

TOWARDS A NON-TOXIC ENVIRONMENT



THAI EDUCATION FOUNDATION

ADDRESS

28 Piboonwattana Soi 7,
Rama VI Rd., Samsen Nai,
Phayathai Bangkok 10400
Thailand

PHONE

66-02-279-1381

WEB

<http://www.thaied.org/>
info@thaied.org



PESTICIDE USE IN SOUTHEAST ASIA

HEALTH IMPACTS ON SCHOOL CHILDREN

BRIEFING NOTE
JULY 2018



THAI EDUCATION FOUNDATION



The Field Alliance

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THAI EDUCATION FOUNDATION

Thai Education Foundation

The Thai Education Foundation (TEF) is a non-profit organization working to improve education in Thailand. To TEF, education is first and foremost a continuous process guided primarily by the participant-learners themselves. To optimize this learner-centered approach in a rapidly changing national context, formal, non-formal and private-sector institutions must continually develop diverse and responsive capacities and programs. Linking innovative field projects, training and policy development support, TEF works to make innovative, practical and effective contributions to this end.

The Field Alliance

The Field Alliance is an alliance of governmental and civil societies agencies that promotes ecological agriculture and healthy livelihood for rural communities through educational process that enable each woman, man and child has the right to knowledge, has the responsibility to decide, and should have the freedom to act in ways which ensure the health and sustainability of human and environmental systems. Further, each woman, man, and child has the inherent ability to undertake these tasks, and that the role of governments, corporations and international organisations is to support the efforts of individuals and local communities. Finally, we believe that efforts to promote healthy and sustainable systems should be informed by a combination of ethical, spiritual, scientific and aesthetic values.



The Field Alliance



Pesticide Use in Southeast Asia

Pesticide use in the Southeast Asia region has grown rapidly in the past decade. Between 2003 and 2012, the average application of pesticides has grown 6.8% annually in Thailand, 9.7% annually in Vietnam, 61% annually in Cambodia, and 55% annually in Laos, as depicted in Figure 1.

The quantity of formulated pesticide products applied per hectare in Thailand increased by a factor of six between 1987 and 2010. The growth of pesticide use has far surpassed the growth of agricultural outputs, as agricultural outputs have actually decreased 7.4% annually between 1987 and 2010. Increased use of herbicides accounts for a significant portion of the growth in pesticide use, especially the herbicides glyphosate and paraquat. Though more pesticides are being applied to crops, yields are decreasing.

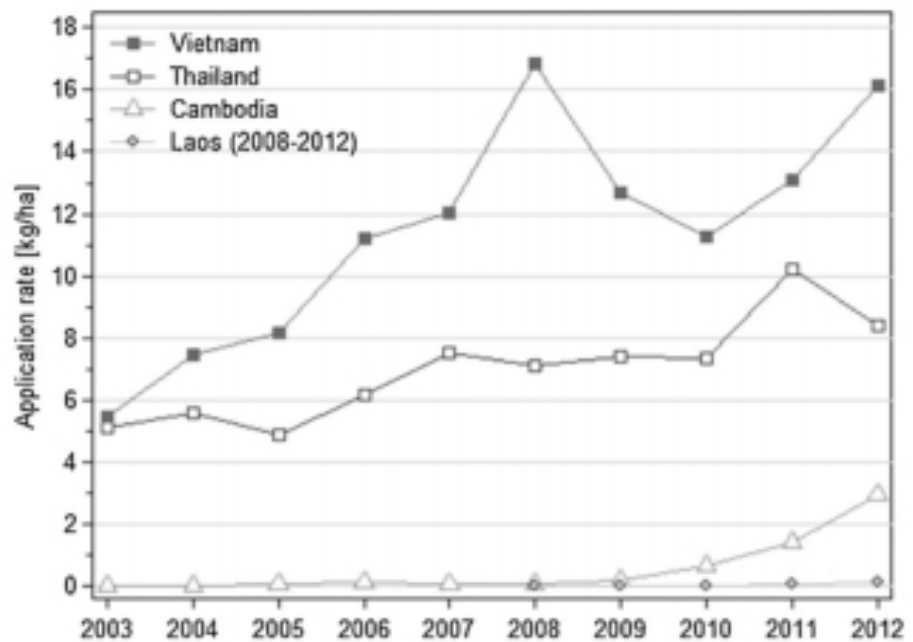


Figure 1: Agricultural pesticide use in Cambodia, Laos, Thailand and Vietnam, in quantity of imported product per hectare of arable land, 2003–2012.¹

After surveying 1029 farmers across four countries in Southeast Asia, The Field Alliance calculated the average liters of pesticide sprayed per hectare of farmland. On average, farmers in the Lao People's Democratic Republic used the largest quantities of pesticides per hectare. Across all countries, government regulation of pesticide use is limited, and low levels of risk awareness amongst farmers and members of the community has contributed to the exponential growth of pesticide use in the region.

