A Centre for Science and Environment report on the contamination of endosulfan in the villagers.

CSE laboratory analysis strengthens suspicion that the Kerala Pesticide Tragedy is a government corporation's creation. Full report in the forth-coming issue of Down to Earth Vol. 9, No 19, February 28, 2001

New Delhi, February 21, 2001: The Centre for Science and Environment (CSE) today released the shocking results of its laboratory analysis on samples brought from Padre village of Enmakaje Gram Panchayat in Kasaragod district, Kerala, where a lot of unusual diseases related to the central nervous system have been reported, especially among children. The first tests conducted on the level of pesticide contamination in the village showed that extremely high levels of the organochlorine pesticide endosulfan were present in all the samples, from human blood and milk, to soil, water, fruits vegetables, cow's milk and skin tissue, fish and frog. The Plantation Corporation of Kerala, run by the state government, has been spraying endosulfan through helicopters for more than two decades over its cashew plantations on the hills in and around Padre to counter the tea mosquito pest. Scientific studies show that endosulfan can **affect the unborn child in the womb**, among the other health effects. Several countries have banned or restricted the use of endosulfan, though the pesticide is not banned in India.

The laboratory results strengthen the suspicion that the **Padre residents are subsidizing government's cashew production with their lives**.

One woman's blood showed 900 times the amount of endosulfan that is permitted in water **-- CSE could not find any permissible limit for blood, meaning that it is unlikely that there is a minimum level at which the pesticide would not harm the human body.** The woman's elder son Kittanna, 21, has cerebral palsy; the younger son Sridhar, 16, is mentally retarded

---

INTRODUCTION

The Plantation Corporation of Kerala has allegedly become a silent killer in North Kerala. The aerial spraying of endosulfan, a deadly organochlorine pesticide, and other toxic chemicals in their plantations has seriously damaged the health of children, women and men.

THE CENTRE FOR SCIENCE AND ENVIRONMENT

The Centre for Science and Environment, a non-governmental organisation based in New Delhi, has recently set up a laboratory to monitor pollution. Its main aim is to undertake scientific studies to generate public awareness about food contaminated by pesticides and heavy metals. It provides scientific services at affordable prices to communities that do cannot obtain scientific evidence against polluters. This can be crucial at times, say, in a court case that a community might be fighting against a polluter in its area. 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 will also provide paid services to become financially self-sufficient. The funds to set up the laboratory have come from Deutsche Gesellschaft fur Technische Zusammenaabeit (GTZ) and the European Union.

CASE BACKGROUND

The international negotiation by UNEP to ban such Persistent Organic Pollutants (POPs) has already short listed 12 chemicals and endosulfan is expected to be the 13th name in the list. The irreversible damages to the environment and human health by the pesticides already used in the last 25 years are beyond any assessment. The damages by the persistent pesticides are long lasting and will create problems for the generations to come.

Recently the people and few voluntary groups involved in conservation activities and environmental education living nearby one of the plantations, Periya Division, have come together and demanded a complete stoppage of aerial spraying and to start a cleaning programme for the area as soon as possible. The people living nearby one of the plantation, Periya division are affected by ailments like headache dizziness, skin lesions, sudden abortions, neurological disorders, epilepsy, cerebral palsy, cancer and physically and mentally handicapped children etc. The younger generation is losing their immunity and occurrence of fever and other diseases are very high .The cattle and dogs die within one week after spraying. Stream fishes and the whole water body and the soil are contaminated with chemicals. The area does not have a public water supply system and the people depend on wells that are contaminated. CSE offered to conduct laboratory tests on sample collected from the Padre village free of cost in their newly established Pollution Monitoring laboratory.

METHOLODY FOR SAMPLE COLLECTION

Sample collection: A researcher from CSE went to Padre to organize 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.

Method used for sample collection:

Soil: Representative Soil samples were collected from three sites

- From near the house of D Subba Moolya of Jeentadka area of Kumbdaje village, neighbouring Padre.
- Soil from a few metres inside the plantation near the house of Krishna Naik, resident of Kajampady area of Padre. Aerial spraying took place here on Dec 26, 2000
- From the heart of the plantation at the top of a hill in Periyal.

Each surface soil sample (0-10cm), comprised collection from a minimum of 12 cores drawn from an acre unit with the help of a U-shaped tube of 2.8 cm internal diameter. The cores be pooled and collected in double walled polyethylene bags, transported to the laboratory on the same day, stored in a deep freezer at -18°C until analysed. Three soil samples were collected similarly from the agricultural lands around the affected areas.

