EXPOSURES AND HEALTH EFFECTS AMONG
FIELD WORKERS USING
THE ORGANOPHOSPHATE CHLORPYRIFOS

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M Sc

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PHILOSOPHY AT MURDOCH UNIVERSITY, SCHOOL OF
ENVIRONMENTAL SCIENCE, PERTH, WESTERN AUSTRALIA 2004
DECLARATION

I declare that this thesis is my own account of my research and contains as its main content work that has not previously been submitted for a degree at any tertiary educational institution.

_________________________________  ____________
M.CATTANI       DATE
ABSTRACT

Chlorpyrifos, an organophosphate pesticide moderately toxic to humans via inhalation and dermal absorption (LD₅₀ oral, rat = 226 mg kg⁻¹, LD₅₀ skin, rabbits = 1265 mg kg⁻¹), is widely used to eradicate termites in Australia. A series of 28 surveys totaling 32 separate assessments, or 10% of all professional users in Perth, Western Australia, comprised biological monitoring, exposure assessment techniques, a health symptoms and work practices questionnaire. Chlorpyrifos metabolite 3,5,6-trichloro-2-pyridinol and alkyl phosphates were extracted from urine, and serum cholinesterase (SChE) and erythrocyte acetylcholinesterase from blood. Chlorpyrifos was extracted from 24 patches removed from a supplied cotton overall, cotton gloves worn under protective gloves, 7 absorbent patches placed on the skin and an organic vapour collection tube. Surface wipes were collected in the workers vehicle and on the workers forehead. Chlorpyrifos was applied in either 0.5% (n=2) or 1% (n=26) concentration of active ingredient in water solution. Surveys took place at pre-construction sites (n=5) where pesticide was sprayed onto a prepared site, existing buildings with concrete foundations (n=17) where pesticide was injected under pressure around the perimeter of the building and existing buildings with suspended floors requiring the worker to spray under floor (n=6). Combined left and right glove deposition was 9 mg hour⁻¹ (SD = 18 mg.hour⁻¹). Mean deposition on overalls was 14 mg.hour⁻¹ (SD = 12 mg.hour⁻¹), on skin patches was 0.2 µg.cm⁻¹.hour⁻¹, on vehicle gear-stick was 3 µg (SD = 8 µg) and, on steering wheels’ was 3 µg (SD = 3 µg). The mean protection
factor of overalls, a ratio of outer layer and inner levels, was 75 (SD = 411). Mean air concentration of chlorpyrifos during an application was 30 µg m\(^{-3}\), and 17 µg m\(^{-3}\) 8 hour TWA (SD = 40 µg m\(^{-3}\) 8 hour TWA), and in one group of 17 workers correlated (p<0.05) with ambient air temperature (15 to 38 °C). Urinary metabolites and SChE activity were effective indicators of exposure. The health symptoms questionnaire did not highlight significant health effects. A discrepancy between operators’ perception of risk and their actual exposure requires addressing, for example the measured high deposition rate to hands was ineffectively controlled, as 48% or workers wore inappropriate or no gloves and only 26% washed their hands after completing their tasks. All workers indicated in the questionnaire they would wash their hands after completing their tasks. The questionnaire also highlighted a high incidence of poor work practices, 58% spilt the concentrate at least once a week, 74% had recently spilt/splashed diluted chlorpyrifos in their eyes and 90% on their boots, and 52% believed they would benefit from more education concerning chlorpyrifos. Observations concluded that workers unnecessarily increased their exposure by poor work practice. Recommendations include modification to pesticide worker education, licencing and health surveillance systems; an improvement in the understanding of the benefits of a health and safety management systems for employers, and pesticide suppliers taking a stewardship role in the usage of their products.
ACKNOWLEDGEMENTS

I would like to thank Associate Professor Kris Cena for being an inspiring research supervisor. He fostered a collegial and productive atmosphere that I hope to replicate or find in my future workplaces. I will fondly remember our discussions, his coaching and mentoring.

Particular thanks to those who introduced me to the project, and provided initial funding, Dr. Dino Pisaniello, Adelaide University; and Dr. John Edwards, Flinders University.

Grateful thanks to Curtin University of Technology, my employer during the majority of the study, for their encouragement and support.

I would like to acknowledge the assistance of the volunteer pesticide workers and their employers who took part in the surveys.