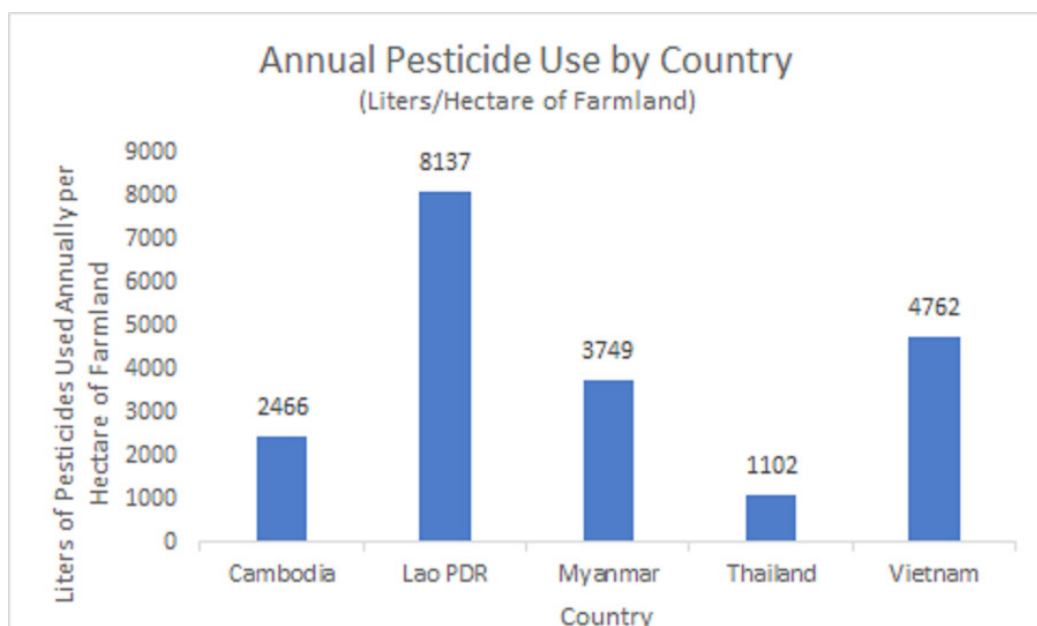


Figure 2: After surveying farmers in five countries in the Southeast Asia region, we found that Lao PDR had the highest application of pesticides, followed by Vietnam.

Types of Pesticides

According to the World Health Organization, "pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds). Pesticides are used in public health to kill vectors of disease, such as mosquitoes, and in agriculture, to kill pests that damage crops. By their nature, pesticides are potentially toxic to other organisms, including humans, and need to be used safely and disposed of properly"².

Insecticides

Organophosphates and Carbamates

Organophosphate (OP) and carbamate (CM) pesticides are a group of insecticides that inhibit a neuromuscular enzyme called acetylcholinesterase³. This enzyme is necessary for normal function in both humans and insects, and both acute and long-term exposure to OP's have health implications on humans, especially children⁴. A growing body of evidence links OP exposure to neurodevelopmental disorders in children. Evidence from studies in animals find that prenatal and early postnatal organophosphate exposure can adversely affect cognitive, motor, and sensory functions as well as the development of the nervous system¹⁵.

Pyrethroids

Pyrethroids are a class of insecticides that act on the membranes of nerve cells in insects, paralyzing the affected organism⁵. Recent studies raise concerns about the effect of pyrethroids on sperm quality and DNA, reproductive hormones, and pregnancy outcomes¹⁵.



Aphids are small sap sucking insect, and they are the most destructive insect pests on cultivated plants..

Herbicides

Paraquat

Paraquat is a non-selective and quick acting herbicide that kills green plant tissue¹⁰. Paraquat is also toxic to mammals, and exposure to the herbicide may have a relationship to the development of Parkinson's disease¹¹. Paraquat is banned in multiple countries around the globe; however, the paraquat is widely used in Asia. For example, in Thailand, paraquat is one of the most frequently imported herbicides¹².

Glyphosate

Glyphosate is a widely used herbicide that is often used to kill broad-leaf weeds and grasses. Asia accounts for a large share of the global glyphosate market¹³. In the past decade, there have been rising concerns about glyphosate resistant weeds¹⁴.



Pigweed is a highly competitive weed that is becoming increasingly resistance to herbicides.

Fungicides

Carbendazim

Carbendazim is a fungicide used on grains and fruits. Studies conducted on animals indicate that high doses of carbendazim are linked to infertility⁶. Carbendazim is amongst the most widely used fungicides in Asia⁷.

Mancozeb

Along with carbendazim, mancozeb is amongst the most widely used fungicides in Asia. Similarly to carbendazim, studies conducted on animals indicate that long term mancozeb exposure can reduce fertility⁸. Mancozeb has been classified as a probable human carcinogen by the United States Environmental Protection Agency⁹.



Cochliobolus heterostrophus is a fungal plant pathogen. that causes southern corn leaf blight in maize.

Pesticide Use by Country

CAMBODIA

TFA's partner¹⁸ surveyed 215 farmers in the Battambang region of Cambodia where the primary crops are rice, cabbage, yard long bean, and chili. On average, these farmers used 2,466 liters of pesticides per hectare of farmland annually. Each farmer used an average of 3,761 liters of pesticide annually, and each farmer was exposed to pesticide spraying for an average of 12 days annually.

MYANMAR

TFA's partner¹⁸ surveyed 85 farmers in the Southern Shan region of Myanmar where the primary crops are tomato, mustard, pea, cabbage, cauliflower, orange, and cut flowers. On average, these farmers used 3,749 liters of pesticides per hectare of farmland annually. Each farmer used an average of 4,190 liters of pesticide annually, and each farmer was exposed to pesticide spraying for an average of 34 days annually.

THAILAND

The Thai Education Foundation (TEF) surveyed 296 farmers in the Uttaradit, Pathum Thani, and Sakon Nakhon regions of Thailand where the primary crops are rice, corn, sugarcane, cassava, calendula, soybean, chili, mango, rubber, bamboo, orange, zucchini, lentil, and cucumber. On average, these farmers used 1,102 liters of pesticides per hectare of farmland annually. Each farmer used an average of 4,724 liters of pesticide annually, and each farmer was exposed to pesticide spraying for an average of 10 days annually.

LAO PDR

TFA's partner¹⁸ surveyed 43 farmers in the Sungthong and Vientiane regions of Laos where the primary crops are chili, tomato, eggplant, and Chinese mustard. On average, these farmers used 8,137 liters of pesticides per hectare of farmland annually. Each farmer used an average of 6,343 liters of pesticide annually, and each farmer was exposed to pesticide spraying for an average of 28 days annually.

