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DRAFT

2,4,5-TRICHLOROPHENOXYACETIC ACID

Health Advisory
Office of Drinking Water
U.S. Environmental Protection Agency

I. INTRODUCTION

The Health Advisory (HA) Program, sponsored by the Office of Drinking Water (ODW), provides information on the health effects, analytical methodology and treatment technology that would be useful in dealing with the contamination of drinking water. Health Advisories describe nonregulatory concentrations of drinking water contaminants at which adverse health effects would not be anticipated to occur over specific exposure durations. Health Advisories contain a margin of safety to protect sensitive members of the population.

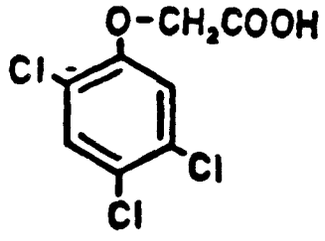
Health Advisories serve as informal technical guidance to assist Federal, State and local officials responsible for protecting public health when emergency spills or contamination situations occur. They are not to be construed as legally enforceable Federal standards. The HAs are subject to change as new information becomes available.

Health Advisories are developed for one-day, ten-day, longer-term (approximately 7 years, or 10% of an individual's lifetime) and lifetime exposures based on data describing noncarcinogenic end points of toxicity. Health Advisories do not quantitatively incorporate any potential carcinogenic risk from such exposure. For those substances that are known or probable human carcinogens, according to the Agency classification scheme (Group A or B), Lifetime HAs are not recommended. The chemical concentration values for Group A or B carcinogens are correlated with carcinogenic risk estimates by employing a cancer potency (unit risk) value together with assumptions for lifetime exposure and the consumption of drinking water. The cancer unit risk is usually derived from the linear multistage model with 95% upper confidence limits. This provides a low-dose estimate of cancer risk to humans that is considered unlikely to pose a carcinogenic risk in excess of the stated values. Excess cancer risk estimates may also be calculated using the One-hit, Weibull, Logit or Probit models. There is no current understanding of the biological mechanisms involved in cancer to suggest that any one of these models is able to predict risk more accurately than another. Because each model is based on differing assumptions, the estimates that are derived can differ by several orders of magnitude.

II. GENERAL INFORMATION AND PROPERTIES

CAS No. 93-76-5

Structural Formula



2,4,5-trichlorophenoxyacetic acid

Synonyms

- 2,4,5-T; Brush rhap; Brushtox; BCF-Bushkiller; Dacamine; Decamine 4T; Ded-Weed; Dinoxol; Envert-T; Estercide t-2 and t-245; Esteron; Fence rider; Forron; Forst U46; Fortex; Fruitone A; Inverton 245; Line rider; Phortox; Reddon; Reddox; Spontox; Tippon; Tormona; Transamine; Tributon; Trinoxol; Trioxon; Veon 245; Verton 2T; VEON; Weedar; Weedone (Meister, 1983).

Uses

- Salts and esters of 2,4,5-T are widely used to control woody plants on industrial sites and rangeland. Amine formulations are used extensively for weed control in rice (Meister, 1983).

Properties (BCPC, 1983; Meister, 1983; Windholz et al., 1983; Khan, 1985; CHEMLAB, 1985)

Chemical Formula	$C_8H_5O_3Cl_3$
Molecular Weight	255.49
Physical State (25°C)	Crystals
Boiling Point	--
Melting Point	153°C
Density	--
Vapor Pressure (25°C)	6.46×10^{-6} mm Hg
Specific Gravity	--
Water Solubility (25°C)	Solubility of acid is 150 g/L; amine salts are soluble at 189 g/L (20°C); esters are insoluble
Log Octanol/Water Partition Coefficient	3.00 (calculated)
Taste Threshold	--
Odor Threshold	--
Conversion Factor	--

Occurrence

- 2,4,5-T has been found in 5,009 of 24,516 surface water samples analyzed and in 360 of 3,238 ground water samples (STORET, 1987). Samples were collected at 3,967 surface water locations and 2,124 ground water locations, and 2,4,5-T was found in 45 states. The 85th percentile of all nonzero samples was 0.1 ug/L in surface water and 1 ug/L in ground water sources. The maximum concentration found was 370 ug/L in surface water and 38 ug/L in ground water.

Environmental Fate

- No information was found in the available literature on the environmental fate of 2,4,5-T.

III. PHARMACOKINETICS

Absorption

- In a study by Gehring et al. (1973), single oral doses of 5 mg/kg 2,4,5-T were ingested by five male volunteers. Essentially all the 2,4,5-T was excreted unchanged via the urine, indicating that gastrointestinal absorption was nearly complete.

- Fang et al. (1973) administered single doses of ^{14}C-labeled 2,4,5-T in corn oil by gavage to pregnant and nonpregnant female Wistar rats at dose levels of 0.17, 4.3 or 41 mg/kg. Expired air, urine, feces, internal organs and tissues were analyzed for radioactivity. During the first 24 hours, an average of 75 ±7% of the radioactivity was excreted in the urine, indicating that at least 75% of the dose had been absorbed.

- Piper et al. (1973) administered single oral doses of ^{14}C-labeled 2,4,5-T in corn oil-acetone (9:1) to adult female Sprague-Dawley rats at dose levels of 5, 50, 100 or 20 mg/kg, and to adult female beagle dogs at 5 mg/kg. Fecal excretion was 3% at the lowest dose (5 mg/kg) and increased to 14% at the highest dose (200 mg/kg) in rats. In dogs given the 5 mg/kg dose, fecal excretion was 20%. These data indicated that absorption was somewhat dose dependent, but was 80% or higher at all doses.

Distribution

- Gehring et al. (1973) administered single oral doses of 5 mg/kg of 2,4,5-T to five male volunteers. Essentially all the 2,4,5-T was absorbed in the body; 65% of the absorbed dose resided in the plasma where 98.7% was bound reversibly to protein. The volume of distribution was 0.097 L/kg. Utilizing the kinetic constants from the single-dose experiment, the expected concentrations of 2,4,5-T in the plasma of individuals receiving repeated doses of 2,4,5-T were calculated. From these calculations, it was determined that the plasma concentrations would essentially reach a plateau value after 3 days. If the

daily dose ingested in mg/kg is A_0, the concentrations in the plasma after attaining plateau would range from 12.7 A_0 to 22.5 A_0 ug/mL (Gehring et al., 1973).