To my family, in particular Helen, for their encouragement, support and understanding during all stages of this work.
The following publications are directly related to the thesis, and are reproduced in Appendix 5:


<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>microgram</td>
<td>µg</td>
<td></td>
</tr>
<tr>
<td>Acetylcholinesterase</td>
<td>AchE</td>
<td></td>
</tr>
<tr>
<td>Australian Standard reference number</td>
<td>AS #</td>
<td></td>
</tr>
<tr>
<td>Building Code of Australia</td>
<td>BCA</td>
<td></td>
</tr>
<tr>
<td>Degrees centigrade</td>
<td>ºC</td>
<td></td>
</tr>
<tr>
<td>Chemical Abstract Service number</td>
<td>CAS #</td>
<td></td>
</tr>
<tr>
<td>Centimetre</td>
<td>Cm</td>
<td></td>
</tr>
<tr>
<td>1,1’-(2,2,2-trichloroethylidene)bis[4-chlorobenzene]</td>
<td>DDT</td>
<td></td>
</tr>
<tr>
<td>Diethylphosphate</td>
<td>DEP</td>
<td></td>
</tr>
<tr>
<td>Diethyl-thiophosphate</td>
<td>DETP</td>
<td></td>
</tr>
<tr>
<td>Erythrocyte Acetylcholinesterase</td>
<td>EACHe</td>
<td></td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>EPA</td>
<td></td>
</tr>
<tr>
<td>horse power</td>
<td>h.p.</td>
<td></td>
</tr>
<tr>
<td>Haemoglobin</td>
<td>Hb</td>
<td></td>
</tr>
<tr>
<td>Hour</td>
<td>Hr</td>
<td></td>
</tr>
<tr>
<td>International Labour Organisation</td>
<td>ILO</td>
<td></td>
</tr>
<tr>
<td>Kilogram</td>
<td>Kg</td>
<td></td>
</tr>
<tr>
<td>Kilo Pascal's</td>
<td>KPa</td>
<td></td>
</tr>
<tr>
<td>Litre</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>lethal dose required for 50% of individuals in a sample</td>
<td>LD50</td>
<td></td>
</tr>
<tr>
<td>Logarithm</td>
<td>Log</td>
<td></td>
</tr>
<tr>
<td>Metre</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>Milligram</td>
<td>Mg</td>
<td></td>
</tr>
<tr>
<td>Minute</td>
<td>Min</td>
<td></td>
</tr>
<tr>
<td>Millilitres</td>
<td>Ml</td>
<td></td>
</tr>
<tr>
<td>Millimetre</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>millimetres Mercury</td>
<td>MmHg</td>
<td></td>
</tr>
<tr>
<td>number of subjects</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>US National Institute of Occupational Safety and Health</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>Nanomole</td>
<td>nmol</td>
<td></td>
</tr>
<tr>
<td>National Occupational Health and Safety Commission</td>
<td>NOHSC</td>
<td></td>
</tr>
<tr>
<td>National Registration Authority</td>
<td>NRA</td>
<td></td>
</tr>
<tr>
<td>Neurotoxic target esterase</td>
<td>NTE</td>
<td></td>
</tr>
<tr>
<td>(US) Occupational Safety and Health Administration</td>
<td>OSHA</td>
<td></td>
</tr>
<tr>
<td>Organic Vapour Sorbent</td>
<td>OVS</td>
<td></td>
</tr>
<tr>
<td>Plasma cholinesterase</td>
<td>PchE</td>
<td></td>
</tr>
<tr>
<td>Pest Control Operator/Operative, also known as pesticide applicator or pest controller.</td>
<td>PCO</td>
<td></td>
</tr>
<tr>
<td>parts per billion</td>
<td>Ppb</td>
<td></td>
</tr>
<tr>
<td>parts per million</td>
<td>Ppm</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl chloride</td>
<td>PVC</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl chloride</td>
<td>PVC</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl chloride</td>
<td>PVC</td>
<td></td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>SCE</td>
<td>Sister Chromatid Exchange</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>standard deviation</td>
<td></td>
</tr>
<tr>
<td>TAFE</td>
<td>Tertiary and Further Education College</td>
<td></td>
</tr>
<tr>
<td>TCP</td>
<td>3,5,6-trichloro-2-pyridinol</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>United States (of America)</td>
<td></td>
</tr>
<tr>
<td>w/v</td>
<td>water to volume ratio</td>
<td></td>
</tr>
</tbody>
</table>

Note: The term “researcher” in this thesis refers to the candidate.
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