ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

PENTACHLOROPHENOL (PCP) ENTRY

July 1, 1997

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Like a library or many large databases (such as EPA's national STORET water quality database), this document contains information of variable quality from very diverse sources. In compiling this document, mistakes were found in peer reviewed journal articles, as well as in databases with relatively elaborate quality control mechanisms [366,649,940]. A few of these were caught and marked with a "[sic]" notation, but undoubtedly others slipped through. The [sic] notation was inserted by the editors to indicate information or spelling that seemed wrong or misleading, but which was nevertheless cited verbatim rather than arbitrarily changing what the author said.

Most likely additional transcription errors and typos have been added in some of our efforts. Furthermore, with such complex subject matter, it is not always easy to determine what is correct and what is incorrect, especially with the "experts" often disagreeing. It is not uncommon in scientific research for two different researchers to come up with different results which lead them to different conclusions. In compiling the Encyclopedia, the editors did not try to resolve such conflicts, but rather simply reported it all.

It should be kept in mind that data comparability is a major problem in environmental toxicology since laboratory and field methods are constantly changing and since there are so many different "standard methods" published by EPA, other federal agencies, state agencies, and various private groups. What some laboratory and field investigators actually do for standard operating practice is often a unique combination of various standard protocols and impromptu "improvements." In fact, the interagency task force on water methods concluded that [1014]:

> It is the exception rather than the rule that water-quality monitoring data from different programs or time periods can be compared on a scientifically sound basis, and that...
>
> No nationally accepted standard definitions exist for water quality parameters. The different organizations may collect data using identical or standard methods, but identify them by different names, or use the same names for data collected by different methods [1014].

Differences in field and laboratory methods are also major issues related to (the lack of) data comparability from media other than water: soil, sediments, tissues, and air.

In spite of numerous problems and complexities, knowledge is often power in decisions related to chemical contamination. It is therefore often helpful to be aware of a broad universe of conflicting results or conflicting expert opinions rather than having a portion of this information arbitrarily censored by someone else. Frequently one wants to know of the existence of information, even if one later decides not to use it for a particular application. Many would like to see a high percentage of the information available and decide for themselves what to throw out, partly because they don't want to seem uniformed or be caught by surprise by potentially important information. They are in a better position if they can say: "I knew about that data, assessed it based on the following quality assurance criteria, and decided not to use it for this application." This is especially true for users near the end of long decision processes, such as hazardous site cleanups, lengthy ecological risk assessments, or complex natural resource damage assessments.

For some categories, the editors found no information and inserted the phrase "no information found." This does not necessarily mean that no information exists; it simply means that during our efforts, the editors found none. For many topics, there is probably information "out there" that is not in the Encyclopedia. The more time that passes without encyclopedia updates (none are planned at the moment), the more true this statement will become. Still, the Encyclopedia is unique in that it contains broad ecotoxicology information from more sources than many other reference documents. No updates of this document are currently planned. However, it is hoped that most of the information in the encyclopedia will be useful for some time to come even without updates, just as one can still find information in the 1972 EPA Blue Book [12] that does not seem well summarized anywhere else.

Although the editors of this document have done their best in the limited time available to insure accuracy of quotes or summaries as being "what the original author said," the proposed interagency funding of a bigger project with more elaborate peer review and quality control steps never materialized.

> The bottom line: The editors hope users find this document useful, but don't expect or depend on perfection herein. Neither the U.S. Government nor the National Park Service make any claims that this document is free of mistakes.

The following is one chemical topic entry (one file among 118). Before utilizing this entry, the reader is strongly encouraged to read the README file (in this subdirectory) for an introduction, an explanation of how to use this document in general, an explanation of how to search for power key section headings, an explanation of the organization of each entry, an information quality discussion, a discussion of copyright issues, and a listing of other entries (other topics) covered.

See the separate file entitled REFERENC for the identity of numbered references in brackets.

HOW TO CITE THIS DOCUMENT: As mentioned above, for critical applications it is better to obtain and cite the original publication after first verifying various data quality assurance concerns. For more routine applications, this document may be cited as:

> **Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese**, and **W. Basham.** 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability

on the internet or NTIS: 1998).

Pentachlorophenol (PCP, CAS number 87-86-5)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Pentachlorophenol (PCP) is priority pollutant semi-volatile, chlorinated phenolic compound [446,302,656].

PCP is a man-made substance, made from other chemicals, and does not occur naturally in the environment. At one time it was one of the most widely used biocides in the United States. Now the purchase and use of it is restricted to certified applicators. It is no longer available to the general public [933].

Pentachlorophenol has two forms: pentachlorophenol and the sodium salt of pentachlorophenol. The sodium salt dissolves easily in water but pentachlorophenol does not [933].

Pentachlorophenol (PCP) is a restricted-use insecticide, fungicide, molluscicide, defoliant, herbicide, and wood preservative [186]. PCP is a common degradation product of lindane and hexachlorobenzene [249].

This compound is among 31 substances classified by the Chief of the Worker Health and Safety Unit of the California Department of Food and Agriculture as having "high carcinogenic or oncogenic potential" (Dr. Keith Maddy, personal communication) and is listed by EPA and/or NCI as a carcinogen.

Pentachlorophenol (PCP) is a substance whose widespread use, mainly in wood protection and pulp and paper mills, has led to a substantial environmental contamination. This in turn accounts for a significant exposure of the general human population, with rather high exposure levels being attained in occupational settings [940].

PCP is a toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations (40 CFR 401.15 (7/1/90) [940].

PCP is designated as a hazardous substance under section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance (40 CFR 116.4, 7/1/90) [940].

The following (next four indented paragraphs) additional summary information was contributed by Hank Brightman and

Fred Sturniolo, Hazardous Waste Management and Pollution Prevention Team, Washington, National Park Service, 1996, as part of an Issue abstract prepared for the National Park Service:

> General Introduction: At one time, pentachlorophenol (also known as pentachlorophenate and 2,3,4,5,6-pentachlorophenol) was among the most widely-used industrial pesticides in the United States. Subsequent restrictions have limited its use primarily to wood-preservative applications, such as treating exterior surfaces of utility poles, fence posts, decks, and walkways. Glued-laminated beams treated with pentachlorophenol are frequently used in vaulted ceilings for sports arenas, indoor swimming pool roof supports, and similar projects. While pentachlorophenol continues to be the most commonly-used oil-borne preservative, recent concerns about adverse health effects, coupled with increasing difficulties in the disposal of both product and treated lumber are gradually curtailing its use.
>
> Regulatory Classifications: Pentachlorophenol is considered a hazardous chemical by the Occupational Safety and Health Administration (OSHA) definition found at 29 CFR 1910.1200(c). It is also classified as a hazardous substance by the U.S. Environmental Protection Agency (U.S. EPA) pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) registration requirement found at 7 U.S.C. 136 et seq.; and as a Hazardous Material by the U.S. Department of Transportation (placard ID numbers NA/NA 2020 and 3155--see 49 CFR 172.101). Once pentachlorophenol has exceeded its useful life, or (pending approval of H.R. 2335) cannot be reused, recycled, or otherwise applied in an operational process, it is classified as hazardous pursuant to the U.S. EPA regulations found at 40 CFR 261.24(b).
>
> Disposal Classifications: Disposal of pentachlorophenol requires that it be manifested and transported in accordance with 40 CFR 262.20 and 49 CFR 172.205--and taken to a licensed Treatment, Storage, and Disposal Facility.
> Disposal requirements of pentachlorophenol-treated lumber: At present, pentachlorophenol-treated lumber is not classified as a hazardous waste pursuant to federal law. In fact, on September 15, 1995, H.R. 2335 was introduced in the U.S. House of Representatives on behalf of the AWPI that would further reduce wood treaters' liability, by stating that these parties would no longer have to manage

and report pentachlorophenol reused in the wood-treating process. While federal law does not consider pentachlorophenol-treated lumber to be a hazardous waste, many states regulate this wood, by classifying it as a special waste. Some states require that a Toxicity Characteristic Leaching Procedure (TCLP) analytical test be performed prior to accepting this wood at a solid waste landfill facility (see 40 CFR 261.30). AWPI standards prohibit the burning of commercial and industrial pentachlorophenol-treated wood in any boiler or incinerator rated at less than 20 million BTU/hour. Many states have adopted similar prohibitions for consumers with wood-burning stoves or furnaces--forbidding the burning of pentachlorophenol-treated lumber in these devices. Nearly all states prohibit the open burning of both commercial and non-commercial quantities of pentachlorophenol-treated wood (e.g., Minnesota State Implementation Plan, sec. 88.171). Despite its federal designation as non-hazardous waste, pentachlorophenol-treated lumber and its associated leachate pose potential risks to our natural resources. More than 14 percent of the most contaminated hazardous waste sites in the United States (i.e., National Priorities List sites) contain high levels of pentachlorophenol (ATSDR, 1989). As noted above, this substance has been linked to mortality in flora and fauna--as well as bioaccumulation in aquatic species. ..Any release of pentachlorophenol into the environment of more than 10 pounds must be reported to the National Response Center (as well as to any state-required response agencies) as soon as possible.

Classification for Usage: Not usually recommended for continued use on NPS lands. There are many less-toxic, alternative products available that will effectively and efficiently substitute for pentachlorophenol and pentachlorophenol-treated lumber. Borates and related substances pose far less potential risk to human health and the environment than pentachlorophenol. In areas where cultural or historic landscape requirements do not apply, recovered-content "plastic" lumber may be used--greatly curtailing both potential health risks and liability for site contamination. Executive Orders 12856 ("Pollution Prevention") and 12873 ("Federal Acquisition, Recycling, and Waste Prevention") further stress the importance of using less-toxic substances when available (e.g., Borate versus Pentachlorophenol) and recovered-content materials such as "plastic" lumber.

Editor's note: Some hardwoods can last as long as treated softwoods in the aquatic environment, thus providing an additional option. An alternative to the use of cheap wood treated with CCA or PCP is the use of oak or black locust, which may last as long in water without being treated with CCA; other options include using recycled plastic instead of wood, soaking CCA treated wood for three months before placing it in the aquatic environment, or using wood which has been soaked for a lengthy period in salt water and then treated with whitewash, a protocol which has produced the longest lasting wood in one (worst-case; coastal tropical environment) terrestrial application in a Hawaii Park (Roy Irwin, National Park Service, personal communication, 1996).

Br.Haz: General Hazard/Toxicity Summary:

Potential Hazards to Fish, Wildlife, Invertebrates, Plants, and other Non-Human Biota:

Effects of this semi-volatile solvent to non-human biota would often result from high concentrations immediately after a spill (before the compound has evaporated or broken down) or be the indirect result of contamination of groundwater or soil, and subsequent equilibria partitioning into other media. For example, if highly polluted groundwater water comes into surface waters from springs or seeps, local effects may occur in the mixing zone where the groundwater enters surface water (Roy Irwin, personal communication, 1996).

PCP is toxic to animals, with major potential effects on the liver, kidney, central nervous system, and immune system. Many other organic contaminants, including hexachlorobenzene are metabolized to PCP or present as contaminants [933].

Growth and survival may be affected in sensitive aquatic species [411]. Avian fatalities have been reported for low oral doses (see Tis.Wild section below).

It is shown that p-tetrachlorohydroquinone (TCH), the metabolite of the environmental chemical pentachlorophenol (PCP), is more toxic to cultured CHO cells than PCP, and that it causes DNA single-strand breaks (Ehrlich W; Mutat Res 244 (4): 299-

302 (1990) [940].

Chlorophenols appear to be mildly hepatotoxic, and studies in animals indicate that pentachlorophenol may reduce humoral and cell-mediated immunity as well as act as a co-carcinogen (Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1099) [940].

Acute dietary studies (using oral doses high enough to cause relatively quick toxicity) feeding this compound to mammal and bird species place it in the "moderately toxic" category for mallards and pheasants and the "relatively nontoxic" category for Japanese quail [185,186].

Animals may be poisoned by licking wood that is treated with chlorophenols or eating from treated feed bunkers (Booth, N.H., L.E. McDonald, eds.,. Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982, 962) [940].

Additional information on pentachlorophenol hazards to fish and wildlife are summarized in Eisler's synoptic review [411].

Potential Hazards to Humans:

There has been more publicity and attention given to PCP as a potential hazard to humans than to fish wildlife; thus there is more literature related to humans. The information summarized in this entry borrows heavily from other government summaries related to human issues: the Hazardous Substances Data Bank [940], EPA IRIS database [893], and the ATSDR Human Toxicology Profile [933].

Extremely toxic, PCP has been the cause of numerous human occupational illnesses and deaths and significant adverse impacts on domestic animals [411]. The toxicity of commercial preparations is often enhanced by variable amounts of toxic impurities including chlorophenols, hexachlorobenzene, and dioxins [411,933].

PCP is toxic to humans, with major potential effects on the liver, kidney, central nervous system, and immune system [933].

The toxicity of pentachlorophenol is increased by impurities contained in the technical product. For example, the No Observed Effect Level for pure pentachlorophenol is 3 mg/kg/day; however, the No Observed Effect Level for technical pentachlorophenol is 1 mg/kg/day, indicating increased toxicity due to impurities (National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 396) [940]. For a list of impurities, see Associated Chemicals section below.

Major human exposure will be workers or other people who handle or breathe air near wood that has been preserved with pentachlorophenol and through consumption of food that contains the pesticide(SRC). General water and air contamination are not likely sources of human exposure. Results of an environmental partitioning model indicate that ingestion of food accounts for 99.9% of human exposure to pentachlorophenol (SRC, Hattemer-Frey HA, Travis CC; Arch Environ Contam Toxicol 18: 482-9 (1989) [940].

The general population is more susceptible during hot weather (Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr., eds., NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.) [940].

The most important effect of pentachlorophenol inhalation is acute poisoning centering in the circulatory system with accompanying heart failure (American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH:American Conference of Governmental Industrial Hygienists, 1986. 461) [940].

A comprehensive toxicological profile for pentachlorophenol, especially as it relates to human health, is available from ATSDR [933]. Due to lack of time, important highlights from this ATSDR document have not yet been completely incorporated into this entry.

The following (next two indented paragraphs) additional summary information was contributed by Hank Brightman and Fred Sturniolo, Hazardous Waste Management and Pollution Prevention Team, Washington, National Park Service, 1996, as part of an Issue abstract prepared for the National Park Service:

PCP: OSHA has set the Permissible Exposure Level (PEL) for pentachlorophenol--the amount of a chemical that an employee can be exposed to in an eight-hour day, 40-hour work week without respiratory protection at 0.5 mg/m3. The American Conference of Governmental Industrial Hygienists (ACGIH) has also set their consensus standard (Threshold Limit Value (TLV)) for this substance at 0.5 mg/m3. Possible short-term effects of overexposure to pentachlorophenol include poisoning of the circulatory system with resultant heart failure; severe irritation to the skin; corneal clouding; and contact dermatitis. Potential chronic effects of overexposure may include damage to kidneys, liver, lungs or the central nervous system. While an increased risk for cancer has been shown in some laboratory animal studies, pentachlorophenol has not yet been classified as a carcinogen, pending additional research. The most common routes of entry for pentachlorophenol are through inhalation and skin contact.

Health hazards of pentachlorophenol-treated wood: Wood that is treated with pentachlorophenol in accordance with the American Wood Preservers Institute (AWPI) or related industry standards poses minimal risks to human health--provided that strict adherence to proper use standards are followed. For example, over-saturation of wood with pentachlorophenol may result in leachate routinely being released from the substrate of the wood, potentially resulting in acute skin exposure. Similarly, cutting or chipping treated wood may result in an inhalation hazard for workers. According to an Agency for Toxic Substances and Disease Registry (ATSDR) Public Health Statement (December 1989), "an estimated 0.5 mg/day of pentachlorophenol can be taken in through the skin by workers who handle treated lumber." The use of pentachlorophenol-treated lumber should be limited to areas where human or animal habitation are not present. Log cabins, playgrounds, livestock fencing, and stables are examples of locations where the use of pentachlorophenol-treated wood products are not appropriate. Pentachlorophenol released from treated lumber has both short-term and long-term ecological effects. Short-term effects include mortality in animals, birds, and fish--as well as low growth rate in plants. Acute effects have been seen as soon as two to four days animals or plants come in contact with this substance. Toxicity of pentachlorophenol increases as pH of water decreases. The substance is moderately persistent in water, with a half-life of between 20 to 200 days depending upon concentration. Bioaccumulation of this substance in aquatic animals has been documented by the U.S. EPA.

Br.Car: Brief Summary of Carcinogenicity/Cancer Information:

EPA 1996 IRIS database information [893]:

Evidence for classification as to human carcinogenicity; weight-of-evidence classification [893]:

Classification: B2; probable human carcinogen [893].

BASIS: The classification is based on inadequate human data and sufficient evidence of carcinogenicity in animals: statistically significant increases in the incidences of multiple biologically significant tumor types (hepatocellular adenomas and carcinomas, adrenal medulla pheochromocytomas and malignant pheochromocytomas, and/or hemangiosarcomas and hemangiomas) in one or both sexes of B6C3F1 mice using two different preparations of pentachlorophenol (PeCP). In addition, a high incidence of two uncommon tumors (adrenal medulla pheochromocytomas and hemangiomas/hemangiosarcomas) was observed with both preparations. This classification is supported by mutagenicity data, which provides some indication that PeCP has clastogenic potential [893].

HUMAN CARCINOGENICITY DATA: Inadequate [893].

ANIMAL CARCINOGENICITY DATA: Sufficient [893].

Older Evaluation: There is inadequate evidence in humans for the carcinogenicity of pentachlorophenol. There is sufficient evidence in experimental animals for the carcinogenicity of pentachlorophenol. Overall evaluation: Pentachlorophenol is possibly carcinogenic to humans, classification 2B (IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on

Cancer,1972-PRESENT. (Multivolume work).,p. 53 394, 1991) [940].

Br.Dev: Brief Summary of Developmental, Reproductive, Endocrine, and Genotoxicity Information:

PCP is fetotoxic and teratogenic, but evidence for mutagenicity is either incomplete or negative [411]. Reproduction may be affected in sensitive aquatic species [411].

ATSDR [933] reports: "No reports of development toxicity following pentachlorophenol exposure in humans were found. The available information from animal studies indicate that pentachlorophenol is not teratogenic."

The rat embryo was shown to be most susceptible to the toxic effect of pentachlorophenol during the early phases of organogenesis (American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH:American Conference of Governmental Industrial Hygienists, 1986. 461) [940].

The teratogenic activities of highly purified pentachlorophenol and pentachloroanisole, administered in the diet of Sprague Dawley rats of both sexes...Embryonic deaths were recorded following treatment with pentachlorophenol at the rate of 43 mg/kg/day, while lower doses of the compound induced dose related reductions in body wt. At the rate of 13 mg/kg/day only, pentachlorophenol reduced the crown to rump length and increased the skeletal alterations of the fetus. Decreased numbers of corpora lutea and embryonic death were recorded following the administration of pentachlorophenol at the rate of 4 and 41 mg/kg/day. At the same dose pentachlorophenol reduced the body wt and the crown to rump length of male fetuses, while their female counterparts were not affected...Results indicate the pentachlorophenol is slightly more toxic than pentachloroanisole in Sprague Dawley rats (Welsh JJ et al; Food Chem Tox 25, 2,: 163-72, 1987) [940].

Purified & commercial grades given orally to /sprague-dawley/ rats at doses ranging from 5-10 mg/kg body wt/day at various intervals during days 6-15 of pregnancy. Signs of embryotoxicity & fetotoxicity ... Resorptions, sc edema, dilated ureters & anomalies of skull, ribs, vertebrae & sternebrae were observed at incidence which incr with dose. Early organogenesis ... Most sensitive period. No-effect ... Level of commercial grade was 5 mg/kg/body wt/day; purified pentachlorophenol given at same ... Level caused ... Significant incr in incidence of delayed ossification of skull bones but no other effect on ... Development. Ingestion of 3 mg/kg body wt/day of commercially available purified grade had no effect on reproduction, neonatal growth, survival or development (IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT., Multivolume work,.,p. V20 315, 1979) [940].