VIETNAM

TFA's partner¹⁸ surveyed 390 farmers in the Bac Giang, Yen Bai, and Lao Cai regions of Vietnam where the primary crops are rice, vegetables, cabbage, potato, kohlrabi, and sweet potato. On average, these farmers used 4,762 liters of pesticides per hectare of farmland annually. Each farmer used an average of 1,421 liters of pesticide annually.

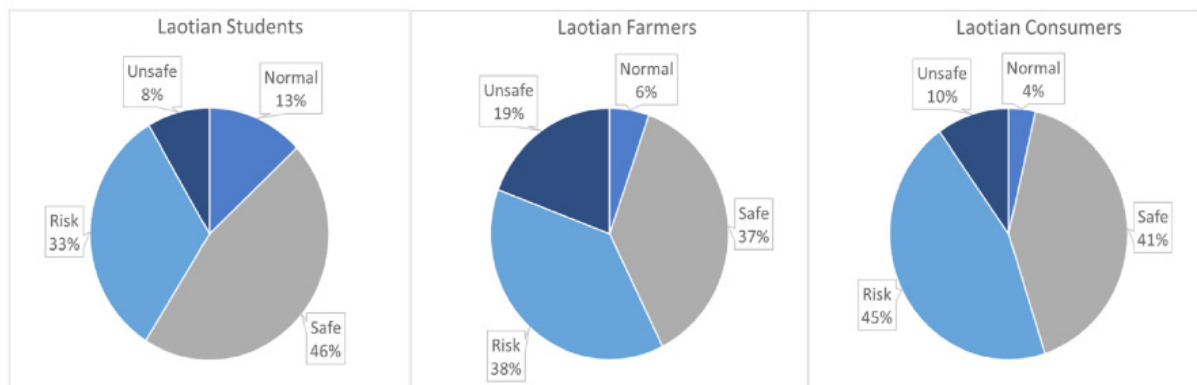


Pesticide Exposure by Country

To assess the implications of pesticide use on the human population in the region, The Field Alliance conducted studies in Laos, the Phillipines, Thailand, and Vietnam to test for residues of organophosphates, a family of insecticides, in the blood of school children, farmers, and consumers using reactive paper. The reactive papers screens for organophosphates and carbamate pesticides based on the inhibition of acetylcholinesterase, a neuromuscular enzyme¹⁶. The color results on the reactive paper indicate the level of risk the subjects displays based on the concentration of pesticide residues in the blood.

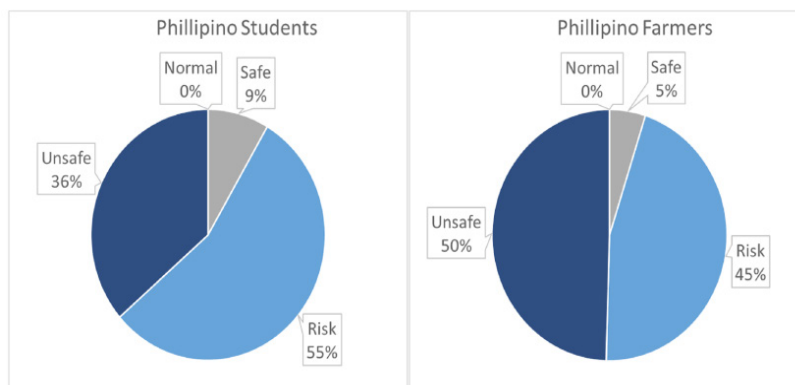
LAOS PDR

Figure 3: Organophosphate and Carbamate presence in blood detected using reactive paper in Laos. This study had a sample of 307 students, 560 farmers, and 193 consumers.



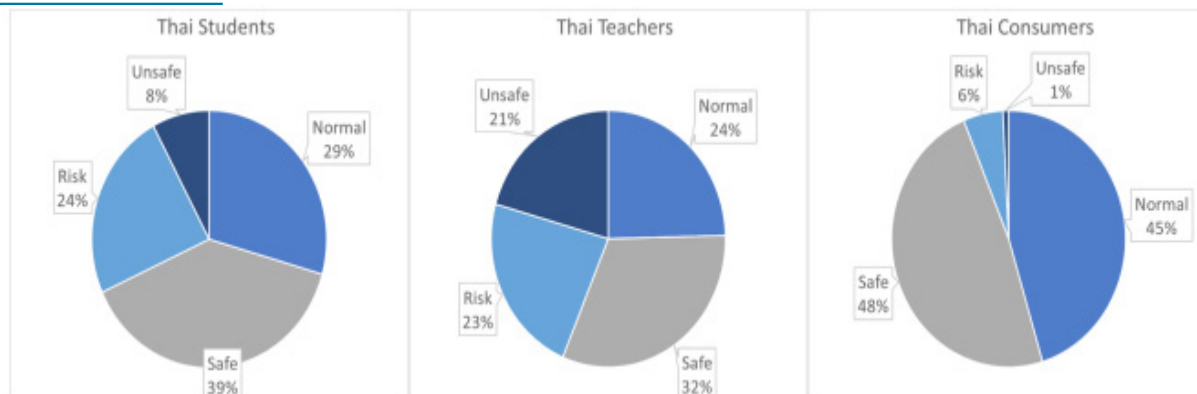
THE PHILLIPINES

Figure 4: Organophosphate and Carbamate presence in blood detected using reactive paper in the Philippines. This study had a sample of 154 students and 222 farmers.