- Fang et al. (1973) administered single oral doses of ^{14}C-labeled 2,4,5-T to pregnant and nonpregnant female Wistar rats and internal organs and tissues were analyzed for radioactivity. Radioactivity was detected in all tissues, with the highest concentration found in the kidney. The maximum concentration in all tissues was generally reached between 6 and 12 hours after administration of the dose (0.17, 4.3 or 41 mg/kg) by gavage, and then started to decline rapidly. Radioactivity also was detected in the fetuses and in the milk of the pregnant rats. The average biological half-life of 2,4,5-T in the organs was 3.4 hours for the adult rats and 97 hours for the newborn.

- Piper et al. (1973) administered single oral doses of 5, 50, 100 or 200 mg/kg 2,4,5-T to Sprague-Dawley rats, and found that the apparent volume of distribution increased with dose, indicating that distribution of 2,4,5-T in the body was dose-dependent.

Metabolism

- Gehring et al. (1973) administered single oral doses of 5 mg/kg 2,4,5-T to human volunteers. Essentially all the chemical was excreted in the urine as parent compound, indicating that there is little metabolism of 2,4,5-T in humans.

- Grunow et al. (1971) investigated the metabolism of 2,4,5-T in male Wistar (AF/Han) rats after receiving single oral doses of 50 mg/kg. The 2,4,5-T was dissolved in peanut oil and administered by gavage. Urine was collected for 7 days after dosing and examined by gas chromatography for 2,4,5-T and its conjugates and metabolites. From 45 to 70% of the administered dose was recovered in urine. In general, about 10 to 30% of this was as acid-hydrolyzable conjugates, and the remainder was unchanged 2,4,5-T. Three animals were given doses of 75 mg/kg, and their urine pooled. A metabolite isolated from this pooled urine was identified as N-(2,4,5-trichlorophenoxy-acetyl)-glycine.

- Piper et al. (1973) administered single oral doses of 2,4,5-T to female Sprague-Dawley rats at dose levels of 5, 50, 100 or 200 mg/kg. A small amount of an unidentified metabolite was detected in urine at the high doses, but not at the lower doses. In adult beagle dogs given oral doses of 5 mg/kg, three unidentified metabolites were detected in urine, suggesting a difference in metabolism between rats and dogs.

- In a study by Fang et al. (1973) in female Wistar rats, urinalysis revealed that 90 to 95% of the radioactivity was unchanged 2,4,5-T. The authors also found three unidentified minor metabolites, two of which were nonpolar, in the urine.

Excretion

- In a study by Gehring et al. (1973), single doses of 5 mg/kg 2,4,5-T were ingested by five male volunteers. The concentrations of 2,4,5-T in plasma and its excretion were measured at intervals after ingestion. The clearances from the plasma, as well as the body, occurred via apparent first-order rate processes with half-lives of 23.1 and 29.7 hours, respectively. Essentially all the 2,4,5-T was excreted unchanged via the urine.

- In a study by Fang et al. (1973), 2,4,5-T labeled with ^{14}C was orally administered to pregnant and nonpregnant female Wistar rats at various dosages, and expired air, urine and feces were analyzed for radioactivity. During the first 24 hours, 75 ± 7% of the radioactivity was excreted in the urine and 8.2% was excreted in the feces. No ^{14}C was found in the expired air. There was no significant difference in the rate of elimination between the pregnant and nonpregnant rats, or among the dosages used (0.17, 4.3 and 41 mg/kg). The average biological half-life of 2,4,5-T in the organs was 3.4 hours for the adult rats and 97 hours for the newborn.

- Grunow et al. (1971) investigated the excretion of 2,4,5-T in male Wistar (AF/Han) rats after single oral doses of 50 mg/kg. The 2,4,5-T was dissolved in peanut oil and administered by gavage. From 45 to 70% of the administered dose was recovered in urine within 7 days.

- Clearance of ^{14}C activity from the plasma and its elimination from the body of rats and dogs were determined after single oral doses of labeled 2,4,5-T (Piper et al., 1973). The half-life values for the clearance of radioactivity from the plasma of Sprague-Dawley (Spartan strain) rats given doses of 5, 50, 100 or 200 mg/kg were 4.7, 4.2, 19.4 and 25.2 hours, respectively; half lives for elimination from the body were 13.6, 13.1, 19.3 and 28.9 hours, respectively. Urinary excretion of unchanged 2,4,5-T accounted for 68 to 93% of the radioactivity eliminated from the body of the rats. Fecal excretion was 3% at 5 mg/kg, and increased to 14% at 200 mg/kg. These results indicate that the excretion of 2,4,5-T is altered when large doses are administered. In adult beagle dogs given doses of 5 mg/kg, the half-life values for clearance from plasma and elimination from the body were 77.0 and 86.6 hours, respectively. After 9 days, 11% of the dose was recovered in urine and 20% was recovered in feces.

IV. *HEALTH EFFECTS*

- Technical 2,4,5-T contains traces of the highly toxic compound 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) as an impurity (NAS, 1977). Preparations of 2,4,5-T formerly contained TCDD at levels of 1 to 80 ppm, a concentration sufficiently high to cause toxic effects that are characteristic of TCDD. It has not been feasible to completely eliminate TCDD from technical 2,4,5-T, but NAS (1977) reported it to be present in commercial 2,4,5-T at less than 0.1 ppm. In the following sections, the purity of 2,4,5-T or the level of TCDD impurity is

given when known. When the generic term "dioxin" is used, no further information was provided, and the 2,4,5-T is presumed to contain a variety of dioxin species as well as other phenoxy compounds and assorted intermediates and breakdown products.

Humans

Short-term Exposure

- No clinical effects were observed in five volunteers who ingested single oral doses of 5 mg/kg of 2,4,5-T (Gehring et al., 1973).

- After an explosion in a chemical plant producing 2,4,5-T in 1949, symptoms in exposed workers included chloracne, nausea, headache, fatigue, and muscular aches and pains (Zack and Suskind, 1980).

Long-term Exposure

- The mortality experience in a cohort of 1,926 men who had sprayed 2,4,5-T acid during 1955 to 1971 was followed prospectively from 1972 to 1980. Exposure was generally rather low because the duration of work had mostly been less than 2 months. In the period 1972 to 1976, mortality from all natural causes in this group was only 54% of the expected value (based on age-specific rates for the general population), and in the next 4-year period, 81% of the expected value. In the assessment of cancer, mortality allowance was made for 10- and 15-year periods of latency between the first exposure and the start of the recording of vital status during the followup. No increase in cancer mortality was detected, and the distribution of cancer types was unremarkable. No cases of death from lymphomas or soft tissue sarcomas were found. It was noted, however, that the study results should be interpreted with caution due to the small size of the cohort, the low past exposure, and the brief followup period (Riihimaki et al., 1982).