Pentachlorophenol was embryotoxic & fetotoxic /to sprague-dawley rats/ @ doses of commercial & pure pentachlorophenol of 15 mg/kg & above. ... Delayed ossification of skull was observed after treatment with pure pentachlorophenol. Oral administration ... To hamsters on days 5-10 of gestation produced fetal death &/or resorptions at 5 mg/kg/day and above (National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 753) [940].

Aside from a rather limited communication linking long-term exposure to pentachlorophenol-containing wood preservatives to reproductive disorders in women, no information is available on the reproductive toxicity of pentachlorophenol in humans. Studies in animals provide evidence that pentachlorophenol decreases the survival of pups in exposed rats. The implications of these findings with regard to human exposure are that, at high enough levels of exposure, reduced survival of offspring may occur in women exposed to pentachlorophenol [933].

The effects of pentachlorophenol on glutathione status were examined in the male reproductive system of rats. Pentachlorophenol was tested for its ability to perturb glutathione levels in the testes and epididymides as well as the liver following single acute dosages to Sprague-Dawley rats. Pentachlorophenol (25 mg/kg) affected hepatic and epididymal glutathione, but had little or no effect on testicular levels (Gandy J et al; Jour Toxicol Environ Health 29, 1,: 45-57, 1990) [940].

The suitability of ejaculated bovine spermatozoa as an in vitro model of the assessment of the cytotoxic potential of chemicals was evaluated using several endpoints: swimming activity, adenine nucleotide content, membrane integrity and oxygen consumption. A series of chlorophenols inhibited sperm motion (motility and velocity) in a concentration dependent manner. This could be determined quantitatively and reproducibly by means of videomicrography and automatic computer image analysis. The sperm immobilizing potency increased with increasing chlorination and was positively correlated with lipophilicity. Concentrations which reduced the percentage of moving sperm to 50% of controls ranged from

43 muM for pentachlorophenol to 1440 muM for 4-monochlorophenol. Determinations of adenine nucleotides and percentages of viable cells revealed qualitative differences between the action of pentachlorophenol and the lower chlorinated phenols. While the latter decreased the total adenine nucleotide contents and the percentage of unstained cells in parallel to motion inhibition, no such changes occurred after exposure to immobilizing concentrations of pentachlorophenol. Penta-, tetra-, and trichlorinated phenols stimulated cellular respiration, indicating their uncouping activity, at concentrations lower than those necessary for motion inhibition. The results indicate that bovine spermatozoa may become a useful in vitro model for the toxicological evaluation of chemicals providing quantitative as well as qualitative data (Seibert H et al; Cell Biol Toxicol 5, 3: 315-30, 1989) [940].

The available genotoxicity data indicate that pentachlorophenol may have some genotoxic potential, but the evidence for this is not conclusive [933].

Pentachlorophenol (PCP) is a substance whose widespread use, mainly in wood protection and pulp and paper mills, has led to a substantial environmental contamination. This in turn accounts for a significant exposure of the general human population, with rather high exposure levels being attained in occupational settings. Investigations on the genotoxic activity of PCP have given rise to divergent results which would seem to make an evaluation difficult. By grouping them into 3 categories a somewhat clearer picture, allowing finally an (admittedly tentative) assessment, can be obtained. PCP does seem to be at most a weak inducer of DNA damage: it produces neither DNA-strand breaks nor clear differential toxicity to bacteria in rec-assays in the absence of metabolic activation. Also in SCE induction no increase can be observed in vivo, while PCP is found marginally active in a single in vitro experiment. Metabolic activation, however, leads to prophage induction and to DNA strand breaks in human lymphocytes, presumably through the formation of oxygen radicals. A possible further exception in this area might be the positive results in the yeast recombination tests, although their inadequate reporting makes a full evaluation difficult. PCP does not seem to induce gene (point) mutations, as most bacterial assays, the Drosophila sex-linked recessive lethal test and in vitro assays with mammalian cells did not demonstrate any effects. Marginally positive results were obtained in the mammalian spot test in vivo and in one bacterial test; the positive result in the yeast assay for cycloheximide resistance is fraught somewhat with its questionable genetic basis. PCP does, however, induce chromosomal aberrations in mammalian cells in vitro and in lymphocytes of exposed persons in vivo. Those in vivo results that were unable to provide evidence of chromosomal damage are hampered either by methodological inadequacies or by too low exposure levels. The (rodent) metabolite tetrachlorohydroquinone might be a real genotoxic agent, capable of binding to DNA and producing DNA strand breaks; this activity is probably due to semiquinone radical formation and partly mediated through active oxygen species. Since this compound has not been tested in the common bacterial and mammalian mutagenicity assays, the few ancillary results on this substance cannot be used in a meaningful human risk assessment of PCP. Furthermore, this metabolite has only been produced by human liver microsomes in vitro, but has not been detected in exposed humans in vivo (Seiler JP; Mutat Res 257, 1, 27-47, 1991) [940].

It is shown that p-tetrachlorohydroquinone (TCH), the metabolite of the environmental chemical pentachlorophenol (PCP), is more toxic to cultured CHO cells than PCP, and that it causes DNA single-strand breaks and/or alkali-labile sites at concentrations of 2-10 microgram/ml as demonstrated by the alkaline elution technique (Ehrlich W; Mutat Res 244, 4: 299-302, 1990) [940].

Br.Fate: Brief Summary of Key Bioconcentration, Fate, Transport, Persistence, Pathway, and Chemical/Physical Information:

In living organisms PCP is rapidly accumulated and rapidly excreted and is degraded in the environment by chemical, microbial, and photochemical processes [411]. Pentachlorophenol (PCP) residues have been detected in air, precipitation, ground and surface water, fish, aquatic invertebrates, and human urine, blood, and milk [411].

Pentachlorophenol enters surface waters and groundwater from factories, wood treatment facilities, and hazardous waste sites. It also enters soils as a result of spills, disposal at hazardous waste sites, and its use as a pesticide. The physical and chemical properties of the compound suggest that not much will evaporate into the atmosphere and that most of it will move with water and generally stick to soil particles. Movement of pentachlorophenol in soils depends on the soil's acidity [933].

PCP is released to the air by evaporation from treated wood surfaces and from industrial sources [933].

In air, soils, and surface waters, pentachlorophenol lasts for hours to days. The compound is broken down in soils and surface waters by micro-organisms and in surface waters and the air by sunlight to compounds that are also harmful to humans [933].

This chemical was considered by EPA to be likely enough to accumulate in fish tissues (in areas where it is present) to be included among the chemicals analyzed in EPA's National Bioaccumulation Study [507].

Environmental Fate/Exposure Summary [940]:

Pentachlorophenol is used in large quantities as a wood preservative for utility poles, crossarms, and fenceposts. These uses may result in some environmental releases from the wood and during spills. Releases to soil can decrease in concentrations due to slow biodegradation and leaching into groundwater. If released in water, pentachlorophenol will adsorb to sediment, photodegrade (especially at higher pHs) and slowly biodegrade. Bioconcentration in fish will be moderate. In air, pentachlorophenol will be lost due to photolysis and reaction with photochemically produced hydroxyl radicals. Human's will be occupationally exposed to pentachlorophenol via inhalation and dermal contact primarily in situations where they use this preservative or are in contact with treated wood product. The general population will be exposed primarily from ingesting food contaminated with pentachlorophenol. (SRC)

Synonyms/Substance Identification:

PCP [940]
PENCHLOROL [940]
AI3-00134 [940]
Caswell No. 641 [940]
NCI-C55378 [940]
NCI-C56655 [940]
EPA Pesticide Chemical Code 063001 [940]
Pentachlorphenol (German) [940]
DOWICIDE 7 [940]
PERMASAN [940]
EP 30 [940]
FUNGIFEN [940]
GRUNDIER ARBEZOL [940]
LAUXTOL [940]
LIROPREM [940]
Chlon [940]
Dura Treet II [940]
Santophen 20 [940]
Woodtreat [940]
Dowicide EC-7 [940]

Penta Concentrate [940]
Penta Ready [940]
Penta WR [940]
Dowicide 7 Antimicrobial [940]
Forpen-50 Wood Preservative [940]
Ontrack WE Herbicide [940]
Ortho Triox Liquid Vegetation Killer [940]
Osmose Wood Preserving Compound [940]
Watershed Wood Preservative [940]
Weed and Brush Killer [940]

Molecular Formula:
C6-H-Cl5-O [940]

Associated Chemicals or Topics (Includes Transformation Products):

Related HSDB Records [940]:

Pentachlorophenol, sodium salt
(Parent) Hexachlorobenzene
(Parent) Pentachlorobenzene

Impurities [940]:

Technical PCP has been reported to contain chlorodiphenylethers, chlorodibenzo-p-dioxins, chlorodibenzofurans, and hydroxychlorodiphenylethers; the octachlorodibenzo-p-dioxin content is typically 500-1500 ppm. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

Fourteen technical pentachlorophenol and three sodium pentachlorophenate samples were obtained from several manufacturers and analyzed for various chlorinated phenolic impurities. Reversed-phase liquid chromatography with an electrochemical (coulometric mode) detector was used for qualitative and quantitative determinations. 2,4-Dichlorophenol, 3,5-dichlorophenol, 2,3,4-trichlorophenol, 2,4,6-trichlorophenol, 3,4,5-trichlorophenol, 2,3,5,6-tetrachlorophenol, 2,3,4,6-tetrachlorophenol, and 2,3,4,5-tetrachlorophenol were detected as contaminants in the various samples. [Lanouette M et al; J Assoc Off Anal Chem 67 (3): 494-7 (1984)].

Commercial pentachlorophenol (PCP) contains significant quantities of tetrachlorophenol (TCP). The ratio of PCP to TCP in Dowicide G-ST, a commercial PCP formulation, was 2.5 + or - 0.1. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

Hexachlorobenzene contaminates pentachlorophenol. [Chem Mark

Rep 229 (2): 44 (1986)].

Commercial grade PCP contains 88.4% Pcp, 4.4% Tetrachlorophenol, 6.2% Higher-chlorinated phenoxyphenols, less than 0.1% Trichlorophenol & various dibenzo-p-dioxins & dibenzofurans. /Srp: 2,3,7,8-tetrachlorodibenzo-p-dioxin has not been found./ [National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 750].

The identification of 2-bromo-3,4,5,6-tetrachlorophenol, a halogenated phenol, in commercial pentachlorophenol samples is described. The concentration of the phenol impurity in the samples was on the order of 0.1%. [Timmons L et al; J Chromatog 314: 476-81 (1984)].

Pentachlorophenol available after about 1973 contained only 1 ppm of the hexachloro- and 26 ppm of the octachlordibenzo-p-dioxin. [Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982. 474].

Metabolism/Metabolites [940]:

The metabolism of pentachlorophenol is generally similar in mammalian species. In rodents, more than 40% is excreted in urine unchanged. The remainder is excreted as tetrachlorohydroquinone and glucuronide conjugates of pentachlorophenol. In limited studies of humans, pentachlorophenol, tetrachlorohydroquinone, & pentachlorophenol glucuronide have been found in urine. In vivo retention of pentachlorophenol by lipid-containing tissues may be attributable to conjugation with fatty acids. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 385].

Unchanged pentachlorophenol is excreted in the urine of rabbit, rat, mouse, and monkey. In addition to free pentachlorophenol, rats excrete tetrachloro-p-hydroquinone and trichloro-p-hydroquinone. ... Both metabolites as well as the parent cmpd are excreted free and as glucuronides. [Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982. 474].

Pentachlorophenol yields octachlorobiphenylquinone in horseradish: Nabih I et al; J Pharm Sci 60: 1242 (1971). /From table; pentachlorophenol/ [Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976.,p. P-2].

The metabolism of pentachlorophenol in animals and man was reviewed. Tetrachlorophenols, 2,3,5,6-tetrachloro-1,4-benzoquinone, 2,3,4-trichlorophenol, 2,3,5-trichloro-1,4-hydroquinone, and their glucuronide conjugates were found in animals and man. Also identified were pentachlorophenylacetate, pentachloroanisole, and pentachlorophenylsulfate. The biotransformation of pentachlorophenol in man and animals takes place by conjugation, hydrolytic dechlorination, and reductive dechlorination. Further species dependent reactions are oxidation and methylation. The reaction with glutathione results in the formation of conjugates and cleavage of glycine and glutamate gives cysteine conjugates. Acetylation of the amino group of the cysteinyl moiety in mammals gives mercapturic acids. The metabolic pathways leading to dechlorinated derivatives may be mediated by the reaction with glutathione as the presence of the N-acetyl-S-(pentachlorophenyl)cysteine would indicate. The results of metabolic in vivo studies on hexachlorobenzene, pentachloronitrobenzene, pentachlorobenzene, and pentachlorophenol indicate that one pathway stems from hexachlorobenzene and pentachloronitrobenzene via sulfur containing conjugates to thiophenolic derivatives and to chlorinated benzenes, primarily to pentachlorobenzene. Another pathway transforms pentachlorophenol to less chlorinated phenols. The authors state that pentachlorophenol is a metabolite of various environmental chemicals and is itself metabolized. Therefore there is no direct relationship between the level of pentachlorophenol in body fluids and the degree of exposure. [Renner G, Mucke W; Toxicological and Environmental Chemistry 11 (1): 9-29 (1986)].

Major metabolite of HCB /Hexachlorobenzene/ ... . [The Royal Society of Chemistry. Foreign Compound Metabolism in Mammals. Volume 6: A Review of the Literature Published during 1978 and 1979. London: The Royal Society of Chemistry, 1981. 327].

Following single oral dose of pentachloro-(14)c-benzene (0.5 Mg/kg) to rhesus monkeys ... /7% Was excreted/ as pentachlorophenol ... In urine. [The Royal Society of Chemistry. Foreign Compound Metabolism in Mammals. Volume 6: A Review of the Literature Published during 1978 and 1979. London: The Royal Society of Chemistry, 1981. 346].

Pentachlorophenol ... Is dechlorinated in vivo & in vitro in rat to tetra- & tri-chlorohydroquinone ... Dechlorination is mediated by liver-microsomal enzymes, & their activity is enhanced by pre-treatment with several well-known inducers of cytochrome p450. ... Pharmacokinetic study of single oral dosage (0.1 Mg/kg) ... In human subjects ... Revealed no metabolites were detected apart from glucuronide of pcp (about 12%). [The Royal Society of Chemistry. Foreign Compound Metabolism in Mammals. Volume 6: A Review of the Literature Published during 1978 and 1979. London: The Royal Society of Chemistry, 1981. 327].

Bacterial isolate, related to saprophytic coryneform bacteria, was able to metabolize pentachlorophenol as sole source of carbon & energy. Pentachlorophenol was rapidly metabolized to co2. In cultures of trichoderma virgatum, pentachlorophenol was methylated to form pentachloroanisole. Similarly, pentachloroanisole was formed from pentachlorophenol by penicillium sp & cephaloascus fragrans. [Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior, Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. Government Printing Office, l974. 288].

The protoporphyrin enzyme peroxidase, detected in snails, catalyzed oxidation of pentachlorophenol to 2,2',3,3',5,5',6,6'-octachlorobiphenylquinone. [Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior, Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. GovernmentPrinting Office, l974. 287].

Most of pentachlorophenol transferred to hepatopancreas /in goldfish/ was detoxified by sulfate conjugation or by decomposition. Excretion ... Was in form of conjugate identified as pentachlorophenylsulfate. [Menzie, C.M. Metabolism of Pesticides, Update II. U.S. Department of the Interior, Fish Wildlife Service, Special Scientific Report - Wildlife No. 2l2.Washington, DC: U.S. Government Printing Office, 1978. 221].

The biotransformation of pentachlorophenol in man and animals takes place by conjugation, hydrolytic dechlorination, and reductive dechlorination. Further species dependent reactions are oxidation and methylation. The reaction with glutathione results in the formation of conjugates and cleavage of glycine and glutamate gives cysteine conjugates. Acetylation of the amino group of the cysteinyl moiety in mammals gives mercapturic acids. The metabolic pathways leading to dechlorinated derivatives may be mediated by the reaction with glutathione as the presence of the N-acetyl-S-(pentachlorophenyl)cysteine. [Renner G, Mucke W; Toxicol Environ Chem 11 (1): 9-29 (1986)].

This study investigated impairment of oxidative phosphorylation in mitochondria isolated from the liver of hexachlorobenzene treated rats. Partial and reversible uncoupling of the phosphorylative process was found in liver mitochondria from rats dosed with hexachlorobenzene for 60 days. Pentachlorophenol, endogenously formed by hexachlorobenzene metabolism was detected in the mitochondria at a concentration of 0.3-0.4 nmol/mg protein. Based on the effect of pentachlorophenol, added in vitro at a similar concentration to that found in vivo, it was concluded that the uncoupling of oxidative phosphorylation under the experimental conditions was almost completely due to the presence of pentachlorophenol. [Trenti T et al; IARC Sci Pub 77: 329-31 (1986)].

The metabolism of pentachlorophenol and its covalent binding to protein and DNA were tested in the microsomes of Wistar rats of both sexes pretreated with hexachlorobenzene, phenobarbital, 3-methylcholanthrene, or isosafrole. Pentachlorophenol when incubated with microsomes, was converted into tetrachloro-1,2-hydroquinone and tetrachloro-1,4-hydroquinone. Isosafrole increased the rate of conversion 7 times as compared to control microsomes, while hexachlorobenzene, pentachlorophenol and 3-methylcholanthrene increased the rate of conversion 2 to 3 times. The fact that pentachlorophenol and hexachlorobenzene accounted for the production of tetrachloro-1,4-hydroquinone and tetrachloro-1,2-hydroquinone in a ratio of about 2, as compared to a ratio of about 1.3 for 3-methylcholanthrene and isosafrole, and the fact that this ratio decreased with increasing concentrations of pentachlorophenol in microsomes from hexachlorobenzene treated rats, were indicative of the involvement of the various cytochrome p450 isoenzymes. The covalent binding of pentachlorophenol to protein was inhibited by ascorbic acid, with a subsequent increase in the production of tetrachlorohydroquinones. The rate of covalent protein binding was constant, regardless of variation in the rate of conversion observed in the mirosomes of rats treated with various inducers. DNA binding was conversion dependent and was lower than protein binding. The addition of DNA did not affect the formation of soluble metabolites. [Van Ommen B et al; Chemico-Biol Interact 60 (1): 1-11 (1986)].

Water Data Interpretation, Concentrations and Toxicity (All Water Data Subsections Start with "W."):

W.Low (Water Concentrations Considered Low):

No information found.

W.High (Water Concentrations Considered High):

No information found.

W.Typical (Water Concentrations Considered Typical):

In U.S. surface water, PCP levels are usually below 1 ug/L except in industrial areas [933].

Information from HSDB [940]:

Drinking water: Corvallis, Oregon - 0.06 parts/billion(1). [(1) Buhler DR et al; Environ Sci Technol 7: 929-34 (1973)].

Drinking water: Concentrations of 98 ppt have been detected in Dade County, FL, municipal drinking water. GROUNDWATER: Levels up to 24 ppm have been detected in wells near a sawmill in Hayfork, CA. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 384].

Groundwater: Germany - 6.9% occurrence(1). Pentachlorophenol was detected in groundwater in monitoring program in California, Oregon and Minnesota(2). In Minnesota 3% of wells monitored by the Agriculture Department had detectable pentachlorophenol with a maximum level of 0.64 ppb. In Oregon, 1.4% of tested wells contained pentachlorophenol and the maximum concentration was 0.12 ppb(2). Concentrations of pentachlorophenyl in groundwater were 1047 and 152 ppb at Havertown PCP site, Havertown, PA(3) and Doepke disposal site, Holliday, KS, respectively(4). [(1) Dyksen JE, Hess AF; J Amer Water Works Assoc 394-403 (1982) (2) Hallberg GR; Agric Ecosystems Environ 26: 299-367 (1989) (3) USEPA; Superfund Record of Decision: Havertown PCP, PA p. 13 USEPA Report NTIS PB90-178112 (1989) (4) USEPA; Superfund Record of Decision: Doepke Disposal (Holliday), KS p. 78 USEPA Report NTIS PB90-162645 (1989)].