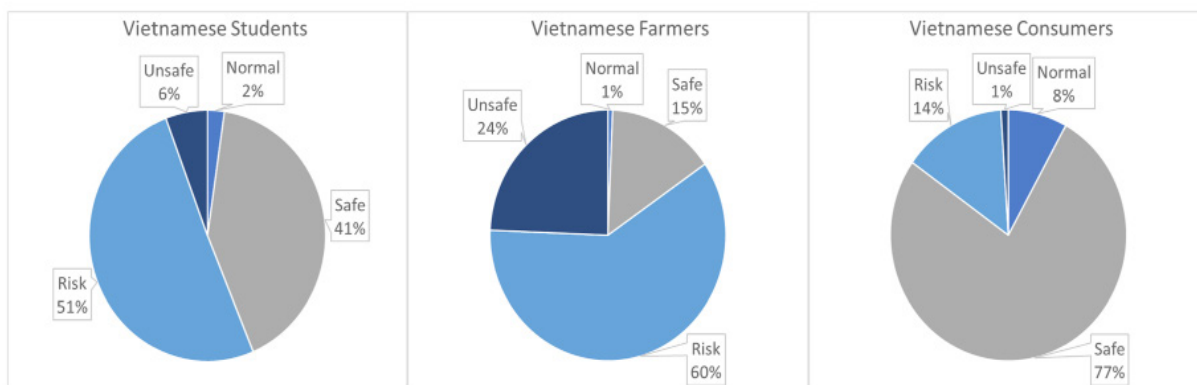
THAILAND

Figure 5: Organophosphate and Carbamate presence in blood detected using reactive paper in Thailand. This study had a sample of 1,306 students, 126 teachers, and 748 consumers.



VIETNAM

Figure 6: Organophosphate and Carbamate presence in blood detected using reactive paper in Vietnam. This study had a sample of 87 students, 156 farmers, and 99 consumers.

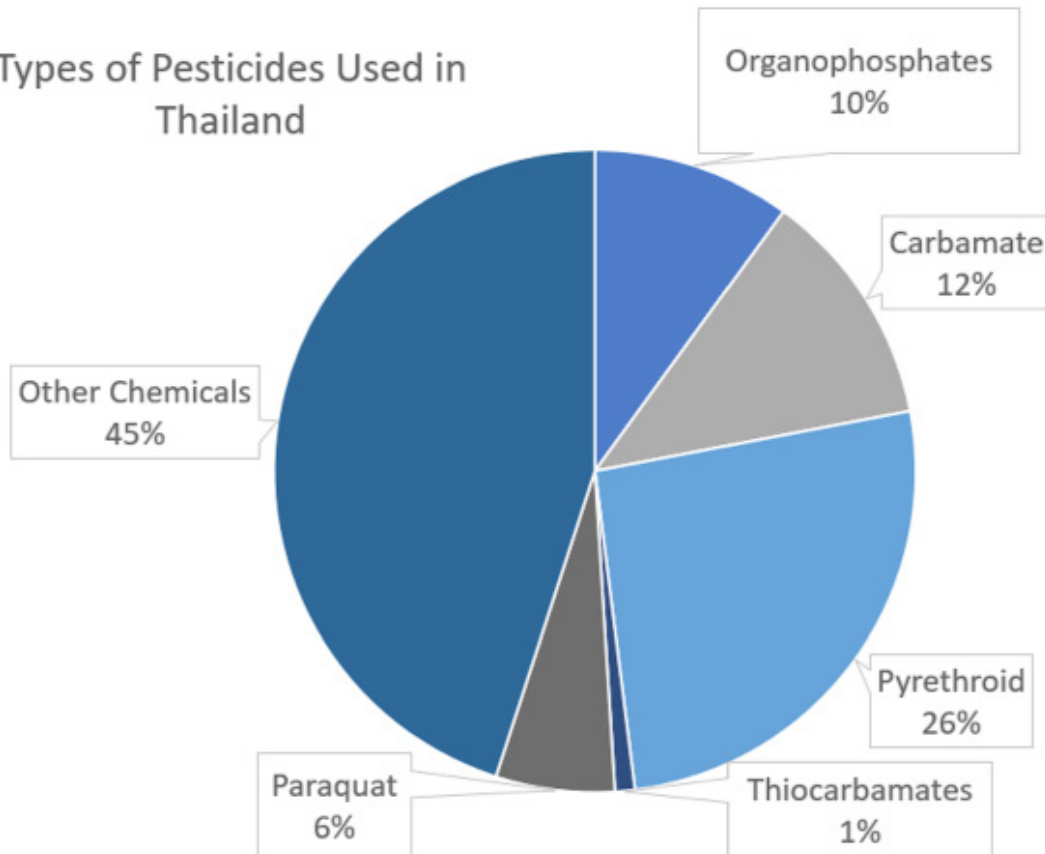


Pesticide Use in Thailand

Our findings from the blood reactive paper samples led the Thai Education Foundation to conduct an in-depth study of pesticide use and exposure in Thailand. We surveyed farmers in the Sakon Nakhon, Phangnga, Pathumthani, and Chiang Mai regions of Thailand to assess which pesticides are used most frequently. Amongst the most commonly used pesticides were organophosphates, carbamates, and pyrethroid.

Figure 7: Organophosphates, carbamates, and pyrethroid pesticides were the most frequently used pesticides in Thailand.

Types of Pesticides Used in Thailand



Organophosphate Residues in Food and Vegetables

The Thai Education Foundation also tested the presence of organophosphate and pyrethroid residues on vegetables and fruits from local markets in the four Thai provinces. Schools purchase food from these markets for children's lunches. When testing for pyrethroid residues, the presence of fenpropathrin, L-cyhalothrin, permethrin, cyfluthrin, cypermethrin, esfenvalerate, and deltamethrin in a sample of 221 vegetables. Of these vegetables, 217 had detectable levels of one or more of the tested chemicals. When testing for organophosphate residues, the lab tested the presence of methamidophos, diazinon, dimethoate, chlorpyrifos, and ethion in a sample of 222 vegetables. Of these vegetables, 201 had detectable levels of one or more of the tested chemicals.

90.5% of sampled vegetables had detectable levels of organophosphate residues, and 98.2% had detectable levels of pyrethroids.