- An investigation of the rate of birth malformations in the Northland region of New Zealand was analyzed with reference to the exposure in the area to 2,4,5-T, which was applied as frequently as once a month from 1960 to 1977. The chosen area was divided into sectors rated as high, intermediate or low, based on the frequency of aerial spraying. During this period, there were 37,751 babies born in the hospitals in these sectors. It was estimated that well over 99% of all births occur in hospitals in this Nortnland area. The epidemiological analysis of the birth data gave no evidence that any malformation of the central nervous system, including spina bifida, was associated with the spraying of 2,4,5-T. Heart malformations, hypospadias, and epispadias increased with spraying density, but the increases were not statistically significant ($p > 0.05$). The only anomaly that increased in a statistically significant ($p < 0.05$) manner with respect to the spraying was talipes (club foot) (Hanify et al., 1981).

- The relationship between the use of 2,4,5-T in Arkansas and the concurrent incidence of facial clefts in children was studied retrospectively. The estimated levels of exposure were determined by

categorizing the 75 counties into high, medium and low exposure groups on the basis of their rice acreage during 6- to 7-year intervals beginning in 1943. A total of 1,201 cases of cleft lip and/or cleft palate for the 32 years (until 1974) was detected by screening birth certificates and hospital records. Facial cleft rates, presented by sex, race, time period and exposure group, generally rose over time. No significant differences were found for any race or sex combination. The investigators concluded that the general increase seen in facial cleft incidence in the high- and low-exposure groups was attributable to better case finding rather than maternal exposure to 2,4,5-T (Nelson et al., 1979).

- Ott et al. (1980) reported no effects in a survey of 204 workers engaged in 2,4,5-T production at estimated airborne levels of 0.2 to 0.8 mg/m^3 for 1 month to 10 years.

- Numerous epidemiological studies on the relationship between exposure to chlorophenoxyacetic acids and cancer induction are reviewed in U.S. EPA (1985). The conclusion in this review is that there is "limited" evidence for the carcinogenicity of chlorinated phenoxyacetic herbicides and/or chlorophenols with chlorinated dibenzodioxin impurities, primarily based on Swedish case-control studies that associated induction of soft-tissue sarcomas with exposure to these agents.

Animals

Short-term Exposure

- The acute oral toxicity of 2,4,5-T was determined in mice, rats and guinea pigs by Rowe and Hymas (1954) over a 2-week period. The LD_{50} values were 500 mg/kg for rats, 389 mg/kg for mice and 381 mg/kg for guinea pigs.

- Drill and Hiratzka (1953) investigated the acute oral toxicity of 2,4,5-T in adult mongrel dogs given single oral doses of 50, 100, 250 or 400 mg/kg by gelatin capsule. Animals were observed for 14 days, at which time survivors were necropsied. The number of deaths at the four dose levels were 0/4, 1/4, 1/1 and 1/1, respectively. The LD_{50} value was estimated to be 100 mg/kg or higher. Marked changes were not observed in animals that died, effects being limited to weight loss, slight to moderate stiffness in the hind legs and ataxia (at the highest doses).

- Weanling male Wistar rats were fed diets containing 2,4,5-T for 3 weeks to investigate effects on the immune system (Vos et al., 1983). 2,4,5-T (>99% purity, TCDD content not specified) was fed at levels of 200, 1,000 or 2,500 ppm (approximately 20, 100 or 250 mg/kg/day, assuming 1 ppm equals 0.1 mg/kg/day in a younger rat by Lehman, 1959). Following the 3-week feeding period, the animals were sacrificed and the organs of the immune system, as well as other parameters of general toxicity, were examined. Even at the lowest dose level of 200 ppm in the diet, 2,4,5-T caused a significant ($p < 0.05$) decrease in relative kidney weight and a significant ($p < 0.05$) increase in

serum IgG level, the most sensitive indicators of its effects. In this study, based on general toxicologic and specific immunologic effects in the rat, the Lowest-Observed-Adverse-Effect-Level (LOAEL) was 20 mg/kg/day.

Dermal/Ocular Effects

- Gehring and Betso (1978) summarized the effects of 2,4,5-T on the skin and the eye. The dry material is slightly irritating to the skin and the eye. Highly concentrated solutions may burn the skin with prolonged or repeated contact and can strongly irritate the eye and possibly cause corneal damage. Preparations of 2,4,5-T formerly contained 1 to 80 ppm 2,3,7,8-TCDD, a concentration high enough to cause chloracne in industrial workers (NAS, 1977).

Long-term Exposure

- Drill and Hiratzka (1953) investigated the subchronic toxicity of 2,4,5-T in adult mongrel dogs. One or two dogs of each sex per group were fed capsules in food containing 0, 2, 5, 10 or 20 mg/kg 2,4,5-T, 5 days per week for 13 weeks. Animals were weighed twice weekly, and blood was taken on days 0, 30 and 90. Upon death or completion of the study, animals were necropsied with histological examination of a number of tissues. No deaths occurred at doses of 10 mg/kg/day or less, but 4/4 animals receiving 20 mg/kg/day died. No effects on body weight, hematology and pathology were seen except in animals that died. The No-Observed-Adverse-Effect-Level (NOAEL) was identified as 10 mg/kg/day.

- McCollister and Kociba (1970) examined the effects of 2,4,5-T administered in the diet for 90 days to male and female Sprague-Dawley rats (Spartan strain). The 2,4,5-T (99.5% pure, <0.5 ppm dioxin) was included in the diet at levels corresponding to doses of 0, 3, 10, 30 or 100 mg/kg/day. Five animals of each sex were used at each dose level. At the conclusion of the study, necropsy, urinalyses, blood counts and clinical chemistry assays were performed. There was no mortality in any group. At 100 mg/kg, animals of both sexes had depressed ($p < 0.05$) body weight gain, a slight but significant ($p < 0.05$) decrease in food intake and elevated ($p < 0.05$) serum alkaline phosphatase (AP) levels. Necropsy revealed paleness and an accentuated lobular pattern of the liver, with some inconsistent hepatocellular swelling. Males (but not females) had slightly elevated serum glutamic-pyruvic transaminase (SGPT) levels, and slight decreases in red blood cell counts and in hemoglobin. Males given 100 mg/kg/day had increased ($p < 0.05$) kidney/body and liver/body weights. At the 30 mg/kg/day dose level, males exhibited increased ($p < 0.05$) liver/body, kidney/body, and kidney weights. Females given 30 mg/kg/day had slightly but significantly ($p < 0.05$) elevated AP and SGPT levels, but the authors felt that the clinical significance of these latter findings was doubtful. No effects observed at the 3 or 10 mg/kg dose level were considered to be related to the intake of 2,4,5-T. From this study, a NOAEL of 10 mg/kg/day and a LOAEL of 30 mg/kg/day were identified.

