

CONFIDENTIAL
SUBJECT TO PROTECTIVE ORDER.

FOR ADMINISTRATIVE USE
LIMITED DISTRIBUTION
NOT FOR PUBLICATION

PUBLIC HEALTH SERVICE-CDC-Atlanta
EPI-75-17-2 March 31, 1975

TO : Director, Center for Disease Control

FROM : Cancer and Birth Defects Division, Bureau of Epidemiology, and
Clinical Chemistry Division, Bureau of Laboratories

SUBJECT: 2,3,7,8-Tetrachlorodibenzodioxin Contamination of Salvage Motor Oil
Used in Dust Control Spraying in Missouri

SUMMARY

In May and June 1971, a salvage oil company sprayed sludge oil on 3 horse arenas in eastern Missouri for dust control. After the sprayings, many horses, birds, rodents, cats, dogs, and insects exposed to the arenas died. Horses' symptoms included chronic emaciating weight loss, alopecia, skin lesions, dependent edema, joint stiffness, conjunctivitis, and laminitis. Human illnesses attributed to arena exposure included skin lesions, headaches, intermittent arthralgia, and hemorrhagic cystitis. Detailed toxicological studies subsequently identified the probable toxic agent as 2,3,7,8-tetrachlorodibenzodioxin (TCDD). A follow-up investigation in 1974 traced the source of TCDD to trichlorophenol distillate residues accumulated by a hexachlorophene producer. The salvage oil company collected these waste residues and stored them in the same tank from which sludge was obtained for the arena spraying.

INTRODUCTION

In August 1971, the St. Louis Division of Health, the Missouri Division of Health, and CDC investigated toxic illnesses among horses, dogs, cats, birds, and humans exposed to a horse arena in Missouri which had been sprayed with salvage motor oil for dust control (EPI-72-13-2). The Toxicology Branch, Clinical Chemistry Division, Bureau of Laboratories, subsequently identified 2,3,7,8-tetrachlorodibenzodioxin (TCDD), a highly toxic and relatively stable chemical, in high concentration in soil samples taken at the arena. In August 1974 after discussions with Clark W. Heath, Jr., M.D., Director, Cancer and Birth Defects Division, Bureau of Epidemiology; Philip J. Landrigan, M.D., Chief, Environmental Hazards Activity, Cancer and Birth Defects Division, Bureau of Epidemiology; Vernon N. Houk, M.D., Acting Director, Environmental Health Services Division, Bureau of State Services; and William F. Barthel, Chief, Toxicology Branch, Clinical Chemistry Division, Bureau of Laboratories; H. Denny Donnell, Jr., M.D., Missouri State Epidemiologist, invited CDC to participate in a follow-up investigation of the extent and source of TCDD exposure. Accordingly, Coleman D. Carter, M.D., and Matthew M. Zack, Jr., M.D., EIS Officers, Cancer and Birth Defects Division, departed for St. Louis on August 8 to meet with Pat Philips, D.V.M., Missouri Division of Health, and begin the investigation.

004059

BACKGROUND

On August 23, 1971, a physician at a children's hospital in Missouri reported to John V. Bennett, M.D., then Chief of the Bacterial Diseases Branch, the occurrence of acute hemorrhagic cystitis in a 6-year-old girl. The unique feature of the child's illness was that she lived on a horse farm where many animals had died after waste oil had been sprayed on the farm show arena in late May. The patient had played frequently in the arena, and the possibility of a common toxic agent affecting the child and the animals was suggested. The ensuing investigation (EPI-72-13-2) confirmed the death of 7 horses on the farm as of September 1971. The temporal relation to symptoms and the exposure history of affected horses strongly implicated the salvage oil as the toxic agent. Numerous organic compounds were detected in arena soil samples by several different laboratories during the original investigation, but no specific substance was identified in concentrations capable of producing the observed toxicity.