Additionally, the Thai Education Foundation compared the percentage of unsafe samples in high-risk and low-risk areas, and found that the percentage of unsafe samples is slightly higher in high-risk area. In high-risk areas, 42.3% of samples had unsafe levels of pesticides, whereas 40.80% of samples were unsafe in low-risk areas, as depicted in Figure 10 below.

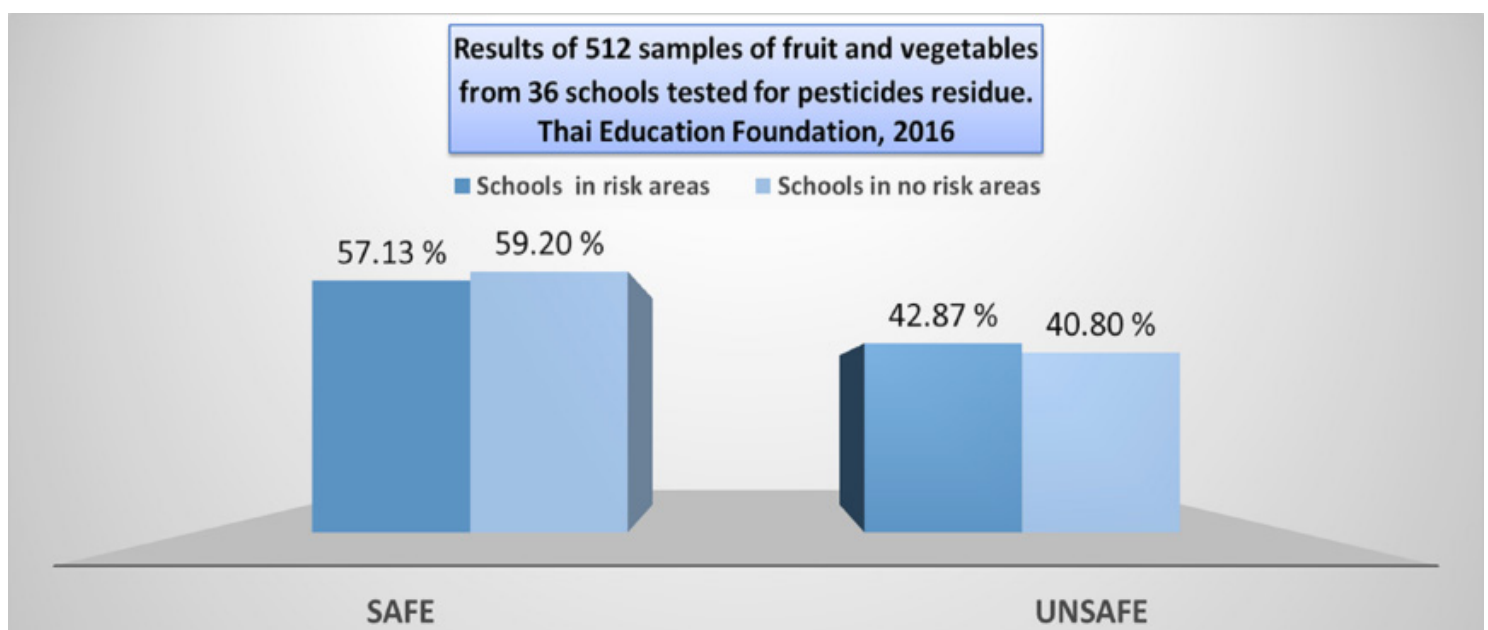


Figure 8: Pesticide residues in fruit and vegetables.

Pyrethroid Residues in Vegetable Samples in Sakon Nakhon

Figure 9: From a sample of 51 vegetables from markets in Sakon Nakhon, we tested for seven types of pyrethroid residues.