Before extraction, the samples were thawed to room temperature, thoroughly mixed and stoned and plant materials were removed. Two sub-samples, each weighing 50g, were drawn from each sample, one of which was used for residue analysis and the other for determination of moisture content.

Water: Water samples were collected from three different sites

- From a small stream in Jeentadka area of Kumbdaje village, neighbouring Padre; aerial spraying took place here on Dec 26, 2000
- From a tank in the house of Krishna Naik, about 20 metres from the cashew plantations in Kajampady area of Padre. Aerial spraying took place here on Dec 26, 2000
- From a channel that brings water from the Kodenkiri stream to the farms of S Narayan Bhat, resident of Padre.

Samples (1litre) were collected in clean plastic bottles. The bottles were tightly capped to prevent contamination of the sample. The samples were stored under refrigeration at 2-4^0 C

Bovine milk: Samples of bovine milk were collected from a cow that grazes in the plantation around Krishna Naik's house in Kajampady area of Padre. Its two-month-old calf died after epileptic fits on Dec 29, three days after aerial spraying took place in the area. Cow is still fed on fodder brought from in and around the cashew plantation of Inasa Chrastha's house in Jeentadka, Kumbdaje village, near Padre. Each sample (500 ml) of milk was refrigerated until analyzed.

Blood: Bood samples were collected in glass vials of the following people

- Prabhawati Shastri, 46, of Kollenkana, Padre, adjacent to Kodenkiri stream. Has skin allergies and asthma
- Vishnu Prasad Kulkarni, 16, who has epilepsy and mental retardation
- Mohana Kumar, doctor, living in Kumbdaje village and practicing medicine in and around Padre. Has chronic throat infections now
- Kittanna Shetty, 21, lives right next to the Kodenkiri stream in Padre. Has cerebral palsy. Brother Sridhar, 16, suffers from mental retardation
- Muthakka Shetty, 50, mother of Kittanna Shetty.
- Lalitha, 35, of Jeentadka, Kumbdaje village, near Padre. Has a one-year-old child. Both parents died of neurological problems two years ago. Sister Girija died of cancer four years ago. First sister-in-law died of an unknown cause. Second sister-in-law had a miscarriage two months ago.

Caps of these vials were air tight. Blood samples were stored at 2-4 ^{0} C until analysed.

Butter: One butter samples, churned from the milk of a 4-year-old cow that grazes in and around the cashew plantations adjacent to Saletadka Area of Vaninagar, Padre, about 30 metres from the plantation. Aerial spraying took place here on Dec 26, 2000 This was transported immediately as such or in ice-cooled thermos bottle to the laboratory.

Coconut oil: Samples of coconut oil were collected from produce of coconut trees about 50 metres from the plantations near the house of Vishnu Bhat in Saletadka Area of Vaninagar, Padre; aerial spraying took place here on Dec 26, 2000

Vegetables: Samples of vegetables, each weighing approximately 500g were collected

- *Basale*, a leafy vegetable eaten like spinach, from the house of Krishna Naik of Kajampady
- From just inside the plantation near the house of Krishna Naik in Kajampady area of Padre; aerial spraying took place here on Dec 26, 2000
- Pepper bunch from tree close to the house of Krishna Naik in Kajampady area of Padre. About 20 metres from the plantation; aerial spraying took place here on Dec 26, 2000

The samples were wrapped in polyethylene bags and immediately taken to the laboratory for analysis. The samples were chopped to small pieces and thoroughly mixed. From the well-mixed samples, two sub-samples of 50 g each were after quartering. These sub-samples were analyzed separately for organochlorine and organophosphorus pesticide residues.

Fish: Two fish samples each weighing 50 g were collected from a tank in the house of Krishna Naik, about 20 metres from the cashew plantations in Kajampady area of Padre. Aerial spraying took place here on Dec 26, 2000 The samples were packed in polyethylene bags and immediately to the laboratory. After removing the inedible portion like head, scales, etc., the sample was homogenised in a Waring blender. Sub-sample weighing 50 g was taken from the homogenised sample for analysis.

Human milk: Human milk samples were obtained from a nursing mother, Lalitha, 35, of Jeentadka, Kumbdaje village, near Padre. She has a one-year-old child. Both parents died of neurological problems two years ago. Sister Girija died of cancer four years ago. First sister-in-law died of an unknown cause. Second sister-in-law had a miscarriage two months ago. Approximately 20 ml of milk was collected with hands Milk was stored at -20 ^{0}C in a stoppered glass conical flask, until analyzed. Information on age, weight, number of births, interval between delivery and sampling and food habits were obtained.