After extensive analysis the Toxicology Branch, Clinical Chemistry Division, Bureau of Laboratories, detected trichlorophenol crystals in the arena soil. The high concentration of trichlorophenol and the presence of other chlorinated hydrocarbon compounds suggested the possible presence of a very toxic byproduct, TCDD. Application of a neutral fraction of soil extract once a day for 3 days killed rabbits within 7 days. Each 0.2 milliliters applied to the rabbits' ear skin contained only 61 micrograms of TCDD. The resulting skin and liver lesions observed in the treated rabbits were consistent with TCDD toxicity. Gas liquid chromatography and mass spectrometry subsequently identified TCDD in concentrations of 31-33 ppm in the arena soil. Such unusually high levels of this very toxic compound in soil could not be obtained from known commercial products contaminated with TCDD. An industrial waste residue containing extremely high concentrations of TCDD was suspected, and a follow-up investigation was initiated in 1974 to trace its ultimate source and disposal. Since affected animal tissue was no longer available for TCDD analysis, the investigators attempted to define and compare the pathological effects among humans, horses, and other animals with the known toxic effects of TCDD.

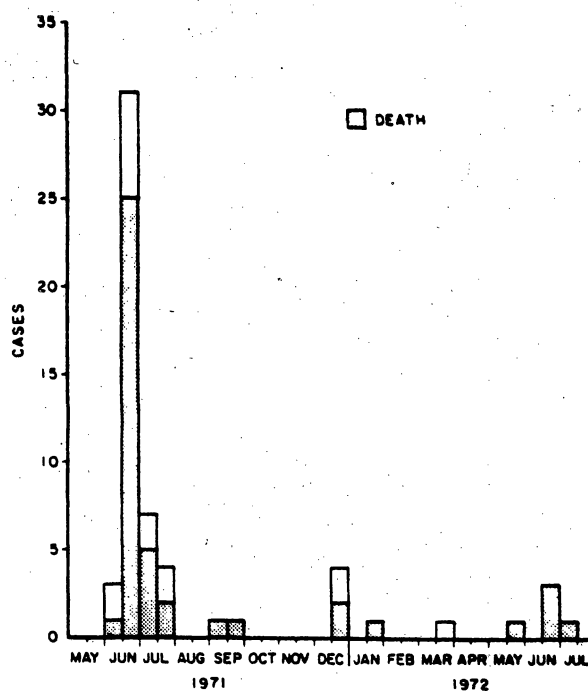
AFFECTED ARENAS

The first affected farm (arena A), had been breeding horses for 10 years before the spraying. The 125 horses on the farm were primarily show horses or breeding stock of the Quarter Horse and Appaloosa variety. Horses were routinely kept in pasture or in stables outside the arena barn. They were stabled in the arena barn for days or weeks when they were bred, checked for pregnancy, or watched for other reasons. During these periods the horses were frequently exercised in the oiled arena. The horse population was generally in good health before May 30, 1971.

On May 26, 1971, a salvage oil company sprayed the arena with waste oil for dust control. Strong, irritating fumes were noticed after the spraying, and within 3 days barn sparrows were found dead on the arena floor. Over the next several weeks hundreds of birds, 11 cats, and 4 dogs were found dead in or near the arena. The first horse became symptomatic on May 30, with straining on urination and signs of intestinal colic. The first horse died on June 20. Despite excavations of the arena soil in October 1971 and again in April 1972, horses continued to die until January 1974. All the ill horses had walked on the original arena soil during the summer of 1971. Of 85 horses ridden in the arena during this time, 58 became ill; 43 subsequently died (Figure 1). There were 26 known abortions, and many foals, exposed only in utero, died either at birth or shortly thereafter. Six birth abnormalities with limb girdle deformities were observed. Table 1 lists signs and symptoms in 37 affected horses. A characteristic syndrome included polydipsia, anorexia, severe weight loss, intestinal colic, alopecia, skin lesions, oral ulcers, dependent edema, conjunctivitis, joint stiffness, and laminitis. Severe laminitis was frequently associated with inflammation of the sole and frog of the horses' hooves, parts that would have contacted arena soil. In terminally ill horses, the length of illness varied from 4 to 132 weeks with an

average of 47.6 weeks. Dying horses with heavy exposure had a significantly shorter duration (32.5 weeks) than those with less exposure (74 weeks). Since the excavation and replacement of arena soil, there have been no newly affected horses.