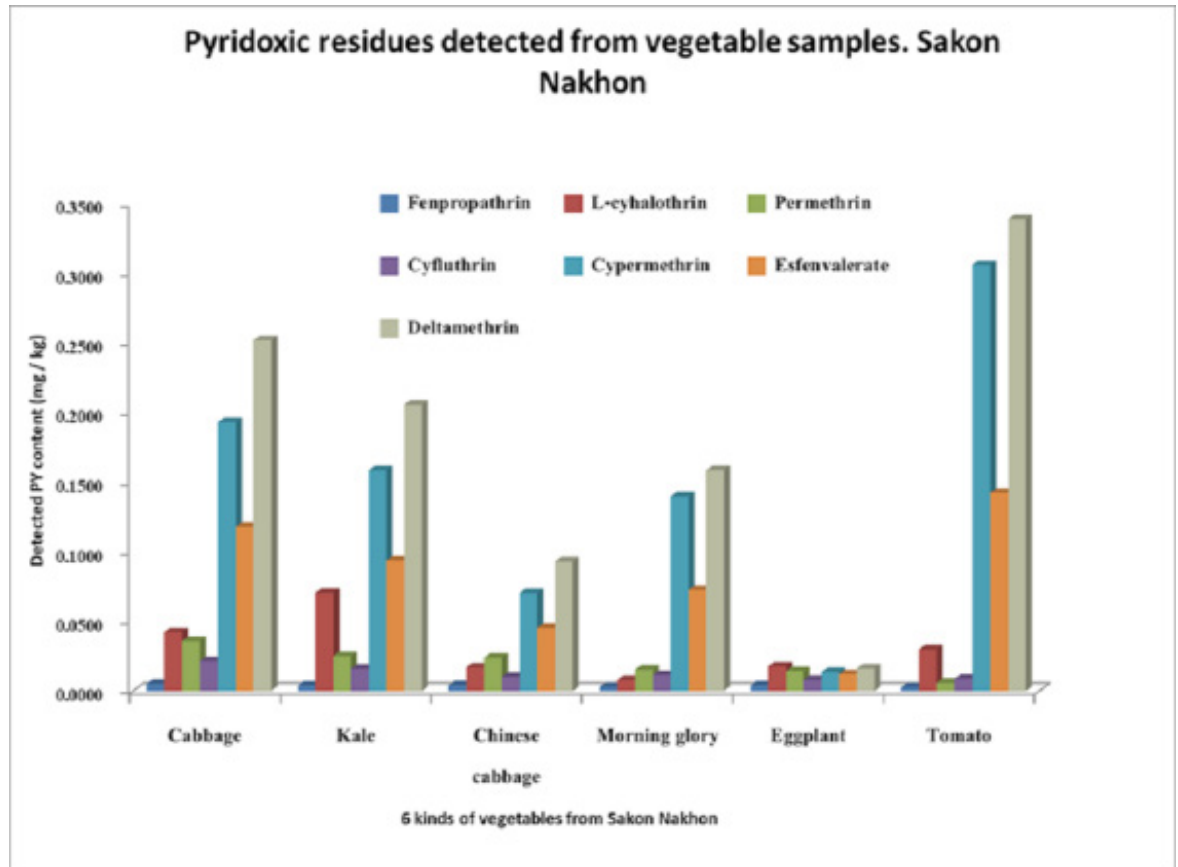
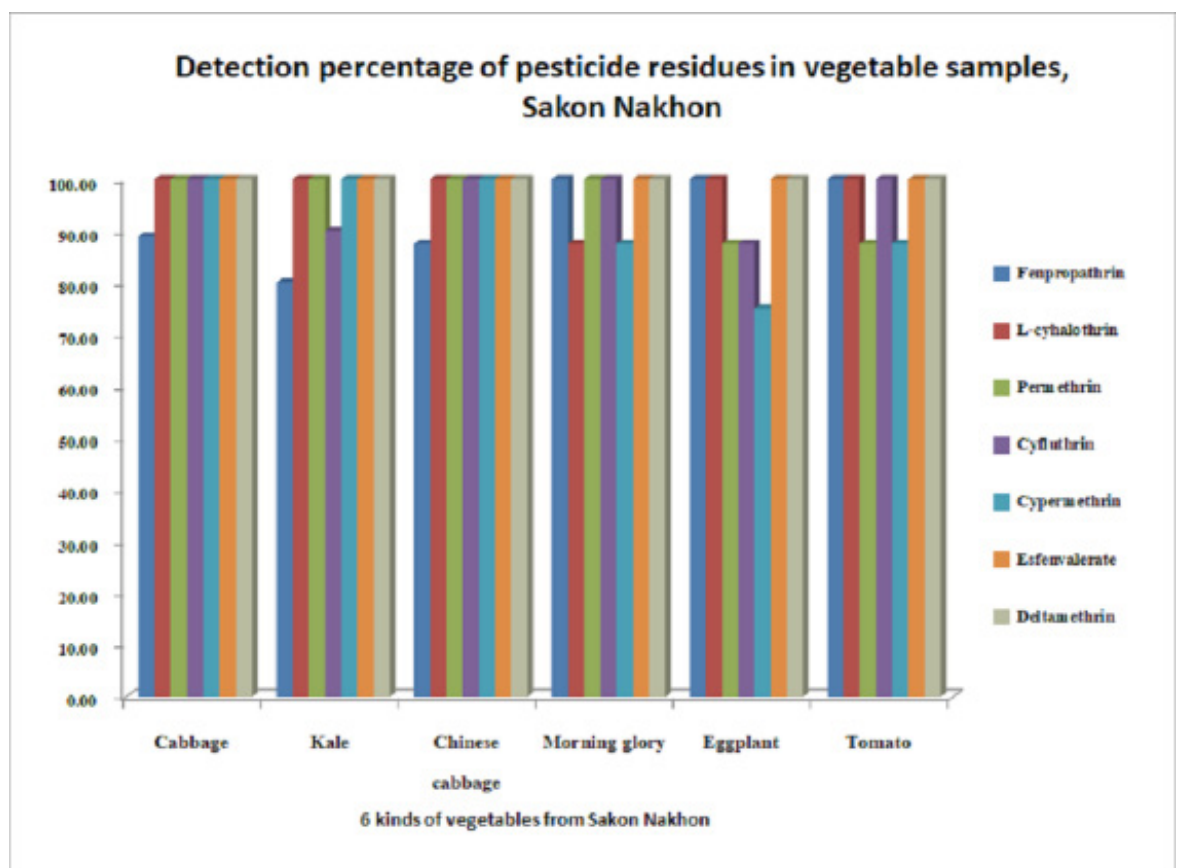


Figure 10: Of the 51 samples, all of the tested vegetables had at least one of the pyrethroid residues present.



Chemical Residues in Meat and Processed Food

While pesticide residues raise health concerns for fruits and vegetables, meats and processed foods are also treated with chemicals as preservatives or whitening agents. Amongst these are sodium hydrosulfite, sodium borate, and formalin. Sodium hydrosulfite is a water-soluble salt that is used in food preservation to prevent the decolorization of organic materials. Sodium borate, also known as Borax, is a salt of boric acid that acts as a preservative or a firming agent. The use of borax as a food additive is banned in multiple countries, with the Canadian government stating that exposure to the compound may cause developmental and reproductive health effects. Formalin is the saturated water solution of formaldehyde, which is used as a disinfectant and a preservative. In 2016, the Thai Education Foundation tested the presence of these compounds in meats and processed foods and found unsafe levels of each in 19.4% to 33.8% of samples.

