Dioxin Contamination in New Zealand from the Historical Use of Pentachlorophenol in the Timber Industry: Assessment and Management Issues

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Abstract

Sodium pentachlorophenate (NaPCP) was widely used by the New Zealand (NZ) timber processing industry, between the late1950s and 1988, to control sapstain fungi in freshly sawn *Pinus* softwood timber. Pentachorophenol (PCP) in diesel oil was also used in lesser amounts as a timber preservative, but at two or three sites only. These historical activities, involving the use of at least 5,000 tonnes of PCP, may have led to the contamination of approximately 250 sites throughout the country. The great majority of these sites are small and of lesser concern than sites at which PCP was used in larger quantities. Since 1988 the use of PCP declined rapidly and ceased altogether in response to occupational health concerns and environmental impacts.

The NZ Government has recently issued Health and Environmental Guidelines for Selected Timber Treatment Chemicals to assist the assessment, management and regulatory control of sites contaminated with dioxins and PCP. This paper outlines the nature of the dioxin and PCP contamination in NZ, illustrated by three case studies based on site assessment data. The scope of the guidelines is presented along with the acceptance criteria developed to protect human health and the environment. Recent initiatives arising from this work are described.

Introduction

The PCP used at NZ sawmills was imported from a range of manufacturing countries, including Brazil, China, USA, Canada, France and Germany. Analyses of some of the technical grade PCP formulations used, and of samples of contaminated soils, reveal the significant presence of dioxin contaminants. Dioxin (TEQ) toxicity contributions are dominated by the presence of the higher chlorinated dioxin and furan congeners, and in particular by OCDD. Sludge wastes from NaPCP formulation, storage and dip tanks have also been found to be enriched with dioxins to hazardous levels (up to 270 mgTEQ/kg). Studies of the presence of PCP and dioxins in the off-site environment, combined with the knowledge that the use of PCP had been widespread, led to the concern that residual site contamination may be a continuing hazard to sawmill workers and the environment.

A National Task Group was set up to assess the potential contamination problems, to determine the management needed, and to facilitate actions among central and local government agencies and industry.

A limited survey of 57 sawmills by the timber industry indicated that: 5 mills used PCP extensively (in excess of 100 tonnes); 12 mills made moderate use of PCP (10 - 20 tonnes); 23 mills made light use of PCP (less than 20 tonnes); and 17 mills reported no use of PCP. The NaPCP formulation typically comprised 0.5 - 1.0 % NaPCP buffered with borax.

Assuming 70% of NZ's approximately 400 sawmills used PCP (ranging from one to thirty or more years), and because of the environmental persistence of dioxins, as many as 280 sites might be expected to contain "hot spots" in addition to more diffuse areas of contamination. The heaviest contamination can be expected to be found on mill sites that made the most use of PCP.

Site assessment information on PCP and dioxins

Site assessments of a number of sawmill sites have yielded data on the extent and degree of PCP and dioxin contamination. The heaviest contamination tends to be closely associated with chemical formulation, tank storage, application areas and waste disposal. The dioxin contamination of the soil in particular has proved resistant to natural attenuation.

Case Study 1.

A site risk assessment was carried out at the largest solid wood processing facility in NZ. The mill used approximately 3,000 tonnes of PCP over a period of about 30 years, making it by far the greatest single user of PCP in NZ. Significant quantities of PCP had been spilled over time around the site. The study [1)] found major areas of contamination:

- in the vicinity of the pressure treatment plant and in some areas of the pole storage yard;
- in soils near antisapstain dip areas, the highest level dioxins (3,300 μgTEQ/kg) being found beneath the PCP antisapstain formulation/mix area; in building dust;
- of the groundwater and the stormwater drainage system with PCP migrating to an adjacent stream such that the aquatic ecosystem of the stream was likely to be adversely affected.

Elevated levels of PCP and dioxins were also found in the biota and sediments of the downstream lake, but no clear picture emerged concerning environmental effects and there appeared to be no significant human health concerns related to the consumption of fish.

