan is not carcinogenic on mice and rats. It was negative in short term tests for genetic activity. The longterm no-observed adverse effect level(NOEL) in rats was 1.5mg/kg body weight and 0.75mg/kg body weight in dogs(IPCS/WHO,1988).In this context,we do not know if endosulfan can cause cancer in humans. Studies in animals have provided inconclusive results(ATSDR, 1993). Endosulfan does not have harmful effects on reproduction of experimental animals. Evidence to implicate endosulfan as an endocrine hormonal disrupter is also lacking(NRA,1998).

In normal applications of endosulfan ,it has not been shown to be very toxic to plants(IPCS,1984). Koeman *et al* (1974) reported that residues were not present in molluscs,crabs,shrimps when endosulfan was applied for the control of yellow stem borer(YSB).

Matthiessen *et al* (1982) showed that the accumulation of endosulfan in fish and their predators following aerial spraying of endosulfan to control the tsetse fly in Botswana. Residue levels in fish predators viz. birds and crocodiles were similar to those in the prey. The tests indicated rapid degradation and low accumulation of the pesticide residues.

The International Programme on Chemical Safety(IPCS) has stated that endosulfan does not seem to be a hazard to birds (LD_{50} – 6.6 to 34mg/kg body weight) (IPCS,1984).

In this context, some of the studies on chronic toxicity of endosulfan on test animals are worth mentioning. Thaker and Garg(1993) reported that oral administration of endosulfan in male chicks did not cause toxicity. Exposure to endosulfan for 16 weeks reduced the growth rate in fish.,*Puntius* sp. (Khillare and Wagh,1988). In one study,exposure of endosulfan for 78 weeks did not produce neo- plastic lesions in mice(NRA,1998).

The above reports indicate that endosulfan is "soft" and not highly toxic under conditions of chronic exposure to test animals and human beings.

There is no doubt that endosulfan has merits as an effective insecticide and over the years, it has played an invaluable role in mankind's fight against a wide range of pests. However, man's overdependence and indiscriminate use of pesticides like endosulfan in the wake of pest outbreaks has created adverse effects on the environment ,man and other non-target organisms. Poor agricultural practices have a big hand in enhancing the hazards of endosulfan.

DEMERITS

A few of the problems arising out of the acute and chronic exposure and related toxicity as well as demerits have been reviewed.Endosulfan has been described in general as a persistant organic pollutant (POP) being reviewed for continous use in agriculture worldwide.Its readily absorbed by the stomach,lungs and skin(IPCS,1988).Endosulfan can build up in bodies of animals living in endosulfan contaminated water.

Acute toxicity studies

Endosulfan has high acute toxicity in experimental animals with a wide variation in the LD_{50} values. Females were more sensitive to endosulfan compared to males.

Endosulfan is highly toxic to fishes. The acute LC_{50} of Australian fish is as low as 0.2 microgram per litre. Adverse effects on earthworms, soil arthropods and algae have also been reported (NRA 1998). It is an irony that harvesting of fish in West Bengal is sometimes done after application of endosulfan in the fish ponds.

In test animals, central nervous system(CNS) and its functions are affected. Muscular twitching and convulsions leading to death have been reported in test animals exposed to endosulfan (IPCS, 1984). In one study the NOEL for toxicity was reported to be to the level off 2.0 mg/m^3 (NRA, 1998). Testicular and renal damage have also been reported

Endosulfan is moderate to highly toxic to birds when it was administered orally and highly to moderately toxic through the diet. (NRA, 1998)

Acute toxicity due to endosulfan affects human testis and causes mutations. When human adults were exposed to high doses of endosulfan, hyperactivity, nausea, dizziness, headaches and convulsions were observed. Only severe poisioning may result in death.(ATSDR, 1993). Mutagenic effects causing damage to chromosomes and cell cycle effects are induced by endosulfan. Death in humans have occurred after ingestion of endosulfan upto 467 mg./kg body weight. (ATSDR, 1993).

Chronic toxicity studies

Studies on long term exposure of endosulfan have been conducted by several workers. Even though endosulfan degrades in about a year in soil and aquatic sediments, small levels are carried over year after year. Thus aquatic and soil organisms are exposed to endosulfan residues in the environment at large. This occurs in regions where endosulfan is usually applied for pest control.

Exposure to endosulfan over a period of 16 weeks caused 10 to 40 percent mortality in the fish,*Puntius* sp. (Khillare and Wagh, 1988). In long term studies on rats, exposure, at a high dose (20mg/kg/day), resulted in testicular atrophy. Sperm count was reduced and high incidence of sperm abnormalities have been reported in rodents exposed to endosulfan (NRA, 1998).

Endosulfan causes adverse effects on the immune system in humans. The liver and kidney are affected and high doses cause anaemia (ATSDR, 1993).

In brief, acute toxicity and exposure is definitely deleterious to man, rodents, fishes etc. Chronic toxicity studies indicate that health of test organisms are adversely affected. In areas where endosulfan is usually used, small amounts of residues are present in the ecosystem. It is possible that these can enter into organisms like fishes and terrestrial animals. However, the metabolism of the organisms gets adjusted to suit the functional needs in them.

Insect Management strategies using endosulfan - pros and cons

In the light of the above, the obvious question arises whether to use or debar endosulfan in crop protection.

Based on adverse effects on the environment, it might have to be phased out. However a ban on endosulfan would require the use of more dangerous chemicals. The repeated sprays of these would in turn lead to harsher problems like insecticide resistance. The fact that endosulfan belongs to a different class of chemicals compared to most available chemicals, warrants its use in insecticide resistant management programmes. Endosulfan *per se* is an effective insecticide but lack of good agricultural practices have compounded the environment problems.

Hence, urgent steps have to be taken to find out the special areas where its use is essential. Endosulfan has to be applied only based on monitoring results and economic threshhold levels which is difficult for pests like TMB. Environment

monitoring is essential to prevent contamination. Aerial application should not be allowed in densely populated areas with water bodies. Thus the drift and possible contamination can be minimised. During rainy season, application of endosulfan should not be done if rains are imminent (within 48 hours). This can reduce the runoff to a great extent. Application of endosulfan during high temperatures can increase the volatility of the same

Hence the use of endosulfan with all the precautions is not a easy task . Its use has to be minimised and phased out when suitable alternatives are available.

Management of Tea Mosquito Bug(TMB)

The question of whether to use or prohibit the aerial spraying of endosulfan in the PCK plantations assumes relevance.Another aspect is to verify whether endosulfan is the root cause of the maladies in Kasargode.

Manangement strategies to contain the TMB are being suggested.Aerial application of plant protection chemicals in a densely populated state like Kerala is bound to cause environment problems. Hence aerial application of endosulfan should not be permitted as it is hazardous to the inhabitants living nearby.Inspite of its efficacy, the use of endosulfan for two decades is too long a period.It is high time to switch over to other recommended pesticides. This is being suggested inspite of the fact that residue analysis of endosulfan conducted by the Kerala Agricultural University(KAU) from samples collected in the problem area indicated non detectable to very low levels of residues. These findings were in line with those reported by FIPPAT, Chennai and contradictory to the high residue values reported by the NGO viz. CSE, New Delhi.

Endosulfan has been much maligned as the culprit behind the human tragedy in the PCK cashew plantation areas. A thorough foolproof investigation is the need of the hour. The services of medical, agricultural, veterinary, geological and social science experts are required.

Thus proper management strategies are required to control the tea mosquito bug in lieu of aerial spraying of endosulfan. These strategies would be more costly but there is no other alternative for the moment.

A long term strategy would be to intensively search for natural enemies. Search and development of promising parasites, predators or microorganisms has to be intensified. Some of the natural enemies of TMB reported are

Telenomus sp. (Braconidae).
Oecophylla sp. (Formicidae)
Crematogaster sp. (Formicidae)
Reduvid bugs and spiders

Another line would be the search for semiochemicals especially pheromones. This could be used in monitoring and mass trapping of adults. The management of alternate hosts like neem, cocoa, mango, drumstick, tea etc. has to be looked into and

better strategies developed. Newer "safe" but effective, less persistent, selective pesticides (chemicals) have to be found out.

One alternative to chemicals is the development of botanicals. Five percent NSKE has been reported to be effective against TMB. (Senguttuvan ,1998) More powerful botanicals like Neem-Azal Ts (1% azadirachtin) mixed with adjuvants can be tried. The management of anthracnose using bioagents to control the fungus is another line of work.

Surveillance and regular crop loss assessment for economic decision making is important. However, this is easier said than done especially in the control of TMB. Feeding by TMB in low numbers is reported to cause economic loss in cashew. This warrants the use of prophylatic sprays especially in the endemic areas.

Blanket application of pesticide need not be resorted to. Instead it would be better to identify the hot spots and restrict the application of pesticides. In this context, as younger trees are more prone to TMB attack, these have to be monitored and sprayed if needed. The application in older trees can be skipped for a year or so.

Apart from endosulfan, the other pesticides recommended are carbaryl (0.01%) and quinalphos (0.05%) (POP recommendations, KAU 1996). Carbaryl can be sprayed at time of flushing (Sept. - Oct.) and quinalphos at flowering (Nov-Dec.) and early fruit set (Jan. - Feb.) A good sticker has to be mixed with the spray solution of chemicals.

Instead of aerial application, ground application using power operated sprayers can be recommended wherever possible. Hydraulic power sprayer mounted on a pair of handles (stretcher/ skid sprayer) is useful. Power operated sprayer blowers or mist blowers can also be used in the hotspots of TMB attack. Low volume or ultra low volume application of pesticides can be done. Proper training for personnel on proper application of chemicals, maintenance of equipment and safety precautions are very important. Good personal protective clothing, respirators etc. have to be provided to the workers involved. Re-entry in pesticide treated areas should be restricted for human beings as well as grazing animals.