Fig. 1 CASES OF ILLNESS* IN HORSES ASSOCIATED WITH ARENA A, BY DATE OF ONSET, MAY 1971-JULY 1972



*EXCLUDING ILLNESSES, ABORTIONS, OR MALFORMATIONS FROM EXPOSURE IN UTERO.

Table 1

Signs and Symptoms in 37 Horses Affected at Arena A

Intestinal colic	33
Oral ulcers	31
Severe weight loss	31
Conjunctivitis	31
Polydipsia	25
Laminitis	25
Anorexia	24
Foaming at mouth	24
Swollen pharynx	23
Alopecia	22
Stiffness in hind legs	22
Fever	19
Ventral edema	19
Oral hyperemia	16
Skin lesions	16
Ataxia	9

The most acute human illness occurred in a 6-year-old girl who used the arena soil for sandbox-like play. Her symptoms were headache, epistaxis, diarrhea, and lethargy and, on August 21, 1971, hemorrhagic cystitis. Bacterial and viral cultures of urine were negative, and cystoscopy confirmed hemorrhagic inflammation of the bladder wall. A retrograde pyelogram indicated signs of focal pyelonephritis. This patient had an uneventful recovery. Symptoms were less severe and subjective in 3 other individuals exposed to the arena. They included recurrent headaches, skin lesions, and polyarthralgias.

The same salvage oil company sprayed 2 additional horse arenas with salvage sludge oil within 3 weeks of arena A. Arena B is a riding arena owned by a private club which participates as a horse drill and riding troop in the midwest area. The troop's black quarter horses are drilled in the arena approximately once a week. The arena has been oiled for dust control each year from 1962 through 1971. From 1969 until 1971, the salvage oil company performed this operation without any consequences, but on June 11, 1971, it sprayed arena B with sludge oil that had unusually strong and irritating fumes. Between January 1972 and August 1973, 7 horses died. Signs and symptoms including conjunctivitis, skin lesions, anorexia, weight loss, and alopecia, developed in approximately 28-30 additional stable horses.

Arena C was built in 1970 and used for riding, breeding, and showing horses. The salvage oil company sprayed this arena twice. The second oiling, on June 16, 1971, was associated with severe, irritating fumes. Within a few weeks after the oiling, mice, 7 cats, and a dog exposed to the arena became ill with conjunctivitis, alopecia, and emaciation and then died. Approximately 25 horses were permanently stabled in the arena barn at the time of the June 16 spraying. Seven horses and 5 colts subsequently died. Several other horses exposed to the arena showed signs of weight loss and alopecia.

Two 3-year-old boys played frequently in arena C during the summer of 1971. About a month and a half after the arena spraying, small, pale, non-pruritic, firm papules covered by a blackhead developed on exposed skin surfaces of the boys. The condition increased in severity and lasted for more than a year before gradually subsiding.