Clean up activity has included:

- the complete cleaning (including dust removal) of operating areas; hazard isolation;
- the diversion of all contaminated groundwater and stormwater (350 m^3/day) and its treatment by an ultra violet/hydrogen peroxide (Rayox) treatment plant. PCP levels are reduced from an average of 6,000 ppb to less than 1 ppb (destructing 750 kg PCP /year in groundwater; dioxins are reduced from 12 ppt to 4 ppt TEQ;
- Stream water quality has improved from a loading of 575 kg/year PCP (56 ppb PCP) to 20kg PCP/year (2 ppb) representing a 96% reduction of contaminants entering the stream via contaminated groundwater.

The clean up of soils (in the order of 50 to 100,000 m^3) is being considered.

Case Study 2.

At this site, PCP and diesel (a solution of 5% PCP w/v) was used as a preservative to treat timber poles from between 1954 to 1973. During this time an average of 22 tonnes of PCP per year had been used. Creosote was previously used on the site from 1940 to 1954. The treatment plant was disestablished in 1973, all equipment removed, and an upper layer of contaminated soil reportedly disposed off site. Anecdotal reports indicated that spillage and drippage of PCP had occurred during the time the plant was operational.

Site assessment [2] revealed the following pattern of contamination:

- minor surface PCP contamination of the treatment plant area (confirming the importation of clean backfill to the site); significant PCP/dioxins and oil contamination at depth greater than 1.0m; a plume of contaminated groundwater with floating product;
- contaminated dust in ex worker accommodation huts and buildings on the site;
- PCP and hydrocarbon contamination of soils and groundwater of the log storage area;
- hydrocarbon and PCP contamination of a waste dump area;

In total, 12 to 15,000 m^3 contaminated soil may need excavation and treatment.

Case Study 3.

Soil assessments were carried out at three smaller sawmills that had used PCP antisapstain (0.5% PCP w/v) treatment over a number of years. This was undertaken to gain an understanding of the level and distribution of contamination associated with smaller PCP operations [3]. Contamination was localised and highest in the vicinity of chemicals application and treated timber storage areas:

- Site A: PCP antisapstain treatment for 10 years; non-operative since 1986 but sawmill building and associated sheds intact; site generally flat, unsealed and largely covered with gravel; surface topsoil overlays a metre of clay.
- Site B: an operating sawmill and timber treatment plant; PCP used for approximately 10 years between 1976 and the mid 80's; only derelict foundations remain of the former sawmill and PCP facilities which are open to the weather; lower areas of the site periodically subject to flooding.
- Site C: operated PCP antisapstain for approximately 20 years, closed since 1984; only derelict foundations remain of treatment structures; site generally open to the weather; flat, unsealed terrain; a sandy gravely topsoil of variable organic content overlaying sandy gravels at 0.5 m depth.

Adequate and precautionary measures would probably be achieved on each of the three smaller sites by the removal and treatment of the top 10 - 25 cm of soil from the contaminated areas, and the decontamination of on-site buildings by the clean up of dust.

A summary of the maximum contaminant levels found at the above three case studies is set out in Table 1 below.

Table 1. PCP and dioxin contaminant levels in soils and building dust in three case studies of New Zealand sawmill sites

		PCP mg/kg		Dioxins TEQ µg/kg	
		Soil	Building dust	Soil	Building dust
Case Study 1	PCP in diesel	50 - 1,250	6,500	0.5 - 25	
	Antisapstain	0.35 - 3,600		< 30 to 3,300	90 - 150
Case Study 2	PCP in diesel	830 to 5,700	no analysis	159	2.4
Case Study 3	Site A	620	1000	0.527	10.7
	Site B	370	1.5	0.7	no analysis
	Site C	3.4	7.1	4.22	no analysis

Guidance for site assessment and management

Prior to the discovery and assessment of dioxin and PCP contamination, little if any attention in NZ had been given to potential health and environmental impacts associated chemical contamination on industrial land. A number of initiatives concerning the assessment and management of contaminated sites have followed:

1. **Guidelines.** Due to the large number of sawmills and timber treatment sites throughout most regions of New Zealand, many with a history of PCP use, comprehensive guidelines have been prepared [4] for regulatory authorities and industry to assist site assessments. The scope of the guidelines is presented in Table 2. The guidelines outline a cost effective approach to the assessment of contamination, and the derivation of clean up criteria are documented. The guidelines were developed using consultative processes, and involved the collaboration of central and local government and the timber industry. The soil acceptance criteria for PCP and dioxins with respect to land use are provided in Table 3.