Steps have to be taken to ensure timely medical treatment of personnel who might be affected during spraying. The availability of doctors and other medical staff with adequate quantities of antidotes and medicines is very important in the event of an emergency.

Summary :

The uses, merits, demerits of endosulfan and alternate methods of TMB control are discussed in this paper. Endosulfan is a versatile, broad spectrum and effective chemical used against a wide array of pests in agriculture, animal and public health in several countries. However, its use or rather misuse has resulted in adverse effects on the environment, man,livestock and other fauna. In Kerala, its continued

aerial application in the PCK estates has allegedly affected the health of inhabitants of the area. They have demanded the banning of aerial application of endosulfan which is the cheapest method of control of TMB in the PCK cashew plantations.

In this context, perusal of the issues at stake and after weighing the pros and cons of the same, we suggest that:- 1) A thorough investigation into the root cause of the human tragedy may be conducted at the earliest.

2) Aerial spraying of endosulfan should be discontinued. Instead ground sprays of carbaryl/ quinalphos with adjuvants using power operated equipment in the hot spots (especially in young trees) are recommended.

3) Earliest efforts should be made through R and D to find out and develop promising natural enemies, semiochemicals, newer "safe" chemicals as well as botanicals with suitable formulations

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Chemistry, Toxicology and Environmental Fate of Endosulfan

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INTRODUCTION

Endosulfan is a cyclodiene compound belonging to the family of organochlorine pesticides. It is an efficient contact insecticide capable of controlling a variety of insect pests. Since it is relatively harmless to natural enemies as well as beneficial insects, it is often used as a component in integrated pest management programmes. Though its acute mammalian toxicity is high, it gets degraded fast in plants. Since it is rapidly degraded in the system of animals and eliminated from the body within a few days to few weeks, it can be used safely on food crops provided the prescribed waiting periods are observed. Since it is highly toxic to fish, water bodies should be protected from contamination during its application.

Soil is the environment component in which endosulfan residues is highly persistent. It is somewhat strongly adsorbed on to clay colloids from where it is seldom released into water. Its inherently low water solubility (0.32 ppm at 20°C) and the strong adsorption to soil matrix makes it immobile in soil. Hence ground water pollution by endosulfan is not likely under recommended practices.

High insecticidal efficacy, fairly good environment compatibility and low cost make it a good choice for pest control in agricultural crops. An effort is made in this paper to review scientific information on the chemistry, toxicology and environmental fate of endosulfan.

A. Physico-chemical properties of endosulfan (technical ~ 94% pure) :

1. Physical state : Brown crystalline solid
2. Melting point : 70-100°C
3. Vapour pressure : 1.2 Pa at 80 °C
4. Odour : Of sulphur dioxide
5. Water solubility : alpha-endosulfan : 0.32 mg/litre at 22 °C
   beta-endosulfan : 0.33 mg/litre at 22 °C
6. Chemical name: 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzathiophen-3-oxide
7. Molecular weight : 406.96
8. Isomeric composition : Chemically the technical product is a 3:1 mixture of alpha and beta isomers.

(Alpha isomer is more toxic whereas the beta isomer is more persistent in the environment.)

B. Toxicological information

Acute toxicity:

Endosulfan has high acute toxicity both through the oral and dermal routes. It is denoted as "Highly Toxic". Its use is restricted in many countries. The results of acute toxicity studies in approved animals is summarised in the following table.

Oral LD_{50} (mg/kg body wt.)	Rats	18-220
	Cats	2
	Dogs	76.7
Dermal LD_{50} (mg/kg body wt.)	Rats	74
	Rabbits	200-359
Inhalation LC_{50}	Rats	8 mg/m^3 (4h)

Chronic toxicity:

Several animal experiments have been conducted to study the chronic toxicitv of endosulfan. A gist of the findings is presented below

- Organ toxicity : The organs that are most likely to be afgfected are kidney, liver, blood chemistry and parathyroid gland.
- Reproductive effects: No ill effects in rat up to 2.5 mg.kg/day
- Female mice developed damage of reproductive organs at a dose of 0.1 mg/kg/day for 78 weeks.
- Teratogenicity: 2.5 mg/kg/day dose in a three generation study in rat produced no ill effects but 5 & 10 mg doses produced abnormalities in bone development
- Carcinogenicity: No evidence of carcinogenicity in rats or mice at regular exposure levels

Based on the above results the Acceptable Daily Intake (ADI) for man has been fixed at 0.006 mg/kg/day. Endosulfan is rapidly degraded into mainly water-soluble compounds and eliminated in mammals with very little absorption in the gastro-intestinal tract. In rabbit, the beta isomer is cleared from blood plasma more quickly than the alpha-isomer at a half-life of 6 hours and 10 days respectively. Most of the endosulfan seems to leave the body in a few days to few weeks.

C. Ecological effects

It is moderately toxic to birds. Oral LD_{50} (mg/kg body wt.) for mallards : 31-243 and pheasants : 80-320.

It is very highly toxic to fishes. The reported 96-hour LC_{50} values (µg/lit) are rainbow trout : 1.5, fathead minnow : 1.4, channel catfish : 1.5, bluegill sunfish : 1.2. Corresponding values in two aquatic invertebrates, scuds and stoneflies were 5.8 and 3.3 respectively. It is prone to bioaccumulation with the mussel shown to accumulate 600 times more level than the surrounding water.

It is moderately toxic to bees and is relatively non-toxic to beneficial insects such as parasitic wasps, lady bird beetles and some mites.

D. Degradation and metabolism of endosulfan

The overall degradative pathway in different organisms is shown in the accompanying figure. In plants, microorganisms and in animals, it is quickly and massively converted to the sulphate by oxidation. The significance of this conversion is that sulphate is equally toxic and persistent as the parent compound. It is slightly prone to storage in fat as well. In mammals, it is further oxidised and with the removal of elements of sulfuric acid, to endosulfan lactone, which in turn gets hydrolysed to endosulfan hydroxyether. However, the lactone and the hydroxyether are inter-convertible. Part of the hydroxyether is as such excreted in the feces and urine. Most of the hydroxyether is further hydrolysed to the diol. Diol is the most important degradative product, which is excreted through urine as such or after conjugation. In mice, there is evidence of the direct conversion of endosulfan sulfate to the diol by hydrolytic desulfuration. Out of a variety of the metabolic products, only endosulfan sulfate is toxic and the persistence of the pesticide in any matrix is decided by the rate at which the sulfate is degraded.

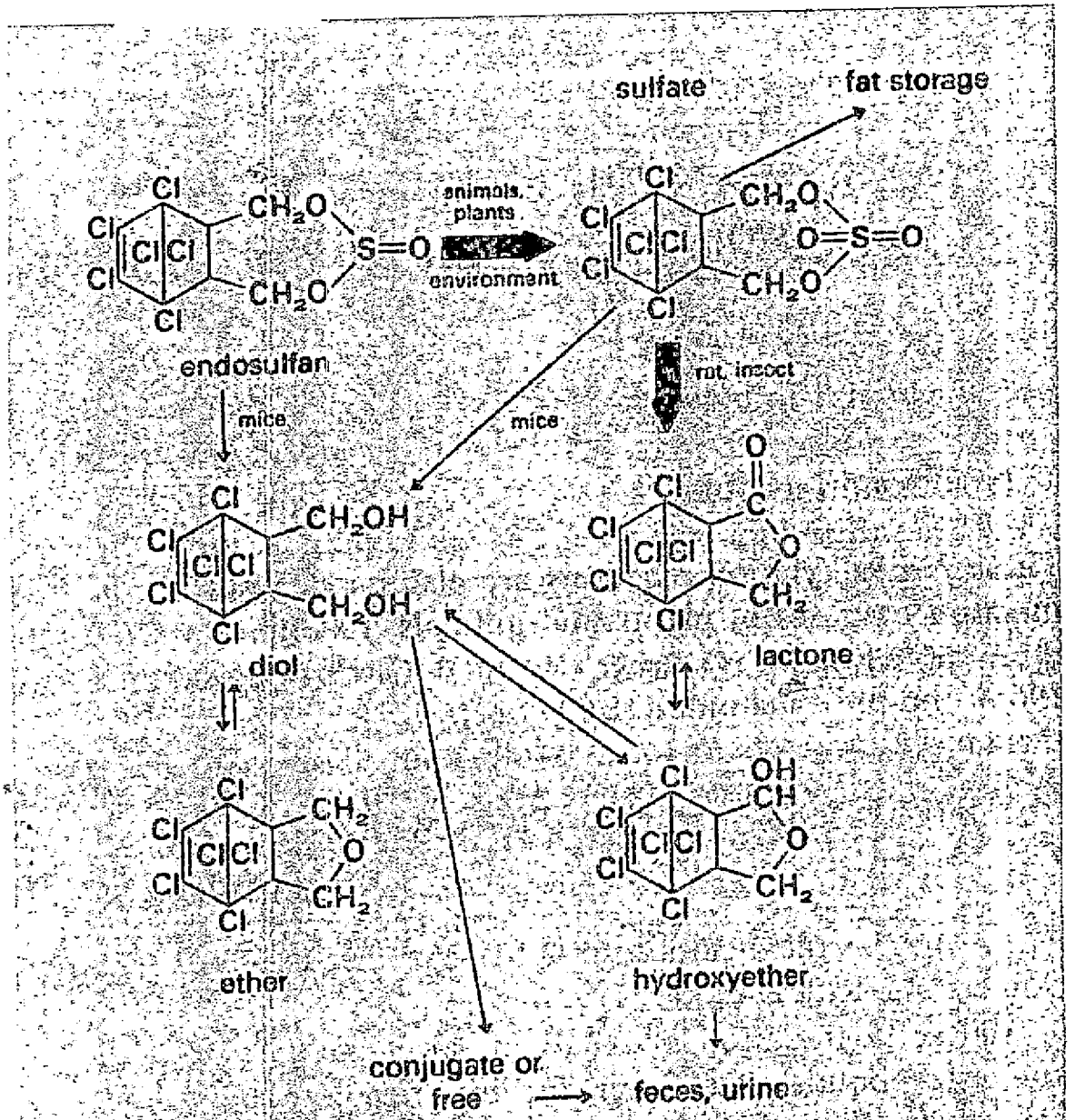

Fig. 5-10. Metabolic fate of endosulfan in rats, mice, and insects.