SURFACE WATER: Netherlands - 5 rivers - 0.41 to 9.9 ppb(1,2) Japan - urban rivers 0.1 to 10 parts/trillion(3); Williamette R, Oregon 0.1-0.7 ppb(5), Lake Erie 0-1.7 ppb(5); SEAWATER: Gulf of Mexico 4.3-11 parts/trillion(6) Germany 0.02-1.30 parts/trillion(7). Pentachlorophenol was the only halogenated phenolic compound found in more than 20% of the raw water samples from 40 potable water treatment plants across Canada in the fall and winter samples at levels up to 53 ng/l with mean values of 1.9 and 2.8 ng/l, respectively(8). Four sites located in the Scheldt estuary in North West Beligium and South West Netherlands had concentrations of 0.1, 0.18, and 0.02 ppb, respectively(9). [(1) Wegman RCC, Hofstee AWM; Water Res 13: 651-7 (1979)(2) Wegman RCC, VanDen Broek HH; Water Res 17: 227-30 (1983) (3) Matsumoto G et al; Wat Res 11: 693 (1977) (4) Buhler DR et al; Environ Sci Technol 7: 929-34 (1973) (5) Konasewich D et al; Great Lakes Water Qual Board Status Report (1978) (7) Weber K, Ernst W; Chemosphere 7: 873-9 (1978) (8) Sithole BB, Williams DT; J Assoc Off Anal Chem 69: 807-10 (1969) (9) VanZoest R, VanEck GTM; Sci Total Environ 103: 57-71 (1991)].

Effluents Concentrations [940]:

Oregon cities sewage treatment plant effluent 1-4 ppb(1). Detected in the effluents of the following industries (industry - max concn, ppb): auto and other laundries - 27, coal mining - 3, iron and steel manufacturing - 25, leather tanning and finishing - 3100, electrical/electronic components - 10, foundries - 140, photographic equipment/supplies - 350, pharmaceutical manufacturing - 110, paint and ink formulation - 490, pulp and paperboard mills - 1400, rubber processing - 10, steam electric power plants - 6.5, textile mills - 15, timber products processing - 8300(2). 4.6 ppb mean concentration reported for organic manufacturing/plastics(2). Waste from a municipal compositions facility on Long Island, NY has a concentration range of 7-210 ppb(3). Effluent from a pulp and paper bleach plant, aerated lagoon, and treated effluent discharging into a river on site contained concentrations of pentachlorophenol of 3.1, 1.3 and 0.6 ppb, respectively(4). Primary-treated and municipal wastewater from the Iona Island treatment plant in Vancouver, British Columbia, Canada contained pentachlorophenol concentrations ranging from 0.4-13.2 ppb(5). [(1) Bukler DR et al; Environ Sci Technol 7: 929-34 (1973) (2) USEPA: Treatability Manual 1:8.5.1-8.5.5 USEPA-600/2-82-001a (1981) (3) Harnad SJ et al; Chemosphere 23: 181-91 (1991) (4) Lee HB et al; J Assoc Off Anal Chem 72: 979-84 (1989) (5) Rogers IH et al; Water Poll Res J Canada 12: 187-204 (1986)].

W.Concern Levels, Water Quality Criteria, LC50 Values, Water Quality Standards, Screening Levels, Dose/Response Data, and Other Water Benchmarks:

W.General (General Water Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Water Concentrations Versus Mixed or General Aquatic Biota):

EPA 1996 IRIS database information [893]:

Ambient Water Quality Criteria for Aquatic Organisms [893].

Acute Chronic Freshwater: 2.2E+1 ug/L, 1 hour avg. [893].

Previous Water Quality Criteria in ug/L [446]:

Freshwater Acute Criteria: 20 pH dependent criteria (7.8 pH used).

Chronic Freshwater 1.3E+1 ug/L 4 day avg. [893].

Previous Water Quality Criteria in ug/L [446]:

Freshwater Chronic Criteria: 13 pH dependent criteria (7.8 pH used).

Acute Marine: 1.3E+1 ug/L 1 hour avg. [893].

Previous Water Quality Criteria in ug/L [446]:

Marine Acute Criteria: 13

Chronic Marine: 7.9E+0 ug/L 4 day avg. [893].

Previous Water Quality Criteria in ug/L [446]:

Marine Chronic Criteria: 7.9

Reference: 51 FR 43665 (12/03/86) [893].

Contact: Criteria and Standards Division / OWRS / (202)260-1315 [893].

Discussion: Criteria were derived from a minimum data base consisting of acute and chronic tests on a variety of species. The toxicity of penta-chlorophenol is dependent on the pH of the ambient water. The value given is for a pH of 7.8. A more complete discussion can be found in the reference document [893].

W.Plants (Water Concentrations vs. Plants):

Growth, survival, and reproduction may be affected in sensitive aquatic species at concentrations of 8 ug/L in algae [411].

EC50 Thalassia testudinum (seagrass) flow through bioassay 0.74 ppm/40 hr (Walsh GE et al; Mar Environ Res 7 (1): 1-12, 1982) [940].

W.Invertebrates (Water Concentrations vs. Invertebrates):

Growth, survival, and reproduction may be affected in sensitive aquatic species at concentrations of 3 in invertebrates [411].

LC50s for Aplexa hypnorum (snail) were 157 and 142 ug/L (ppb) for 96-hr exposures [998].

LC50s for Artemia salina (brine shrimp) were 5.8 and 20.0 mg/L (ppm) for 48-hr exposures, 4.6 and 16.0 mg/L for 96-hr exposures, 4.5 and 11.0 mg/L for 7-day exposures, 9.5 mg/L for a 14-day exposure, and 4.4 mg/L for a 28-day exposure [998].

LC50s for Asellus racovitzai (aquatic sowbug) averaged about 3.4 mg/L for 96-hr exposures [998].

LC50s for Astacus fluviatilis (crayfish) were 53.0 and 9.0 mg/L for 8-day exposures [998].

LC50s for Biomphalaria glabrata (snail) were 0.18 and 0.37 mg/L for 72-hr exposures [998].

LC50s for Callibaetis skokianus (mayfly) were 1.78 and 1.30 mg/L for 96-hr exposures [998].

LC50s for Ceriodaphnia reticulata (water flea) ranged from 0.15 to 0.70 mg/L for 48-hr exposures, with most around 0.20 mg/L [998].

LC50s for Chironomus riparius (midge) were 0.384, 0.465 and 1.948 mg/L for 24-hr exposures [998].

LC50s for Crangonyx pseudogracilis (amphipod) ranged from 0.139 to 3.120 mg/L for 96-hr exposures, with values falling over this entire range [998].

LC50s for Marinogammarus marinus (amphipod) were 0.180 for both 21- and 56-day exposures [998].

LC50s for Daphnia magna (water flea) ranged from 0.39 to 3.91 mg/L for 24-hr exposures, with most values between 1.2 and 2.6 mg/L [998].

LC50s for Daphnia magna (water flea) ranged from 0.038 to 2.79 mg/L for 48-hr exposures, with values across this entire range [998].

LC50s for Daphnia magna (water flea) ranged from 1.15 to 2.46 mg/L for 72-hr exposures [998].

LC50s for Daphnia magna (water flea) ranged from 0.32 to 0.80 mg/L for 96-hr exposures [998].

LC50s for Daphnia magna (water flea) were 0.60 and 0.58 mg/L for 7-day exposures [998].

LC50s for Daphnia magna (water flea) ranged from

0.40 to 0.80 mg/L for 21-day exposures, with most values between 0.40 and 0.50 mg/L [998].

LC50s for Dreissena polymorpha (zebra mussel) were 0.11 and 0.19 mg/L for 96-hr exposures, 0.052 and 0.18 mg/L for a 7-day exposure, and 0.042 and 0.14 mg/L for 21-day exposures [998].

Information from HSDB [940]:

> The inhibition of methane production by Methanosaeta concilii GP6, Methanospirillum hungatei GP1, Methanobacterium espanolae GP9, and Methanobacterium bryantii during short term (6 hr) exposure to eight benzene ring compounds was studied. The concentration that caused 50% inhibition of the methane production rate was dependent on the species and the toxicant. Pentachlorophenol was the most toxic of the tested compounds, with an IC50 of less than 8 mg/liter for all species except Methanospirillum hungatei. [Patel GB et al; Appl Environ Microbiol 57 (10): 2969-74 (1991)].
>
> Twenty one day chronic mortality of Daphnia magna was produced at 320 ug/l, but not at 180 ug/l. [Adema DMM; Hydrobiologia 59: 125 (1978) as cited in USEPA; Ambient Water Quality Criteria Doc: Pentachlorophenol p.B-5 (1980) EPA 440/5-80-065].
>
> The acute toxicity of a technical formulation of pentachlorophenol and pure pentachlorophenol to three age classes of Daphnia magna, and adult Daphnia pulex and Daphnia galeata mendotae was determined by static toxicity tests. The influence of a number of factors on toxicity of pentachlorophenol was also examined. The 48 hr LC50 estimates for adult daphnids of the three species exposed to pure pentachlorophenol were 1.78, 4.59 and 0.51 mg/l, respectively, while those for the technical formulation were 2.57, 3.66 and 0.33 mg/l, respectively. There was little difference in toxicity between the technical and pure pentachlorophenol; however, toxicity of both forms of pentachlorophenol was influenced by duration of exposure, age (and/or size) and species of test organism and pH of the test solution. Pentachlorophenol caused a toxic response over a very narrow range of concentrations, with the greatest response occurring immediately between 0 and

24 hr. Pure pentachlorophenol was equally toxic to all age classes of Daphnia magna but susceptibility to technical pentachlorophenol decreased with maturation. Daphnia galeata mendotae was ten times more sensitive than Daphnia pulex to pentachlorophenol. Pure pentachlorophenol was significantly more toxic to Daphnia magna at pH 5.5 than 7.0 with mean 48 hr LC50 values of 0.082 and 1.78 mg pentachlorophenol/l, respectively. At 12 deg C, the toxicity of both forms of pentachlorophenol to Daphnia galeata mendoate and Daphnia pulex did not differ significantly from that at 20 deg C; however, technical pentachlorophenol was significantly more toxic to Daphnia magna at 12 deg C for an exposure duration of 48 hr. There was no effect of test container size (100, 250, 600 and 1,000 ml) on the toxicity of pentachlorophenol to Daphnia magna at 20 deg C with the lower pH of 5.5, suggesting that adsorption to glassware was not a factor in availability of pentachlorophenol to test organisms. Beaker size had no effect on the toxicity of pentachlorophenol to Daphnia pulex at 20 deg C with test solutions having a pH of 7.0-8.0. [Stephenson GL et al; Arch Environ Contam Toxicol 20 (1): 73-80 (1991)].

Chronic toxicity test procedures (static, with renewal) were used to determine the chronic toxicity of sublethal concentrations of a technical formulation of pentachlorophenol (PCP) and pure pentachlorophenol to Daphnia magna. Test organisms 48 +/- 12 h old were exposed for their entire lifespan (ie, until death) to 0.01, 0.05, 0.1 and 0.5 mg technical PCP/L and 0.01, 0.087 and 0.1 mg pure PCP/L. Criteria used to assess chronic toxicity were mean time to appearance of the primiparous instar in the brood chamber, mean number of days to release of the first brood, mean number of broods produced per female, mean brood size per female, mean number of reproductive days, mean number of young produced per reproductive day per female and survivorship. Pentachlorophenol differentially affected maturation and reproduction but not survivorship or longevity. Mean number of broods produced per daphnid, length of the reproductive period, longevity and survivorship were insensitive criteria relative to mean time to appearance of the primiparous instar, time to release of first brood, brood size, and number of young produced per daphnid per reproductive day. Generally, there was little difference in toxicity of the three concentrations of pure PCP, for they significantly reduced mean brood size and rate of reproduction of young and significantly but differentially affected maturation. Technical PCP, at the highest concentration of 0.5 mg/L, significantly reduced mean brood size and the rate of production of young, and significantly delayed both time to appearance of the primiparous instar and release of the first brood. When differences in toxicity occurred, generally, pure PCP was more toxic than comparable concentrations of technical PCP. Although enhanced maturation was observed there was no compensatory reproduction. [Stephenson GL et al; Arch Environ Contam Toxicol 21 (3): 388-94 (1991)].

LC50 Tubifex tubifex 286, 619, and 1294 ug/l/24 hr at pH values of 7.5, 8.5, and 9.5, respectively. [USEPA; Ambient Water Quality Criteria Doc: Pentachlorophenol p.B-3 (1980) EPA 440/5-80-065].

LC50 (Lymnaea acuminata) pulmonate snails, static bioassay, 0.16 Mg/l (95% confidence limit 0.138-0.186 Mg/l) [Gupta pk, rao ps; arch hydrobiol 94 (2): 210-217 (1982)].

LC50 (Viviparus bengalensis) Freshwater pond snails 0.840 mg/l/96 hr static bioassay [Gupta PK, Durve VS; Arch Hydrobiol 101 (3): 469-75 (1984)].

W.Fish (Water Concentrations vs. Fish):

Growth, survival, and reproduction may be affected in sensitive aquatic species at concentrations of <1 ug/L in fish [411].

LC50 for Pimephales promelas (fathead minnow) was 0.20 mg/L for an 8-day exposure [998].

LC50s for Alburnus alburnus (Bleak, freshwater) were 78 ug/L (ppb) for 48-hr exposure, and 66 ug/L (ppb) for 96-hr exposure [998].

LC50s for Carassius auratus (goldfish) ranged from 0.023 to 0.572 mg/L (ppm) for 96-hr exposures, with most values between 0.05 and 0.200 mg/L [998].

LC50s for Lepomis macrochirus (bluegill) were: 0.057 mg/L for a 6-hr exposure; between 0.038 and 0.224 mg/L for 24-hr exposures; between 0.029 and 0.201 mg/L for 48-hr exposures; between 0.025 and 0.156 mg/L for 72-hr exposures; and between 0.024 and 0.270 mg/L for 96-hr exposures [998].

LC50s for Micropterus salmoides (largemouth bass) ranged from 0.136 to 0.287 mg/L for 96-hr exposures, and was 0.054 mg/L for a 120-day exposure [998].

LC50s for Oncorhynchus mykiss (rainbow trout, donaldson trout) ranged from 0.018 to 3.0 mg/L for 96-hr exposures, with most values between 0.032 and 0.115 mg/L [998].

LC50s for Salmo salar (Atlantic salmon) ranged from 0.058 to 0.14 mg/L for 96-hr exposures [998].

Lowest-observed-effect-concentrations (LOEC) for death for Jordanella floridae (flagfish) were 0.075 mg/L for a 10-day exposure, and 0.135 mg/L for a 28-day exposure [998].

Information from HSDB [940]:

> Acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 53 and 34 ug/l, respectively. [USEPA; Ambient Water Quality Criteria Doc: Pentachlorophenol p.B-10 (1980) EPA 440/5-80-065].
>
> LC50 (Cyprinodon variegatus) sheephead minnows, 1 day old, 329 ug/l/96 hr, static test [borthwick pw; schimmel sc; environ sci res 12 (issue pentachlorophenol: Chem, Pharmacol, Environ Toxicol): 141-46 (1978)].
>
> LC50 (Cyprinodon variegatus) sheepshead minnows, 2 wk old, 392 ug/l/96 hr, static test [borthwick pw; schimmel sc; environ sci res 12 (issue pentachlorophenol: CHEM, PHARMACOL, ENVIRON TOXICOL): 141-46 (1978)].
>
> LC50 (Cyprinodon variegatus) sheepshead minnows, 4 wk old, 240 ug/l/96 hr, static test [borthwick pw; schimmel sc; environ sci res 12 (issue pentachlorophenol: chem, pharmacol, environ toxicol): 141-46 (1978)].
>
> LC50 (Cyprinodon variegatus) sheepshead minnows, 6 wk old, 232 ug/l/96 hr, static test [borthwick pw; schimmel sc; environ sci res 12

(issue pentachlorophenol: CHEM, PHARMACOL, ENVIRON TOXICOL): 141-46 (1978)].

LC50 Fathead minnows, 4 wk old, 0.222 + or - 0.021 mg/l/24 hr /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 Fathead minnows, 7 wk old, 24 hr: 0.245 + or - 0.039 mg/l; 96 hr: 0.230 + or - 0.03 mg/l /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 Fathead minnows, 11 wk old, 24 hr: 0.232 + or - 0.052 mg/l; 96 hr: 0.222 + or - 0.3 mg/l. /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 Fathead minnows, 14 wk old, 24 hr: 0.200 + or - 0.016 mg/l; 96 hr: 0.190 + or - 0.0 mg/l. /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 Pimephales promelas, fathead minnow, 205 ug/l/96 hr at 20 deg c (95% confidence limit 179-234 ug/l) wt 1.1 G. Static bioassay without aeration, ph 7.2-7.5, Water hardness 40-50 mg/l as caco3 and alkalinity of 30-35 mg/l. [U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government PrintingOffice, 1980. 58].

LC50 Poecilia reteculata Guppy 0.38 ppm/24 hr at pH 7.3 /Conditions of bioassay not specified/ [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

TLm Goldfish, flow through bioassay at 25 deg C/96 hr: 0.22 mg/l; 120 hr: 0.253 mg/l; 336 hr: 0.189 mg/l [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

TLm Bluegill, flow through bioassay at 25 deg C 30 hr: 0.303 mg/l; 243 hr: 0.251 mg/l; 406 hr: 0.188 mg/l [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 Lepomis macrochirus, bluegill, 32 ug/l/96 hr at 15 deg c (95% confidence limit 23-44 ug/l) wt 0.4 G. Static bioassay without aeration, ph 7.2-7.5, Water hardness 40-50 mg/l as caco3 and alkalinity of 30-35 mg/l. [U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government PrintingOffice, 1980. 58].

LC50 (Brachydanio rerio) Zebra fish, flow through bioassay 48 hr: 1.24 mg/l; 96 hr: 1.13 mg/l; 10 days: 1.08 mg/l at 25 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 (Jordanella floridae) Flagfish, flow through bioassay 48 hr: 1.82 mg/l; 96 hr: 1.74 mg/l; 10 d: 1.74 mg/l at 25 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 (Channa gachua) Freshwater fish, static test (test solutions changed every 24 hr) 24 hr: 0.79 mg/l; 48 hr: 0.56 mg/l; 72 hr: 0.43 mg/l; 96 hr: 0.39 mg/l [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 Trout, flow through bioassay 48 hr: 0.25 mg/l; 96 hr: 0.23 mg/l; 10 day: 0.23 mg/l at 15 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 956].

LC50 Salmo gairdneri, rainbow trout, 52 ug/l/96 hr at 11 deg c (95% confidence limit 48-56 ug/l) wt 1 g. Static bioassay without aeration, ph 7.2-7.5, Water hardness 40-50 mg/l as caco3 and alkalinity of 30-35 mg/l. [U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government PrintingOffice, 1980. 58].

LC50 Ictalurus punctatus, channel catfish, 68 ug/l/96 hr at 20 deg c (95% confidence limit 58-80 ug/l) wt 0.8 G. Static bioassay without aeration, ph 7.2-7.5, Water hardness 40-50 mg/l as caco3 and alkalinity of 30-35 mg/l. [U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government PrintingOffice, 1980. 58].

LC50 Oncorhynchus tshawytscha, chinook salmon, 68 ug/l/96 hr at 10 deg c (95% confidence limit 48-95 ug/l) wt 1 g. Static bioassay without aeration, ph 7.2-7.5, Water hardness 40-50 mg/l as caco3 and alkalinity of 30-35 mg/l. [U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government PrintingOffice, 1980. 58].