PATHOLOGY OF AFFECTED ANIMALS

Autopsies were performed on 13 affected horses and 2 cats from the 3 arenas. Different veterinarians performed the autopsies, and observations of the oral cavity, brain, urinary bladder, and feet were not routinely reported. They invariably noted alopecia, skin lesions, emaciation, hepatomegaly, ascitic fluid, and multiple ulcerations of the gastrointestinal tract. Fixed tissue was obtained from 7 horses for histological review by the Toxicology Branch, Bureau of Laboratories. Cholestasis and extensive centrolobular fibrosis were present in all 5 liver specimens, necrosis and bile duct proliferation in 4, and an inflammatory exudate in 3. Of 3 skin sections, slight hyperkeratosis was present in 2, acanthosis in 3, and widened hair follicles with keratin plugs in 1. The 1 available section of urinary bladder revealed epithelial degeneration and inflammation of the submucosa. Blood vessels had thickened walls with endothelial proliferation. Loss of follicles and atrophy were observed in the only 2 submitted specimens of spleen. Glomerular and tubular degeneration and microabscesses were present in 3 of 7 available kidney specimens, and a focal interstitial nephritis in 2. The observed histological changes in horses from the 2 arenas on which tissue was available were similar except for the severity of the lesions. Two cats, from arena A and arena C, were autopsied. Liver sections from these cats revealed hepatocellular degeneration, fibrosis, and bile duct proliferation. Interstitial nephritis and splenic atrophy were present in the cat from arena A. The severe emaciation, toxic hepatitis, gastric ulcers, splenic atrophy, buccal mucosal and skin lesions, and blood vessel abnormalities in affected animals were consistent with TCDD poisoning and have been reported in experimental animals (1).

SOURCE OF TCDD

Salvage Oil Company - The salvage oil company which sprayed the 3 affected arenas is operated by the owner, who employs 3 drivers and owns 5 trucks and several storage tank facilities. The company collects discarded motor oil and lubricants from over 2,000 service stations in eastern Missouri and southwestern Illinois and a limited amount of used organic solvents, transformer oils, and other compounds from various sources. All liquid waste sources other than routine service stations originally furnished by the salvage oil company denied making, using, or distributing chemicals likely to be contaminated with TCDD.

Trichlorophenol Producer - TCDD is a byproduct during the chemical formation of 2,4,5-trichlorophenol, trichlorophenoxyacetic acid (2,4,5-T) and related compounds. Waste residues removed during these processes may contain high concentration of TCDD. Accordingly, the waste disposal practices of the 2,4,5-T and trichlorophenol producers in the U.S. during the early 1970s were reviewed. On the assumption that improper disposal of waste residue might be related to closing down a 2,4,5-T plant, a list was obtained of 2,4,5-T contracts terminated by the Department of Defense in the late 1960s and early 1970s. This list identified a company in southwestern Missouri which has since changed name and ownership. The company terminated production of 2,4,5-T in February 1969, sold the 2,4,5-T equipment, and leased plant space to a company which produced trichlorophenol as an intermediate reagent for hexachlorophene production. A former supervisor of the trichlorophenol producer confirmed that during the production of 2,4,5-trichlorophenol, a neutral phase of the reaction was distilled to remove impurities and waste byproducts. These distillate residues could have contained high concentration of TCDD. The residues were emptied once a week into a residue storage tank (tank 1) adjacent to the production site. The company experienced a serious financial crisis in 1971, when the market for hexachlorophene collapsed, and discontinued trichlorophenol production in December 1971. Since the discontinuance of production, the trichlorophenol equipment and the residue storage tank had been undisturbed. Inspection of this tank disclosed the presence of approximately 4,300 gallons of remaining residue when it was sampled on August 31, 1974.

Waste Disposal Contractor - The trichlorophenol producer stated that an environmental service company hauled the initial residues to a distant state for incineration. After the financial crisis in 1971, the trichlorophenol company contracted this disposal to 1 of its chemical suppliers. The chemical supplier, not actually equipped to handle waste disposals, subcontracted this service to the salvage oil company that sprayed the affected arenas. Records from each of the companies involved document that the salvage oil company made 6 direct hauls containing residue from the trichlorophenol company to the salvage oil company's storage tank facilities in eastern Missouri between February and October 1971. The total volume of residue was in excess of 10,000 gallons. On the third haul on May 20, 1971, the salvage oil company's truck driver was given a traffic citation for overloading. To reduce weight, the truck driver sprayed waste residue on a farm road owned by the salvage oil company's owner. All of 70 chickens exposed to the sprayed farm road died within the next 2 weeks. Each of the residue hauls, including the 1 on May 25, 1971, the day before the spraying of arena A, was stored in the same storage tank (tank 2). On May 26, 1971, a spray truck unloaded sludge from this tank to spray arena A. Arenas B and C were sprayed within 3 weeks with sludge also taken from storage tank 2.