The guidelines recommend that restrictions be placed on the quantities of PCP/dioxin contaminated wastes and soils accepted for disposal to landfill. The waste acceptance criteria developed for these contaminants are based upon their concentration (range 4 to 100 mg/kg PCP) and a leachate test (range 0.05 to 50 mg/l PCP) relative to the level of security offered by the landfill design and its operation. Dioxin containing wastes are not to exceed a concentration of 10 µg TEQ/ kg at any landfill.

Due to uncertainties about the toxicity of dioxins, the dioxin criteria are presented as interim criteria (based on the WHO acceptable daily intake of 10 pg TEQ/kg.body weight/day) and are to be reviewed by the Ministry for the Environment during 1998/99.

Table 2. The major components of the Health and Environmental Guidelines for Selected Timber Treatment Chemicals

Sampling Strategies and Analysis Protocols

- Protocols for site characterisation, sampling and analysis of soils, groundwater, surface water and dust.
- Analytical procedures for the chemicals of interest are referenced.

Soil Acceptance Criteria

- Acceptable residual chemical concentrations are given for a number of site uses: agriculture, residential, and industrial. Consideration of the protection given by paving and management practices.
- Criteria primarily based on protection of human health, plant life, contaminant uptake by plants and animals.
- An incremental lifetime risk of 1 in 100,000 additional cancers per year adopted for assessing the effects of chemicals with carcinogenic properties.

Surface Water and Groundwater Acceptance Criteria

- Criteria (based on the protection of human health) are developed for a range of site uses, such as potable water, stock watering, irrigation and recreation; (criteria for the protection of aquatic ecosystems are planned).

Landfill Disposal

- a classification system for New Zealand landfills;
- guidance on waste characterisation;
- acceptance criteria for disposal to landfill of PCP/dioxin contaminated wastes and soils.

Table 3. Health and Environmental Guidelines for Pentachlorophenol and Dioxins: Summary of soil acceptance criteria

	Agricultural	Residential	Industrial			
			Unpaved	Paved - no management plan	Paved - with management plan	Maintenance
PCP mg/kg	0.1	10	570	1000	2800 -NL	1500
Dioxins µg/kg I-TEQ	0.01	1.5	18		90	21

2. **Screening Method.** As full congener dioxin analysis is expensive, a lower cost analytical screening method for dioxins was developed for the determination of hepta and octa dioxins and furans [5]. The method has a limit of detection of about 1 ppb OCDD (ng/g) in soils, which would produce 1 ppt (pg/g) of TCDD toxic equivalent. OCDD is the predominant dioxin congener contaminant of the PCP formulation used in NZ.

3. **Code of Practice.** The timber industry helped develop a Code of Practice [6] with explicit work place construction and operating standards for to prevent future site contamination from the use of antisapstains and timber treatment chemicals.

4. **Technology Review.** The Ministry for the Environment and the timber industry have jointly reviewed the status of clean up technologies [7,8]. A combined approach has also facilitated the development of a thermal desorption technology recently demonstrated as capable of remediating sites contaminated by PCP and dioxins [9].

5. **Organochlorines Programme.** A major nationwide environmental survey of background levels of organochlorine contaminants (dioxins, PCP, PCBs and OC pesticides) in air, soil, and aquatic environments is currently underway [10,11]. This work, the Organochlorines Programme, is consistent with international concern about the presence of persistent organic pollutants (POPs) in the environment. A key outcome will be the development of a national standard to regulate future emissions of dioxins from activities such as incineration, and to identify dioxin clean up criteria for contaminated sawmill sites.

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