The overview of endosulfan metabolism in mammals is that most of the residues leave the body in a few days to few weeks. There is apparently no accumulation in milk, body fat or muscle in cattle. In plants, it is rapidly degraded to the diol, which is conjugated. In most of the plants, it is dissipated with a half-life of 5-15 days.

E. Dissipation of endosulfan residues from crops

A large number of studies have been conducted in India and abroad on the persistence and residues of endosulfan on various crops and crop commodities. An abstract of the detils of the studies and results is presented in the following table.

Table. Dissipation of residues of endosulfan from different crops

Crop	Location	Dosage	Waiting Period (days)	T ½ (days)	Reference
Sorghum	*Kanpur, UP*	0.5 kg/ha	5.0	11.95	Singh et al. (1988)
Mustard	*Bihar*	0.02-0.10%		3.0	Kumari et al. (1998)
Green gram	*Rajastan*	350-700 g/ha	2.5-4.0		Banani et al. (1997)
Red gram	*Jaipur, Rajastan*	500-1000 g/ha		4.9-5.03	Parihar & Gupta (1990)
Pigeon pea	*Hissar, Haryana*	525 g/ha	3.0	3.43	Baruah et al. (1998)
Pigeonpea	*Delhi*	350-700 g/ha	1-5	4.2-4.7	Tanwar & Handa (1998)
Chickpea	*Delhi*	0.05%	4.0		Ravi & Verma (1997)
Coriander	*Jobner, Raj.*	0.05%	10.9		Jain & Yadav (1989)
Cotton	*Delhi*		3.4		Kennedy et al. (1998)
Long Melon	*Rajastan*	0.61 kg/ha	7.86		Pareek & Kavadia (1992)
Musk Melon	*Rajastan*	1.2 kg/ha	8.18		Pareek & Kavadia (1992)
Sorghum	*Kanpur, UP*	0.5 kg/ha	5.0	11.95	Singh et al. (1988)
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Musk Melon	*Rajastan*	1.2 kg/ha	8.18		Pareek & Kavadia (1992)
Bhindi	*Coimbatore, TN*	0.07%	4.0		Rajukannu et al. (1988)
Brinjal	*Rahuri, Mah.*		3.6		Dethe & Bothara (1991)
Brinjal	*Anand, Guj.*		14.0	1.9	Raj et al. (1991)
Brinjal	*Parbhani, Mah.*		5.46		Ashtaputre & Jadhav(1989)
Brinjal	*Rahuri, Mah.*	0.05-0.10%	2.57-4.48d		Dethe et al. (1988)
Brinjal	*Udaipur, UP*	0.07%	7.0	3.0	Singh & Kavadia (1988)
Cabbage	*Hyderabad, AP*	0.07%	0.0		Malathi et al. (1999)

Table. Dissipation of residues of endosulfan from different crops (continued)

Crop	*Location*	Dosage	Waiting Period (days)	T ½ (days)	Reference
Cauliflower	*Shalimar, J&K*	0.05%	10.26	4.25	Sheikh & Tikoo (1998)
Chillies	*Frankfort, NY*	0.61 kg/ha		2.0	Antonious et al. (1998)
Cowpea	*Vellayani, Kerala*	0.07-0.14%	2.85-5.21		Beevi et al. (1997)
Cowpea	*New Delhi*	250-500 g/ha		8.0	Mukherjee & Gopal (1998)
Cowpea	*Hissar, Haryana*	250 g/ha	3.0		Kumari et al. (1996)
Knol-khol	*Shillong Assam*	0.075-0.2%	2.5-9.6	1.3-3.3	Gangwar & Singh (1988)
Mung bean	*Udaipur, UP*			1.1-4.64	Verma & Saxena (1988)
Okra	*W. Bengal*	0.5–1.0 kg/ha	15.0		Bhattacharya et al. (1989)
Okra	*Hissar, Haryana*	0.56 kg/ha	3.0		Yadav & Yadav (1989)
Radishes	*Kanpur, UP*	0.05%	3.03		Singh et al. (1993)
Ridge Gourd	*Rajastan*	0.70 kg/ha	8.19		Pareek & Kavadia (1992)
Round gourd	*Jobner, Raj.*	0.07%	3.0		Pareek & Kavadia (1990)
Soybean	*Delhi*	0.07%	3.1	3.78	Pal & Handa (1994)
Soybean	*Shillong, Assam*	0.4-1.6 kg		3.06-7.61	Singh et al. (1990)
Sponge gourd	*Kanpur UP*	0.05%	4.70		Singh et al. (1993)
Tomato	*Anand, Guj.*	0.07%	3.6	7.0	Raj et al. (1991)
Tomato	*Frankgurt NY*	0.61 kg/ha		4.6	Antonious et al. (1998)
Leucerne	*Jhansi, UP*	0.05-1.00%	7-14		Shivsankar & Ram (1988)
Chewing tobacco	*Anand, Guj.*	0.5-1.0	15-30d		Shah et al. (1990)
FCV tobacco	*Rajamundry, Karn*		5.0		Murty et al. (1988)

The exhaustive review demonstrates that endosulfan gets degraded on plants irrespective of the type of crop or the location. The half-life of the pesticide on crops was

in the range of 2 - 10 days and the waiting period suggested varied between 0 and 15 days.

F. Contamination of food commodities in Indian market with residues of endosulfan

Regular monitoring of residues of endosulfan in commodities in Indian market is being undertaken at different centres of the All India Co-ordinated Research Project on Pesticide Residues. The extract of results of the study conducted in the project as well as by other agencies on endosulfan contamination in food commodities is given in the following table.

Commodity	Location	Percentage of samples contaminated	Mean residues (ppm)	MRL (ppm)	Reference
Groundnut oil	Rahuri, MP	50	0.02	0.2	Annual Report of All India Co-ordinated Research Project on Pesticide Residues, 1999. ICAR, New Delhi
Cotton seed oil	Rahuri, MP	70	0.07	0.2	
Sesamum oil	Rahuri, MP	30	0.02	0.2	
Safflower oil	Rahuri, MP	30	0.02	0.2	
Linseed oil	Rahuri, MP	20	0.01	0.2	
Sunflower oil	Rahuri, MP	60	0.05	0.2	
Soybean	Rahuri, MP	nil	--	2.0	
Fish	Kerala	nil	--	2.0	
,,	Assam	19	0.17	2.0	
,,	AP	11	0.01	2.0	
Made tea	South India (1993-94)	??	0.01-2.00	2.00	Muraleedharan (1994)
Tomatoes	Rahuri, Maharastra	33.3	below MRL	2.00	Dethe et al. (1995)
Brinjal		73.3			
Okra		14.3			
Cabbage		88.9			
Cauliflower		100.0			
Vegetables	Jaipur, Rajastan	??	6.5 % above MRL	2.00	Alamelu-Gupta et al. (1998)

The results clearly indicate that except for 6.5% samples of vegetables in Jaipur, Rajatan, UP, all the samples of food commodities monitored did not show presence of endosulfan above the permissible level.

H. Environmental fate of endosulfan

Endosulfan is moderately persistent in the soil. The two isomers vary greatly in their amenability to degradation. No much information is available on the dissipation of

endosulfan from treated soil. A summary of work available in literature is presented in the table below.

Location	Soil type	T ½ (days)	Reference
New South Wales, Australia	cotton soil	110	Kennedy et al. (1998)
Hissar, Haryana	bare cotton soil	39-42	Kathpal et al. (1997)
Lucknow	--	15.8	Hans et al. (1994)
Farukkabad, UP	sandy loam	10.3-10.6	Agnihotri et al. (1996)

The dissipation rate of endosulfan reported from different parts of the world varied from 15.8 days in Lucknow to 110 days in Australia. This can very well be expected. The rate of dissipation in a given ratio is governed by the isomeric ratio, temperature, pH of the soil, microbial population and level of activity etc. However, it can be summarised from the reports from India that the half-life of endosulfan in soil under Indian conditions is in the range of 10-50 days.

Owing to low water solubility, it is not likely to move down the soil profile and contaminate ground water sources. However, it gets strongly adsorbed to soil surface and hence, soil transport by erosion can contaminate off-target locations.

I. Off-target transport of endosulfan residues

Rao *et al.* (1978) in a study conducted at Nagarjuna Sagar, Andhra Pradesh demonstrated that endosulfan applied in one field may get tranported to places down the hill under the influence of rain. Endosulfan was applied to field crop in arable soil uphill. There were rains on days following the application. They detected residues of endosulfan to the extent of 0.01-0.04 ppm in paddy field down the slope.

Wan et al. (1995) found that a field soil cropped to cotton contained endosulfan residues in the level of 7.825 ppm. They detected 0.01 – 13.4 ppb residues in the ditch water and 0.005-2.461 ppm in the ditch sediments. Kennedy (1998) estimated that as much as 1-2% of the soil borne endosulfan residues are removed by run off and that about 50% of it is carried away by storms. Further, Hugo *et al.* (2000) estimated that out of the total amount of endosulfan carried away by run off waters, about 65% is associated with sediment and the rest only is with water.

Robinson et al. (1997) demonstrated the influence of land slope on the downhill transport of endosulfan residues in soil. They found that the endosulfan loss from the

field was to the tune of 27.8% when the slope was only 5°. The loss increased to 53.9% when the slope was increased to 23°, and to 56.6% in case of 38° slope.