In a 7 day experiment, food conversion efficiency (as g of growth/g of food eaten) in fry of largemouth bass was significantly affected in a concentration-dependent fashion at concentration of pentachlorophenol >10 ug/l; with exposure to increasing pentachlorophenol concentration >10 ug/l, there was a significant concentration-related reduction in total length of largemouth bass at the end of a 57 day exposure. For the length data, the threshold response value was 25.2 ug/l which was very close to that of the food-coversion efficiency value (23.4 ug/l). When comparing pentachlorophenol induced mortality, behavioral responses, length at the end of a long-term exposure, and food-conversion efficiency, the latter two are the most sensitive indicators of pentachlorophenol effects on fish. [Johansen PH et al; Bull Environ Contam Toxicol 39 (3): 379-84 (1987)].

Bluegill sunfish (Lepomis macrochirus), exposed to a 22 day subchronic exposure of pentachlorophenol at concentrations of approximately 20 and 75% of the 96 hr LC50, showed significant reductions in food conversion efficiency measured during the last 10 days of exposure. Bluegills exposed to a 3 day acute spill mimicking exposure of pentachlorophenol at a concentration of approximately 100% of the 96 hr LC50 failed to show a significant reduction in food conversion efficiency measured during the 10 days following exposure. Bluegill sunfish exposed to pentachlorophenol at continuous low level concentrations are at a greater risk for decreased growth than those exposed to a more concentrated short term pulse of toxicant. [Samis A JW et al; Aquat Toxicol (Amst) 19 (3): 231-40 (1991)].

Rainbow trout were exposed for 4 or 8 days to various types of toxicants, each applied to the test water at a high sublethal concn. The activity of liver UDP-glucuronosyltransferase was assayed from the submitochondrial fraction using p-nitrophenol as an aglycone. Activity of UDP-glucuronosyltransferase was inhibited ... by pentachlorophenol, a toxicant regularly found in effluents of the pulp and paper industry. [Castren M, Oikari A; Comp Biochem Physiol C Comp Pharmacol Toxicol 86C (2): 357-60 (1987)].

Largemouth bass Micropterus salmoides were reared over their first 8 weeks of free-swimming life in uncontaminated control water or in water containing one of five concentrations of pentachlorophenol ranging from 1.6 to 88 ug/l. Over the final 3 weeks of the study, fish reared in concentrations of 67 and 88 ug pentachlorophenol/l performed significantly fewer feeding acts (orientations, bites) and had a lower rate of prey capture than did control fish. However, fish in high concentrations spent significantly more time swimming than did control fish, which indicated that exposure to pentachlorophenol made them hyperactive. By inhibiting energy intake while inducing higher energy expenditures, pentachlorophenol may reduce survival of young largemouth bass over the winter. [Brown JA et al; Trans Am Fish Soc 116 (1): 71-8 (1987)].

Interspecies variability in the metabolism of pentachlorophenol (PCP) was investigated by exposing rainbow trout, fathead minnows, sheepshead minnow, firemouth, and goldfish to water-borne (14)C-PCP for 64 hr. 2. The amounts of metabolites in bile and exposure water were species-dependent; all of the metabolites excreted into the water were sulfate conjugates while bile was enriched in glucuronide conjugates. 3. Biliary excretion accounted for less than 30% of the total PCP metabolites. 4. Biliary metabolites alone were a poor indication of the metabolites produced and of the major routes of elimination. [Stehly GR, Hayton WL; Xenobiotica 19 (1): 75-81 (1989)].

W.Wildlife (Water Concentrations vs. Wildlife or Domestic Animals):

Neurochemical effects were observed in 30 male Wistar rats given 20 mg/l concentration of technical grade pentachlorophenol in drinking water for 3 to 14 wk. Thirty controls were also studied. ... The main effects seen in the rat brain were transient biochemical effects (National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 391) [940]

W.Human (Drinking Water and Other Human Concern Levels):

EPA 1996 IRIS database information [893]:

Ambient Water Quality Criteria for Human Health [893]:

Water & Fish: 1.01E+3 ug/liter [893].

Previous Published Criteria for Water and Organisms was the same: 1,010 ug/L [446].

Previous IRIS Recalculated (9/90) Criteria for Water and Organisms was 1,000 ug/L [446].

Fish Only: None [893].

Previous IRIS Recalculated (9/90) Criteria for Organisms Only was 29,000 ug/L [446].

Reference: 45 FR 79318 (11/28/80) [893].

Contact: Criteria and Standards Division / OWRS / (202)260-1315 [893].

Discussion: The WQC necessary for the protection of public health is 1.01E+3 ug/L. Its basis is a NOAEL of 3 mg/kg in a mammalian study, a safety factor of 100, and an assumption of daily ingestion of 2 L of water and 6.5 g of fish. A WQC of 30.0 ug/L based upon organoleptic effects has also been derived. However, organoleptic endpoints have limited value in setting water quality standards, since there is no demonstrated relationship between taste/odor effect and adverse health effects [893].

Maximum Contaminant Level Goal [893].

Value: 0 mg/L Status/Year: Final 1991 Econ/Tech?: No, does not consider economic or technical feasibility Reference: 56 FR 3600 (01/30/91); 56 FR 30266 (07/01/91) [893].

Contact: Health and Ecological Criteria Division / (202)260-7571 Safe Drinking Water Hotline / (800)426-4791 [893].

Discussion: The MCLG of 0 mg/L for pentachlorophenol is based upon potential carcinogenic effects (B2) [893].

Maximum Contaminant Level (MCL) [893].

Value: 0.001 mg/L Status/Year: Final 1991 Econ/Tech?: Yes, does consider economic or technical feasibility Reference: 56 FR 3600 (01/30/91); 56 FR 3526 (01/30/91); 56 FR 30266 (07/01/91). [893].

Contact: Drinking Water Standards Division / OGWDW / (202)260-7575 Safe Drinking Water Hotline / (800)426-4791 [893].

Discussion: EPA has set an MCL equal to the PQL of 0.001 mg/L, which is associated with a lifetime individual risk of less than E-6 [893].

Older references to Federal Drinking Water Standards were the same concentration:

EPA 1 ug/l [940,952, USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93).

Crit. Dose: 3 mg/kg-day [Study 1 NOAEL] UF: 100 MF: 1 [893].

RfD: 3E-2 mg/kg-day Confidence: Medium [893].

Slope Factor: 1.2E-1 per mg/(kg/day) Unit Risk: 3E-6 per ug/liter Extrapolation Method: Linearized multistage procedure [893].

Drinking Water Concentrations at Specified Risk Levels:

Risk Level Concentration E-4 (1 in 10,000) 3E+1 ug/liter E-5 (1 in 100,000) 3E+0 ug/liter E-6 (1 in 1,000,000) 3E-1 ug/liter [893].

Note: Before citing a concentration as EPA's water quality criteria, it is prudent to make sure you have the latest one. Work on the replacement for the Gold Book [302] was underway in March of 1996, and IRIS is updated monthly [893].

EPA 1995 Region 9 preliminary remediation goal (PRG) and Region 3 RBC concentration for tap water: 0.56 ug/L based on cancer risk [868,903].

State Drinking Water Guidelines [940]:

(AZ) ARIZONA 220 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(CA) CALIFORNIA 30 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

(ME) MAINE 1 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) [940]. Six ug/L [933].

(MN) MINNESOTA 200 ug/l [USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)].

W.Misc. (Other Non-concentration Water Information):

No information found.

Sediment Data Interpretation, Concentrations and Toxicity (All Sediment Data Subsections Start with "Sed."):

Sed.Low (Sediment Concentrations Considered Low):

No information found.

Sed.High (Sediment Concentrations Considered High):

Analyses of sewage sludges from 50 publicly owned treatment works by the U.S. Environmental Protection Agency (1985): The mean concentration of pentachlorophenol was 10.4 ppm (dry weight) [347].

Sed.Typical (Sediment Concentrations Considered Typical):

SEDIMENT: Mississippi R outlet 1.6 ppm near spill(1), Bremerhaven, Germany 0.095-20 ppb(2), German rivers 0.2-8 ppb(3), Portland, ME 9 coastal sites, all pos, 0.01-2.4 ppb(4). [(1) Delaune RD et al; Environ Pollut Ser B 6: 297-308 (1983) (2) Eder G, Weber K; Chemosphere 9: 111-8 (1980) (3) Wegman RCC, VanDenBroek HH; Water Res 17: 227-30 (1983) (4) Ray LE et al; Chemosphere 12: 1031-8 (1983)] [940].

In Europe, measured concentrations in sediments have been 20-fold higher than those found in surface water (National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 384) [940].

Sed.Concern Levels, Sediment Quality Criteria, LC50 Values, Sediment Quality Standards, Screening Levels, Dose/Response Data and Other Sediment Benchmarks:

Sed.General (General Sediment Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Sediment Concentrations Versus Mixed or General Aquatic Biota):

AET, EPA, 1988: The apparent effects threshold concentrations for this compound in sediments proposed for Puget Sound ranged from 0.14 mg/kg dry weight (microtox) to 0.69 mg/kg dry weight (benthic) [416]. Although the authors of the Puget Sound AETs have cautioned that Puget Sound AETs may not be appropriate for comparison with data from other geographic areas, so few sediment concern levels for this compound have been published that the proposed Puget Sound concern level is included in this text as an item of interest.

Oak Ridge National Lab, 1994: Risk Assessment Screening Benchmarks for Sediment Concentrations. To be considered unlikely to represent an ecological risk, field concentrations should be below all of the following benchmarks in mg/kg (ppm) dry weight [652]:

CAS 87-86-5 PENTACHLOROPHENOL

SEDIMENT QUALITY VALUE (WASHINGTON STATE): 0.36

Sed.Plants (Sediment Concentrations vs. Plants):

No information found.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

No information found.

Sed.Fish (Sediment Concentrations vs. Fish):

No information found.

Sed.Wildlife (Sediment Concentrations vs. Wildlife or Domestic Animals):

No information found.

Sed.Human (Sediment Concentrations vs. Human):

No information found.

Sed.Misc. (Other Non-concentration Sediment Information):

No information found.

Soil Data Interpretation, Concentrations and Toxicity (All Soil Data Subsections Start with "Soil."):

Soil.Low (Soil Concentrations Considered Low):

No information found.

Soil.High (Soil Concentrations Considered High):

Analyses of sewage sludges from 50 publicly owned treatment works by the U.S. Environmental Protection Agency (1985): The mean concentration of pentachlorophenol was 10.4 ppm (dry weight) [347].

Soil.Typical (Soil Concentrations Considered Typical):

SOIL: Abandoned sawmill site near a wood-preserving site in Finland - 390 ppm(5). Gas Works Parks, Seattle, Wash - 0.052 ppm(6); Lipar landfill, Manutua, Township, Gloucester Co., NJ - 2033 ppb(7). [(5) Kitunen VH, Salkionoja-Salonen MS; Chemosphere 20: 1671-77 (1990) (6) Turney GL, Georlitz DF; Ground Water Monitoring Review 10: 187-98 (1990) (7) USEPA; Superfund Record of Decision (EPA Region 2): Lapri Landfill, NJ USEPA NTIS PB89-219224 (1989)] [940].

After treatment of greenhouse soil ... At levels of 15 & 45 kg/ha, residues in soil were 20.4 & 69.1 Mg/kg, respectively (IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 307, 1979) [940].

Soil.Concern Levels, Soil Quality Criteria, LC50 Values, Soil Quality Standards, Screening Levels, Dose/Response Data and Other Soil Benchmarks:

Soil.General (General Soil Quality Standards, Criteria, and Benchmarks Related to Protection of Soil-dwelling Biota in General; Includes Soil Concentrations Versus Mixed or General Soil-dwelling Biota):

Canadian 1991 interim remediation criteria for residential/parkland for all chlorophenolic compounds: 0.5 ug/g (ppm) dry weight [656].

Canadian 1991 interim remediation criteria for commercial/industrial land for all chlorophenolic compounds: 5 ug/g (ppm) dry weight [656].

Soil.Plants (Soil Concentrations vs. Plants):

Canadian 1991 interim remediation criteria for residential/parkland for all chlorophenolic compounds: 0.5 ug/g (ppm) dry weight [656].

Soil.Invertebrates (Soil Concentrations vs. Invertebrates):

No information found.

Soil.Wildlife (Soil Concentrations vs. Wildlife or Domestic Animals):

No information found.

Soil.Human (Soil Concentrations vs. Human):

EPA 1996 National Generic Soil Screening Level (SSL) designed to be conservative and protective at the majority of sites in the U.S. but not necessarily protective of all known human exposure pathways, land uses, or ecological threats [952]:

SSL = 3 mg/kg for ingestion pathway [952].

SSL = none given for inhalation pathway [952].

SSL = 0.001 to 0.03 mg/kg for protection from migration to groundwater at 1 to 20 Dilution-Attenuation Factor (DAF) [952].

EPA 1995 Region 9 Preliminary remediation goals (PRGs), 1995 [868]:

Residential Soil: 2.5 mg/kg wet wt.
Industrial Soil: 7.9 mg/kg wet wt.

NOTE:
1) PRGs focus on the human exposure pathways of ingestion, inhalation of particulates and volatiles, and dermal absorption. Values do not consider impact to groundwater or ecological receptors.
2) Values are based on a non-carcinogenic hazard quotient of one.
3) PRGs for residential and industrial land uses are slightly lower concentrations than EPA Region III RBCs, which consider fewer aspects [903].

EPA 1995 Region 3 Risk based concentration (RBC) to protect from transfers to groundwater:

0.2 mg/Kg dry weight [903].

Soil.Misc. (Other Non-concentration Soil Information):

PCP concentrations of 3.4 to 654 ppm have been found in soil with a foot of PCP treated utility poles [933].

Tissue and Food Concentrations (All Tissue Data Interpretation Subsections Start with "Tis."):

Tis.Plants:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Plants:

No information found.

B) Body Burden Residues in Plants: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Lettuce grown on ... Soil /which had been treated with pentachlorophenol at levels of 15 & 45 kg/ha/ contained residues of 0.73 & 1.56 Mg/kg, respectively (IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 307, 1979) [940].

Tis.Invertebrates:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Invertebrates:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Invertebrates:

No information found.

C) Body Burden Residues in Invertebrates: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

See also Tis.Fish, C) section below.

Snails 36-8 ppm (IARC; Some Halogenated Hydrocarbons 20: 308, 1979) [940].

Tis.Fish:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Fish (Includes FDA Action Levels for

Fish and Similar Benchmark Levels From Other Countries):

EPA 1995 Region 3 Risk based concentration (RBC) to protect humans eating fish:

0.026 mg/Kg concentration of PCP in fish tissue [903].

B) Concentrations or Doses of Concern in Food Items Eaten by Fish:

No information found.

C) Body Burden Residues in Fish: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Mean fish tissue concentrations for the years 1976 to 1970 were [933]:

Lake Michigan: 0.002 mg/k
Lower Mississippi: 0.478 mg/kg
Pacific Northwest: 16.38 mg/kg
Alaska: 5 mg/kg

Western Gulf and S.Central Lower Missippi: not detected.

One value was as high as 50 ppm.

Fish/Seafood Concentrations [940]:

Not detected in meat, fish and poultry in market basket surveys(1). New Brunswick, Canada fish 0.5-4 ppb, White shark liver - 10.8 ppb, (2). Wabash R, IN - composite fish samples - detected, not quantified(3). Fish 0.35-59 ppm(4). Gulf of Mexico, TX - flounder, killifish, shrimp, crab and squid 2.6-7.5 ppb(5). [(1) Duggan RE et al; Pesticide Residue Levels in Foods in the US p 5 FDA and AOAC (1983) (2) Zitko V et al; Bull Environ Contam Toxicol 12: 649-53 (1974) (3) Kuehl DW et al; J Assoc Off Anal Chem 63: 1238-44 (1980) (4) IARC; Some Halogenated Hydrocarbons 20: 308 (1979) (5) Murray HE et al; Chemosphere 10: 1327-34 (1981)

Interspecies variability in the metabolism of pentachlorophenol (PCP) was investigated by exposing rainbow trout, fathead minnows, sheepshead minnow, firemouth, and goldfish to water-borne (14)C-PCP for 64 hr. 2. The amounts of metabolites in bile and exposure water were species-dependent; all of the metabolites excreted into the water were sulfate conjugates while bile was enriched in glucuronide conjugates. 3. Biliary excretion accounted for less than 30% of the total PCP metabolites. 4. Biliary metabolites alone were a poor indication of the metabolites produced and of the major routes of elimination. [Stehly GR, Hayton WL; Xenobiotica 19 (1): 75-81 (1989)

Tis.Wildlife: Terrestrial and Aquatic Wildlife, Domestic Animals and all Birds Whether Aquatic or not:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Wildlife, Domestic Animals, or Birds:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Wildlife, Birds, or Domestic Animals (Includes LD50 Values Which do not Fit Well into Other Categories, Includes Oral Doses Administered in Laboratory Experiments):

Avian fatalities have been reported for oral doses of 380 to 580 mg/kg body weight and >285 mg/kg in contaminated nest materials; however, adverse sublethal effects have been reported at dietary levels as low as 1 mg/kg ration [411].

Acute dietary studies (using oral doses high enough to cause relatively quick toxicity) feeding this compound to mammal and bird species place it in the "moderately toxic" category for mallards and pheasants and the "relatively nontoxic" category for Japanese quail [185,186].

Information from HSDB [940]:

LC50 Colinus virginianus, bobwhite, 10 days old, oral (5-day diet) approx 3400 ppm [U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife. Lethal Dietary Toxicities of Environmental Pollutants to Birds. Special Scientific Report - Wildlife No. 191. Washington, DC: U.S. Government Printing Office, 1975. 30].

LC50 Coturnix japonica, japanese quail, 20 days old, oral (5-day diet) 5204 ppm (95% confidence limit 4536-6034 ppm) [U.S. Department of the Interior, Fish and Wildlife

Service, Bureau of Sports Fisheries and Wildlife. Lethal Dietary Toxicities of Environmental Pollutants to Birds. Special ScientificReport - Wildlife No. 191. Washington, DC: U.S. Government Printing Office, 1975. 30].

LC50 Phasianus colchicus, ring-necked pheasant, 16 days old, oral (5-day diet) 4331 ppm (95% confidence limit 3926-4787 ppm) [U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife. Lethal Dietary Toxicities of Environmental Pollutants to Birds. Special ScientificReport - Wildlife No. 191. Washington, DC: U.S. Government Printing Office, 1975. 30].

LC50 Anas platyrhynchos, mallard ducks, 10 days old, oral (5-day diet) approx 4500 ppm [U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife. Lethal Dietary Toxicities of Environmental Pollutants to Birds. Special ScientificReport - Wildlife No. 191. Washington, DC: U.S. Government Printing Office, 1975. 30].

LD50 Coturnix japonica, Japanese quail oral 5139 ppm (95% confidence limit 4149-6365 ppm) [Hill, E.F. and Camardese, M.B. Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix. Fish and Wildlife Technical Report 2.Washington, DC: United States Department of Interior Fish and Wildlife Service, 1986. 110].

Mean oral/ LD50 for female mallards at age 3 mo was 380 mg/kg and for female pheasants at age 3-6 mo, 504 mg/kg./ Signs of intoxication: Polydipsia and regurgitation (in mallards), tachypnea, wing shivers or twitching, jerkiness, shakiness, ataxia, imbalance, tremors, and spasms. Signs appeared as soon as 10 min and mortalities in mallards usually occurred between 2 and 24 hr after treatment and in pheasants between 3 and 5 days after treatment. However, one pheasant died after about 3 hr and one died between 10 and 12 days after treatment. Remission took up to 2 wk. [U.S. Department of the Interior, Fish and Wildlife Service. Handbook of Toxicity of Pesticides to Wildlife. Resource Publication 153. Washington, DC: U.S. Government Printing

Office, 1984. 63].

