Pesticides Use in Thailand and Developmental Effects on Children

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Outline

- Pesticide use in Thailand
- Pesticide residues in fruits and vegetables
- Exposure monitoring
- Field studies
  - adults
  - pregnant women and newborns
  - young children
Pesticide Use in Thailand

Pesticides have been widely used in agriculture in Thailand

Herbicides are dramatically increased in 12 years, average 9.4% per year

**Herbicides**: glyphosate, paraquat and phenoxyacetic acid
(i.e. 2, 4-Dichlorophenoxyacetic acid ; 2,4,5- Trichlorophenoxyacetic acid )

**Insecticides**: organophosphates (OPs) and pyrethriods (PYRs) are common used.
Pesticides Imported into Thailand (2006-2017)

- Herbicide
- Insecticide
- Fungicide
- Others

tonnes
Pesticides vs Analytical Techniques

• Mostly focus on insecticides i.e. OPs, PYRs

• Herbicides: glyphosate

• Analytical instrumentations:
  – GC-FPD: OP residues
  – GC-ECD: PYR residues
  – GC-MS: Other organic pollutants
    i.e. Polycyclic Aromatic Hydrocarbons (PAHs)
  – HPLC-FLD: glyphosate
Instruments at Research Institute for Health Sciences, Chiang Mai University

- **GC-MS 7890A**: for PAHs analysis
- **GC-ECD, FPD 7890B**: for pesticides residues and biomarkers analysis
- **HPLC-UV, FLD HP110**: for biomarkers analysis
- **HPLC-FLD, DAD 1260 Infinity**: for biomarker analysis
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**Pesticide Residues in Northern Provinces**


- Sixteen different **vegetables** (n=412 samples)

- Eleven different **fruits** (n=301 samples)

- Analyses of 43 pesticides including
  - 20 organophosphates (OPs),
  - 6 synthetic pyrethroids (PYRs),
  - 12 carbamates,
  - Others: 2 abamectins, **imidacloprid**, dithiocarbamates, and **carbendazim**.

Prapamontol et al, 2019 (In press).
Pesticide Residues:
4 Provinces in Upper Northern Thailand

[Map showing Chiang Mai, Chiang Rai, Phayao, Lampang provinces in Thailand]
What Methods We Used?

**Organophosphate (OP) residues**
- using GC-FPD (Polyiem et al., 2018)

**Synthetic pyrethroids (PYR) residues**
- using GC-ECD (Pakvilai et al., 2015)

**OPs in human plasma and milk**
- using GC-FPD (Naksen et al., 2016)

**PYR metabolite, 3-Phenoxybenzoic acid (3-PBA)**
- using GC-ECD and immunoassay (with Prof. B.D. Hammock, UCD)
Pesticide Residues Found

• Total 412 **vegetable samples**,  
  – 235 (57%) had pesticide residues and  
  – 185 (45%) had pesticide residues that exceeded the maximum residue limits (MRLs).

• Total 301 **fruit samples**,  
  – 245 (81%) had pesticide residues and  
  – 165 (55%) had pesticide residues that exceeded the MRLs.

Prapamontol et al, 2019 (In press).
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Human exposure monitoring

• Exposure to OPs - Six Dialkylphosphates (DAPs) including DAP, DMTP, DMDTP, DEP, DETP, and DEDTP using GC-FPD (Prapamontol et al., 2014).

• For QA/QC of DAPs; Participation of G-EQUAS testing

• Internal quality control
Pesticide Residues Found

• Multiple synthetic pyrethroid residues found higher levels, cypermethrin was the most frequently detected.