° Groups of Sprague-Dawley rats (50/sex/level) were maintained on diets supplying 3, 10 or 30 mg/kg/day of 2,4,5-T for 2 years (Kociba et al., 1979). The 2,4,5-T was approximately 99% pure, containing 1.3% (w/w) other phenoxy acid impurities. Dioxins were not detected, the limit of detection for TCDD being 0.33 ppb. An interim sacrifice was performed on an additionally included group of 10 animals of each sex at 118 to 119 days. Control groups included 86 animals of each sex. The highest dose level was associated with some degree of toxicity, including a decrease in body weight gain ($p < 0.05$ in females) and an increase in relative kidney weight ($p < 0.05$ in males). Increases ($p < 0.05$) in the volume of urine excreted and in the urinary excretion of coproporphyrin and uroporphyrin were also observed at this dose level. Increased ($p < 0.05$) morphological changes were observed in the kidney, liver and lungs of animals administered 30 mg/kg/day. The kidney changes involved primarily the presence ($p < 0.05$) of mineralized deposits in the renal pelvis in females. Effects noted at the 10 mg/kg dose level were primarily an increased ($p < 0.05$) incidence of mineralized deposits in the renal pelvis in females. During the early phase of the study there was an increase ($p < 0.05$) in urinary excretion of coproporphyrin in males. At the lowest dose level (3 mg/kg), there were no changes that were considered to be related to treatment throughout the 2-year period. From this study in rats, a NOAEL of 3 mg/kg/day was identified.

Reproductive Effects

° Male and female Sprague-Dawley rats (F_0) were fed lab chow containing 2,4,5-T (<0.03 ppb TCDD) to provide dose levels of 0, 3, 10 or 30 mg/kg/day for 90 days and then were bred (Smith et al., 1981). At day 21 of lactation, pups were randomly selected for the following generation (F_1) and the rest were necropsied. Subsequent matings were conducted to produce F_2, F_{3a} and F_{3b} litters, successive generations being fed from weaning on the appropriate test or control diet. Fertility was decreased ($p < 0.05$) in the matings of the F_{3b} litters in the group given 10 mg/kg/day. Postnatal survival was significantly ($p < 0.05$) decreased in the F_2 litters of the 10 mg/kg group and in the F_1, F_2 and F_3 litters of the 30 mg/kg group. A significant decrease ($p < 0.05$) in relative thymus weight was seen only in the F_{3b} generation of the 30 mg/kg group, but the relative liver weights of weanlings was significantly ($p < 0.05$) increased in the F_2, F_{3a} and F_{3b} litters of this dosage group. Smith et al. concluded that dose levels of 2,4,5-T that were sufficiently high to cause signs of toxicity in neonates had no effect on the reproductive capacity of the rats, except for a tendency toward a reduction of postnatal survival at a dose of 30 mg/kg. Reproduction was not impaired at the lowest dose of 3 mg/kg. The apparent NOAEL with respect to reproductive capacity and fetotoxic effects in this study is 3 mg/kg/day. Smith et al. (1978) noted a significant ($p < 0.05$) decrease in F_1 (10 and 30 mg/kg on days 14 and 21) and F_3 (3 mg/kg on day 14, and 10 and 30 mg/kg on day 21) litters, and they concluded that there was no effect of 2,4,5-T on rat reproduction except for a tendency toward a reduction in neonatal survival at 10 and 30 mg/kg.

Developmental Effects

- Sparschu et al. (1971) tested 2,4,5-T (commercial grade, 0.5 ppm TCDD) at levels of 50 or 100 mg/kg/day in pregnant rats (strain not specified) on either days 6 to 15 (50 mg/kg) or days 6 to 10 (100 mg/kg) of gestation. The 2,4,5-T was administered by oral intubation in a solution of Methocel, and controls were given an appropriate volume of Methocel. At the 50 mg/kg dose, there was a slightly higher incidence of delayed ossification of the skull bones, but this was not considered a teratogenic response. The 100 mg/kg dose (administered on days 6 to 10) was toxic to the dams and caused a high incidence of maternal deaths (only 4 of the 25 pregnant rats survived). Of these, three had complete early resorptions, and one had a litter of 13 viable fetuses that showed toxic effects (not further described) but no terata. From these data for maternal effects, a NOAEL of 50 mg/kg and a LOAEL of 100 mg/kg were identified. Also identified were a NOAEL of 100 mg/kg for teratogenicity and a LOAEL of 50 mg/kg for fetotoxicity.

- A sample of 2,4,5-T (technical grade) containing 0.5 ppm TCDD as well as other phenoxy compounds was administered to CD-1 rats by oral intubation on days 6 through 15 of gestation at dose levels of 10, 21.5, 46.4 or 80 mg/kg/day (Courtney and Moore, 1971). Examination of offspring revealed that the sample was not teratogenic at these dose levels. There was a significant ($p < 0.05$) increase in fetal mortality at the 80 mg/kg/day dose levels (the maternal LD_{40}). In two 2,4,5-T-treated fetuses, mild gastrointestinal hemorrhages were observed as a fetotoxic effect. Kidney anomalies were also slightly increased with the effect most pronounced at the 80 mg/kg level, but the number of litters examined was too small to evaluate this observation. In a separate study, rats were administered 50 mg/kg/day in an identical protocol, but in this case they were allowed to litter, and the neonates were examined and weighed on day 1 and followed for 21 days. Postnatal growth and development were comparable to that of the control animals. A NOAEL of 46.4 mg/kg/day for both fetotoxicity and teratogenicity in the CD-1 rat was identified from these data.