Summary of residue detection in meat and processed products.					
In November, 46 schools in Chiang Mai, Pathum Thani, Sakon Nakhon and Phang Nga					
Sodium hydrosulfite (Bleach)		Sodium borate (Borax)		Formalin	
Number of raw materials inspected: 144 samples	Types of Products Sampled:	Number of raw materials inspected: 198 samples	Types of Products Sampled:	Number of raw materials inspected: 152 samples	Types of Products Sampled:
Of the samples products, 28 were unsafe (19.4%)	1. Fresh Squid	Of the samples products, 67 were unsafe (33.8%)	1. Pork	Of the samples products, 33 were unsafe (21.7%)	1. Fried squid
	2. Bamboo shoots		2. Fish Ball / Pork Ball / Meat Ball		2. Fish balls
	3. Pickled fruits		3. Chicken sausage		3. Talapia
	4. Shredded ginger		4. Thai Pork sausage		4. Pickled ginger
	5. Rice noodles		5. Picked fruits/lettuce		5. Cow intestines
	6. Sugar		6. Fermented pork		6. Tiger prawns
	7. Bean sprouts		7. Fried potato		7. Fresh squid
	8. Fermented Rice noodles		8. Fried pumpkin/yams/banana fritters		8. Shitake mushrooms
			9. Fried onion rings/ papaya		9. Dried Grapes
Note: The majority of the raw products originated from the main markets of each province or the local village markets where the schools are located.					

Figure 11: The table above displays the the number of samples with unsafe levels of soduim hydrosulfite, sodium borate, and formalin.



Organophosphate residues in urine.

The frequent application of potentially harmful pesticides raises concerns about the level of pesticide exposure in the population, particularly amongst children. Due to their possible adverse effects on neurodevelopment in children, the primary concern of this study was organophosphate exposure. The level of exposure was measured by the quantity of dialkyl phosphate (DAP) metabolites found in the urine of the subjects. In this study, we measured the concentration of six different DAP metabolites, dimethylphosphate (DMP), dimethylthiophosphate (DMTP), dimethyldithiophosphate (DMDTP), diethylphosphate (DEP), diethylthiophosphate (DETP), and diethyldithiophosphate (DEDTP), and we detected at least one of these metabolites in 97.8% of sampled students. The DAP detected at the highest concentration was dimethylphosphate (DMP).

Our study found that between 97.8% of sampled Thai students had organophosphate residues in their urine.

Figure 12:
The urine testing results shown that 98% of 393 students from 4 provinces detected organophosphate chemicals

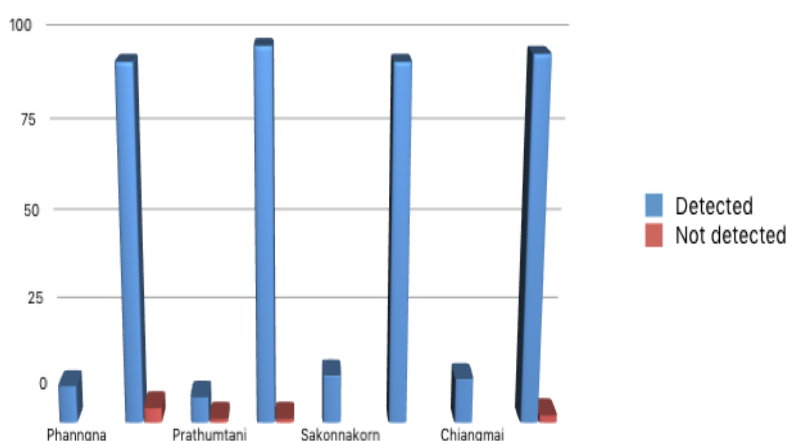
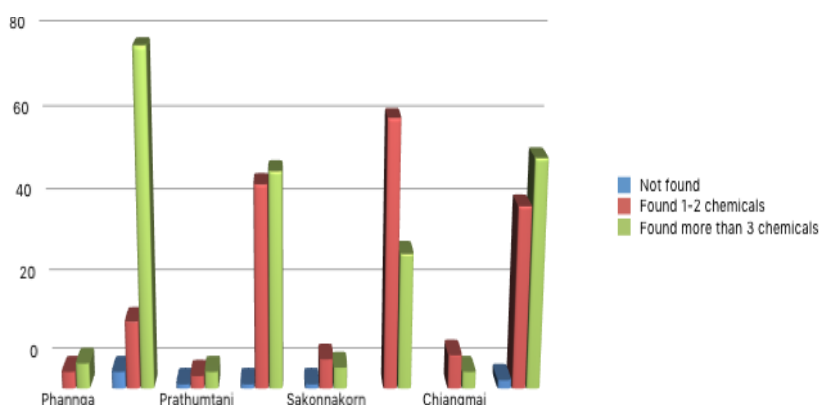


Figure 13:
The results also shown that majority of students and teachers had 2 and more than 3 chemicals of organophosphate in their urine. Chlorpyrifos was the most frequent detected chemical.

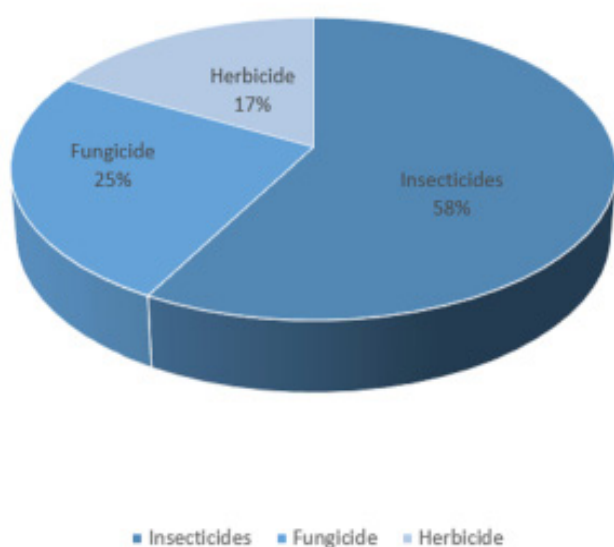


The results from the studies had shown that vegetables and fruits from local markets used for school lunch are nearly 100% contaminated with pesticides (organophosphate and pyrethroids). Nearly 100% of students and teachers' urine also detected organophosphates. Chlorpyrifos was the most frequently detected chemical in both vegetables and human. However, this study is inconclusive as further investigation is needed to see if other mostly used pesticides of carbamate, pyrethroids, paraquat and glyphosate are residual in students and teachers' urine. The results of this studies were used to discuss and plan for policies and measures with regards to the safe school lunch and establishment of green market at the local, district, provincial and the national levels.