ULTIMATE DISTRIBUTION OF TCDD

There was limited road and arena spraying during the summer of 1971, and the remaining oil and sludge in tank 2 were removed by a refinery in southern Illinois. The refinery recovers sludge from its salvage oil and uses it for road spraying. Roads sprayed during this time were primarily rural oil field lease roads. Specimens from the surface of these roads were sampled for analysis on September 18, 1974.

All 3 arenas were excavated and the dirt dumped at other sites. Arena A's soil was excavated twice to a depth of 12 inches and placed under the road bed of a recently constructed 4-lane concrete highway. Arena B was excavated in March 1973, and the dirt was used for landfill purposes near a residence in eastern Missouri. Soil samples at this residence were collected on August 14, 1974. Arena C was excavated and the dirt emptied into a sanitary landfill in a rural area. Later this landfill was leveled. The contaminated dirt is estimated to be 70 feet deep.

TOXICOLOGICAL ANALYSIS

Table 2 lists sample sites and concentrations of TCDD obtained. Analytical procedures included gas liquid chromatography and mass spectrometry. Although sampled more than 3 years after its production, the residue in the storage tank of the trichlorophenol producer (tank 1) contained 306-356 ppm of TCDD. The chromatographic configuration of an extract of arena A's soil reflected the myriad of organic compounds comprising the mixture in the salvage oil company's storage tank (tank 2). Although in subtoxic concentrations, the presence of polychlorinated biphenyls in the arena soil is attributed to the presence of discarded transformer oils in storage tank 2. Neither residue storage tank 1 sample nor the soil sample taken from the farm road sprayed during transport between the 2 storage tanks contained polychlorinated biphenyls. The matching of organic compound peaks in the residue storage tank 1 sample with soil samples from arena A confirms the former as the source of TCDD. Although original samples from arena B are not available, the dirt excavated from that arena and sampled more than 3 years after the oiling did reveal the presence of TCDD. Considering the dilution effect caused by excavation and the degradation of the compound during the 3-year interval, the original concentrations in arena B soil undoubtedly were high. Random sampling of the roads oiled by the refinery was performed. All samples were negative, and it is presumed that the tremendous dilution effect occurring at the refinery and the normal degradation occurring over the years make the hazard from TCDD in these roads extremely remote.

Table 2

TCDD Concentrations in Samples Analyzed

<u>Source of Sample</u>	<u>Date Collected</u>	<u>Concentration</u>
Arena A	1971	31-33 ppm
Dumped soil from Arena B at several rural sites	1974	0.17-0.74 ppm
Storage tank 1	1974	306-356 ppm
Farm road	1974	0.46 ppm
Illinois roads	1974	negative

RECOMMENDATIONS

TCDD is not as stable as originally assumed, and present evidence suggests that its half-life in most soils is 1 year (2). It does not move readily in soil. For these reasons, it was recommended that: 1) those excavations inaccessible to surface exposure should remain undisturbed, 2) those excavations used as residential fills should be re-excavated and dumped at a remote, deep landfill, 3) the contents of the

residue storage tank 1 should be removed and incinerated under specified time and temperature conditions by a properly informed and equipped environmental service company, 4) the tank itself should be marked as to its hazardous contents and deep-buried in a remote and secure site, and 5) a follow-up evaluation should be performed on each previously symptomatic individual.

DISCUSSION

TCDD is 1 of the most toxic synthetic compounds known with an oral LD-50 for many animal species in the microgram per kilogram range (1). It is a relatively stable, nonvolatile compound which can be absorbed through the skin. Evidence suggests that it accumulates in body tissue after recurrent exposure and is only gradually excreted in urine and feces (1,3,4). Its known toxic effects include severe weight loss, hepatotoxicity, hepatoporphyrria, vascular lesions, chloracne, gastric ulcers, teratogenicity, and delayed death (1). Chlorinated dibenzodioxins have no useful purpose and occur as contaminants in technical products such as tri-, tetra-, and penta-chlorophenol, and 2,4,5-trichlorophenoxyacetic acid (5,6).