The above studies very well demonstrates that endosulfan has the potential of contaminating non-target areas by the movement of the residue laden soil particles during soil erosion. Rao et al. (1998) detected endosulfan residues in fish grown around paddy fields subjected to endosulfan application and the level in prawns exceeded the Maximum Residue Limit of 0.2 ppm.

CONCLUSION

The foregoing discussion gave an overview of the properties and behaviour of endosulfan as a pesticide. The chemical is cheap and at the same time highly effective as a pesticide. Though it is highly toxic, if used carefully, it can deliver the results safely. It undergoes fast degradation in mammalian system and so is eliminated from the body quickly. It does not show any chronic toxicity problems at the dose at which it is recommended for use in agriculture. It has got a short life on plants. Hence the produce can be harvested for consumption after a relatively short period of time. It is moderately toxic to birds and honeybees and highly toxic to fish. It is non-toxic to beneficial insects.

Due to very low water solubility, it is not likely to contaminate ground water. However, it is fairly persistent in the environment. It is strongly adsorbed by colloids and in the adsorbed form it may get transported over long distances during soil erosion. This property leaves chance for off-target contamination and hazards to sensitive fauna like fish and aquatic invertebrates. Hence the chemical is to be used carefully in view of the potential environmental contamination. The dosage and frequency of application should be chosen carefully such that the rate of contamination of soil is far less than the rate of its degradation in soil. As far as possible, its application may be restricted in terrains that are highly prone to soil erosion. In situations where the chemical is used for a long span of time, the soil and biota should be monitored for build up of residues and suitable modifications made in the pest management strategies.

Man could so far discover only a few insecticide target sites. An important one is the nerve channels which the organochlorines and pyrethroids make use of. It is thus

important that we conserve at least a few chemicals that are nerve channel blockers. Most of the organochlorines have been weeded out due to their extremely long persistence in the environment and proneness to biomagnification. Most of the pyrethroids have limitations in crop pest control due to the problem of resistance development by insects. Endosulfan is a very important chemical in this respect. Due to high selectivity, it is often included in integrated pest management programmes. It is the chemical of choice in management of situations where the pest has developed resistance to most organophosphates and carbamates. It is the most eligible representative of the organochlorine group in pesticide rotations. Hence the chemical is to be used most carefully and judiciously so that it can be preserved in the armory that man has with him to fight insect pests.

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WHO/PCS/99.18

Pesticide residues in food—1998

Toxicological evaluations

Sponsored jointly by FAO and WHO
with the support of the International Programme
on Chemical Safety (IPCS)

Joint meeting of the
FAO Panel of Experts on Pesticide Residues
in Food and the Environment
and the
WHO Core Assessment Group

...me, 21–30 September 1998

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ENDOSULFAN

First draft prepared by
D.B. McGregor
International Agency for Research on Cancer
Lyon, France

Explanation

Endosulfan (6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide), an insecticide, has been evaluated toxicologically on several occasions by previous Joint Meetings (Annex 1, references 2, 4, 8, 10, 38, 44, and 56), the latest being the 1989 JMPR (Annex 1, reference 56), when an ADI of 0–0.006 mg/kg bw was established. Endosulfan was reviewed by the present Meeting within the Periodic Review Programme of the Codex Committee on Pesticide Residues. In this evaluation, full use was made of the review of endosulfan prepared by the Australian National Registration Authority, the entire version of which may be obtained at http://www.dpie.gov.au/nra/prsendo.html. This monograph summarizes the new data and relevant data from the previous monographs and monograph addenda on endoslufan (Annex 1, references 4, 9, 11, 39, and 58)

Evaluation for acceptable daily intake

1. Biochemical aspects

(a) Absorption, distribution, and excretion

When radiolabelled endosulfan was administered to mice as a single dose of 4 mg/kg bw by gavage, a single dose of 4.7 mg/kg bw in the diet, or a 21-day administration of 2.4 mg/kg bw per day in the diet, most of the radiolabel was recovered from the faeces. Within three weeks after

assay in which sexually immature rats were treated with endosulfan or dieldrin alone or in a combination on three successive days and the uterine mass weighed on the following day. The highest doses used in the human estrogen receptor assay were determined by the solubility of the compounds, and the highest doses in the uterotropic assay were 100 mg/kg bw for endosulfan or dieldrin alone and 75 mg/kg bw of each in combination. Both chemicals were inactive in both assays, and there was no evidence of synergism (Ashby et al., 1997). In a further study with the human estrogen receptor assay, however, 0.1 mmol/L endosulfan increased the activity of β-galactosidase (Ramamoorthy et al., 1997).

More doubt was cast upon the thesis of synergism by an independent study in which endosulfan and dieldrin showed no additive effect in displacing ^{3}H-17β-estradiol from rat uterine estrogen receptors or in inducing the proliferation of MCF-7 breast cancer cells. The weak proliferative potential described by Soto et al. (1994, 1995) was, however, confirmed in this assay *in vitro*. Endosulfan or dieldrin alone at 3 mg/kg bw per day or in combination, injected intraperitoneally daily for three days, did not stimulate uterotrophic activity and had no effect on pituitary prolactin or other endocrine-related end-points in immature female rats, indicating that these weakly estrogenic compounds do not interact in a synergistic fashion in binding to estrogen receptors or in activating estrogen-receptor-dependent responses in mammalian tissues or cells (Wade et al., 1997). The paper in which synergism was originally proposed was later withdrawn, since the results could not be reproduced, even in the same laboratory (McLachlan, 1997). Overall, these results suggest that concomitant exposure to weakly estrogenic compounds probably does not result in reproductive toxicity related to estrogen action.

3. Observations in humans

In general, the doses of endosulfan involved in cases of poisoning have been poorly characterized. In a summary of case reports (Lehr, 1996), the lowest reported dose that resulted in death was 35 mg/kg bw; deaths have also been reported after ingestion of 295 and 467 mg/kg bw, within 1 h of ingestion in some cases. Intensive medical treatment within 1 h was reported to be successful after ingestion of doses of 100 and 1000 mg/kg bw. The clinical signs in these patient were consistent with those seen in laboratory animals, dominated by tonic–clonic spasms. In a case in which a dose of 1000 mg/kg bw was ingested, neurological symptoms requiring anti-epileptic therapy were still required one year after exposure.

Comments

More than 90% of an oral dose of endusulfan was absorbed in rats, with maximum plasma concentrations occurring after 3–8 h in males and about 18 h in females. Elimination occurs mainly in the faeces and to a lesser extent in the urine, more than 85% being excreted within 120 h. The highest tissue concentrations were in the kidneys. The metabolites of endosulfan include endosulfan sulfate, diol, hydroxy-ether, ether, and lactone but most of its metabolites are polar substances which have not yet been identified. Endosulfan would not be expected to accumulate significantly in human tissues. No data on plant metabolites were available to the Meeting.

A battery of tests for acute toxicity in several species with technical-grade endosulfan showed that it is highly toxic after oral or dermal administration, with respective LD_{50} values of 10–160 mg/kg bw and 45–135 mg/kg bw. The LC_{50} value for rats in a single study was 13 mg/m^3 in females and 35 mg/m^3 in males. Endosulfan, administered by any route, is more toxic to female than to male rats. Clinical signs of acute intoxication include piloerection, salivation, hyperactivity, respiratory distress, diarrhoea, tremors, hunching, and convulsions.

WHO has classified endosulfan as moderately hazardous (WHO, 1996).

The kidney is the target organ for toxicity. The renal effects include increased renal weights and granular pigment formation after short-term administration and progressive, chronic glomerulonephrosis or toxic nephropathy after long-term exposure, although the observation of progressive

glomerulonephrosis is complicated by the fact that this is a common lesion in ageing laboratory rats and occurs at high incidence in control rats.

In a 90-day feeding study in rats, the cytoplasm of isolated cells in the renal proximal convoluted tubules had a yellowish colour, particularly in males, at all dietary concentrations from 10 ppm. The presence of this yellow pigmentation was largely reversible during a four-week recovery period, and it did not appear to indicate nephrotoxicity. A darker, more particulate, granular and/or clumped pigment was also observed, predominantly in cells of the straight portions and occasionally in the proximal convoluted tubules, at dietary concentrations of 30 ppm and above. This darker pigment was more persistent than the yellow one, and urinalysis revealed darker urine and marginally more ketones at doses from 60 ppm, and marginally more protein, particularly in males, indicating renal damage at doses of 360 ppm and above. Similar findings emerged from a multigeneration study but not from a two-year study of carcinogenicity in rats. The changes in pigmentation were considered to be due to the presence of endosulfan and/or its metabolites in the enlarged lysosomes. To test this hypothesis, a four-week feeding study was conducted in which male rats were given dietary concentrations of 360 or 720 ppm endosulfan. Light and electron microscopy of the kidneys of these animals clearly showed increases in the number of lysosomes and the size of cells in the convoluted tubule, probably as a result of accumulation of the test material and/or its metabolites. Lysosomal changes were not observed in either brain or liver, and the renal changes receded appreciably during a 30-day recovery period. Chemical analysis of the kidneys indicated the presence of α-endosulfan and, to a lesser extent β-endosulfan sulfate, and endosulfan lactone. The concentrations of the dominant α-endosulfan in the kidneys were about 50 times those in the liver. The concentrations in blood were usually below the level of detection. After the 30-day recovery period, renal α-endosulfan was detected only in traces and β-endosulfan not at all. Similar analysis of tissues from rats in the two-year study of toxicity and carcinogenicity did not reveal the presence of these substances in the kidney, although measurable α-endosulfan was found in the liver at 75 ppm. The yellow colour therefore indicates the presence of endosulfan and/or its metabolites, rather than either a stage in the pathogenesis of nephropathy or an independent expression of toxicity. It was postulated that in longer studies its removal from lysosomes is accelerated by enzyme induction, which has not been investigated.