- Sprague-Dawley rats (50/group) and New Zealand White rabbits (20/group) were given oral doses (gavage for rats, capsules for rabbits) of 2,4,5-T (containing 0.5 ppm TCDD) during gestation (Emerson et al., 1971). The rats received daily doses of 1, 3, 6, 12 or 24 mg/kg on days 6 through 15, while the rabbits were administered 10, 20 or 40 mg/kg on days 6 through 18 of gestation. In both species, animals were observed daily, weighed periodically and subjected to Cesarean section prior to parturition. Rabbit pups were kept for observation for 24 hours and then sacrificed. There were no observable adverse effects in dams of either species treated with the 2,4,5-T. Litter size, number of fetal resorptions, birth weights and sex ratios all appeared to be unaffected in the treated groups. Detailed visceral and skeletal examinations were performed on the control and high-dose groups for each species, and no embryotoxic or teratogenic effects were revealed. A NOAEL for fetotoxic and maternal effects identified from this study was 24 mg/kg/day for the rat and 40 mg/kg/day for the rabbit.

° Several different samples of 2,4,5-T (containing <0.5 ppm TCDD) were tested in pregnant Wistar rats by daily oral administration on days 6 through 15 of gestation at dose levels between 25 and 150 mg/kg/day (Khera and McKinley, 1972). In some cases, fetuses were removed by Cesarean section for examination; some animals were allowed to litter, and the offspring were observed for up to 12 weeks. At doses of 100 mg/kg, there was an increase ($p < 0.05$) in fetal mortality and an increase ($p < 0.05$) in skeletal anomalies; a visceral anomaly was noted (dilatation of the renal pelvis), which was slightly increased over the control level, but was not statistically significant ($p > 0.05$). The survival of the progeny was not affected up to doses of 100 mg/kg, and in only one trial was there a low average litter size and viability. This effect was not duplicated in a repeat test with the same sample. At the 25 and 50 mg/kg dose levels, significant ($p < 0.05$) differences from controls were not apparent. With respect to fetotoxicity, this study identified a NOAEL of 50 mg/kg/day in the rat.

° The teratogenic effects of 2,4,5-T were examined in golden Syrian hamsters after oral dosing (by gavage) on days 6 through 10 of gestation at dose levels of 20, 40, 80 or 100 mg/kg/day (Collins et al., 1971). Four samples of 2,4,5-T with dioxin levels of 45, 2.9, 0.5 or 0.1 ppm were administered. Three samples, which had no detectable dioxin (based on TCDD), were also tested. The 2,4,5-T samples induced fetal death and terata. The incidence of effects increased with increasing content of the TCDD impurity. 2,4,5-T with no detectable dioxin produced no malformations below the 100 mg/kg dose level. Using the data from the 2,4,5-T samples with no detectable dioxin, a NOAEL of 80 mg/kg/day for the hamster was identified.

° Behavioral effects resulting from <u>in utero</u> exposure to 2,4,5-T were examined in Long-Evans rats after single oral doses were administered during gestation (Crampton and Rogers, 1983). The sample of 2,4,5-T contained <0.03 ppm TCDD. Novelty response abnormalities were detected after single doses as low as 6 mg/kg were administered on day 8 of gestation. Examination of the brain in the affected offspring failed to reveal any changes of a qualitative or quantitative structural nature in various areas of the brain. With respect to behavioral effects, the LOAEL for this study is 6 mg/kg.

° The teratogenic effects of technical 2,4,5-T (TCDD content 0.1 ppm) were studied using large numbers of pregnant mice of C57BL/6, C3H/He, BALB/c and A/JAX inbred strains and CD-1 stock (Gaines et al., 1975). Dose-response curves were determined for the incidence of cleft palate, embryo lethality and fetal growth retardation. These determinations were replicated 6 to 10 times for each inbred strain and 35 times for the CD-1. The number of litters studied ranged from 236 for BALB/c mice to 1,485 for CD-1 mice. Treatment was by gavage on days 6 to 14 of pregnancy, and dose levels of 2,4,5-T ranged from 15 to 120 mg/kg/day. The lowest dose tested in the A/JAX was 15 mg/kg, and this dose was teratogenic. The other strains and CD-1 demonstrated teratogenicity at 30 mg/kg, the lowest dose tested. There were significant ($p < 0.05$) differences in sensitivities among the strains for the parameters measured. Based on this study in the mouse, the

LOAEL for teratogenic effects is 15 mg/kg/day for the A/JAX strain and 30 mg/kg/day for the other strains.

- Neubert and Dillmann (1972) studied the effects of 2,4,5-T in pregnant NMRI mice. Three samples of 2,4,5-T were utilized: one had <0.02 ppm dioxin, and was considered "dioxin-free"; a second sample had a dioxin content of 0.05 ± 0.02 ppm; and the third sample had an undetermined dioxin content. The 2,4,5-T was administered by gavage on days 6 through 15 of gestation at dose levels from 8 to 120 mg/kg/day. Fetuses were removed on day 18 and examined. Cleft palate frequency exceeding ($p < 0.05$) that of the controls was observed with doses higher than 30 mg/kg with all samples. Reductions ($p < 0.05$) in fetal weight were observed with all samples tested at doses as low as 10 to 15 mg/kg. There was no clear increase in embryo lethality over that of controls at these lower doses. With the purest sample of 2,4,5-T, single oral doses of 150 to 300 mg/kg were capable of producing significant ($p < 0.05$) incidences of cleft palate. The maximal teratogenic effect was seen when the 2,4,5-T was administered on days 12 to 13 of gestation. Based on the data obtained with the purest sample of 2,4,5-T, the teratogenic NOAEL is 15 mg/kg/day and the fetotoxic NOAEL is 8 mg/kg/day.

- Roll (1971) examined the teratogenic effects of 2,4,5-T in NMRI-Han mice after oral administration on days 6 to 15 of gestation at dose levels of 0, 20, 35, 60, 90 or 130 mg/kg/day. The 2,4,5-T sample had a purity of 99.6%, with a dioxin content of <0.01 ppm (measured by the DOW method), or 0.05 ± 0.02 ppm (measured by the U.S. Food and Drug Administration (FDA) method). Peanut oil was used as the vehicle. Animals were sacrificed on day 18 and examined for defects. Fetal weight was significantly ($p < 0.05$) lower than control at all doses. Resorptions were significantly ($p < 0.05$) increased at 60 mg/kg and above. The incidence of cleft palates was significantly ($p < 0.05$) higher at 35 mg/kg and higher, but there was no effect at 20 mg/kg. There were also dose-dependent increases in ossification defects of sternum and various other bones. The authors concluded that 2,4,5-T alone (independent of TCDD contamination) was teratogenic in mice, and that the teratogenic NOAEL in this strain was 20 mg/kg/day. In view of the significantly ($p < 0.05$) lower fetal weight at 20 mg/kg/day, this level may also be considered the LOAEL for fetotoxicity.