In this investigation the nature of exposure for many horses was such that the feet were the only significant contact with the arena soil. Laminitis is a nonspecific finding in many systemically ill horses but was particularly common and severe in the incident reported here. In addition, the sole, frog, and coronet were frequently involved structures. Blood flow in some of these parts is markedly increased during exercise. This suggests that inflamed parts of the foot may have been the primary route of entry for TCDD. The prolonged contact of retained clumps of contaminated soil under the horses' hooves and the recurrent exposure probably contributed to toxicity. The lack of serious illness in humans may represent significantly less skin exposure, effective bathing, and possible differences in species susceptibility. Although chloracne is a well-known TCDD-related illness that probably occurred in 2 individuals, the persistent complaints of arthralgia are previously undescribed effects of TCDD toxicity. TCDD is nonvolatile and the strong, irritating fumes in the residue is attributed to the less toxic 2,4,5-trichlorophenol. Whether trichlorophenol enhances dermal absorption of TCDD is unknown.

This investigation demonstrates that the improper disposal of toxic chemical wastes may have serious consequences. TCDD and some other halogenated dibenzodioxins and dibenzofurans found in waste products of halogenated benzenes, phenols, and poly-biphenyls are extremely toxic substances. Companies responsible for disposal of such wastes should be aware of this toxicity and use the proper methods of disposal. More extensive regulations of toxic industrial waste disposal may be necessary to prevent similar or more serious occurrences.

REFERENCES

1. Kimbrough RD: Critical Reviews in Toxicol 2:445, 1974
2. Kearney PC, Woolson EA, Ellington CP Jr: Environ Science Technol 6:1017, 1972
3. Piper WN, Rose JQ, Gehring PJ: Environ Health Perspect No 5:241, 1973
4. Allen JR, Carstens LA: Amer J Vet Res 28:1513, 1967
5. Elridge DA: Analyst 96:721, 1971
6. Woolson EA, Thomas RF, Ensor PDJ: J Org Ed Chem 20:351, 1972

Matthew Zack, Jr.

Matthew Zack, Jr., M.D.
Cancer and Birth Defects Division
Bureau of Epidemiology

John A. Liddle

John A. Liddle, Ph.D.
Chemical Chemistry Division
Bureau of Laboratories

Coleman D. Carter

Coleman D. Carter, M.D.
Cancer and Birth Defects Division
Bureau of Epidemiology

Renate Kimbrough

Renate Kimbrough, M.D.
Chemical Chemistry Division
Bureau of Laboratories

Clark W. Heath, Jr.

Clark W. Heath, Jr., M.D., Director
Cancer and Birth Defects Division
Bureau of Epidemiology

Distribution

Mailing keys 53-1, 2, 3

David P. Rall, M.D., Ph.D., Director, National Institute of Environmental Health Sciences, National Environmental Health Sciences Center, P.O. Box 12233, Research Triangle Park, North Carolina 27709

Lawrence Plumlee, M.D., Medical Science Advisor, Environmental Protection Agency, 401 "M" Street, S.W., Room 625, West Tower, Washington, D.C. 20460

Jack Finklea, M.D., Director, National Institute for Occupational Safety and Health, 5600 Fishers Lane, 330 Park, Rockville, Maryland 20852

H. Denny Donnell, Jr., M.D., Division of Health, Missouri Department of Health and Welfare, State Office Building, Jefferson City, Missouri 65101

Patrick E. Phillips, D.V.M., Division of Health, Missouri Department of Health and Welfare, State Office Building, Jefferson City, Missouri 65101

RECEIVED
APR 17 1975
MISSOURI DIVISION OF HEALTH
SECTION OF EPIDEMIOLOGY