In a 78-week study, exposure of rats to endosulfan at a high dose of 20 mg/kg bw per day resulted in testicular atrophy, characterized by degeneration and necrosis of the germinal cells lining the seminiferous tubules. In addition, decreased sperm counts accompanied by an increased incidence of sperm abnormalities have been reported in mice, again at high doses of endosulfan. Reductions in the activities of some testicular xenobiotic-metabolizing enzymes and some hormones that are necessary for normal testicular function were also seen in a 30-day study in rats at 10, but not at 7.5 mg/kg bw per day. The functional significance of these findings was not clear, as studies of reproductive and developmental toxicity in rats and rabbits showed neither impaired fertility nor any increase in the incidence of defects or abnormalities in offspring. Given the high doses at which these testicular effects were observed, it would appear that they are of little human significance.

No genotoxic activity was observed in an adequate battery of tests for mutagenicity and clastogenicity *in vitro* and *in vivo*. The Meeting concluded that endosulfan is not genotoxic.

No carcinogenic effect was observed in mice at 18 ppm for 24 months, in female rats at 445 ppm for 78 weeks in one study or in male or female rats at 75 ppm or 100 ppm for two years in two other studies. The Meeting noted the differences in the dietary concentrations used in these studies, but non-neoplastic responses were seen even at the lower doses.

Endosulfan at dietary concentrations of 0, 3, 15, or 75 ppm did not affect reproductive performance or the growth or development of the offspring of rats over the course of a two-generation study. The NOAEL was 75 ppm, the highest dose tested, equal to 5 mg/kg bw per day for males and 6.2 mg/kg bw per day for females. The NOAEL for parental toxicity was 15 ppm, equal to 1 mg/kg bw per day for males and 1.2 mg/kg bw per day, on the basis of increased liver and kidney weights at 75 ppm.

In two studies of developmental toxicity in rats given oral doses of 0, 0.66, 2, or 6 mg/kg bw per day, the NOAEL for maternal toxicity was 0.66 mg/kg bw per day in one study and 2 mg/kg bw per day in the other. In the first case, the basis was decreased body-weight gain at 2 mg/kg bw

per day and decreased body-weight gain and clinical signs of toxicity at 6 mg/kg bw per day; in the second case, the basis was mortality, clinical signs of toxicity, and decreased body-weight gain at 6 mg/kg bw per day. In both studies, the NOAEL for developmental toxicity was 2 mg/kg bw per day, in the first case on the basis of delayed development and a low incidence of skeletal variations seen at 6 mg/kg per day and in the second on the basis of an increased incidence of fragmented thoracic vertebral centra seen at 6 mg/kg bw per day. In neither study was there any treatment-related major malformation.

In a study of developmental toxicity in rabbits given oral doses of 0, 0.3, 0.7, or 1.8 mg/kg bw per day, the NOAEL for maternal tocicity was 0.7 mg/kg bw per day on the basis of clinical signs of toxicity at 1.8 mg/kg bw per day. The NOAEL for developmental toxicity was 1.8 mg/kg bw per day, the highest dose tested.

Several recent studies have shown that endosulfan, alone and in combination with other pesticides, may bind to estrogen receptors and may perturb the endocrine system. The available studies show only very weak binding to hormone receptors *in vitro*, and the evidence for its relevance to adverse physiological effects *in vivo* is extremely limited. Long-term assays of toxicity and studies of reproductive and developmental toxicity in experimental mammals did not indicate that endosulfan induces functional aberrations that might result from loss of endocrine homeostasis.

The absence of immunotoxic effects in a large number of bioassays with endosulfan suggested that it does not have an adverse effect on the immune function of laboratory animals. However, in two studies, rats given endosulfan in the diet at 30 or 50 ppm for 6 weeks or 20 ppm for 22 weeks had reduced serum titres of tetanus toxoid antibody and reduced immunoglobulins G and M, and inhibition of migration of both leukocytes and macrophages. These findings have not been confirmed.

In a summary of case reports of human poisoning incidents, the lowest reported dose that caused death was 35 mg/kg bw. Higher doses caused death within 1 h. The clinical signs in these patients were dominated by tonic–clonic convulsions, consistent with the observations in experimental animals.

An ADI of 0–0.006 mg/kg bw was established on the basis of the NOAEL of 0.6 mg/kg bw per day in the two-year dietary study of toxicity in rats and a safety factor of 100. The ADI is supported by similar NOAEL values in the 78-week dietary study of toxicity in mice, the one-year dietary study of toxicity in dogs, and the study of developmental toxicity in rats.

An acute RfD of 0–0.02 mg/kg was established on the basis of the NOAEL of 2 mg/kg bw per day in the study of neurotoxicity in rats and a safety factor of 100.

Toxicological evaluation

Levels that cause no toxic effect

Mouse: 3.9 ppm, equal to 0.58 mg/kg bw per day (females in a 78-week study of toxicity)

Rat: 15 ppm, equal to 0.6 mg/kg bw per day (two-year dietary study of toxicity)
75 ppm, equal to 6 mg/kg bw per day (reproductive toxicity)
0.66 mg/kg bw per day (maternal toxicity in a study of developmental toxicity)
2 mg/kg bw per day (fetotoxicity in a study of developmental toxicity)

Rabbit: 0.7 mg/kg bw per day (maternal toxicity in a study of developmental toxicity)

Dog: 10 ppm, equivalent to 0.57 mg/kg bw per day (one-year study of toxicity)

Estimate of acceptable daily intake for humans

0–0.006 mg/kg bw

E X T O X N E T
Extension Toxicology Network

A Pesticide Information Project of Cooperative Extension Offices of Cornell University, Michigan State University, Oregon State University, and University of California at Davis. Major support and funding was provided by the USDA/Extension Service/National Agricultural Pesticide Impact Assessment Program.

Endosulfan

TRADE OR OTHER NAMES

Commercial names for the product include Thiodan, Endocide, Beosit, Cyclodan, Malix, Thimul and Thifor.

INTRODUCTION

Endosulfan is a chlorinated hydrocarbon insecticide of the cyclodiene subgroup which acts as a contact poison in a wide variety of insects and mites. It can also be used as a wood preservative. It is used primarily on food crops like tea, fruits, vegetables and on grains.

The commercial product is made up of a mixture of two separate parts (isomers): the alpha and beta configurations. Endosulfan will be considered as a single (homogenous) product unless otherwise stated in this profile.

TOXICOLOGICAL EFFECTS

ACUTE TOXICITY

Endosulfan is a highly toxic substance and carries the signal word DANGER on the label. Toxicity is partly dependent on the manner with which the pesticide is administered (7). Undiluted endosulfan is slowly and incompletely absorbed into the body whereas absorption is more rapid in the presence of alcohols, oils and emulsifiers.

Stimulation of the Central Nervous System is the major characteristic of endosulfan poisoning (9). Symptoms of acute exposure are indistinguishable from symptoms from other cyclodienes (10). They include incoordination, even a loss of the ability to stand. Other signs of poisoning include gagging, vomiting, diarrhea, agitation, convulsions and loss of consciousness. Blindness has been documented for cows which grazed in a field sprayed with the compound. The animals completely recovered after a month following the exposure (10). In an accidental exposure, sheep and pigs grazing on a sprayed field suffered a lack of muscle coordination and blindness.

The oral LD50 in rats ranges from 18 - 220 mg/kg. Some other oral LD50 values are: mice 7.36 mg/kg, hamsters 118 mg/kg, cats 2 mg/kg, and dogs 76.7 mg/kg. The dermal LD50 for rats is 74 mg/kg while for rabbits figures from 200 to 359 mg/kg are recorded. As noted before, the solvents and emulsifiers used to dissolve endosulfan influence its toxicity. Rats have an inhalation LC50 of 8.0 mg/m3 for four hours. Dogs are less tolerant than rats to this compound and rats are nearly twice as susceptible to endosulfan when they have been deprived of protein.

CHRONIC TOXICITY

Several chronic effects have been noted for animals exposed to endosulfan. The pesticide is most likely to affect kidneys, liver, blood chemistry and the parathyroid gland (9).

Reproductive Effects

Rats fed low doses of endosulfan (2.5 mg/kg/day) for three generations showed no ill effects. The same dose in dogs, however, produced vomiting, tremors, and convulsions. These are the symptoms of acute endosulfan poisoning. Higher doses of endosulfan (5.0 mg/kg/day) caused death in rat dams, increased resorption and caused skeletal deformities in the rat fetuses (10). Female mice fed the compound for 78 weeks (0.1mg/kg/day) had damage to their reproductive organs.

Teratogenic Effects

When moderate to high levels of endosulfan (5 or 10 mg/kg/day) were given orally to female rats on days 6 to 14 of pregnancy, no soft tissue defects were found in their offspring. Some delayed bone formation occurred, however. It is possible that chronic exposure to endosulfan may result in reproductive and/or developmental difficulties in humans. There is no direct evidence of this in humans though.

Mutagenic Effects

Endosulfan is mutagenic to bacterial cells and to yeast cells. The metabolites of endosulfan have also shown the ability to cause cellular changes (10). This compound has also caused mutagenic effects in two different mammalian species. It is possible that it would induce these changes in humans.

Carcinogenic Effects

In a National Cancer Institute study done with both mice and rats, the males of both groups experienced such a high mortality rate that no conclusions could be drawn (1). However, the females of both species failed to develop any carcinogenic conditions 78 weeks after being fed diets containing up to 445 ppm (about 23 mg/kg). There are no reports of cancer in humans exposed to endosulfan. The EPA has placed endosulfan in the "not classifiable" category due to the lack of data on its carcinogenicity

Fate in Humans and Animals

Endosulfan is rapidly degraded and eliminated in mammals with very little absorption in the gastrointestinal tract. Cattle fed 0.15 mg/kg for 60 days had no residues in the fat. The metabolite, endosulfan sulfate, seems to show similar acute toxicity to the parent compound. The beta isomer is cleared from blood plasma more quickly than the alpha isomer (3). Most of the endosulfan seems to leave the body within a few days to a few weeks.