- No teratogenic effects were observed in the offspring of female rhesus monkeys that were given oral doses of 0.05, 1.0 or 10.0 mg 2,4,5-T (containing 0.05 ppm TCDD)/kg/day in capsules during gestation days 22 through 38. Neither was toxicity evident in the mothers (Dougherty et al., 1976).

Mutagenicity

- At 250 and 1,000 ppm 2,4,5-T (with no detectable TCDD), mutation rate was significantly ($p < 0.05$) increased at the higher dose in the sex-linked recessive lethal test in Drosophila as carried out by Majumdar and Golia (1974). The sex-linked test was not affected by 920 or 1,804 ppm of the sodium salt of 2,4,5-T at pH 6.8 in a study

carried out by Vogel and Chandler (1974). Although they found no cytogenetic effects in Drosophila, Magnusson et al. (1977) concluded that 1,000 ppm 2,4,5-T (<0.1 ppm TCDD) did cause an increase ($p < 0.05$) in the number of recessive lethals compared to the controls. Rasmusson and Svahlin (1978) treated Drosophila larvae to food containing 100 and 200 ppm 2,4,5-T; survival was low at 200 ppm, but 2,4,5-T had no observable effect on somatic mutational activity.

- Anderson et al. (1972) found that neither 2,4,5-T nor its butyric acid form showed any mutagenic action when tested on histidine-requiring mutants of Salmonella typhimurium.

- Buselmaier et al. (1972) found that intraperitoneal injection of 2,4,5-T (dioxin levels not given) had no effect in the host-mediated assay (500 mg/kg) or in the dominant lethal test (100 mg/kg) with NMRI mice. Styles (1973), likewise, found no increase in back mutation rates with the serum of rats treated orally with 2,4,5-T in the host-mediated assay with Salmonella typhimurium (dosages and purity of the samples not given).

- Shirasu et al. (1976) found that 2,4,5-T did not induce mitotic gene conversion in a diploid strain of Saccharomyces cerevisiae. When the pH of the treatment solution was less than 4.5, Zetterberg (1978) found that 2,4,5-T was mutagenic in haploid, DNA-repair-defective S. cerevisiae.

- Jenssen and Renberg (1976) investigated the cytogenetic effects of 2,4,5-T in mice by examining the ability of the herbicide to induce micronuclei formation in the erythrocytes of mouse bone marrow. CBA mice were treated at 8 to 10 weeks of age (20 to 30 g) with a single intraperitoneal injection of 100 mg/kg of 2,4,5-T (<1 ppm TCDD) dissolved in Tween 80 and physiological saline. Cytogenetic examination at 24 hours and 7 days after treatment showed no detectable increase in micronuclei in the erythrocytes compared to controls. A weak toxic effect on the mitotic activity was indicated, as judged by a decrease in the percentage of polychromatic erythrocytes.

Carcinogenicity

- Innes et al. (1969) investigated the potential carcinogenic effects of 2,4,5-T in two hybrid strains of mice derived by breeding SPF C57BL/6 female mice to either C3H/Anf or AKR males. Beginning at 6 days of age, 2,4,5-T was administered by gavage in 0.5% gelatin to a group of 72 mice at a dose level of 21.5 mg/kg/day. This was reported to be the maximum tolerated dose. At 28 days of age, the 2,4,5-T was added to the diet at a level of 60 ppm, corresponding to a dose of about 9 mg/kg/day (assuming that 1 ppm equals 0.15 mg/kg/day in the diet from Lehman, 1959). This dose was fed for 18 months, at which time the study was terminated. All animals were necropsied and the tissues were examined both grossly and microscopically. There were no significant ($p > 0.05$) increases in tumors in either strain of treated mice.

- A lifetime study using oral administration of 2,4,5-T in both sexes of two strains of mice, C3Hf and XVII/G, was performed by Muranyi-Kovacs et al. (1976). The 2,4,5-T, which contained less than 0.05 ppm of dioxins, was administered in the water (1,000 mg/L) for 2 months beginning at 6 weeks of age, and thereafter in the diet at 80 ppm (12 mg/kg/day) until death or when the mice were sacrificed *in extremis*. In the treated C3Hf mice there was a significant ($p < 0.03$) increase in the incidence of total tumors found in female mice and a significant ($p < 0.001$) increase in total nonincidental tumors in each sex, which the authors interpreted as life-threatening. No significant ($p > 0.05$) difference was found in the XVII/G strain between the treated and control mice. The authors felt that 2,4,5-T demonstrated carcinogenic potential in the C3Hf strain, but that additional studies in other strains and in other species of animals needed to be performed before a reliable conclusion with respect to carcinogenicity could be made.

- Groups of Sprague-Dawley rats (50 each of males and females) were maintained on diets supplying 3, 10 or 30 mg/kg/day of 2,4,5-T for 2 years (Kociba et al., 1979). The 2,4,5-T was approximately 99% pure, containing 1.3% (w/w) other phenoxy acid impurities. Dioxins were not detected, the limit of detection for TCDD being 0.33 ppb. An interim sacrifice was performed on an additionally included group of 10 animals of each sex at 118 to 119 days. Control groups included 86 animals of each sex. At the end of the 2-year period, there was no significant ($p > 0.05$) increase in tumor incidence in any treated group compared to the control for either male or female animals.

V. QUANTIFICATION OF TOXICOLOGICAL EFFECTS

Health Advisories (HAs) are generally determined for one-day, ten-day, longer-term (approximately 7 years) and lifetime exposures if adequate data are available that identify a sensitive noncarcinogenic end point of toxicity. The HAs for noncarcinogenic toxicants are derived using the following formula:

$$HA = \frac{(NOAEL \text{ or } LOAEL) \times (BW)}{(UF) \times (\_\_\_ \text{ L/day})} = \_\_\_ \text{ mg/L } (\_\_\_ \text{ ug/L})$$

where:

NOAEL or LOAEL = No- or Lowest-Observed-Adverse-Effect-Level in mg/kg bw/day.

BW = assumed body weight of a child (10 kg) or an adult (70 kg).

UF = uncertainty factor (10, 100 or 1,000), in accordance with NAS/ODW guidelines.