LD50 Rat male oral 146 mg/kg [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

LD50 Rat female oral 175 mg/kg [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

LD50 Rat oral 210 mg/kg [Hartley, D. and H. Kidd (eds.). The Agrochemicals Handbook. 2nd ed. Lechworth, Herts, England: The Royal Society of Chemistry, 1987.,p. A473].

Six groups of 27 male & ... Female weanling sprague-dawley (spartan substrain) rats ... Given lab chow ... Containing pentachlorophenol (sample xd-9108.002: Pentachlorophenol 90.4%; Tetrachlorophenol 10.4%; Trichlorophenol less than 0.1%; Hepta- & octachlorodibenzo-p-dioxins about 21 mg/kg; hexa- & heptachlorodibenzofurans about 5.2 Mg/kg; & hexachlorobenzene 400 mg/kg) to provide ... Levels of 0, 1, 3, 10 or 30 mg pcp/kg body/day. Pentachlorophenol was dissolved in anisole & concentration ... Adjusted on a monthly basis to maintain designated dose levels ... Groups of 27 male & 27 female controls ... Received lab chow containing anisole only. Female rats were maintained on test diets for 24 mo, but the male/s/ ... Were taken off ... After 22 mo because of high mortality ...The total & individual tumor incidences by sites, times of appearance ... & Avg numbers ... Per animal (predominantly benign neoplasms) were not significantly different from those observed in control rats. The number of rats with tumors/those exam were, in males: 11/27 (controls), 13/26 (1 mg/kg), 13/27 (3 mg/kg), 12/27 (10 mg/kg), 11/27 (30 mg/kg); in females: 27/27 (controls), 26/27 (1 mg/kg), 25/27 (at all other doses). [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 313 (1979)].

Groups of 18 male & ... Female (c57bl/6xc3h/anf)f1 mice & 18 male & female (c57bl/6xakr)f1 mice received ... Dowcide-7 (impurities unspecified) ... /At/ 46.4 Mg/kg body wt in 0.5% Gelatin at 7 days of age by stomach tube & same amt (not adjusted for incr body wt) daily up to 4 wk of age; subsequently, the mice were fed 130 mg/kg /ppm/ diet until ... 78 Wk of age at which time 16, 18, 17 & 16 mice were still alive in the 4 groups, respectively. Tumors developed in 3/18, 4/18, 3/17 and 2/18 male & female ... Mice; these incidences were not significantly greater than in 79-90 necropsied mice of each sex & strain, which had either been untreated or had received gelatin only. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 309 (1979)].

Pregnant Syrian golden hamsters given daily oral doses of pentachlorophenol (unspecified purity) ranging from 1.25 to 20 mg/kg from days 5 to 10 of gestation experienced an increase in fetal deaths & resorptions. The no effect level was 2.5 mg/kg/day. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 392].

Pentachlorophenol was embryotoxic & fetotoxic /to sprague-dawley rats/ @ doses of commercial & pure pentachlorophenol of 15 mg/kg & above. ... Delayed ossification of skull was observed after treatment with pure pentachlorophenol. Oral administration ... To hamsters on days 5-10 of gestation produced fetal death &/or resorptions at 5 mg/kg/day and above. [National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 753].

The teratogenic activities of highly purified pentachlorophenol and pentachloroanisole, administered in the diet of Sprague Dawley rats of both sexes, at the rate of 4, 13 or 43 mg/kg and 4, 12 or 41 mg/kg/day, respectively, for a period of 181 days, were investigated. Pregnant females treated with pentachlorophenol ate more food than untreated controls. As compared to controls, dams treated with the highest doses of both compounds had a lower body wt on day 0 of gestation and gained less weight during their pregnancy. Animals treated with the highest dose of pentachlorophenol gained less weight during pregnancy than controls. Embryonic deaths were recorded following treatment with pentachlorophenol at the rate of 43 mg/kg/day, while lower doses of the compound induced dose related reductions in body wt. At the rate of 13 mg/kg/day only, pentachlorophenol reduced the crown to rump length and increased the skeletal alterations of the fetus. Decreased numbers of corpora lutea and embryonic death were recorded following the administration of pentachlorophenol at the rate of 4 and 41 mg/kg/day. At the same dose pentachlorophenol reduced the body wt and the crown to rump length of male fetuses, while their female counterparts were not affected. Neither pentachlorophenol nor pentachloroanisole affected the soft tissue of the animals. Results indicate the pentachlorophenol is slightly more toxic than pentachloroanisole in Sprague Dawley rats. [Welsh JJ et al; Food Chem Tox 25 (2): 163-72 (1987)].

The immunosuppressive effects produced by exposure to technical grade pentachlorophenol were compared with those produced by purified pentachlorophenol both in vitro and in vivo in mice. Female B6C3F1 mice were administered daily doses of 10, 30, or 100 mg/kg technical grade pentachlorophenol, or corn oil via gastric intubation for 14 days. Animals were sacrificed the day after the last dose, and antibody responses to multiple antigenic stimuli were measured in spleen cell suspensions from the mice. There were no differences in the antibody responses in the spleen cell suspensions from technical grade pentachlorophenol or purified pentachlorophenol treated animals as compared to controls. When mice were immunized with sheep erythrocytes on day 10 or 11 of the 14 day exposure period, there was a dose dependent suppression of the immunoglobulin-M antibody response to sheep erythrocytes in spleen cells from mice treated with technical grade pentachlorophenol. No changes were observed in the antibody responses of spleen cells from mice to purified pentachlorophenol which were immunized during exposure. When added directly to spleen cell cultures from untreated mice, both technical grade pentachlorophenoland purified pentachlorophenol suppressed the in vitro antibody responses and were cytotoxic to the spleen cells. The in vitro antibody assay is of limited value in studying the mechanism of immunosuppression by technical grade pentachlorophenol, and that technical grade pentachlorophenol induced immunosuppression cannot be attributed to a direct effect on immunocompetent cells. [Holsapple MP et al; J Tox Environ Health 20 (3): 229-39 (1987)].

The effect of pentachlorophenol on microsomal mixed function oxidases was studied in cattle. Four adult lactating Holstein cattle were fed 0.2 mg/kg technical grade pentachlorophenol for 75 to 84 days, followed by 2 mg/kg for 56 to 60 days. Twelve adult nonlaboratory Holstein cattle were administered 0, 0.1, 1.0, or 10.0 mg/kg purified pentachlorophenol for 95 days. The pentachlorophenol was administered directly into the rumen by way of a permanent cannula. Fifteen male calves were administered 1, 2, 10, or 20 mg/kg technical grade or purified pentachlorophenol from 5 to 43 days of age. The animals were observed for clinical signs of toxicity; they were killed at the end of the dosing period and the liver and lungs were removed and weighed. Liver and lung microsomes were prepared and assayed for benzo(a)pyrene-hydroxylase, ethoxycoumarin-O-deethylase, hexobarbital-hydroxylase, ethylmorphine-N-demethylase, aminopyrine-N-demethylase, cytochrome-P450(448), or cytochrome-b5. None of the adult cattle exhibited clinical signs of toxicity. Liver and lung weights were significantly elevated in cattle given technical grade pentachlorophenol. Liver and lung benzo(a)pyrene-hydroxylase was significantly increased in these animals. Purified pentachlorophenol had no effect on any enzyme activities. Toxic effects such as growth impairment and mortality were observed in calves fed 10 and 20 mg/kg pentachlorophenol. Liver weights were significantly increased. No toxic effects were seen in calves fed pure pentachlorophenol. Cytochrome-P450(448) and cytochrome-b5 were significantly increased by 10 mg/kg technical or pure pentachlorophenol. Technical grade pentachlorophenol at 1 and 10 mg/kg induced benzo(a)pyrene-hydroxylase and ethoxycoumarin-O-deethylase. The 10 mg/kg dose of purified pentachlorophenol also stimulated these enzymes. The /results suggest/ that pentachlorophenol induces organ enlargement and stimulates cytochrome-P450(448) and certain mixed function oxidases. Benzo(a)pyrene-hydroxylase is the most inducible enzyme. The effects observed with technical grade pentachlorophenol are attributed to chlorinated dioxin and furan impurities. Newborn cattle are more susceptible to the inducing properties of pentachlorophenol and its impurities than adults. [Shull LR et al; Pest Biochem Physiol 25 (1): 31-9 (1986)].

Toxicity of pentachlorophenol to sheep & calves has been examined ... Min acute lethal dose rate was found to be approx 120 & 140 mg/kg respectively in the 2 species. ... Death occurred in 2 to 14 hr. Most prominent clinical sign was accelerated breathing ... Which distinguished dosed animals from controls 1 to 2 hr after /oral/ drenching. Badly affected animals stood swaying, with head lowered, panted noisily, & made little attempt to move when approached. Salivation was observed in calves & coat felt damp. Recovery from this stage ... Was rapid & complete. In fatal cases, complete collapse occurred, animals lying with legs limp & panting vigorously through open mouth. Asphyxial tremors, but no convulsions, set in just before death. [Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 132].

In a 160 day study, cattle fed 20 mg/kg doses of technical pentachlorophenol for 42 days, followed by 15 mg/kg/day for the remainder of the study, had decreased wt gain, progressive anemia, & immune effects. Only minimal adverse effects were observed after exposure to analytical grade pentachlorophenol (National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 390) [940].

C) Body Burden Residues in Wildlife, Birds, or Domestic Animals: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Acute toxicosis has been noted in birds with residue concentrations >11 mg/kg fresh weight [447].

Information from HSDB [940]:

Birds 0.04-0.49 ppm; dairy cattle in pentachlorophenol treated barn 58-1136 ppb(1); bird eggs 0.36-0.51 ppb(2). [(1) IARC; Some Halogenated Hydrocarbons 20: 308 (1979) (2) Zitko V et al; Bull Environ Contam Toxicol 12: 649-53 (1974)].

In the state of michigan, herds of dairy cattle were contaminated with pentachlorophenol used to treat wood of barns where they were housed & from feed bins treated with pentachlorophenol; the contaminating pentachlorophenol was said to contain 1 to 1000 mg/kg dioxin. Pcp levels in 18 cows ranged from 58 to 1136 ug/kg. Pentachlorophenol has been found in blood of 8 such herds. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 308 (1979)].

Not detected in milk in market basket surveys(1). [(1) Duggan RE et al; Pesticide Residue Levels in Foods in the US FDA and AOAC (1983)]].

1 sample of milk was found to contain 0.09 Mg/kg. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 308 (1979)]].

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

Before so many restrictions were placed on its use, PCP was found at concentrations of 1 to 1000 ppb in grains and sugars, and at 1.8 to 62 ppb in peanut butter and 6-12 ppb in chicken [933].

See also Tis.Fish, C) above.

Food Survey Results [940]:

US daily intake - % pos (ug): 1971 - 0.6% (0.03 ug), 1972-0, 1973 - 2.5% (0.7 ug), 1974 - 3.0% (0.8 ug), 1975 - 5.4% (2.0 ug), 1976 - 0.8% (1.0 ug)(1). Results from the US FDA's

Adult Total Diet Study in which the typical 14-day diet of a 16-19 yr male was collected throughout the US from market basket composite samples in 12 food groups (Fiscal Year-average intake (ug/kg body wt/day)) are: FY79 0.006, FY 80 0.040, FY 81/82 0.052(2). An analogous study for infants and toddlers calculated that in FY 81/82, that daily pentachlorophenol input per unit body weight was 0.023 and 0.079 ug/kg, respectively(2). In the 1988 Total Diet Study, the intake of pentachlorophenol in ug/kg body wt/day was 0.0004, 0.0002, and 0.0003 for a 6-11 month old, 14-16 yr male, and 60-65 yr female, respectively(3). For the FY 81/82 Adult Total Diet Survey, 27 cities were samples. In FY 81/82, there were 48 positive samples out of the 27 composites from each of the 12 food groups containing pentachlorphenol levels up to 0.024 ppm(2). The average 70 kg man would have an average intake of 3.62 ug/day(2). The food groups that contained pentachlorphenol are (class, average concentration number of positives): meat, fish and poultry, 0.0037 ppm 14 positives; grain and cereral products, 0.0048 ppm 12 positives; oils and fats, 0.0072 ppm 18 positives; and sugar and adjuncts, 0.0010 ppm, 4 positives(2). [(1) Duggan RE et al; Pesticide Residue Levels in Foods in the US, FDA and Assoc Off Anal Chem p. 5 (1983) (2) Gartrell MJ et al; J Assoc Off Anal Chem 69: 146-61 (1986) (3) Gartrell MJ et al; J Assoc Off Anal Chem 69: 123-45 (1986) (4) US FDA; Residues in Food-1988. Food and Drug Administration, Washington, DC (1989)].

Not detected in milk in market basket surveys (Duggan RE et al; Pesticide Residue Levels in Foods in the US FDA and AOAC (1983) [940]].

Lettuce grown on ... Soil /which had been treated with pentachlorophenol at levels of 15 & 45 kg/ha/ contained residues of 0.73 & 1.56 Mg/kg, respectively (IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 307 (1979) [940].

B) Concentrations or Doses of Concern in Food Items Eaten by Humans (Includes Allowable Tolerances in Human Food, FDA, State and Standards of Other Countries):

EPA 1995 Region 3 Risk based concentration (RBC) to protect humans eating fish:

0.026 mg/Kg concentration of PCP in fish tissue [903].

EPA 1996 IRIS database information [893]:

Crit. Dose: 3 mg/kg-day [Study 1 NOAEL] UF: 100 MF: 1 [893].

RfD: 3E-2 mg/kg-day Confidence: Medium [893].

Average Daily Intake [940]:

Air intake (assume 0) - 0; Water intake (assume 0) - 0; Food intake - 0.014(1), 3.6(2), 16(3) ug(SRC). [(1) Gartrell MJ et al; J Assoc Off Anal Chem 69: 146-61 (1986) (2) US FDA; Residues in Food-1988. Food and Drug Administration, Washington, DC (1989) (3) Hattermer-Frey HA, Travis CC; Arch Environ Contam Toxicol 18: 482-9 (1989)].

In the United States, the estimated average daily intake of pentachlorophenol from food in 1974 was 0.76 ug. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 384].

Acceptable Daily Intake [940]:

EPA RfD = 0.03 mg/kg [USEPA/OPP; Health Effects Div RfD/ADI Tracking Report p.44 (8/26/91)].

C) Body Burden Residues in Humans: Typical, Elevated, or of Concern Related to the Well-being of Humans:

Information from HSDB [940]:

BLOOD: 15 ppb(1), 10-120 ppb in users of PCP contaminated water(2). Serum of 123 residents of PCP-treated log homes ranged from 69-1340 ppb, 420 ppb mean, while 34 controls ranged from 15-75 ppb, 40 ppb(3). Serum levels in 25 occupationally-exposed workers in 5 workplaces ranged from 26 to 84,900 ppb(3). Median serum PCP levels 4 of the workplaces ranged from 83 to 490 ppb, while in the chemical packaging area of a chemical plant it was 62,000 ppb(3). Serum and who blood samples from workers in the plant ranged from 21,700-84,900 and 8,600-

45,200 ppb, respectively(5). Average serum concentration of 7 workers continuously exposed to chlorophenol at 2 saw mills was 0.225 ppm(4). [(1) IARC; Some Halogenated Hydrocarbons 20: 303-25 (1979) (2) Morgade C et al; Bull Environ Contam Toxicol 24: 257-64 (1980) (3) Cline RE et al; Arch Environ Contam Toxicol 18: 475-81 (1989) (4) Pekari K et al; Int Arch Occup Environ Health 63: 57-62 (1991)].

HUMAN MILK: Bavaria, Germany - 0.03-2.83 ppb - 21 donors(1). URINE: 85% pos over 400 samples 6.3 ppb mean, 193 ppb max(2). Urine of 118 residents of PCP-treated log homes ranged from 1-340 ppb, 69 ppb mean, while 143 controls ranged from 1-7 ppb, mean 3.4 ppb(3). All urine samples from 197 Arkansas children contained pentachlorophenol(4). The median and maximum pentachlorophenol concentration was 14 and 240 ppb. SEMINAL FLUID: 20-70 ppb(2), 100-200 ppb(5). ADIPOSE TISSUE: 250-500 ppb(5), 23 ppb(6). [(1) Gebefugi I, Korte F; Chemosphere 12: 1055-60 (1983) (2) IARC; Some Halogenated Hydrocarbons 20: 303-25 (1979) (3) Cline RE et al; Arch Environ Contam Toxicol 18: 475-81 (1989) (4) Hill RH Jr et al; Arch Environ Contam Toxicol 18: 469-74 (1989) (5) Kuehl DW, Dougherty RC; Environ Sci Technol 14: 447-9 (1980) (6) Morgade C et al; Bull Environ Contam Toxicol 24: 257-64 (1980)].

Lethal Blood Level: >46 ug/ml. /The lethal blood level is defined as/ the concentration of ... chemical present in the blood (its serum or plasma) that has been reported to cause death, or is far above reported therapeutic or toxic concentration that one can judge that it might cause death in humans. [Winek, C.L. Drug and Chemical Blood-Level Data 1985. Pittsburgh, PA: Allied Fischer Scientific, 1985.].

Tis.Misc. (Other Tissue Information):

No information found.

Bio.Detail: Detailed Information on Bioconcentration, Biomagnification, or Bioavailability:

Notable (ppm range) amounts of PCP have been found in fish flesh [933] (for details, see Tis.Fish section above).

Bioconcentration [940]:

Pentachlorophenol is expected to bioconcentrate because of its low water solubility, but the bioconcentration factor (BCF) will be dependent upon the pH of the water since pentachlorophenol will be more dissociated at higher pHs(SRC). The log BCF with goldfish varied from 0.30 at pH 10 to 1.75 at pH 7 to 2.12 at pH 5.5(1). Other reported log BCF values are 2.89 in fathead minnow(2); 2.4-3.73 in rainbow trout(3-4); 0.7-1.7 in sheepshead minnows(5); and 2.47 in mosquito fish(6); 2.85 in zebra fish(8); 2.62 in golden orfe(8). The accumulation increased with temperature in orfe and decreased with temperature in zebra fish(8). The BCF of PCP in humans was measured from daily intake of PCP and measured concentration in different tissues, giving the following results: 5.7, 3.3, 1.4, 1.4, and 1.0 in liver, brain blood, spleen and adipose tissue respectively(7). Calculation using linear 1 compartment pharmacokinetic model yielded similar results(8). [(1) Kabayashi K, Kishino T; Bull Jap Soc Scient Fish 46: 167-70 (1980) (2) Veith GD et al; J Fish Res Board Can 36: 1040-8 (1979) (3) Statham CN et al; Science 193: 680-1 (1976) (4) Niimi AJ, McFadden CA; Bull Environ Contam Toxicol 28: 11-9 (1982) (5) Parrish PR et al; Chronic Toxicity of Chlordane, Trifluralin, and Pentachlorophenol to Sheepshead Minnows (Cyprinodon Variegatus) p. 67 USEPA Report NTIS PB278-269 (1978) (6) Lu PY, Metcalf RL; Environ Health Perspect 10: 269-84 (1975) (7) Geyer HJ et al; Chemosphere 16: 887-99 (1987) (8) Bude A et al; Chim Acta Turc 13: 235-52 (1985)].

Biological Half-Life [940]:

Absorbed by goldfish from water and rapidly excreted as a sulfate conjugate. Biological half-life of approx 10 hr. [U.S. Dept of Int, Fish and Wildlife Serv; Metabolism of Pesticides-Update III p.438 (1980) U.S. Dept Int Special Scientific Report - Wildlife No. 232].

Biological half-life for excretion in the Rhesus monkey was 41 and 92 hr in males and females, respectively. [U.S. Dept of Int, Fish and Wildlife Serv; Metabolism of Pesticides-Update III p.437 (1980) U.S. Dept Int Special Scientific Report - Wildlife No. 232].