Mice fed endosulfan had both isomers plus two breakdown products in the feces. There were only traces of oxidized endosulfan in the kidney and muscle.

ECOLOGICAL EFFECTS

Birds in general are fairly sensitive to endosulfan poisoning. The oral LD50 is 33 mg/kg for young ducks (205-243 mg/kg for mature mallards). The oral LC50 is 805 mg/kg for bobwhite quail and 1,275 mg/kg for ring-necked pheasants. Male mallards from three to four-months-old exhibited wings crossed high over their back, tremors, falling, and other symptoms as soon as ten minutes after an acute, oral dose. The symptoms persisted for up to a month in a few animals (3).

Several fish species are quite susceptible to endosulfan. The 96- hour LC50 is 1.2 ppb for bluegill and 1.4 ppb for rainbow trout. In an accidental fish kill, the initial water level was 30.9 ppb which dropped to 0.01 - 6.5 ppb in four days. Endosulfan is also quite toxic to birds and to shellfish. It is moderately toxic to bees and is relatively non-toxic to beneficial insects such as parasitic wasps, lady bird beetles and some mites (8).

ENVIRONMENTAL FATE

Endosulfan does not easily dissolve in water. It does stick to soil particles readily. Transport of this pesticide is most likely occur if endosulfan is attached to soil particles in surface runoff. Large amounts of endosulfan can be found in surface water near areas of application (9). It has also been found in surface water throughout the country at very low concentrations and has been detected in the air at minute levels. It is has been found, but not quantified, in well water in California (11). It is not expected to pose a threat to groundwater.

In raw river water at room temperature and exposed to light, both isomers disappeared in four weeks. A breakdown product first appeared within the first week. The breakdown in water is faster (five weeks) under neutral conditions than at more acidic conditions (five months). Under strongly alkaline conditions the half-life of the compound is one day.

The two isomers have different degradation times in soil. The half-life for the alpha isomer is 35 days and 150 days for the beta isomer under neutral conditions. These two isomers will persist longer under more acidic conditions. The compound is broken down in soil by fungi and by bacteria (2).

The breakdown product, endosulfan sulfate, has been observed in several field studies involving plants. The sulfate is more persistent than the parent compound, accounting for 90% of the residue in 11 weeks. Sulfate formation increases as temperatures increase (2). However, sunlight may play a role in the reaction, perhaps in starting the process. On most fruits and vegetables, 50% of the parent residue is lost within three to seven days.

Endosulfan and endosulfan residues have been found in numerous food products at very low concentrations. They have been detected in vegetables (0.0005 - 0.013 ppm), in tobacco, in various seafoods (0.2 ppt - 1.7 ppb), and in milk.

Exposure Guidelines:

NOEL (rat):	0.15 mg/kg/day
TLV-TWA:	0.1 mg/m3
TLV STEL:	0.3 mg/m3
ADI:	0.006 mg/kg/day (ppm) (WHO)
RfD:	0.00005 mg/kg/day (EPA); 0.0015 mg/kg/day (OPP)
LEL:	0.75 mg/kg/day (rat)

Physical Properties:

CAS #:	115-29-7
Chemical name:	6,7,8,10,10-hexachloro-1,5,51,6,9,9a-hexahydro-6,9-methano-2,4,3-benzadioxathiepin 3-oxide
Chemical class/use:	chlorinated hydrocarbon insecticide
Solubility in water:	alpha isomer: 0.32 mg/l; beta isomer: 0.33 mg/l
Solubility in other	toluene 20 g/100 g; hexane 2.4 g/100 g;

solvents:

Melting Point: alpha isomer: 109.2 degrees C; beta isomer: 213.3 degrees C; technical material 70-100 degrees C.

Vapor Pressure: 1.7 x 10 to the minus 7 power mm Hg

BASIC MANUFACTURER

FMC Corporation
Agricultural Chemicals Group
2000 Market Street
Philadelphia, PA 19103
Telephone: 215/299-6000
Emergency: 800-331-3148

Review by Basic Manufacturer:

Comments solicited: October, 1992
Comments received:

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EXTOXNET PIP - ENDOSULFANE X T O X N E T
Extension Toxicology Network
Pesticide Information Profiles
A Pesticide Information Project of Cooperative Extension Offices of Cornell University, Oregon State University, the University of Idaho, and the University of California at Davis and the Institute for Environmental Toxicology, Michigan State University. Major support and funding was provided by the USDA/Extension Service/National Agricultural Pesticide Impact Assessment Program.
EXTOXNET primary files maintained and archived at Oregon State University
Revised June 1996

Red - 1-50 mg/kg - Poison - Extremely toxic
Yellow - 51-500 " - Poison - Highly toxic
Blue - 501-5000 - Danger - Toxic
Green - >5001 - Caution - Moderately toxic

Endosulfan

Trade and Other Names: Trade or other names for the product include Afidan, Beosit, Cyclodan, Devisulfan, Endocel, Endocide, Endosol, FMC 5462, Hexasulfan, Hildan, Hoe 2671, Insectophene, Malix, Phaser, Thiodan, Thimul, Thifor, and Thionex.
Regulatory Status: Endosulfan is a highly toxic pesticide in EPA toxicity class I. It is a Restricted Use Pesticide (RUP). Labels for products containing endosulfan must bear the Signal Words DANGER - POISON, depending on formulation.
Chemical Class: chlorinated hydrocarbon
Introduction: Endosulfan is a chlorinated hydrocarbon insecticide and acaricide of the cyclodiene subgroup which acts as a poison to a wide variety of insects and mites on contact. Although it may also be used as a wood preservative, it is used primarily on a wide variety of food crops including tea, coffee, fruits, and vegetables, as well as on rice, cereals, maize, sorghum, or other grains. Formulations of endosulfan include emsulsifiable concentrate, wettable powder, ultra-low volume (ULV) liquid, and smoke tablets. It is compatible with many other pesticides and may be found in formulations with dimethoate, malathion, methomyl, monocrotophos, pirimicarb, triazophos, fenoprop, parathion, petroleum oils, and oxine-copper. It is not compatible with alkaline materials. Technical endosulfan is made up of a mixture of two molecular forms (isomers) of endosulfan, the alpha- and beta-ispmers. Information presented in this profile refers to this technical product unless otherwise stated.
Formulation: Formulations of endosulfan include emulsifiable concentrate, wettable powder, ultra-low volume (ULV) liquid, and smoke tablets.
Toxicological Effects:
Acute toxicity: Endosulfan is highly toxic via the oral route, with reported oral LD50 values ranging from 18 to 160 mg/kg in rats, 7.36 mg/kg in mice, and 77 mg/kg in dogs [2,9]. It is also highly toxic via the dermal route, with reported dermal LD50 values in rats ranging from 78 to 359 mg/kg [2,9]. Endosulfan may be only slightly toxic via inhalation, with a reported inhalation LC50 of 21 mg/L for 1 hour, and 8.0 mg/L for 4 hours [2]. It is reported not to cause skin or eye irritation in animals [2]. The alpha-isomer is considered to be more toxic than the beta-isomer [2]. Animal data indicate that toxicity may also be influenced by species and by level of protein in the

diet; rats which have been been deprived of protein are nearly twice as susceptible to the toxic effects of endosulfan [2]. Solvents and/or emulsifiers used with endosulfan in formulated products may influence its absorption into the system via all routes; technical endosulfan is slowly and incompletely absorbed into the body whereas absorption is more rapid in the presence of alcohols, oils, and emulsifiers [2]. Stimulation of the central nervous system is the major characteristic of endosulfan poisoning [51]. Symptoms noted in acutely exposed humans include those common to the other cyclodienes, e.g., incoordination, imbalance, difficulty breathing, gagging, vomiting, diarrhea, agitation, convulsions, and loss of consciousness [2]. Reversible blindness has been documented for cows that grazed in a field sprayed with the compound. The animals completely recovered after a month following the exposure [2]. In an accidental exposure, sheep and pigs grazing on a sprayed field suffered a lack of muscle coordination and blindness [2].
Chronic toxicity: In rats, oral doses of 10 mg/kg/day caused high rates of mortality within 15 days, but doses of 5 mg/kg/day caused liver enlargement and some other effects over the same period [2]. This dose level also caused seizures commencing 25 to 30 minutes following dose adiministration that persisted for approximately 60 minutes [2]. There is evidence that administration of this dose over 2 years in rats also caused reduced growth and survival, changes in kidney structure, and changes in blood chemistry [2,51].
Reproductive effects: Rats fed doses of endosulfan of 2.5 mg/kg/day for three generations showed no observable reproductive effects, but 5.0 mg/kg/day caused increased dam mortality and resorption [2,51]. Female mice fed the compound for 78 weeks at 0.1 mg/kg/day had damage to their reproductive organs [52]. Oral dosage for 15 days at 10 mg/kg/day in male rats caused damage to the semeniferous tubules and lowered testes weights [2,5]. It is unlikely that endosulfan will cause reproductive effects in humans at expected exposure levels.
Teratogenic effects: An oral dose of 2.5 mg/kg/day resulted in normal reproduction in rats in a three-generational study, but 5 and 10 mg/kg/day resulted in abnormalities in bone development in the offspring [2,51]. Teratogenic effects in humans are unlikely at expected exposure levels.
Mutagenic effects: Endosulfan is mutagenic to bacterial and yeast cells [51]. The metabolites of endosulfan have also shown the ability to cause cellular changes [2,51]. This compound has also caused mutagenic effects in two different mammalian species [51]. Thus, evidence suggests that exposure to endosulfan may cause mutagenic effects in humans if exposure is great enough.
Carcinogenic effects: In a long-term study done with both mice and rats, the males of both groups experienced such a high mortality rate that no conclusions could be drawn [52]. However, the females of both species failed to develop any carcinogenic conditions 78 weeks after being fed diets containing up to about 23 mg/kg/day. The highest tolerated dose of endosulfan did not cause increased incidence of tumors in mice over 18 months, and a later study also showed no evidence of carcinogenic activity in mice or rats [2,52]. It appears that endosulfan is not carcinogenic.
Organ toxicity: Data from animal studies reveal the organs most likely to be affected include kidneys, liver, blood, and the parathyroid gland [51].
Fate in humans and animals: Endosulfan is rapidly degraded into mainly

water-soluble compounds and eliminated in mammals with very little absorption in the gastrointestinal tract [2]. In rabbits, the beta-isomer is cleared from blood plasma more quickly than the alpha-isomer, with reported blood half-lives of approximately 6 hours and 10 days, respectively [2], which may account in part for the observed differences in toxicity. The metabolites are dependent on the mixture of isomers and the route of exposure [2]. Most of the endosulfan seems to leave the body within a few days to a few weeks.