___ L/day = assumed daily water consumption of a child (1 L/day) or an adult (2 L/day).

One-day Health Advisory

No information was found in the available literature that was suitable for determination of the One-day HA value for 2,4,5-T. The study in humans by Gehring et al. (1973) was not selected because observations of the subjects were reported simply as clinical effects without further details. The behavioral study in rats by Crampton and Rogers (1983) was not selected because the interpretation of altered novelty response behavior in the absence of other toxic signs needs further investigation before definitive conclusions can be made. It is therefore recommended that the Ten-day HA value for a 10-kg child (0.8 mg/L, calculated below) be used at this time as a conservative estimate of the One-day HA value.

Ten-day Health Advisory

The study by Neubert and Dillman (1972) has been selected to serve as the basis for determination of the Ten-day HA value for 2,4,5-T. This developmental study in rats identified a NOAEL of 8 mg/kg/day and a LOAEL of 15 mg/kg/day, based on reduced body weights in pups from dams exposed on days 6 to 15 of gestation. This LOAEL is supported by a number of other developmental studies in rodents that identified LOAELs ranging from 15 to 100 mg/kg/day (Roll, 1971; Sparschu et al., 1971; Khera and McKinley, 1972; Gaines et al., 1975). In the 21-day feeding study in rats by Vos et al. (1983), a LOAEL of 20 mg/kg/day was identified based on effects on kidney weight and the immune system. The 8 mg/kg/day NOAEL for fetal effects selected from the Neubert and Dillman (1972) study may not be applicable to a 10-kg child; however, the assumptions for a 10-kg child are used with this NOAEL in this case since, although a NOAEL was not found in the 21-day study by Vos et al. (1983) where the observed effects are applicable to a 10-kg child, the LOAEL of 20 mg/kg/day is 2.5 times higher than the NOAEL used for the Ten-day HA.

Using a NOAEL of 8 mg/kg/day, the Ten-day HA for a 10-kg child is calculated as follows:

$$\text{Ten-day HA} = \frac{(8 \text{ mg/kg/day})\ (10 \text{ kg})}{(100)\ (1 \text{ L/day})} = 0.8 \text{ mg/L } (800 \text{ ug/L})$$

where:

8 mg/kg/day = NOAEL, based on absence of maternal or fetal effects in rats exposed by gavage on days 6 to 15 of gestation.

10 kg = assumed body weight of a child.

100 = uncertainty factor, chosen in accordance with NAS/ODW guidelines for use with a NOAEL from an animal study.

1 L/day = assumed daily water consumption of a child.

Longer-term Health Advisory

The reproduction study by Smith et al. (1981, 1978) has been selected to serve as the basis for the Longer-term HA value for 2,4,5-T because the

reduction in neonatal survival over multiple generations is concluded to be relevant to the Longer-term HA for a 10-kg child. The NOAEL identified was 3 mg/kg/day, and the LOAEL was 10 mg/kg/day. Other possible selections have a higher NOAEL [10 mg/kg/day in the 90-day feeding study in rats by McCollister and Kociba (1970) and the 90-day oral treatment study in dogs by Drill and Hiratzka (1953)].

Using a NOAEL of 3 mg/kg/day, the Longer-term HA for a 10-kg child is calculated as follows:

$$\text{Longer-term HA} = \frac{(3\ \text{mg/kg/day})\ (10\ \text{kg})}{(100)\ (1\ \text{L/day})} = 0.3\ \text{mg/L}\ (300\ \text{ug/L})$$

where:

3 mg/kg/day = NOAEL, based on absence of adverse effects in neonatal rats in the three-generation reproduction study in rats given 2,4,5-T in the diet.

10 kg = assumed body weight of a child.

100 = uncertainty factor, chosen in accordance with NAS/ODW guidelines for use with a NOAEL from an animal study.

1 L/day = assumed daily water consumption of a child.

The Longer-term HA for a 70-kg adult is calculated as follows:

$$\text{Longer-term HA} = \frac{(3\ \text{mg/kg/day})\ (70\ \text{kg})}{(100)\ (2\ \text{L/day})} = 1.05\ \text{mg/L}\ (1{,}050\ \text{ug/L})$$

where:

3 mg/kg/day = NOAEL, based on absence of adverse effects in neonatal rats in a three-generation reproduction study in rats given 2,4,5-T in the diet.

70 kg = assumed body weight of an adult.

100 = uncertainty factor, chosen in accordance with NAS/ODW guidelines for use with a NOAEL from an animal study.

2 L/day = assumed daily water consumption of an adult.

Lifetime Health Advisory

The Lifetime HA represents that portion of an individual's total exposure that is attributed to drinking water and is considered protective of noncarcinogenic adverse health effects over a lifetime exposure. The Lifetime HA is derived in a three-step process. Step 1 determines the Reference Dose (RfD), formerly called the Acceptable Daily Intake (ADI). The RfD is an estimate of a daily exposure to the human population that is likely to be without appreciable risk of deleterious effects over a lifetime, and is derived from

the NOAEL (or LOAEL), identified from a chronic (or subchronic) study, divided by an uncertainty factor(s). From the RfD, a Drinking Water Equivalent Level (DWEL) can be determined (Step 2). A DWEL is a medium-specific (i.e., drinking water) lifetime exposure level, assuming 100% exposure from that medium, at which adverse, noncarcinogenic health effects would not be expected to occur. The DWEL is derived from the multiplication of the RfD by the assumed body weight of an adult and divided by the assumed daily water consumption of an adult. The Lifetime HA is determined in Step 3 by factoring in other sources of exposure, the relative source contribution (RSC). The RSC from drinking water is based on actual exposure data or, if data are not available, a value of 20% is assumed for synthetic organic chemicals and a value of 10% is assumed for inorganic chemicals. If the contaminant is classified as a Group A or B carcinogen, according to the Agency's classification scheme of carcinogenic potential (U.S. EPA, 1986), then caution should be exercised in assessing the risks associated with lifetime exposure to this chemical.

The study by Kociba et al. (1979) has been selected to serve as the basis for the Lifetime HA value for 2,4,5-T. In this study, rats were fed 2,4,5-T in the diet for 2 years. Based on observations of effects of 2,4,5-T on various biochemical parameters in addition to gross and microscopic observations related to general toxicity in the rats, this study identified a NOAEL of 3 mg/kg/day and a LOAEL of 10 mg/kg/day. This study is supported by the three-generation rat study (Smith et al., 1981, 1978) that identified a NOAEL of 3 mg/kg/day.