EXTRACTION, CLEAN-UP AND ANALYSIS

EXTRACTION

Soil: The samples were extracted for residues of commonly used pesticides following the extraction and cleanup procedure of Drager (1969) with suitable modifications. A sub-sample (50 g. wet weight of soil) was extracted twice by dipping in a 100 ml of methanol-water solvent mixture (2:1, v/v) for a day with occasional shaking. After filtration, the extract was partitioned with 100 and 50 ml portions of n-hexane. The aqueous layer was then partitioned with 50 ml dichloromethane. The combined organic phase of n-hexane and dichloromethane was concentrated to about 5 ml. The concentrated extract normally did not require any further cleanup. However, certain samples which needed further cleanup, were chromatographed on natural alumina using n-hexane and n-hexane-acetone (4:1, v/v) as eluants.

Water: Water samples were shaken well and filtered . After filtration, the extract was partitioned with 100 and 50 ml portions of n-hexane(twice) The aqueous layer was then discarded. The combined organic phase of n-hexane was concentrated to about 5 ml. The concentrated extract normally did not required any further cleanup. However, certain samples which needed further cleanup, were chromatographed on natural alumina using n-hexane and n-hexane-acetone (4:1, v/v) as **eluants**.

Bovine milk: Extraction and cleanup of the milk samples selected during 1979 and 1980 were accomplished by suitable combination of the extraction method of de Faubert Maunder et al, (1964) and cleanup technique of Veirov and Aharonson (1978). A subsample of milk (20 ml) was homogenized with 40 ml of acetone-hexane (1:1, v/v) mixture. The homogenate was allowed to stand till a clear separation into two layers occurred. After the removal of the upper organic phase, the lower aqueous **base** was re-extracted twice with n-hexane (40 ml). The combined organic phase was evaporated till almost free of the solvent. The residue was dissolved in 40 ml of petroleum ether (B.P. 60-80 ^{0} C) and was cleaned up by drop-wise addition of 40 ml of concentrated sulphuric acid (sp. gravity 1.84) in a specially designed apparatus . The petroleum ether fraction was washed with distilled water till natural to litmus and concentrated to a suitable volume.

Butter fat: The method described by de Faubert Maunder et al. (1964) with slight modifications was used to extract and isolate DDT residues from butter samples collected during 1977. Butter was warmed at about 50 ^{0}C to separate the fat which was decanted through dry filter paper. A 5 g sample of the clarified fat was dissolved in 10 ml of hexane and transferred quantitatively to a 125 ml separatory funnel additional small portions of hexane. The hexane extract was

partitioned three times into dimethyl formamide (hexanesaturated), using 10 ml of solvent each time. The dimethyl formamide after back washing with 10 ml of hexane (dimethyl formamide-saturated) was diluted with 250 ml of water and 50 ml of sodium chloride-saturated aqueous solution, and was extracted twice with 100 ml of hexane. The combined n-hexane extract was concentrated to about 5-10 ml and was then cleanup on silicagel column as described under cereals.

Vegetables:: The procedure of Mills et al. (1963) with slight modification was followed for extraction of organochlorine insecticide residues. Sub-sample (50 g) was blended with 100 ml of acetonitrile for 2-3 minutes in the Waring blender. The macerate was filtered through a suction filter using mild vacuum. The filter-cake was blended again with 100 and 50 ml of acetonitrile and filtered. The blending jar and the filter were rinsed with additional 50 ml of acetonitrile. The filtrates and the washings were combined, diluted with volumes of water and 30 ml of sodium chloride saturated aqueous solution and then partitioned thrice using 100, 50 and 50 ml of petroleum ether (BP 60-80^0 C). The petroleum ether fraction after concentration to a small volume was further cleanup by column chromatography using silica gel as an adsorbent (Joia et al. 1987). The elutes were concentrated to small volume for analysis.

Fish: The procedure of Mills et al, (1963) with slight modification was followed for extraction of pesticide residue from fish. Sub-sample (50 G) was homogenised with 100 ml acetonitrile and 25 ml of distilled water in a Waring blender for 3 minutes at high speed. The homogenate was filtered and the residual material was re-extracted with 100 ml of methyl cyanide and 15 ml of distilled water. The filtrates were combined and the aliquot equivalent to 10 g of the sample was transferred to a 1 litre separatory funnel. To it, distilled water (250 ml) , n-hexane (100 ml) and brine solution (50 ml) were added. The contents were shaken for few minutes and allowed to stand till there was complete separation of two layers. The upper organic layer was removed and the lower aqueous layer was re-extracted with 50 ml n-hexane. Both the n-hexane fractions were combined, washed with distilled water and then dried over anhydrous sodium sulphate. The n-hexane fraction was concentrated at about 20 ml and was taken in a 125 ml separatory funnel. To it, conc. Sulphuric acid (sp. Gr. 1.84) was added dropwise till the n-hexane layer become clear. The spent sulphuric acid layer was discarded and the upper n-hexane layer was washed with distilled water till neutral to litmus. This was then evaporated to a suitable volume.