Ecological Effects:

Effects on birds: Endosulfan is highly to moderately toxic to bird species, with reported oral LD50 values in mallards ranging from 31 to 243 mg/kg [9,53], and in pheasants ranging from 80 to greater than 320 mg/kg [53]. The reported 5-day dietary LC50 is 2906 ppm in Japanese quail [54]. Male mallards from 3 to 4 months old exhibited wings crossed high over their back, tremors, falling, and other symptoms as soon as 10 minutes after an acute, oral dose. The symptoms persisted for up to a month in a few animals [53].

Effects on aquatic organisms: Endosulfan is very highly toxic to four fish species and both of the aquatic invertebrates studied; in fish species, the reported 96-hour LC50 values were (in ug/L): rainbow trout, 1.5; fathead minnow, 1.4; channel catfish, 1.5; and bluegill sunfish, 1.2. In two aquatic invertebrates, scuds (G. lacustris) and stoneflies (Pteronarcys), the reported 96-hour LC50 values were, respectively, 5.8 ug/L and 3.3 ug/L [55]. The bioaccumulation for the compound may be significant; in the mussel (Mytelus edulis) the compound accumulated to 600 times the ambient water concentration [17].

Effects on other organisms: It is moderately toxic to bees and is relatively nontoxic to beneficial insects such as parasitic wasps, lady bird beetles, and some mites [9,17].

Environmental Fate:

Breakdown in soil and groundwater: Endosulfan is moderately persistent in the soil environment with a reported average field half-life of 50 days [14]. The two isomers have different degradation times in soil. The half-life for the alpha -somer is 35 days, and is 150 days for the beta-isomer under neutral conditions. These two isomers will persist longer under more acidic conditions. The compound is broken down in soil by fungi and bacteria [9]. Endosulfan does not easily dissolve in water, and has a very low solubility [9,14]. It has a moderate capacity to adhere or adsorb to soils [14]. Transport of this pesticide is most likely to occur if endosulfan is adsorbed to soil particles in surface runoff. It is not likely to be very mobile or to pose a threat to groundwater. It has, however, been detected in California well water [12].

Breakdown in water: In raw river water at room temperature and exposed to light, both isomers disappeared in 4 weeks [12]. A breakdown product first appeared within the first week. The breakdown in water is faster (5 weeks) under neutral conditions than at more acidic conditions or basic conditions (5 months) [12]. Under strongly alkaline conditions the half-life of the compound is 1 day. Large amounts of endosulfan can be found in surface water near areas of application [51]. It has also been found in surface water throughout the country at very low concentrations [12].

Breakdown in vegetation: In plants, endosulfan is rapidly broken down to the corresponding sulfate [9]. On most fruits and vegetables, 50% of the parent

residue is lost within 3 to 7 days [9]. Endosulfan and its breakdown products have been detected in vegetables (0.0005-0.013 ppm), in tobacco, in various seafoods (0.2 ppt-1.7 ppb); and in milk [12].

Physical Properties:

Appearance: Pure endosulfan is a colorless crystal. Technical grade is a yellow-brown color [9].

Chemical Name:
6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzadioxathiepin 3-oxide [9]

CAS Number: 115-29-7 (alpha-isomer, 959-98-8; beta-isomer, 33213-65-9)

Molecular Weight: 406.96

Water Solubility: 0.32 mg/L @ 22 C [9] 0.32 ppm

Solubility in Other Solvents: s. in toluene and hexane [9]

Melting Point: Technical material, 70-100 C [9]

Vapor Pressure: 1200 mPa @ 80 C [9]

Partition Coefficient: Not Available

Adsorption Coefficient: 12,400 [14]

Exposure Guidelines:

ADI: 0.006 mg/kg/day [27]

MCL: Not Available

RfD: 0.00005 mg/kg/day [8]

PEL: Not Available

HA: Not Available

TLV: 0.1 mg/m3 (8-hour) [56]

Basic Manufacturer:
FMC Corporation
Agricultural Chemicals Group
1735 Market Street
Philadelphia, PA 19103
Phone: 215-299-6661
Emergency: 800-331-3148

References:
References for the information in this PIP can be found in Reference List Number 6

EXTOXNET PIP - REFERENCE LIST 6Reference List 6

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Endosulfan (Thiodan) Chemical Profile 4/85

CHEMICAL NAME: 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiopin-3-oxide (56)

DEC INGRED. CODE:

TRADE NAME(S): Thiodan, Tiovel (56)

FORMULATION(S): Wettable powders (35, 50%), emulsifiable concentrates (17.5%,35%,50%, and 2 pounds and 3 pounds/gallon), ULV (25%), granules (2,3,4,5%), dusts (1,2,3,4,5,6%)(56).

TYPE: Organochlorine insecticide - miticide

BASIC PRODUCER(S): FMC Corp. Velsicol Chemical Corp. Agr. Chem. Group 341 East Ohio Street 2000 Market St. Chicago, IL 60611 Piladelphia, PA 19103

STATUS: Restricted use

PRINCIPAL USES: Controls aphids, thrips, beetles, foliar feeding larvae, mites, borers, cutworms, bollworms, bugs, whiteflies, leafhoppers, and slugs on deciduous, citrus, and small fruits, vegetables, forage crops, oil crops, fiber crops, grains, tobacco, coffee, tea, forest, ornamentals. Controls termites and tsetse fly (56).

I. EFFICACY

Important Pests Controlled: Aphids, beetles, bollworms, spittlebugs, termites, tsetse fly, leafhoppers, pear psylla, fleabeetles, stemborers, stinkbugs, boll weevils, loopers, corn earworms, peach twig borers, armyworms, cyclamen mites, mosquito pupae, and many others (8a).

II. PHYSICAL PROPERTIES

MOLECULAR FORMULA: C9 H6 Cl6 O3 S (62)

MOLECULAR WEIGHT: 406.9 (62)

PHYSICAL STATE: Brown crystalline solid (technical product, at least 94% pure). Endosulfan is a mixture of two stereo-isomers: alpha-endosulfan, endosulfan (I), m.p. 109 C, is 64-67% of the technical grade; beta-endosulfan, endosulfan (II), m.p. 213.3 C, is 29-32% (62).

ODOR: Of sulfur dioxide (technical product) (62)

MELTING POINT: 70-100 C (technical product) (62)

VAPOR PRESSURE: 1.2 Pa at 80 C (technical product) (62)

SOLUBILITY: 0.32 mg/l water (alpha-endosulfan), 0.33 mg/l water (beta-endosulfan) at 22 C (62).

III. HEALTH HAZARD INFORMATION

OSHA STANDARD: None established

NIOSH RECOMMENDED LIMIT: None established

ACGIH RECOMMENDED LIMIT: TWA (Time Weighted Average) = 0.1 mg/m3; STEL (Short Term Exposure Level) = 0.3 mg/m3 (deleted); skin notation (15c).

TOXICOLOGY

A. ACUTE TOXICITY

DERMAL: LD50 = 359 mg (in oil)/kg (rabbit) (62)
Nonirritant (11c)

ORAL: LD50 = 80-110 mg tech. (in oil)/kg (rat); 76 mg alpha isomer/kg (rat); 240 mg beta isomer/kg (rat); 76.7 mg tech./kg (dog) (62).

INHALATION: LC50 (Thiodan 50 WP) = >2 gm/liter of air (rat)(11c) LD50 = 350 mg/m3 when the exposure is four hours (male rat) (15b)

EYES: Nonirritant (11c)

B. SUBACUTE AND CHRONIC TOXICITY:

In 2-yr feeding trials rats receiving 30 mg/kg diet showed no ill-effect; in 1-yr feeding trials NEL for dogs was 3 mg/kg diet (62).

Dogs tolerated endosulfan orally for a year at dosages up to 0.75 mg/kg, the highest level tested. Oral dosages of about 0.5 mg/day (dietary level of 10 ppm) for 2 years were associated with lower survival of female rats and reduced testis weight in males, but these findings were of doubtful statistical significance.

Consistent histopathological findings were apparent only at a dosage ten times as great, which produced renal tubular damage and somehydropic change of the liver (15b).

IV. ENVIRONMENTAL CONSIDERATIONS

Hazardous to birds, fish, and beneficial insects. (?) Moderately hazardous to honey bees. Biological magnification slight. Not recommended for use on Concord grapes. Injury reported on alfalfa, birch and chrysanthemums under greenhouse conditions (1).

It is highly toxic to fish (LC50 (96-hr) for golden ide 2 ug/l water) but, in practical use, should be harmless to wildlife and to honeybees (62).

Fish: Endosulfan is highly toxic. The LC50 of various fish species was determined to range between 0.001 and 0.05 ppm (11c).

Wildlife Studies: the LD50 values obtained are as follows:

Species	Male	Female
Bobwhite Quail	50	56
Japanese Quail	106	85
Mallard Ducks	243	205

No significant difference in sex (11c).

It is metabolised, in plants and mammals, to the corresponding sulphate which is toxicologically similar to endosulfan (the sulphite).