Using this study, the Lifetime HA is calculated as follows:

Step 1: Determination of the Reference Dose (RfD)

$$RfD = \frac{(3.0 \text{ mg/kg/day})}{(100)\ (10)} = 0.003 \text{ mg/kg/day}$$

where:

3.0 mg/kg/day = NOAEL, based on absence of adverse effects on the kidneys, liver and lungs of rats exposed to 2,4,5-T in the diet for 2 years.

100 = uncertainty factor, chosen in accordance with NAS/ODW guidelines for use with a NOAEL from an animal study.

10 = modifying factor used by U.S. EPA Office of Pesticide Programs to account for data gaps (chronic feeding study in dogs) which does not make it possible to establish the most sensitive end point for 2,4,5-T.

Step 2: Determination of the Drinking Water Equivalent Level (DWEL)

$$DWEL = \frac{(0.003 \text{ mg/kg/day})\ (70 \text{ kg})}{(2 \text{ L/day})} = 0.105 \text{ mg/L } (105 \text{ ug/L})$$

where:

0.003 mg/kg/day = RfD.

70 kg = assumed body weight of an adult.

2 L/day = assumed daily water consumption of an adult.

Step 3: Determination of the Lifetime Health Advisory

Lifetime HA = (0.105 mg/L) (20%) = 0.021 mg/L (21 ug/L)

where:

0.105 mg/L = DWEL.

20% = assumed relative source contribution from water.

Evaluation of Carcinogenic Potential

- Chronic feeding studies with 2,4,5-T in Sprague-Dawley rats (Kociba et al., 1979) and C57BL/6 x C3H/Anf, C57BL/6 x AKR and XVII/G strains of mice (Innes et al., 1969; Muranyi-Kovacs, et al; 1976) were negative for carcinogenic effects. A chronic feeding study with 2,4,5-T in C3Hf mice was inconclusive (Muranyi-Kovacs et al., 1976).

- IARC (1982) concluded that the carcinogenicity of 2,4,5-T is indeterminant (Group 3, inadequate evidence in animals and humans).

- Applying the criteria described in EPA's guidelines for assessment of carcinogenic risk (U.S. EPA, 1986), 2,4,5-T may be classified in Group D: not classified. This category is for agents with inadequate animal evidence of carcinogenicity.

- The Carcinogen Assessment Group (CAG) of the U.S. EPA classified chlorophenoxyacetic acids and/or chlorophenols containing 2,3,7,8-TCDD in IARC category 2A (probably carcinogenic in humans on the basis of limited evidence in humans), but a quantitative cancer risk estimate only for 2,3,7,8-TCDD itself was made. The CAG considered the human evidence for the carcinogenicity of 2,3,7,8-TCDD alone to be "inadequate" because of the difficulty in attributing observed effects solely to the presence of 2,3,7,8-TCDD, which occurs as an impurity in the phenoxyacetic acids and chlorophenols (U.S. EPA, 1985).

VI. OTHER CRITERIA, GUIDANCE AND STANDARDS

- The U.S. EPA/Office of Pesticide Programs has calculated a Provisional Acceptable Daily Intake (PADI) value of 0.003 mg/kg/day, based on the results of a rat chronic oral NOAEL of 3 mg/kg/day with an uncertainty factor of 1,000 (used because of data gaps).

- The National Academy of Sciences (NAS, 1977) has calculated an ADI of 0.1 mg/kg/day, using a NOAEL of 10 mg/kg/day (identified in a 90-day feeding study in dogs) and an uncertainty factor of 100. A chronic Suggested-No-Adverse-Effect-Level (SNARL) of 0.7 mg/L was calculated based on the ADI of 0.1 mg/kg/day.

- The American Conference of Governmental Industrial Hygienists (ACGIH, 1981) has recommended a Threshold Limit Value-Time-Weighted Average (TLV-TWA) of 10 mg/m^3 and a Threshold Limit Value-Short-Term Exposure Limit (TLV-STEL) of 20 mg/m^3.

- The ADI recommended by the World Health Organization is 0 to 0.03 mg/kg (Vettorazzi and van den Hurk, 1983).

VII. ANALYTICAL METHODS

- Determination of 2,4,5-T is by a liquid-liquid extraction gas chromatographic procedure (U.S. EPA, 1978; Standard Methods, 1985). Specifically, the procedure involves the extraction of chlorophenoxy acids and their esters from an acidified water sample with ethyl ether. The esters are hydrolyzed to acids, and extraneous organic material is removed by a solvent wash. The acids are converted to methyl esters that are extracted from the aqueous phase. Separation and identification of the esters is made by gas chromatography. Detection and measurement are accomplished by an electron-capture, microcoulometric or electrolytic conductivity detector. Identification may be corroborated through the use of two unlike columns. The detection limit is dependent on the sample size and instrumentation used. Typically, using a 1-L sample and a gas chromatograph with an electron-capture detector results in an approximate detection limit of 10 ng/L for 2,4,5-T.

VIII. TREATMENT TECHNOLOGIES

- Available data indicate that granular-activated carbon (GAC) and powdered-activated carbon (PAC) adsorption will effectively remove 2,4,5-T from water.

- Robeck et al. (1965) experimentally determined adsorption isotherms for the butoxy ethanol ester of 2,4,5-T on PAC. Based on these results, it was calculated that 14 mg/L PAC would be required to remove 90% of 2,4,5-T, while 44 mg/L PAC would be required to remove 99% of 2,4,5-T (Pershe and Goss, 1979; Robeck et al., 1965).

- Robeck et al. (1965) reported the results of a GAC column operating under pilot plant conditions. At a flow rate of 0.5 gpm/ft^3, 99+% of 2,4,5-T was removed. By comparison, treatment with 5 to 20 mg/L PAC removed 80 to 95% of the same concentration of 2,4,5-T.

- In a laboratory study conducted with an exchange resin, Rees and Au (1979) reported 89±2% removal efficiency of 2,4,5-T from contaminated water by adsorption onto synthetic resins.

- Conventional water treatment technique of coagulation with alum, sedimentation and sand filtration removed 63% of the 2,4,5-T ester present in spiked river water (Robeck et al., 1965).

- Treatment technologies for the removal of 2,4,5-T from water are available and have been reported to be effective. However, selection of individual or combinations of technologies to attempt 2,4,5-T removal from water must be based on a case-by-case technical evaluation, and an assessment of the economics involved.

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