Half-life for absorption in man following ingestion of 1.0 mg/kg was 1.3 + or - 0.4 hr. Peak plasma concentration of 0.248 mg/l occurred at 4 hr. [USEPA; Ambient Water Quality Criteria Doc: Pentachlorophenol p.C-12 (1980) EPA 440/5-80-065].

In humans, urinary excretion half-lives following chronic exposure are significantly longer than after single high-dose exposure (20 days versus 10 hr). [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 386].

Interactions:

Information from HSDB [940]:

Several factors affect toxicity of chlorophenols ... . Toxicity is enhanced by high ambient temperature, physical activity, poor condition, oily or organic solvent vehicles, prior exposures, and hyperthyroid states. Toxicity is diminished by cold temperatures, antithyroid drugs, and presence of body fat, which is the major substrate for the metabolic stimulant effects of these compounds (Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 963) [940].

The toxicity to Pseudomonas fluorescens was greater when pentachlorophenol and 2,3,4,5-tetrachlorophenol were given sequentially than when pentachlorophenol alone was given. The antioxidant butylated hydroxyanisole enhances the toxicity of pentachlorophenol to Pseudomonas fluorescens. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 386].

Hexachlorobenzene (HCB) at 1000 ppm and 99% pure pentachlorophenol (PCP) at 500 ppm admin to female Wistar rats for up to 8 wk resulted in an increased accumulation of pentachlorophenol in the liver. Pentachlorophenol ... accelerated the onset of hepatic porphyria by hexachlorobenzene. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 386].

Pretreatment with pentachlorophenol inhibits the carcinogenic effect of hydroxyamine acids and the hepatoxicity of N-hydroxy-2-acetylaminofluorene. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 386].

Pentachlorophenol enhances the transplacental carcinogenicity of ethylnitrosourea. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 392].

The organochlorine pesticide, pentachlorophenol, a potent sulfotransferase inhibitor, reportedly reduces the binding of 2,6-dinitrotoluene, an industrial hepatocarcinogen to hepatic DNA by 95% after a single ip injection. Activation of 2,6-dinitrotoluene to genotoxic metabolites involves enzymes in both the liver and the intestinal flora. Since pentachlorophenol also has bactericidal activity and induced hepatic mixed function oxidase activity after longer treatment, the effect of pentachlorophenol on intestinal enzyme and the biotransformation of 2,6-dinitrotoluene to genotoxic metabolites was studied after 1, 2, 4, and 5 weeks of treatment. Male Fischer 344 rats were dosed daily, by gavage, with either 20 mg/kg pentachlorophenol or the peanut oil vehicle. After 1, 2, 4, and 5 wk, select control and treated animals were injected orally with 75 mg/kg 2,6-dinitrotoluene and transferred to metabolism cages, where urine was collected for 24 hr and tested for mutagenic activity in the Ames Salmonella typhimurium reversion assay. At 2 and 4 wk, six control and six treated animals were sacrificed and nitroreductase, azo reductase, beta-glucuronidase, dechlorinase, and dehydrochlorinase activities were analyzed in homogenates of the small intestine, large intestine, and cecum. At 5 wk, hepatic DNA adduct formation was assayed by the (32)P postlabeling of DNA. Results from this study indicated that pentachlorophenol accelerated the biotransformation of 2,6-dinitrotoluene genotoxic metabolites and potentiated the formation of 2,6-dinitrotoluene induced DNA adducts in the liver. This is the first report of a chemical interaction leading to increased DNA adduct formation and indicates that chemical interactions could be important to risk assessment since they alter the relationship between exposure, dose, and the effect of genotoxicants. [Chadwick RW et al; Pestic Biochem Physiol 39 (2): 168-81 (1991)].

The aim of the present work was to explore the possibility that pentachlorophenol influences the behavior of the resting Na efflux in single muscle fibers from the barnacle, Balanus nubilus. It is shown here that pentachlorophenol causes a transitory rise in the sodium efflux in both unpoisoned and ouabain poisoned fibers and that the response is dose dependent, the minimal effective concentration in ouabain treated fibers being less than 1X10-6 M. The efficacy of pentachlorophenol is significantly greater than that of 2,3,4-trichlorophenol. 2,3-Dichlorophenol is ineffective. This is also the case with phenol. The magnitude of the response to pentachlorophenol is a function of external pH. Lowering pHe increases the response. The response has an absolute requirement for external calcium ion and is a sigmoidal function of external calcium ion concentration. Since treatment of these fibers with pentachlorophenol in high concentration leads to prompt contraction, experiments were designed to determine whether the observed rise in ouabain insensitive sodium efflux is due to a fall in myoplasmic pCa and whether trigger calcium ion originates from the bathing medium. The results obtained show that prior injection of ethylene glycol bis(beta-aminoethyl ether) N,N'-tetraacetic acid or 1,2-bis(2-aminophenoxyethane-N,N,N',N'-tetraacetic acid) leads to a drastic reduction in the response to pentachlorophenol. They also show that prior external application of verapamil or devapamil stops the response to pentachlorophenol from occurring. Both cadmium ion and cobalt ion are also effective but only temporarily. Last, the effects of ryanodine and 8-(N,N-diethylamino)octyl-3,4,5-trimethoxybenzoate were tested, since the former is known to block the sarcoplasmic reticulum calcium ion release channel, and the latter to impair the action of agents known to release calcium ion from internal depots. Both ryanodine and 8-(N,N-diethylamino)octyl-3,4,5-trimethoxybenzoate are found to reduce the response to pentachlorophenol. Taken together, these observations support the hypothesis that pentachlorophenol stimulates the ouabain insensitive sodium efflux by increasing the internal free calcium ion and that the increase in internal calcium ion is due to the entry of trigger calcium ion from the outside via calcium ion channels, as well as release of calcium ion by the sarcoplasmic reticulum via its channel. They also indicate that the efficacy of pentachlorophenol depends on the 5 chlorine atoms present in its aromatic ring and external pH. [Nwoga J, Bittar EE; Toxicol Appl Pharmacol 108 (2): 330-41 (1991)].

Uses/Sources:

This compound has been used primarily as a wood preservative and only secondarily as a herbicide, insecticide, fungicide, molluscicide, or bactericide [411].

Major Uses [940]:

Has been recommended for use in the preservation of starches, dextrins, glues [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

As a molluscicide [American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH:American Conference of Governmental Industrial Hygienists, 1986. 461].

To inhibit fermentation in various materials [International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1672].

Registered homeowner uses incl maintenance of boats, trailers, station wagons, siding, fences, outdoor furniture & similar articles. There are a large number of registered industrial uses, such as construction of boats and buildings, mold control in petroleum drilling & prodn, & in treatment of cable coverings, canvas belting, nets, construction lumber & poles. Other ... Uses incl incorporation in paints, pulp stock, in pulp & paper, cooling tower water, hardboard & particle board. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 306 (1979)].

Wood preservative (fungicide) [sri].

Chem int for sodium pentachlorophenate [sri].

Soil fumigant for termites [sri].

Herbicide for weeds & preharvest defoliant for seed crops /srp: former use/ [sri].

Seed treating agent for beans [sri].

Herbicide for control of moss-eg, on lawns & roofs [sri].

Fungicide-eg, for use on prunes [sri].

Preservative-eg, for paints, leather, textiles & inks [sri].

Slimicide & algaecide in indust applications [sri].

Antibacterial agent in disinfectants & cleaners [sri].

Used as a preharvest defoliant on selected crops /SRP: Former use/ [Farm Chemicals Handbook 87. Willoughby, Ohio: Meister Publishing Co., 1987.,p. C-194].

In various products, pentachlorophenol has been used as a herbicide, algacide, defoliant, wood preservative, germicide, fungicide, and molluscicide. As a wood preservative, it is commonly applied as a 0.1% solution in mineral spirits, NO 2 fuel oil, or kerosene. It is used in pressure treatment of lumber at 5% concentration. Weed killers contain higher concentrations. PCP is no longer available for over-the-counter sale in the USA. [Morgan DP; Recognition and Management of Pesticide Poisonings. 4th ed. p.73 EPA 540/9-88-001. Washington, DC: U.S. Government Printing Office, March 1989].

Natural Sources [940]:

It has been suggested that pentachlorophenol is a product of fungus metabolism(1). [(1) IARC; Some Halogenated

Hydrocarbons 20: 303-25 (1979)].

Artificial Sources [940]:

Pentachlorophenol has been detected in 9/65 commercial samples of paints used on children's toys at levels of 100 to 2700 mg/kg; & in wood-shaving litter from chicken houses at levels of 0.6 To 83 mg/kg (fresh) & 0 to 4.1 Mg/kg (after 8 wk). [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 309 (1979)].

Pentachlorophenol has been detected in: (1) river water and effluent water from a chlorinated biological sewage treatment plant; (2) the effluent waters from various manufacturing and processing plants; (3) well water. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 307 (1979)].

/Pentachlorophenol/ has ... been detected in: (1) sewage influent and effluent water of cities at levels, of 1-5 ug/l; (2) a river, at levels of 0.1-0.7 ug/l; (3) rain- snow-, and lake-water at levels of 2-284, 14 and 10 ng/l; (4) creek-water containing industrial discharges at levels of 0.1-10 mg/l [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 307 (1979)].

After treatment of greenhouse soil with pentachlorophenol at levels of 15 & 45 kg/ha, residues in the soil were 20.4 and 69.1 mg/kg, respectively. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 307 (1979)].

Pentachlorophenol may be released to the environment as a result of its manufacture, storage, transport, or use as an industrial wood preservative for utility poles, cross arms, and fenceposts, and other items that consumes about 90% of its production(1-3). Other former uses that may have lead to its release is the manufacture of sodium pentachlorophenolate and minor uses as a fungicide, bactericide, algicide, and herbicide for crops, leathers and textiles(1-3). Pentachlorophenol's used on wood is "restricted" and its non-wood use is undergoing special review by EPA(4). [(1) IARC; Some Halogenated Hydrocarbons 20: 303-25 (1979) (2) IARC; Some Halogenated Hydrocarbon & Pesticide Exposures 41: 319-56 (1986) (3) Hawley GG; The Condensed Chemical Handbook Van Nostrand Reinhold, NY: pp. 782-3 (1981) (4) USEPA; Status of Pesticides in Registration and Special Review USEPA-700-R-92-

004 (1992)].

Forms/Preparations/Formulations:

Information from HSDB [940]:

Avail as ... Sodium salt, as 5% emulsifiable concentrate or as 3-40% soln in oil or grease, & in formulations with other chlorophenols, methylene bisthiocyanate & copper naphthenate. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 305 (1979)].

The cmpd may be used alone or in combination with other agents such as ... 2,4-dinitrophenol, sodium fluoride, the dichromate salts, sodium arsenate, or arsenious oxide. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 383].

Grades or Purity: 86-100%. [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.].

Dowicide EC-7: Pentachlorophenol 88%; Other chemicals 12%. [Farm Chemicals Handbook 1980. Willoughby, Ohio: Meister, 1980.,p. D-116].

/Available as/ prills, pellets, liquid & concentrates. Also block form. [Farm Chemicals Handbook 1991. Willoughby, OH: Meister, 1991.,p. C-231].

Penta Concentrate contains 9.7 lbs/gal PCP /Los Angeles Chemical Co/ [Farm Chemicals Handbook 1986. Willoughby, Ohio: Meister Publishing Co., 1986.,p. C-179].

Penta Ready contains 5.3% PCP /Los Angeles Chemical Co/ [Farm Chemicals Handbook 1986. Willoughby, Ohio: Meister Publishing Co., 1986.,p. C-179].

Penta WR contains 5.0% PCP /Los Angeles Chemical Co/ [Farm Chemicals Handbook 1986. Willoughby, Ohio: Meister Publishing Co., 1986.,p. C-179].

Technical PCP contains lower chlorinated phenols (4-12%) plus traces of chlorobenzodioxins, chlorobenzofurans, and chlorobenzenes. [Morgan DP; Recognition and Management of Pesticide Poisonings. 4th ed. p.73 EPA 540/9-88-001. Washington, DC: U.S. Government Printing Office, March 1989].

Chem.Detail: Detailed Information on Chemical/Physical Properties:

Solubilities [940]:

0.002 G/100 G of water at 30 DEG C [Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 443].

Slightly sol in petroleum ether [Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-432].

Sol in most organic solvents; slightly sol in paraffins [Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 641].

5 mg/l in water @ 0 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

14 mg/l in water @ 20 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

35 mg/l in water @ 50 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

85 mg/l in water @ 70 deg C [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

Sol in ether [Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988.,p. C-414].

Sol in dilute alkali, carbitol, cellosolve [ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 399].

2 g/100 g in carbon tetrachloride at 20 deg C [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 13(81) 479].

8.5 g/100 g in o-dichlorobenzene at 20 deg C [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 13(81) 479].

3.1 g/100 g in diesel oil @ 20 deg C [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 13(81) 479].

32 g/100 g in pine oil @ 20 deg C [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 13(81) 479].

1.5 g/100 g in Stoddard solvent @ 20 deg C [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 13(81) 479].

In acetone: 50 g/100 g @ 25 deg C [USEPA; Wood Preservative Position Doc 2/3 p.14 (1981) EPA 341-085/4643].

In benzene: 15 g/100 g @ 25 deg C [USEPA; Wood Preservative Position Doc 2/3 p.14 (1981) EPA 341-085/4643].

In diacetone alcohol: 190 g/100 g @ 25 deg C [USEPA; Wood Preservative Position Doc 2/3 p.14 (1981) EPA 341-085/4643].

In ethanol (95%): 120 g/100 g @ 25 deg C [USEPA; Wood Preservative Position Doc 2/3 p.14 (1981) EPA 341-085/4643].

In methanol: 180 g/100 g @ 25 deg C [USEPA; Wood Preservative Position Doc 2/3 p.14 (1981) EPA 341-085/4643].

In isopropanol: 85 g/100 g at 25 deg C [USEPA; Wood Preservative Position Doc 2/3 p.14 (1981) EPA 341-085/4643].

In ethylene glycol: 11 g/100 g @ 25 deg C [USEPA; Wood Preservative Position Doc 2/3 p.14 (1981) EPA 341-085/4643].

Vapor Pressure [940]:

0.00011 mm Hg at 25 deg C [Callahan MA et al; Water-Related Environmental Fate of 129 Priority Pollutants p 87-4 EPA-440/4-79-029b (1979)].

0.12 MM HG AT 100 DEG C [Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 443].

Octanol/Water Partition Coefficient [940]:

Log Kow= 5.12 [Hansch, C. and A. Leo. The Log P Database. Claremont, CA: Pomona College, June 1984.].

Density/Specific Gravity [940]:

1.978 AT 22 DEG C/4 DEG C [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

Molecular Weight [940]:

266.35 [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

Corrosivity [940]:

Noncorrosive in absence of moisture [Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 641].

Vapor Density [940]:

9.20 (air= 1) [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

Boiling Point [940]:

309-310 DEG C (DECOMP) [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

Melting Point [940]:

190-191 DEG C [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

Color/Form [940]:

Colorless crystals (pure); dark greyish powder or flakes (crude product) [Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 443].

Solid beads or flakes [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.].

White monoclinic, crystalline solid [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 953].

Needle-like crystals [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

Odor [940]:

Phenolic odor [Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 443].

Very pungent odor only when hot [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1126].

Taste [940]:

Taste threshold of 30 ug/l. [USEPA; Ambient Water Quality Criteria Doc: Pentachlorophenol p.C-33 (1980) EPA 440/5-80-065].

Other Chemical/Physical Properties [940]:

Density of saturated air: 1.0000011 (Air= 1); percent in saturated air: 0.0000145% By volume at 20 deg c; 1 mg/l is equivalent to 91.9 Ppm & 1 ppm is equivalent to 0.01088 Mg/l at 25 deg C [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2605].

Technical grade: dark grey; MP 187-189 deg C [Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 641].

DRY MATERIAL COMMENCES TO DECOMPOSE AT 392 DEG F, & DECOMPOSES AT BP 592 DEG F [National Fire Protection Association. Fire Protection Guide on Hazardous Materials. 9th ed. Boston, MA: National Fire Protection Association, 1986.,p. 49-71].

Koc = 1000(calc) [SRC; Kenaga EE; Ecotox Environ Safety 4: 26-38 (1980)].

Measured Koc = 3000-4000. [SRC; Delaune RD et al; pp. 297-308 in Environ Pollut (Series B) 6 Appl Sci Essex England (1983)].

Fate.Detail: Detailed Information on Fate, Transport, Persistence, and/or Pathways:

Information from HSDB [940]:

TERRESTRIAL FATE: Results of an environmental partitioning model indicate that pentachlorophenol partitions mainly in soil (96.5%)(1). Photolysis and hydrolysis of pentachlorophenol do not appear to be significant processes in soil. Pentachlorophenol released to soil will biodegrade with half-lives of weeks to months. If the pentachlorophenol dissociates in soil (possible because the pKa= 4.74), little volatilization will occur but leaching to groundwater is possible (dependent upon pH of soil). A survey of 4 RCRA sites that contained wood preserving plants with surface impoundments indicated that all had some groundwater contamination extending down 20 to 60 ft(2). However, considerable amounts of the formulated pesticide applied to soil has been shown to volatilize(SRC). [(1) Hattemer-Frey HA, Travis CC; Arch Environ Contam Toxicol 18: 482-9 (1989) (2) Ball J; Proc Ind Waste Conf 41: 347-51 (1987)].

AQUATIC FATE: Pentachlorophenol released to water undergoes photolysis(1-2). A reported half-life for photolysis of pentachlorophenol is 0.86 hrs(3). Biodegradation probably becomes significant after a period of acclimation (may be several weeks). Adsorption to sediments will be considerable. Hydrolysis and volatilization are not important processes in water (SRC). [(1) Callahan MA et al; Water Related Environmental Fate of 129 Priority Pollutants pp. 81-4 USEPA 440/4-79-029b (1979) (2) Weiss VM et al; J Agric Food Chem 30: 1191-4 (1982) (3) Svenson A, Bjorndal H; Chemosphere 17: 2397-405 (1988)].

ATMOSPHERIC FATE: Pentachlorophenol has been detected associated with particulate matter in air. This pentachlorophenol will be lost by gravitational settling. Vapor phase pentachlorophenol will be lost by photolysis and to a lesser extent, reaction with photochemically produced hydroxyl radicals. The loss from these process in noon-day summer sunshine is 6.2 and 1.5%hr, respectively(1,SRC). [(1) Bunce NJ, Nakai JS; Air Pollut Control Assoc 39: 820-3 (1989)].

Biodegradation [940]:

Screening biodegradability tests give conflicting results(1-7); pentachlorophenol does biodegrade but may require several weeks for acclimation(3-7). [(1) Alexander M, Aleem MIH; J Agric Food Chem 9: 44-7 (1961) (2) Baker MD et al; Water Res 14: 1765-71 (1980) (3) Kirsch EJ, Etzel JE; J Water Pollut Control Fed 45: 359-64 (1973) (4) Korte F, Klein W; Ecotoxicol Environ Saf 6: 311-27 (1982) (5) Rott B et al; Chemosphere 11: 531-8 (1982) (6) Schefer W, Walechi O; Z Abwasser Forsch 13: 205-9 (1980) (7) Tabak HH et al; J Water Pollut Control Fed 53: 1503-18 (1981)].

Pcp applied to rice fields. ... Microorganisms reductively dechlorinated pcp. Products found & identified were 2,3,4,5-, 2,3,5,6- & 2,3,4,6-tetrachlorophenol, 2,4,5- & 2,3,5-trichlorophenol, 3,4- & 3,5-dichlorophenol, & 3-chlorophenol. [Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior, Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. GovernmentPrinting Office, l974. 288].