Biopsy animal fat: Samples weighing approximately 3-5 g were admixtures with about 20 g anhydrous sodium sulphate and were extracted thrice with n-hexane after through maceration. The n-hexane extract was partitioned three times with an equal volume of acetonitrile containing 10 per cent water. The combined aqueous acetonitrile phase, after dilution with 3 volumes of water and 10 ml of brine solution was partitioned twice using 100 and 50 ml of petroleum ether (BP 40-60 C). The combined petroleum ether phase was concentrated to about 5-10 ml and chromatographed on activated silica gel as described under cereals.

Human Milk: The extraction was done by blending 3-5 ml of the sub-sample with 2 volumes of n-hexane-acetone (1:1, v/v) mixture The homogenate was allowed to stand till clear separation into two layers occurred. After the removal of organic phase, the lower phase was re-extracted twice with 15 ml portions of n-hexane. The combined n-hexane extract after concentration to 20 ml was portions of n-hexane. The combined n-hexane extract after concentration to 20 ml was transferred to a separatory funnel, to which 5 ml conc. Sulphuric acid (sp. Gr., 1.84) was added dropwise. The contents in the separatory funnel were shaken and allowed to stand. The lower sulphuric acid layer containing digested fat was discarded. The n-hexane phase was washed with distilled water till neutral to litmus and concentrated to a small volume.

Blood: 2ml blood sample was taken in a stoppered vial and 10 ml hexane was added . Centrifuge for 2hrs. Repeat twice. Combined the hexane extracts. Concentrated. Add 2ml hexane and analysed.

METHOD FOR ANALYSIS

GLC parameters

Gas chromatography technique (GC-Trace, Thermoquest)
with electron capture detector
Column: DB-17
Temperature conditions:
Oven : 200 ^{0} C
Injector: 250 ^{0} C
Detector: 250 ^{0} C
Flow rate: 3ml/min(carrier gas N_2)

Calculations: based on the formula given below

$$\text{Pesticide concentration(ppm)} = \frac{\text{Area of the sample x dilution factor x conc.(std)}}{\text{Area of the standard x wt of the sample(ml or g)}}$$

FINDINGS IN DETAIL AND COMPARISON WITH STANDARDS

Endosulfan test results from the CSE laboratory on samples from Padre village, Kerala are appended as Annexure I.

Summarising the results:

Gas chromatography technique with electron capture detector the model name is GC-Trace was used for the analysis. The extraction methods are from EPA manual.

Alarming high values of endosulfan residues (ppm) for blood, fruits, tissues only go to prove the high diseased condition in the people of Kerala. It is beyond doubt that the dramatic cases of endosulfan poisoning in Padre village in Kasaragod district, of Kerala (PCK plantations) can be directly linked to a decision-making process dominated by a government undertaking which has resorted to aerial spraying of Endosulfan thrice a year for the last twenty five years, without sufficient back-up from, or debate with, experts in other disciplines, including pesticide experts, social scientists, environmentalists and others

IMPACTS OF ENDOSULFAN ONHEALTH -- SCIENTIFIC EVIDENCE

Endosulfan is an organochlorine insecticide and acaricide, and acts as a contact poison in a wide variety of insects and mites. Endosulfan is effective against a wide range of insects and certain mites on cereals, coffee, cotton, fruit, oilseeds, potato, tea, vegetable and other crops. It can also be used as a wood preservative. Short-term toxicity is high, and influenced by the solvents and emulsifiers used to dissolve it. Endosulfan is easily absorbed by the stomach, by the lungs and through the skin, meaning that all routes of exposure can pose a hazard. Exposure to endosulfan may result from, for example: 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; or working in an industry where endosulfan is used. Proper protective clothing (safety goggles, gloves, long sleeves, long pants, respirator) is needed to prevent poisoning when handling 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

The World Health Organisation (WHO) classifies endosulfan in Category II (moderately hazardous). However the US Environmental Protection Agency (US EPA) classifies it as a Category 1b (highly hazardous) pesticide. Labels for products containing endosulfan must bear the Signal Words DANGER - POISON, depending on formulation.