For most fruits and vegetables 50% of the residue is lost in 3-7 days. There is no accumulation in milk, fat or muscle and it is excreted as conjugates of the diol and as other highly polar metabolites depending on the species (62).

Approximate Residual Period: 7-15 days on plant surfaces; 1 season on unexposed surfaces (1).

V. EMERGENCY AND FIRST AID PROCEDURES

The chemical information provided below has been condensed from original source documents, primarily from "Recognition and Management of Pesticide Poisonings", 3rd ed. by Donald P. Morgan, which have been footnoted. This information has been provided in this form for your convenience and general guidance only. In specific cases, further consultation and reference may be required and is recommended. This information is not intended as a sub-stitute for a more exhaustive review of the literature nor for the judgement of a physician or other trained professional.

If poisoning is suspected, do not wait for symptoms to develop. Contact a physician, the nearest hospital, or the nearest Poison Control Center.

FREQUENT SYMPTOMS AND SIGNS OF POISONING BY ORGANOCHLORINE PESTICIDES : APPREHENSION, EXCITABILITY, DIZZINESS, HEADACHE, DISORIENTATION, WEAKNESS, PARESTHESIAE, muscle twitching, tremor, tonic and clonic . CONVULSIONS (often epileptiform), and unconsciousness are the major manifestations. Soon after ingestion, nausea and vomiting commonly occur. When chemicals are absorbed dermally, apprehension, twitching, tremors, confusion, and convulsions may be the first symptoms.

Respiratory depression is caused by the pesticide and by the petroleum solvents in which these pesticides are usually dissolved. Pallor occurs in moderate to severe poisoning. Cyanosis may result a convulsive activity interferes with respiration (25).

SKIN CONTACT: Remove contaminated clothing and wash skin thoroughly with soap and water. Call a physician immediately (11c).

INGESTION: Give a saline emetic (tablespoon of salt in glass of water) and repeat until returns are clear. Call a physician immediately (11c).

EYE CONTACT: Flush with plenty of water. Call a physician immediately (11c)

NOTES TO PHYSICIAN: Endosulfan is a central nervous system stimulant. There is no specific antidote. If patient is convulsing, give pentobarbital (0.25 to 0.50 gram) intravenously. Otherwise phenobarbital (0.06 to 0.10 gram) may be given orally. Do not use oily laxatives as they increase absorption. Patient should be under medical observation for at least 24 hours in any case of suspected Intoxication. Electroencephalogram may show abnormal alpha wave activity (11c).

Diazepam is the treatment of choice for convulsions. If ingested, induce emesis, then administer magnesium sulfate and observe (56).

VI. FIRE AND EXPLOSION INFORMATION

GENERAL: While dry Thiodan formulations will not support combustion, there is the possibility of them giving off sulfur dioxide fumes if a fire occurs where they are stored. For liquid Thiodan formulations observe flammable caution statements. No explosive hazard (for technical material) (11c).

EXTINGUISHER TYPE: Water spray, CO2, dry chemical, fog (16).

VII. COMPATIBILITY

Generally compatible except with alkaline materials (1). Incompatible with calcium arsentate, lime, or zinc sulfate plus lime. Compatible with other pesticides with which it might be used (11c).

VIII. PROTECTIVE MEASURES

STORAGE AND HANDLING: Do not breathe dust or spray mist. Do not get in eyes, on skin, or on clothing. Wash hands immediately after handling. Do not store Thiodan Miscible at temperatures below 20 F. Provide general ventilation plus local exhaust at point of potential fume emission. Protect E.C. from freezing (56).

PROTECTIVE CLOTHING: During commercial or prolonged exposure, wear clean clothing fastened at neck and wrists for dust protection, change clothing daily; wear clean synthetic rubber gloves and a mask or respirator of a type passed by MESA for endosulfan protection. Protective clothing also required for workers entering treated fields within 24 hours of application (56).

PROTECTIVE EQUIPMENT: During commercial or prolonged exposure, wear a mask or respirator of type passed by MESA for endosulfan protection (56).

IX. PROCEDURES FOR SPILLS AND LEAKS

IN CASE OF EMERGENCY, CALL, DAY OR NIGHT : 800) 424-9300

PESTICIDE TEAM SAFETY NETWORK/CHEMTREC : Using respirator sweep up spill and use if possible or package for disposal (16).

X. LITERATURE CITED

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ASHINGTON, D.C. 20460

0129:1

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

DATE: October 7, 1998

MEMORANDUM

SUBJECT: *ENDOSULFAN* - Report of the Hazard Identification Assessment Review Committee.

FROM: David S. Liem, Ph.D
Reregistration Branch II
Health Effects Division (7509C)
and
Jess Rowland, Executive Secretary
Hazard Identification Assessment Review Committee
Health Effects Division (7509C)

THROUGH: K. Clark Swentzel, Chairman,
Hazard Identification Assessment Review Committee
Health Effects Division (7509C)

TO: Steve DeVito, Risk Assessor
Reregistration Branch II
Health Effects Division (7509C)

PC Code: 079401

On September 1, 1998 the Health Effects Division's Hazard Identification Assessment Review Committee evaluated the toxicology data base of Endosulfan, selected the toxicological endpoints for acute and chronic dietary as well as short, intermediate and long-term occupational/residential exposure risk assessments, evaluated the carcinogenic potential, and addressed the potential sensitivity of infants and children as required by the Food Quality Protection Act (FQPA) of 1996. The Committee's conclusions are presented in this report.

A short-term aggregate exposure risk assessment is not feasible since dermal and inhalation NOAELs were selected for the respective routes without a common endpoint (i.e., the dermal NOAEL is based on hepatotoxicity while the inhalation NOAEL is based hematopoietic toxicity). Therefore, the dermal and inhalation exposures cannot be combined with dietary (food + water)exposure; separate MOEs should be calculated.

For intermediate and long-term aggregate exposure risk assessments, the dermal and inhalation exposures should be converted to dermal and inhalation absorption values (oral equivalent dosages), and these should be added to the oral exposures from food, water and incidental oral exposure, and compared to the oral NOEL to calculate an aggregate risk MOE.

III. CLASSIFICATION OF CARCINOGENIC POTENTIAL

1. Combined Chronic Toxicity/Carcinogenicity Study in Rat §83-5

MRID No. 41099502

Executive Summary: See Chronic Dietary

Discussion of Tumor Data: There was no evidence of carcinogenicity.

Adequacy of the Dose Levels Tested: The Committee considered that the doses tested were adequate to test the carcinogenic potential of the test compound.

2. Carcinogenicity Study in Mice

MRID No. 40792401

Executive Summary: In a carcinogenicity study, groups of HOE:NMRKf (SPF71) 60 mice/sex/group were fed with technical endosulfan (97.9% purity) at 0, 2, 6 and 18 ppm (= 0, 0.3, 0.9 and 2.6 mg/kg/day) for 24 months. A satellite group of twenty mice/sex/group was dosed in a similar fashion and were used for hematology and clinical chemistry evaluations. No treatment-related effects were evident in clinical signs, food consumption, hematology, clinical chemistry, urinalysis, organ weights and gross and microscopic evaluations. At study termination, statistically significant increased mortality was noted in the high-dose females (only 28% survivors *versus* 45% of the controls). Increased mortality in the high-dose females is judged to be treatment-related. Mean body weights of the males and females were comparable among all groups. A slight reduction in body weight gain in high-dose males (between weeks 13 and 26) was noted. At 12 months, the lung and ovary weights of the 18 ppm females were significantly ($p<0.05$) decreased and at 18 months, the relative liver weights of males

dosed at 18 ppm and relative ovary weights in females dosed at 18 ppm were slightly but significantly decreased. At 24 months, organ weights were comparable among all groups. Decreases in organ weights noted at various intervals during the study are not judged to be related to treatment, because they are within the normal historical ranges. Histopathologically, slight increased incidences of epithelial thickening of the urinary bladder were noted in all treated males (0, 5, 8 and 12, in the control, low-, mid- and high-dose groups, respectively) and females (0, 6, 9 and 10, in the control, low-, mid- and high-dose groups, respectively). The original reviewer of this study concluded these increases were not toxicologically significant, because of the "absence of a progression to a clear proliferative change". Lymphosarcoma was found in practically all organs of male and female mice. In addition, since it was noted equally among all groups, these occurrences were judged to be spontaneous and strain-related changes. These occurrences were not considered to be treatment-related effects. The systemic NOAEL was 6 ppm (0.9 mg/kg/day) and the LOAEL was 18 ppm (2.65 mg/kg/day), based on increased incidences of mortality in females.

This study is classified as **acceptable/ guideline** and it satisfies the guideline requirements for an oncogenicity study in mice (§83.2).

Discussion of Tumor Data: There was no evidence of carcinogenicity. The lymphosarcoma observed in all organs of male and female mice of both treated and control mice at comparable incidences were judged to be spontaneous and strain-related changes, and were not considered to be treatment-related effects.

Adequacy of the Dose Levels Tested: The Committee considered that the doses used in this study were adequate to test the carcinogenic potential of endosulfan.

IV. MUTAGENICITY

Endosulfan technical was inactive in the primary rat hepatocyte unscheduled DNA synthesis (UDS) assay (MRID#00148265), and was non-mutagenic in the mouse lymphoma forward mutation assay (MRID#00148266).

V. EQPA CONSIDERATIONS

1. Adequacy of the Database:

The toxicology data base is not complete. Datagap exists for a subchronic neurotoxicity study in rats (§82-5). Studies on an acute delayed neurotoxicity in hen and acute neurotoxicity screening in the rat were submitted to the Agency.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

012941

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

DATE: October 7, 1998

MEMORANDUM

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FROM: David S. Liem, Ph.D
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THROUGH: K. Clark Swentzel, Chairman,
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TO: Steve DeVito, Risk Assessor
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