The main degradation products of pentachlorophenol in soil are 2,3,7,8-tetrachlorophenol and CO2. [Knowlton MF, Huckins JN; Bull Environ Contam Toxicol 30: 206-13 (1983)].

Little biodegradation was noted in 40 days in a river die-away study or in stream sediment(1). However, approximately 6% biodegradation occurred in aerobic soil in 160 days(2) while no biodegradation occurred in anaerobic soil(2). Other studies in soil have suggested greater biodegradation under anaerobic conditions producing pentachloroanisole and tri- and tetrachlorophenols(3-4). A study of biodegradation in estuarine sediment indicated that pH and redox potential considerably affected degradation; significant biodegradation (70%-35 days, 17 day lag period) was only noted at pH 6.5 and 8.0 at redox potential of +500 MV(5). [(1) Baker MD et al; Water Res 14: 1765-71 (1980) (2) Baker M, Mayfield CI; Water Air Soil Pollut 13: 411 (1980) (3) Ide A et al; Agric Biol Chem 36: 1937-44 (1972) (4) Murthy NBK et al; J Environ Sci Health B 14: 1-14 (1979) (5) Delaune RD et al; Environ Pollut Ser B 6: 297-308 (1983)].

Half-life in soil is approximately weeks to months(1-3). The main degradation products of pentachlorophenol in soil are 2,3,7,8-tetrachlorophenol and CO2(4). In an artificial stream, microbial degradation became significant after 3 weeks and accounted for 26-46% removal(5). Pentachlorophenol mineralization in the relatively unpolluted water of Long Island Sound and water from several sites in the Hudson Estuary in summer was also very low (<5 ng/L per day)(6). 3 and 5 ppm PCP were completely degraded in 38 and 57 days respectively when incubated in Pennsylvania and Virginia unsaturated soils taken at 4 and 4.5 m depths(7). [(1) Ide A et al; Agric Biol Chem 36: 1937-44 (1972) (2) Murthy NBK et al; J Environ Sci Health B 14: 1-14 (1979) (3) Rao PSC, Davidson JM; Retention and Transformation of Selected Pesticides and Phosphorus in Soil-Water Systems. USEPA 600/S3-82-060 (1982) (4) Knowlton MF, Huckins JN; Bull Environ Contam Toxicol 30: 206-13 (1983) (5) Pignattello JJ et al; Appl Environ Microb 46: 1024-31 (1983) (6) Hudak JP et al; Mar Ecol Progress Series 47: 97-102 (1988) (7) Smith JA, Novak JJ; Water Air Soil Pollut 33: 29-42 (1987)]].

Laboratory and full-scale investigation of pentachlorophenol removal in activated sludge systems has had conflicting results(1). An investigation of reasons for these conflicting results employing bench-scale continuous flow reactors found that it was important to maintain an adequate solids retention time between 10 and 20 days to achieve high removals. These investigations obtained essentially complete pentachlorophenol removal(1). In another recent study 31% mean removal of pentachlorophenol was obtained from a activated sludge pilot plant(2). Since pentachlorophenol is poorly associated with sludge solids and is unlikely to be removed by stripping(1), significant biodegradation was assumed to have occurred. The anaerobic biodegradation potential of pentachlorophenol under methanogenic conditions was assessed by incubating 50 mg of carbon with digester sludge in serum bottles for 60 days(3). Under these conditions pentachlorophenol was inhibitory (i.e., total gas production declined). [(1) Melcer H, Bedford WK; J Water Pollut Control Fed 60: 622-6 (1988) (2) Bussion RSK et al; Water Air Soil Pollut 37: 419-32 (1988) (3) Battersby NS, Wilson V; Appl Environ Microbiol 55: 433-9 (1989)].

The acute toxicity of pentachlorophenol (PCP) was determined at pH levels 4, 6, 9 to the midge, Chironomus riparius, with the findings that PCP is of greatest toxicity at pH 4 and of least toxicity at pH 9. This differential toxicity is attributable to variations in uptake levels at the respective pH levels. At pH 4, PCP is fully protonated and therefore highly lipophilic. The amount of [14C]PCP present in the midges at 24 hr is thus highest at pH 4. Conversely, at pH 9, the compound is completely ionized. The reduction in lipophilicity at pH 9 decreases the ability of the compound to penetrate into the midge, thereby decreasing the observed toxicity of the compound. [Fisher SW, Wadleigh RW; Ecotoxicol Environ Safety 11 (1): 1-8 (1986)].

The 2nd year of a 2 year study of the fate of pentachlorophenol in outdoor artificial streams focused on details of microbial degradation by a combination of in situ and laboratory measurements. Replicate streams were dosed continuously at pentachlorophenol concentrations of 0, 48, and 144 ug/l, respectively, for an 88 day period during the summer of 1983. Pentachlorophenol was degraded both aerobically and anaerobically. Aerobic degradation was more rapid than anaerobic degradation. Mineralization of pentachlorophenol was concomitant with pentachlorophenol disappearance under aerobic conditions, but lagged behind loss of the parent molecule under anaerobic conditions. Biodegradation in the streams, or in specific stream compartments such as the sediment or water column, was characterized by an adaptation period (3-5 weeks for the stream as a whole, and reproducible from the previous year), which was inversely dependent on the concentration of pentachlorophenol and microbial biomass. The adaptation in the streams could be attributed to the time necessary for selective enrichment of an initially low population of pentachlorophenol degraders on surface compartments. The extent of biodegradation in the streams (percent loss of initial concentration of pentachlorophenol) increased with increasing pentachlorophenol input, which was explicable by an increase in the pentachlorophenol degrader population with increasing pentachlorophenol concentration. The sediment zone most significant to overall pentachlorophenol biodegradation was the top 0.5 to 1 cm layer as shown by pentachlorophenol migration rates and depth profiles of degrader density within the sediment. Pentachlorophenol profiles in sediment cores taken during and after the adaptation period for degradation showed that diffusion of pentachlorophenol into the sediment was rate limiting to degradation in this compartment. [Pignatello JJ et al; Can J Microbiol 32 (1): 38-46 (1986)].

Abiotic Degradation [940]:

Pentachlorophenol does not appear to oxidize or hydrolyze under environmental conditions; however, photolysis of the dissociated form in water appears to be a significant process(1-2). A measured half-life for the photolysis of pentachlorophenyl has been reported to be 0.86 hrs(7). In water at pH 7.3, 90% degradation occurred in 10 hr with sunlight while at pH 3 (mostly undissociated form), 40% degradation occurred in 90 hr(2). Reported half-lives for photodegradation of the dissociated form have included 0.2 hr (10 cm deep)(1), 3.5 hr(2), 4.75 hr (300 cm deep)(1), and 10 days(3). Products of photodegradation include 2,3-dichloromaleic acid, 2,3,5,6- and 2,3,4,6-tetrachlorophenol, tetrachlororesorcinol, tetrachlorocatechol, some benzoquinones(2-3), and possibly dioxins(5). Photolysis in a solution of H2O-CH3CN using 290 nm wavelengths and a pH of 12 produces the photoproduct 2-methyl-4,5,6,7-tetrachlorobenazole(6). [(1) Callahan MA et al; Water Related Environmental Fate of 129 Priority Pollutants pp. 87-4 USEPA 440/4-79-029b (1979) (2) Weiss UM et al; J Agric Food Chem 30: 1191-4 (1982) (3) Munakata K, Kuwakara M; Res Rev 25: 13-23 (1969) (4) Wong AS, Crosby DG; J Agric Food Chem 29: 125-30 (1981) (5) Lamparski LL et al; Environ Sci Technol 14: 196-200 (1980) (6) Choudhry GG et al; Can J Chem 65: 2223-33 (1987) (7) Svenson A, Bjorndal H; Chemosphere 17: 2397-405 (1988)].

Photolysis of pcp produced octachlorodibenzo-p-dioxin & smaller amt of heptachloro analog. In other studies, photolysis of solid pcp in oxygen stream produced some co2 & hcl. [Menzie, C.M. Metabolism of Pesticides, Update II. U.S. Department of the Interior, Fish Wildlife Service, Special Scientific Report - Wildlife No. 2l2.Washington, DC: U.S. Government Printing Office, 1978. 221].

Pentachlorophenol was completely degraded in hexane at a wavelength range of 252.6 to 318.6 nm in a 10 ppm solution by 33.3 min irradiation(1). Photodegradation in soil does not appear to be significant(2), however, photodegradation is catalyzed by some metallic oxide such as TiO2(3). Using the quantum yields and solar intensity data relevant to 40 deg N at noon in summer, 6.2%/hr of vapor-phase pentachlorophenol should undergo photolysis(4). The estimated rate constant for attact by hydroxyl radicals is 4.7X10-13 cu cm/mcule-sec. This gives a half-life of 66 hr or a loss of 1.5%/hr, assuming a peak noon summer hydroxyl radical concentration of 6.2X10+6 radicals/cu cm(4). [(1) Koshioka M et al; J Pestic Sci 12: 229-36 (1987) (2) Baker MD, Mayfield CI;Water Res 14: 1765-71 (1980) (3) Choudhry GG et al; Toxicol Environ Chem 17: 267-86 (1988) (4) Bunce NJ, Nakal JS; J Agric Pollut Control Assoc 39: 820-3 (1989)].

PCP readily decomp in sunlight to monomeric & dimeric oxidation products in water. Principal decomp products are tetrachlororesorcinol, chloroanilic acid, & dimeric products. [Kearney, P.C., and D. D. Kaufman (eds.) Herbicides: Chemistry, Degredation and Mode of Action. Volumes 1 and 2. 2nd ed. New York: Marcel Dekker, Inc., 1975. 678].

Soil Adsorption/Mobility [940]:

Pentachlorophenol has a tendency to adsorb to soil and sediment; calculated Koc= 1000(1), measured sediment Koc= 3,000-4,000(2). Adsorption to oxidized sediment is higher than to reduced sediment(2). Adsorption to soil and sediment appears to be pH dependent, stronger under acid conditions(3). Approximately 15% of the dose in an artificial freshwater stream adsorbed to sediments(4). An accidental spill in a lake resulted in pentachlorophenol in the sediment(5). After a 180 day microcosm experiment using radioactive substrate, 40 to 43% of the radioactivity was present in the sediments(6). [(1) Kenaga EE; Ecotox Environ Safety 4: 26-38 (1980) (2) Delaune RD et al; pp. 297-308 in Environ Pollut (Series B) 6 Appl Sci Essex England (1983) (3) Callahan MA et al; Water Related Environmental Fate of 129 Priority Pollutants pp. 87-4 USEPA-440/4-9-029b (1979) (4) Pignatello JJ et al; Appl Environ Microbiol 46: 1024-31 (1983) (5) Pierce RH Jr, Victor DM; pp. 41-52 in Pentachlorophenol: Chemistry, Pharmacology and Environmental Toxicology. KR Rao (ed) Plenum Press NY (1978) (6) Knowlton MF, Huckins JN; Bull Environ Contam Toxicol 30: 206-13 (1983)].

Since pentachlorophenol has a pKa of 4.74(1), its adsorptivity will be strongly dependent on pH. The Freundlich adsorption constant for 6 Dutch soils are (soil (% organic carbon, pH) log KF, 1/N): humic sand (1.7%, 3.4) 2.2, 0.9; humic sand (2.2%, 4.9) 2.2, 0.9; humic-rich sand (3.2%, 4.7) 2.6, 1.0; peat (29.8%, 4.6) 3.3, 0.8; light loam (0.9%, 7.5) 1.1, 0.9; heavy loam (1.7%, 7.1) 1.5, 0.8(1). For loam soil where pH >pKa, significant contribution from the phenolate ion can be expected. The Koc values for the total dissociated phenol was calculated to be 1250 and 1800 for light and heavy loam, respectively, while for the undissociated species, the Koc is 25,000(1). [(1) Lagas P, Chemosphere 17: 205-16 (1988)].

Volatilization from Water/Soil [940]:

The low water solubility (14 ppm) and moderate vapor pressure (0.00011 torr at 20 deg C) would suggest that evaporation from water is not rapid, especially at natural pHs where pentachlorophenol is present in the dissociated form (pKa= 4.74)(1). This agrees with a field study in an artificial stream in which <0.006% of the added pentachlorophenol was lost by volatilization(2). However, significant amounts (25-51%) of pentachlorophenol in terrestrial microcosms have been detected in the air(3-4), which suggests that evaporation from soil or formulated pesticide will be significant(5). [(1) Callahan MA et al; Water-Related Environmental Fate of 129 Priority Pollutants pp. 87-4 USEPA-440/4-79-029b (1979) (2) Pignatello JJ et al; Appl Environ Microbiol 46: 1024-31 (1983) (3) Gile JD, Gillett JW; J Agr Food Chem 27: 1159-64 (1979) (4) Metcalf RL et al; Design and Evaluation of a Terrestrial Model Ecosystem for Evaluation of Substitute Pesticide Chemicals p. 308 USEPA 600/3-79-004 (1979) (5) Weiss UM et al; J Agric Food Chem 30: 1191-4 (1982)]].

Absorption, Distribution and Excretion [940]:

1. Rapid absorption of pentachlorophenol has been reported in rodents, monkeys, & humans following oral, dermal, or inhalation exposure. ... The major tissue deposits vary somewhat between species. In humans whose deaths were not related to pentachlorophenol exposure, the liver (containing pentachlorophenol residues of 0.067 ug/g), kidney, brain, spleen, & fat (0.013 ug/g) appeared to be major deposition sites. In the mouse, the gall bladder is a principal storage site. In the rat, it is the kidney. [National Research Council. Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986. 385].

2. When worker exposure to pentachlorophenol at wood treatment plant was measured over 5 mo period, serum & urine levels ... Were 348.4 To 3963 ug/l & 41.3 To 760 ug/l, respectively. Pentachlorophenol residues in workplace air were in the range of 5.1 To 15275.1 Ng/cu m. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 309 (1979)].

3. (14)C-Pcp was admin to mice by sc or ip injection. Most of the activity (72-83%) was excreted in urine in 4 days; about half, in 24 hr; & only trace (0.05%), In expired air. High activity observed in gallbladder & its contents, wall of stomach fundus, contents of gi tract & liver. [Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior, Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. GovernmentPrinting Office, l974. 287].

4. Enterohepatic circulation of pentachlorophenol occurs in monkeys & mice. In rats, it is found mainly in plasma protein; liver & kidney have highest tissue concn. Plasma half-lives at 10 mg/kg body wt dose were about 15 hr in rats & 78 hr in macaca mulatta monkeys. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 316 (1979)].

5. Unless renal & liver functions are impaired, pentachlorophenol is rapidly eliminated from blood & tissues. [Morgan, D.P. Recognition and Management of Pesticide Poisonings. EPA 540/9-80-005. Washington, DC: U.S. Government Printing Office, Jan. 1982. 22].

6. Pentachlorophenol has been detected in human blood plasma at levels of 15.69 To 15.86 Ug/l in hemodialyzed pt & 15.0 Ug/l in persons used as control. It also has been detected in urine, seminal fluid (20-70 ug/kg) & fingernails of non-occupationally exposed individuals. Pentachlorophenol was

found in 85% of 416-418 samples of urine collected from general population ... Max level was 193 ug/l & mean level 6.3 Ug/l. ... Urine samples taken at 25 factories using pentachlorophenol ... Showed that avg worker's exposure to pentachlorophenol in air was 0.013 Mg/cu m, with max range of 0.004-1.000 Mg/ cu m, & level in urine ranged from 0.12 To 9.68 Mg/l. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 308 (1979)].

7. Small amounts have been shown to cross the placenta. [Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 443].

8. Plasma and urinary pentachlorophenol was measured in 209 workers who had occupational exposure to wood preservatives containing this compound and 101 workers not exposed occupationally to pentachlorophenol. Workers were examined for chloracne and blood concentrations of bilirubin, gamma-glutamyltransferase, cholesterol and high-density lipoproteins were determined. All the occupationally exposed groups showed evidence of pentachlorophenol absorption; highest mean concentrations were found in timber treatment operatives (6.0 mmol/l for plasma and 274 nmol/mmol of creatinine for urine). [Jones RD et al; Hum Toxicol 5 (3): 189-94 (1986)].

9. Pentachlorophenol was given orally to ... volunteers at single doses of 3.9, 4.5, 9, and 18.8 mg. Daily urinary excretion of pentachlorophenol and pentachlorophenol conjugated to glucuronic acid was monitored using gas chromatography with electron capture detection. Based on first order elimination kinetics an elimination half-life of 20 days was derived. To eliminate interference by the uncontrolled absorption of pentachlorophenol from the environment 0.98 mg (13)C-pentachlorophenol was taken by one of the volunteers. Pentachlorophenol levels in urine and plasma were determined using mass spectrometry with negative chemical ionization. An elimination half-life of 17 days was found in both urine and blood. The collected data were used to calculate the clearance of pentachlorophenol: a value of 0.07 m1/min was found. The long elimination half-life of pentachlorophenol is explained by the low urinary clearance due to the high plasma protein binding (> 96%) and the tubular reabsorption. The pH-dependency of the elimination of pentachlorophenol was investigated, and a distinct increase in the daily excretion was observed following alkalinization by oral administration of sodium bicarbonate. In order to elucidate the role of the enterohepatic circulation as a possible pool for pentachlorophenol in humans, the bile of cholelithiasis patients with postoperative T-drainage was investigated for pentachlorophenol and compared with the corresponding urine and plasma levels, but no accumulation of pentachlorophenol in the enterohepatic circulation could be observed. The daily

elimination and plasma levels of pentachlorophenol in a group of individuals without a specific exposure were found to range from 10 to 48 ug/day and 19 to 36 ug/1, respectively. [Uhl S et al; Arch Toxicol 58 (3): 182-6 (1986)].

10. Urine from 230 Finnish sawmill workers exposed to a combination of 2,3,4,6-tetrachlorophenol (80%), 2,4,6-trichlorophenol (10-20%), and pentachlorophenol (5%), was analyzed for the sum of the three chemicals as chlorophenols. Samples were collected at the end of the work shift. Workers were divided into the following exposure groups according to work tasks: primarily skin exposure (n= 112), primarily respiratory tract exposure (n= 34), and equal exposure by both routes (n= 84). Air concentrations at the workplace and amount of time spent with skin contact were not studied. There was no control group; values were compared to the nonexposed Finnish population level of < 0.1 umol/l. Skin absorption was the most effective route of exposure as reflected by urinary chlorophenol concentrations. The median concentration in workers with skin absorption was 7.8 umol/l (range 0.1 to 210.9 umol/l) and was significantly different from that in workers with the respiratory tract as the main route of exposure (median concentration 0.9 umol/l; range 0.1 to 13.3 umol/l; p< 0.001) and from those with both routes of equal importance (1.4 umol/l; range 0.1 to 47.8 umol/l; p< 0.001). /Tri-, Tetra-, and Pentachlorophenols/ [Lindroos L et al; Int Arch Occupat Environ Health 59 (5): 463-7 (1987)].

11. The compounds are readily absorbed from the gastroenteric tract and from parenteral sites of injection. /Chlorophenols/ [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2614].

12. Chlorophenols ... are readily absorbed from all routes including percutaneous and inhalation. /Chlorophenols/ [Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 963].

13. Plasma half-life in man is 30.2 + or - 4.0 hr. Half-lives for elimination of pentachlorophenol and pentachlorophenol-glucuronide from the urine are 33.1 + or - 4.5 and 12.7 + or - 5.4 hr, respectively. [USEPA; Ambient Water Quality Criteria Doc: Pentachlorophenol p.C-18 (1980) EPA 440/5-80-065].

14. Plasma half-lives of 10 mg/kg body wt dose were about 15 hr in rats & 78 hr in macaca mulatta monkeys. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V20 316 (1979)].