Chemical Class

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. 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-isomers. 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. It is also highly toxic via the dermal route, with reported dermal LD50 values in rats ranging from 78 to 359 mg/kg. 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 . It is reported not to cause skin or eye irritation in animals . The beta-isomer is considered to be more toxic than the alpha-isomer. Animal data indicate that toxicity may also be influenced by species and by level of protein in the diet; rats which have been deprived of protein are nearly twice as susceptible to the toxic effects of endosulfan. 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. Stimulation of the central nervous system is the major characteristic of endosulfan poisoning. 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. 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. In an accidental exposure, sheep and pigs grazing on a sprayed field suffered a lack of muscle coordination and blindness.

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. This dose level also caused seizures commencing 25 to 30 minutes following dose administration that persisted for approximately 60

minutes . 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 .

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. Female mice fed the compound for 78 weeks at 0.1 mg/kg/day had damage to their reproductive organs . Oral dosage for 15 days at 10 mg/kg/day in male rats caused damage to the semeniferous tubules and lowered testes weights .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 .Teratogenic effects in humans are unlikely at expected exposure levels.

Mutagenic effects
Endosulfan is mutagenic to bacterial and yeast cells. The metabolites of endosulfan have also shown the ability to cause cellular changes .This compound has also caused mutagenic effects in two different mammalian species . Thus, evidence suggests that exposure to endosulfan may cause mutagenic effects in humans if exposure is great enough.

Carcinogenic effects
Reuber et al (1981) showed that Endosulfan was carcinogenic in male and female rats at all sites examined during the studies. Another study showed that Endosulfan is a potential live tumour promoter in similar manner as the structurally related chlorinated insecticide like Aldrin. Yuquan Lu et al, (2000), have proved by their toxicogenocity studies of Endosulfan that it is a potent genotosic chemical which can break the DNA and the β-Endosulfan seems stronger than of α-Endosulfan.

Organ toxicity
Data from animal studies reveal the organs most likely to be affected include kidneys, liver, blood, and the parathyroid gland .

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 . 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 , 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. 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, and in pheasants ranging from 80 to greater than 320 mg/kg . The reported 5-day dietary LC50 is 2906 ppm in Japanese quail . 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.

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 . The bioaccumulation for the compound may be significant; in the mussel (Mytelus edulis) the compound accumulated to 600 times the ambient water concentration

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 .

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 . 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 . Endosulfan does not easily dissolve in water, and has a very low solubility . It has a moderate capacity to adhere or adsorb to soils 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 .

Breakdown in water
In raw river water at room temperature and exposed to light, both isomers disappeared in 4 weeks 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) . 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 . It has also been found in surface water throughout the country at very low concentrations .

Breakdown in vegetation
In plants, endosulfan is rapidly broken down to the corresponding sulfate . On most fruits and vegetables, 50% of the parent residue is lost within 3 to 7 days . 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.

Physical Properties

- **Appearance:** Pure endosulfan is a colorless crystal. Technical grade is a yellow-brown color.
- **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
- **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 @ 22^0 C
- **Solubility in Other Solvents:** s. in toluene and hexane
- **Melting Point:** Technical material, 70-100^0 C
- **Vapor Pressure:** 1200 mPa @ 80 ^{0C}
- **Partition Coefficient:** Not Available
- **Adsorption Coefficient:** 12,400

Exposure Guidelines

- **ADI:** 0.006 mg/kg/day
- **MCL**: Not Available
- **RfD:** 0.00005 mg/kg/day
- **PEL:** Not Available
- **HA**: Not Available
- **TLV**: 0.1 mg/m3 (8-hour)

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

Basic Manufacturers In India

- Excel India Limited
- Hindustan Insecticides
- E.I.D Parry

CONCLUSIONS

Endosulfan should be banned as a compound in India for cashew plantation or any other crop, just like all other organochlorine compounds. Organochlorines are not adapted to local growing conditions or to local patterns of use.

Decision-making in cashew plantation pesticide use in parts of Kerala should be more consultative, rather than remaining in the hands of PCK. It needs to be more open and public so that other cashew planter and development experts, other stakeholders and groups such as consumers' unions and environmental NGOs are actively involved. Integrated management of pests, pesticides, pesticide resistance and crops requires an interdisciplinary and participative approach that goes well beyond the technical level to include socio-economic, cultural and ecological considerations, as well as the preferences of farmers, livestock herders and fishing communities. Personnel and consumers of food crops from cashew growing areas in this areas.

The CSE project has made a small start by copying the already mixed Australian experiences and West African with endosulfan use of cashew growing conditions without adequate consideration of local conditions and patterns of pesticide use. The result should open up as soon as possible, and actively invite other stakeholders to participate in the design, elaboration, execution, monitoring and evaluation or strategies put in place to manage pests, pesticides, pesticide resistance and crops.