• Among the OP pesticides, chlorpyrifos was the most frequently detected pesticide.
Comparison with other report

<table>
<thead>
<tr>
<th>DI (µg/day)</th>
<th>Chlorpyrifos</th>
<th>Parathion</th>
<th>Diazinon</th>
<th>Cypermethrin</th>
<th>Total&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>4.2</td>
<td>5.7</td>
<td>1.0</td>
<td>5.4</td>
<td>16.3</td>
</tr>
<tr>
<td>Greece</td>
<td>18.3</td>
<td>5.7</td>
<td>1.0</td>
<td>6.4</td>
<td>31.4</td>
</tr>
<tr>
<td>China</td>
<td>10.2</td>
<td>17.8</td>
<td>0.7</td>
<td>5.0</td>
<td>33.7</td>
</tr>
<tr>
<td>India</td>
<td>12.9</td>
<td>16.7</td>
<td>0.7</td>
<td>8.1</td>
<td>38.4</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>4.5</td>
<td>6.1</td>
<td>3.7</td>
<td>6.7</td>
<td>21.0</td>
</tr>
<tr>
<td>Japan</td>
<td>3.0</td>
<td>7.5</td>
<td>2.0</td>
<td>3.0</td>
<td>15.5</td>
</tr>
<tr>
<td>Korea</td>
<td>9.9</td>
<td>10.0</td>
<td>3.1</td>
<td>7.7</td>
<td>30.6</td>
</tr>
<tr>
<td>Vietnam</td>
<td>27.9</td>
<td>9.3</td>
<td>0.7</td>
<td>21.8</td>
<td>59.7</td>
</tr>
<tr>
<td>All&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.6</td>
<td>9.6</td>
<td>1.0</td>
<td>6.0</td>
<td>26.3</td>
</tr>
</tbody>
</table>

<sup>a</sup> Total refers to sum DIs of chlorpyrifos, parathion, diazinon and cypermethrin.

<sup>b</sup> All refers to DIs of pesticides estimated from urinary metabolite concentrations for the entire dataset from the eight countries.

Urinary concentrations and profiles of organophosphate and pyrethroid pesticide metabolites and phenoxy acid herbicides in populations in eight countries  (Li and Kannan, 2018)
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A Pilot Survey, evaluated the exposure levels of OPs and neonicotinoids

50 couples of farmers in intensive agriculture areas of Chiang Mai; Fang (FA) and Chom Thong (CT) in February 2018

Urinary DAPs were analyzed in spot urine samples.

Personal data was collected by face-to-face questionnaire
### Personal Data of Farmers: FA and CT Sites

<table>
<thead>
<tr>
<th></th>
<th>FA</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>29.2</td>
<td>31.1</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>24.1</td>
<td>24.7</td>
</tr>
</tbody>
</table>

![Bar chart showing weight categories](image)
FANG (FA)

Year as a farmer
12.3 year

Hour in field work
8.4 hour per day
Education of Farmers: FA and CT Sites

- **No education**: CT (p=0.000), FA
- **Primary 1-6**: CT (p=0.106), FA
- **Junior high school**: CT (p=0.014), FA
- **Senior high school**: CT (p=0.081), FA
- **Diploma**: CT (p=0.400), FA
- **Bachelor’s degree**: CT, FA

Suwannarin N, Prapamontol T, Nakayama SF, MS preparation
### Personal Protection in Working of FA and CT Farmers

**Personal protective equipment (PPE)**

<table>
<thead>
<tr>
<th>Type of Protection</th>
<th>FA</th>
<th>CT</th>
<th>p-value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>wore masks</td>
<td>31(62)</td>
<td>45(90)</td>
<td>0.001</td>
<td>76(76)</td>
</tr>
<tr>
<td>wore hat or scarf as head protection</td>
<td>27(54)</td>
<td>26(52)</td>
<td>0.841</td>
<td>53(53)</td>
</tr>
<tr>
<td>Eye protection</td>
<td>3(6)</td>
<td>6(12)</td>
<td>0.295</td>
<td>9(9)</td>
</tr>
<tr>
<td>wore long-sleeved shirts/pants</td>
<td>40(80)</td>
<td>46(92)</td>
<td>0.084</td>
<td>86(86)</td>
</tr>
<tr>
<td>wore the gloves</td>
<td>21(42)</td>
<td>45(90)</td>
<td>0.000</td>
<td>66(66)</td>
</tr>
<tr>
<td>wore the boots</td>
<td>37(74)</td>
<td>46(92)</td>
<td>0.000</td>
<td>83(83)</td>
</tr>
</tbody>
</table>
Organophosphate Exposure: Six Urinary Dialkylphosphate (DAP) Metabolites

**Percentage of DAPs detection**

<table>
<thead>
<tr>
<th>DAPs metabolites</th>
<th>FA</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMP</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>DMTP</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>DMDTP</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>DEP</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>DETP</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>DEDTP</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Suwannarin N, Prapamontol T, Nakayama SF, MS preparation
Evaluated prenatal organophosphate (OP) exposure.