15. The dependence of bats in Britain on houses as roosts may

result in them being exposed to pesticides used in remedial timber treatments Pentachlorophenol and permethrin are used as a fungicide and a insecticide for timber treatment, respectively. The present study investigated toxicity and distribution in body tissues of these two pesticides in pipistrelle bats. Four groups of nine to ten bats were kept in separate outdoor flight enclosures and were provided with roost boxes treated with either pentachlorophenol only, permethrin, pentachlorophenol/permethrin mixture or solvent only (control). At the start of the experiment, mean (: standard error) pentachlorophenol and permethrin concentrations on the surface of wooden blocks that had been treated in the same way as roost boxes were 69.32 : 6.76 mg/g (n = 6) and 3.3 : 1.6 mg/g (n = 3), respectively. All bats exposed to pentachlorophenol and pentachlorophenol/permethrin treated boxes died within 24 and 120 hr, respectively; nine out of the ten controls survived the 32 day experimental period (p< 0.001; both groups compared with control). Bats exposed to permethrin treated boxes survived as well as controls. Mean (: standard error) carcass pentachlorophenol concentration (excluding deposits on fur) of bats exposed to pentachlorophenol and pentachlorophenol/permethrin treated boxes was 13.11 : 2.52 ug/g body wt (n = 20). Pentachlorophenol burdens on fur were positively correlated with total weight of Pentachlorophenol in the carcass (p< 0.001). Pentachlorophenol was present in fat depots, liver, kidney and the remainder of the body which, despite containing low pentachlorophenol concentrations, was the main pentachlorophenol reservoir (66.4 : 5.0% of carcass pentachlorophenol load; n = 20). Total pentachlorophenol in the carcass was significantly correlated with lipid weight (p< 0.005). Permethrin was not detectable in body washes and tissues of bats exposed to pentachlorophenol/permethrin mixture or permet. [Shore RF et al; Environ Pollut 73 (2): 101-18 (1991)].

16. A pilot study was conducted to determine the overall efficiency of transdermal penetration of pentachlorophenol and tetrachlorophenol applied to human cadaver skin. Two commercially available wood preservatives were tested, one diesel oil based and the other a water based product. To simulate human exposure conditions at the workplace, small doses were used. The objective was to document the portion of applied dose which permeated the skin and to examine the effect of vehicle or formulation on the relative and absolute absorption of the chlorinated compounds. The penetration of the diesel oil preparations was 62% for pentachlorophenol and 63% for tetrachlorophenol. In the case of the aqueous based preparation, penetration was 16% for sodium-pentachlorophenate and 33% for sodium tetrachlorophenate. The incomplete recovery of each compound may have been due in part to the irreversible binding or unfavorable partitioning of the chlorophenols which would be consistent with the lipophilic character of these compounds. [Horstman SW et al; J Environ Sci Health A24 (3):

229-42 (1989)].

17. The excretion and conjugation of chlorophenols were studied in workers exposed to 2,4,6-tri-, 2,3,4,6-tetra-, and pentachlorophenolates, the main components of the chlorophenolate product manufactured by direct chlorination of phenol. The workers were exposed in two different saw mills in which sodium chlorophenolate was used for treatment of lumber during the warm season. Urine specimens were collected at the end of the treatment season as well as at the start of a new treatment period in the spring. Serum specimens were collected towards the end of the treatment period. Total and unconjugated chlorophenols were analyzed with a GC method. The maximal concentrations of urinary 2,4,6-tri-, 2,3,4,6-tetra- and pentachlorophenol at the end of the lumber-treatment period were 1-11.8, 3.4-17.3, and 0.2-0.9 umol/l, respectively, and the average apparent half-times calculated using a one compartment model were 18 hr, 4.3 days and 16 days, respectively. For 2,3,4,6-tetrachlorophenol, the data of some subjects showed a better fit with a two compartment model; the corresponding half-times were 5.3 and 26 days. During the continuous-exposure period the average serum levels of tetra- and pentachlorophenol were rather similar before and after the working day: 2.79 + or - 1.78 umol/l for tetrachlorophenol and 0.85 + or - 0.4 umol/l for pentachlorophenol. Renal clearance values for tetra- and pentachlorophenol were related to urine flow and indicated tubular reabsorption. At low concentrations, sulfate conjugation was dominant. With increasing chlorophenol concentrations the proportion of glucuronide conjugation was increased, especially for pentachlorophenol. [Pekari K et al; Int Arch Occup Environ Health 63 (1): 57-62 (1991)].

Laboratory and/or Field Analyses:

Many lab methods have been used for pentachlorophenol [861,938,1010,1011,1013]. In the past, for drinking water, EPA has recommended that determination of pentachlorophenol is by a liquid-liquid extraction gas chromatographic procedure [893]. PCP has been analyzed by various semi-volatile methods [861].

EPA methods for NPDES permits are specified in 40 CFR Part 136 [1010]. EPA methods for drinking water are specified in 40 CFR Part 141 [1011].

EPA (RCRA Group) publishes requirements for solid waste methods in 40 CFR Part 261, Appendix III, with details in the following periodically updated publication [1013]:

Environmental Protection Agency. 1995. Test methods for evaluating solid waste, physical/chemical methods, SW-846, EPA Office of Solid Waste and Emergency Response, EPA, Washington, D.C. [1013]. Available from NTIS.

The guidance in SW-846 must be used in some states, but is considered "guidance of acceptable but not required methods" in most federal applications. RCRA (SW-846) methods tend to include provisions for using the specified method or something better, whereas the CERCLA CLP methods tend to require things done exactly per contract specifications. RCRA SW-846 methods typically require instrument calibration before analyses, but some labs don't do it, and many labs actually use some kind of hybrid between RCRA, CERCLA, or other "standard protocols" (Roy Irwin, Park Service, Personal Communication, 1997, based on conversations with various EPA and lab staff).

In the past, EPA has also published separate (not SW-846) guidance documents with suggestions on field sampling and data quality assurance related to sampling of sediments [1016] and soils [1017,1018,1019].

Since they are designed for highly contaminated superfund sites, the CERCLA (CLP) methods typically have higher detection limits than many other EPA standard methods and are thus less appropriate for use in baseline assessments of very clean areas or for use in analyzing environmental concentrations for comparison with low-concentration criteria or benchmarks. EPA (CERCLA) publishes various Contract Laboratory Program (CLP) methods documents periodically, with information available from EPA, NTIS, and the internet. A few past examples (this list is not complete) [861]:

User's Guide CLP CERCLA User's Guide to the Contract Laboratory Program. USEPA - Office of Emergency and Remedial Response. Dec 1988

9240_0-0XFS Multi-Media/Conc Superfund OSWER CERCLA Multi-Media, Multi-Concentration Organic/Inorganic Analytical Service for Superfund, Quick Reference Fact Sheets, 9240.0-08FS (organic) and 9240-0-09FS (inorganic), August 1991. The organic/inorganic analytical service provides a technical and contractual framework for laboratories to apply EPA/Contract Laboratory Program (CLP) analytical methods for the isolation, detection and quantitative measurement of 33 volatile, 64 semi-volatile, 28 pesticide/Aroclor, and 24 inorganic target analytes in water and soil/ sediment environmental samples.

For optimum risk or hazard assessment work for pentachlorophenol, most of the above listed methods are inadequate and semi-volatile methods with low detection limits (at least as low as criteria and benchmarks for the media of concern: see water, soil, sediment, and tissue sections above) should be used to avoid false negatives. Recommended Detection Limits:

GC/ECD (electron capture detector) methods can achieve 0.5 ppb for tissues and 0.1 ppb detection limits for water, sediments and soil [933]; these detection limits should be used as default detection limits when potential impacts to living things are being considered. Drinking water detection limits are 0.00004 mg/L [1011]. Some use CLP methods such as 625 or 8040, but EPA CERCLA detection limits in the CLP program are

> 5-20 ug/L, too high for most purposes other than severely contaminated superfund sites.

As of 1996, EPA was also publishing method 8270C for semi-volatiles including PCP in solids such as soil and sediments. The 8270 methods are GC/MS capillary column techniques [861]. The use of 8270/SIM methods in the third update of EPA RCRA guidance SW-846 [1013] may be needed to get sufficiently low detection limits for risk or damage assessment purposes.

ATSDR summarized additional HPLC and other methods for biological and other media [933].

Although not considered a VOC [868,903], PCP is a semi-volatile. Significant amounts (25-51%) of pentachlorophenol in terrestrial microcosms have been detected in the air, suggesting that evaporation from soil will be significant [940]. Therefore, regardless of what lab methods are used, the investigator must take special precautions to prevent the escape of a portion of the semi-volatile substance during sample shipment, storage, extraction, and cleanup [798]. See field methods discussion below for more details.

The investigator should also specify the addition of any relevant compounds suspected of being present but not typically found on the standard EPA scans;

> One pathway transforms pentachlorophenol to less chlorinated phenols. Pentachlorophenol is a metabolite of various environmental chemicals and is itself metabolized (Renner G, Mucke W; Toxicological and Environmental Chemistry 11, 1: 9-29, 1986) [940].

> PCP is a major metabolite of HCB, also known as hexachlorobenzene (The Royal Society of Chemistry. Foreign Compound Metabolism in Mammals. Volume 6: A Review of the Literature Published during 1978 and 1979. London: The Royal Society of Chemistry, 1981. 327) [940]. Therefore, when PCP is found in areas of no known PCP source, perhaps HCB should also be analyzed (Roy Irwin, National Park Service, Personal Communication, 1996).

> TCH (p-tetrachlorohydroquinone), a metabolite of the environmental chemical pentachlorophenol (PCP), is more toxic to cultured CHO cells than PCP, and it causes DNA single-strand breaks concentrations of 2-10 microgram/ml (Ehrlich W; Mutat Res 244, 4,: 299-302, 1990) [940]. The metabolite tetrachlorohydroquinone might be a real genotoxic agent, capable of binding to DNA and producing DNA strand breaks (Seiler JP; Mutat Res 257, 1, 27-47, 1991) [940].

> Holding Times:

>> Water Samples: Both NPDES and RCRA (SW-846) maximum holding times are 7 days until extraction and 40 days after extraction [1010,1013].

Samples of Solids: EPA RCRA methods for semi-volatiles in solids in SW-846 call for holding times of 14 days until extraction and 40 days after extraction [1013]. The need to get rid of headspace to prevent loss of certain lighter semi-volatiles tends to discourage the freezing of soil and other samples. However, the Fish and Wildlife Service and some other groups nevertheless freeze some soil samples. If this can be accomplished without compromising the sample (for example, breaking a glass container), the freezing tends to stop biodegradation. Once frozen, holding times for samples of semi-volatiles such as PAHs in solids is on the order of decades (John Moore, Fish and Wildlife Service, Personal Communication, 1997).

Field Collection Protocols:

Standard field collection method protocols are published by the Fish and Wildlife Service, the USGS, NOAA, and EPA. These recommendations change over time, with the newest recommendations sometimes being quite different than the old, thereby producing different results. The Fish and Wildlife Service methods are similar in many ways to NOAA field protocols [676]. Many recommended EPA field methods for organics are not very detailed, although the 3rd update of SW-846 for RCRA solid waste methods is becoming more detailed [1013]. For the lighter semi-volatiles, it may be prudent to use EPA method 5021 in SW 846 is a generic "headspace" method for the collection of volatiles in soils and sediments [1013].

The various EPA methods for organics are different from each other, with the selection of the appropriate method depending upon the specific application (RCRA vs. CERCLA vs. NPDES permits, vs. Drinking Water, etc.) [861,1010,1013]. The EPA-recommended field methods are scattered through various EPA and ASTM publications.

EPA methods typically include recommendations that grab samples rather than composites be utilized for organics, and require the proper cleaning of collection bottles and collecting gear for both volatile and semi-volatile organics [1010,1013]. The USGS NAWQA protocols call of sieving of sediment samples composites, a practice that might result in the loss of relatively volatile lighter semi-volatiles. In a soil sampling guidance publication, EPA recommended caution in the use of composite soil samples whether organic or inorganic, citing statistical complications and stating that the compositing of samples cannot, in general, be justified unless for a stated specific purpose and unless a justification is provided [1017].

> For semi-volatiles, EPA recommends: that "conventional sampling practices" be followed as specified by ASTM D-330-76 [1010,1012]. ASTM also publishes standard method guidance for numerous very specific applications, like sampling from pipes (D 3370-95a).

Containers: Both EPA and APHA (Standards Methods Book) recommend glass containers for the collection of organic compounds [141,1010,1013]. EPA also recommends teflon lined caps for semi-volatiles [1010,1013]. Guidance from other federal agencies (USGS, FWS, NOAA) also recommends glass containers for organics, and discourages the use of plastic containers for a variety of reasons (Roy Irwin, National Park Service, Personal Communication, 1997, based on a glance through recent internal guidance of several agencies). Some federal agency quality control procedures call for voiding or red-flagging the results of organic analyses if the lab receives the sample in plastic containers (Roy Irwin, National Park Service, Personal Communication, 1997). The APHA pointed out some the potential hazards of the use of certain plastic containers for storing organic samples [141]:

> A) Potential contamination of the sample via leaching of compounds from the plastic, and/or
>
> B) The plastic container walls can sometimes be attacked by certain organics and fail, and/or
>
> C) The possibility that some of organic compound will dissolve into the walls of the plastic container, reducing the concentration of the compound in the container [141].

Typical "standard method" protocols recommend proper cleaning of glass containers before use. Some collectors simply use pre-cleaned jars from I-Chem or Eagle Pitcher (no government endorsement implied) or equivalent suppliers. EPA [1010], USGS, and most other federal agencies recommend cleaning procedures for the glass containers, usually involving detergent rinsing, baking, and sometimes HCL rinses (Roy Irwin, National Park Service, Personal Communication, 1997).

Variation in concentrations of organic contaminants may sometimes be due to the typically great differences in how individual investigators treat samples in the field and in the lab rather than true differences in environmental concentrations. This is particularly true for volatiles and even for some of the lighter semi-volatiles, which are so easily lost at various steps along the way. Contaminants data from different labs, different states, and different agencies, collected by different people, are often not very comparable (see also: disclaimer section at the top of this entry).

At minimum, before using contaminants data from diverse sources, one should determine that field collection methods, detection limits, and lab and field quality assurance techniques were acceptable and comparable.

As of 1997, the problem of lack of data comparability (not only for water methods but also for soil, sediment, and tissue methods) between different "standard methods" recommended by different agencies seemed to be getting worse, if anything, rather than better. The trend in quality assurance seemed to be for various agencies, including the EPA and others, to insist on quality assurance plans for each project. In addition to quality control steps (blanks, duplicates, spikes, etc.), these quality assurance plans call for a step of insuring data comparability [1015,1017]. However, the data comparability step is often not given sufficient consideration. The tendency of agency guidance (such as EPA SW-846 methods and some other new EPA methods for bio-concentratable substances) to allow more and more flexibility to select options at various points along the way, makes it harder in insure data comparability or method validity. Even volunteer monitoring programs are now strongly encouraged to develop and use quality assurance project plans [1015,1017]. The basics of these quality assurance plans for chemical analyses should include the following quality control steps:

The goals of quality assurance plans in projects which are using comparison benchmarks or criteria should include: that the analysis in the concentration range of the comparison benchmark concentration should be very precise and accurate.

Typical lab and field quality control techniques should have included the following considerations (John Moore, Fish and Wildlife Service, Personal Communication, 1997):

> Procedural Blanks should be analyzed to assure that no contaminants are added during the processing of the samples. The standards for adequacy depend on the method and the media being measured.
>
> > Different federal agencies publish different acceptable limits. For one program, NOAA stated that at least 8% of samples should be blanks, reference or control materials [676].
> >
> > The basic idea is that neither samples nor blanks should be contaminated. Because the only way to measure the performance of the modified procedures is through the collection and analysis of uncontaminated blank samples in accordance with this guidance and the referenced methods, it is highly recommended that any modifications be thoroughly evaluated and demonstrated to be effective before field samples are collected [1003].
>
> Duplicate samples are analyzed to provide a measure of precision of the methods. The standards for adequacy depend on the method and the media being measured.
>
> > Different federal agencies publish different acceptable limits. There appears to be an inverse relationship between precision and sensitivity [676].

Spiked samples are analyzed to provide a measure of the accuracy of the analysis methods. The standards for adequacy depend on the method and the media being measured.

Different federal agencies publish different acceptable limits.

Note: blanks, duplicates, and some other quality assurance steps don't help in the optimum way intended if one is getting false negatives due to the use of detection limits that are too high, losing the contaminant during lab or field handling, or using the wrong analyses (Roy Irwin, National Park Service, personal communication, 1997).

EPA standard methods from EPA EMMI Database on Lab methods include [861]:

EMSLC 625 Base/Neutrals and Acids 84 WASTEWATER GCMS ug/L MDL "Base/neutrals and Acids" A measured volume of sample, approx 1-L, is serially extracted with methylene chloride at a pH greater than 11 and again at a pH less than 2 using s separatory funnel or a continuous extractor [861]. The methylene chloride extract is dried, concentrated to a volume of 1 mL, and analyzed by GC/MS [861]. Qualitative identification of the analytes in the extract is performed using the retention time and the relative abundance of three characteristic masses (m/z) [861]. Quantitative analysis is performed using internal standard techniques with a single characteristic m/z [861].

OSW 8040A ECD Phenols - Derivatization/GCECD 11 SW-846 GCECD ug/L MDL Method 8040A "Phenols by Gas Chromatography" Method 8040 provides gas chromatographic conditions for the detection of phenolic compounds [861]. Prior to analysis, samples must be extracted using appropriate techniques [861]. Both neat and diluted organic liquids (Method 3580, Waste Dilution) may be analyzed by direct injection [861]. A 2 to 5 uL sample is injected into a gas chromatograph using the solvent flush technique, and compounds in the GC effluent are detected by a flame ionization detector Method 8040 also provides for the preparation of pentafluorobenzylbromide derivatives, with additional cleanup procedures for electron capture gas chromatography [861]. This is to lower the detection limits of some phenols and to aid the analyst in the elimination of interferences [861].

OSW 8040A FID Phenols - GCFID 17 SW-846 GCFID ug/L MDL Method 8040A "Phenols by Gas Chromatography" Method 8040 provides gas chromatographic conditions for the detection of phenolic compounds [861]. Prior to analysis, samples must be extracted using appropriate techniques [861]. Both neat and diluted organic liquids (Method 3580, Waste Dilution) may be analyzed by direct injection [861]. A 2 to 5 uL sample is injected into a gas chromatograph using the solvent flush technique, and compounds in the GC effluent are detected by a flame ionization detector Method 8040 also provides for the preparation of pentafluorobenzylbromide derivatives, with additional cleanup procedures for electron capture gas chromatography [861]. This is to lower the detection limits of some phenols and to aid the analyst in the elimination of interferences [861].

OSW 8270A S Semivolatiles - Soil 228 SW-846 CGCMS ug/kg EQL Method 8270A "Semivolatile Organic compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique" A table of analyte specific sample preparation procedures that may be used is given in this method [861]. The two procedures that cover most of the analytes are 3510 and 3580 [861]. Prior to using this method, the samples should be prepared for chromatography using the appropriate sample preparation and cleanup methods [861]. This method describes chromatographic conditions that will allow for the separation of the compounds in the extract [861].

> Note: for update see 8270/SIM methods in the third update of EPA RCRA guidance SW-846 [1013]. Such methods may be needed to get sufficiently low detection limits for risk or damage assessment purposes.

OSW 8270A W Semivolatiles - Water 228 SW-846 CGCMS ug/L EQL Method 8270A "Semivolatile Organic compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique" A table of analyte specific sample preparation procedures that may be used is given in this method [861]. The two procedures that cover most of the analytes are 3510 and 3580 [861]. Prior to using this method, the samples should be prepared for chromatography using the appropriate sample preparation and cleanup methods [861]. This method describes chromatographic conditions that will allow for the separation of the compounds in the extract [861].

> Note: for update see 8270/SIM methods in the third update of EPA RCRA guidance SW-846 [1013]. Such methods may be needed to get sufficiently low detection limits for risk or damage assessment purposes.