Total of 52 pregnant farmworkers in Fang district, Chiang Mai province.

Investigated the changes in maternal acetylcholinesterase (AChE) and paraoxonase 1 (PON1) activities, urinary diakylphosphates (DAPs) over antenatal visits until delivery.

REF: Associations of maternal organophosphate pesticide exposure and PON1 activity with birth outcomes in SAWASDEE birth cohort, Thailand (Naksen et al., 2015).
Among the individuals with low maternal PON1 activity (n=23), newborn head circumference was negatively correlated with log10 maternal $\Sigma$DEAP and $\Sigma$DAP at enrollment (gestational age=12±3 weeks; $\beta$=-1.0 cm, $p=0.03$ and $\beta$=-1.8 cm, $p<0.01$, respectively) and at 32 weeks pregnancy ($\beta$=-1.1cm, $p=0.04$ and $\beta$=-2.6 cm, $p=0.01$, respectively).

The newborn birthweight was also negatively associated with log10 maternal $\Sigma$DEAP and $\Sigma$DAP at enrollment ($\beta$=-219.7 g, $p=0.05$ and $\beta$=-371.3g, $p=0.02$, respectively).

This phenomenon was not observed those with high maternal PON1 activity.

REF: Associations of maternal organophosphate pesticide exposure and PON1 activity with birth outcomes in SAWASDEE birth cohort, Thailand (Naksen et al., 2015).
SAWASDEE birth cohort study: A cohort development in Chiang Mai, Thailand

SAWASDEE is the Study of Asian Women and their OffSpring’s Development and Environmental Exposures 2016-2021

Ongoing study, 80% enrollment, Target: 300 pregnant mothers
A Study of Exposure to POLLUTANTS Among Young Children at a Commercial Roses’ Growing Village, Chiang Mai Province

- We reported the follow-up study at a commercial rose growing village, Buak Toey (BT), 25 km northwest of Chiang Mai City.

- Twenty five children aged 3-5 years old had followed up for collecting urine samples from 2 periods, dry season (March to April 2018) and wet season (July-August 2018)

- Individual urine samples were analysed for six dialkylphosphates (DAPs) as well as polycyclic aromatic hydrocarbons (1-Hydroxypyrene, 1-OHP) and malondialdehyde (MDA); biomarker of oxidative stress.

- Health questionnaire was collected from parent or guardian.
Chiang Mai Province in the Basin
“Trapping Pollution!”
Biomass Burning in Upper Northern, Thailand “Current Environmental Health Issue”

Research Institute for Health Sciences (RIHES), Chiang Mai University (CMU)
Monthly Average of PM$_{10}$ & PM$_{2.5}$ Concentrations in Chiang Mai: 2013-2017

Thailand Standard for PM\(^{(\mu g/m^3)}\)

<table>
<thead>
<tr>
<th></th>
<th>PM$_{10}$</th>
<th>PM$_{2.5}$</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>annual</td>
<td>120</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>24-hour</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

(source: Pollution control department, Thailand)
Results of Exposure to Pollutants Among Young Children

• We found very high level of exposure to organophosphate insecticides in DRY season compared with WET season, p=0.014.

• Levels of urinary 1-OHP and MDA were not different implying no-season related exposure.
Sharing Lab Results to Parents
Summary

Pesticides (insecticides) use and their residues on vegetables and fruits indicate and need increased intervention towards safe foods.

Pesticide exposure results by urinary metabolites show high levels among young couple farmers, pregnant mothers and their newborns, and very young children in farming community.

Analytical laboratory needs to be upgraded to catch up new pollutants in the environment.
We Thank..

- **Funding and Collaborating Agencies**: Chiang Mai University, National Research Council of Thailand (NRCT), USNIH, NIES Japan.
- **Participants**: farmers, children
- **Research team and graduate students**

❖ Thank you ALL