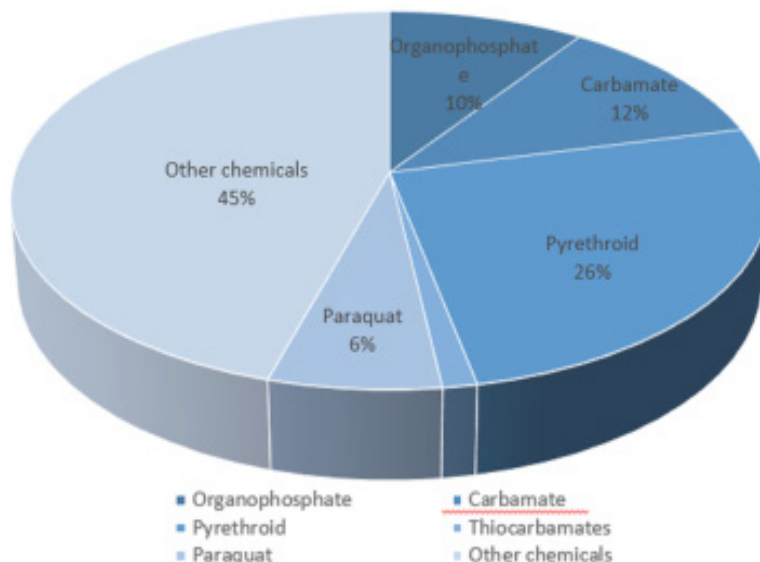
Appendix

Dialkylphosphates (DAPs) metabolites of organophosphate						Pyrethroid metabolites
Dimethylphosphate metabolites			Diethylphosphate metabolites			
DMP	DMTP	DMDTP	DEP	DETP	DEDTP	3PBA
Dichrofos	Acephate	Azinphos methyl	Chlorethoxyfos	Chlorethoxyfos	Disulfoton	Permethrin
Dicrotophos	Chlorpyrifos methyl	Dimethoate	Chlorpyrifos	Chlorpyrifos	Ethion	Cypermethrin
Mevinphos	Fenitrothion	Malathion	Coumafos	Coumafos	Phorate	Esfenvalerate
Naled	Fenthion	Methidathion	Diazinon	Diazinon	Phosalone	Bifenthrin
Tetrachlovinphos	Methamidophos	Phosmet	Ethyl parathion	Ethyl parathion	Terbufos	Cyhalothrin
Trichlorfon	Methyl parathion		Sulfotepp	Sulfotepp		Cyfluthrin
Acephate	Oxydemeton methyl		Disulfoton	Disulfoton		Fenvalerate
Chlorpyrifos methyl	Pirimiphos methyl		Ethion	Ethion		Fluvalinate
Fenitrothion	Temophos methyl		Phorate	Phorate		Flucyinate
Fenthion	Azinphos methyl		Phosalone	Phosalone		Fenpropathrin
Methamidophos	Dimethoate		Terbufos	Terbufos		Phenothrin
Methyl parathion	Malathion					
Oxydemeton methyl	Methidathion					
Pirimiphos methyl	Phosmet					
Temophos methyl						
Azinphos methyl						
Dimethoate						
Malathion						
Methidathion						
Phosmet						

Types of Chemical 80 Farmers Used



Chemical Family 80 Farmers Used



Endnotes

- 1 Schreinemachers, P., Afari-Sefa, V., Heng, C. H., Dung, P. T., Praneetvatakul, S., & Srinivasan, R. (2015). Safe and sustainable crop protection in Southeast Asia: Status, challenges and policy options. *Environmental Science & Policy*, 54, 357-366. doi:10.1016/j.envsci.2015.07.017
- 2 Pesticides. (2017, September 12). World Health Organization. Retrieved from <http://www.who.int/topics/pesticides/en/>
- 3 Fukuto, T. R. (1990). Mechanism of action of organophosphorus and carbamate insecticides. *Environmental Health Perspectives*, 87, 245-254.
- 4 Eskenazi, B., Bradman, A., & Castorina, R. (1999). Exposures of children to organophosphate pesticides and their potential adverse health effects. *Environmental Health Perspectives*, 107(Suppl 3), 409-419.
- 5 Narahashi, T. (1971). Mode of action of pyrethroids. *Bulletin of the World Health Organization*, 44(1-2-3), 337-345.
- 6 Aire, T. A. (2005). Short-term effects of carbendazim on the gross and microscopic features of the testes of Japanese quails (*Coturnix coturnix japonica*). *Anatomy and Embryology*, 210(1), 43-49. doi:10.1007/s00429-005-0001-0
- 7 Haque, A. K., Murty, M. N., & Shyamsundar, P. (2011). *Environmental Valuation in South Asia*. Cambridge: Cambridge University Press. 127.
- 8 Runkle, J., Flocks, J., Economos, J., & Dunlop, A. L. (2017). A systematic review of Mancozeb as a reproductive and developmental hazard. *Environment International*, 99, 29-42. doi:10.1016/j.envint.2016.11.006
- 9 Reregistration Eligibility Decision for Mancozeb (Rep.). (2005). Environmental Protection Agency.
- 10 Bus, J. S., Aust, S. D., & Gibson, J. E. (1976). Paraquat toxicity: proposed mechanism of action involving lipid peroxidation. *Environmental Health Perspectives*, 16, 139-146.
- 11 Vaccari, C., El Dib, R., & de Camargo, J. L. V. (2017). Paraquat and Parkinson's disease: a systematic review protocol according to the OHAT approach for hazard identification. *Systematic Reviews*, 6, 98. <http://doi.org/10.1186/s13643-017-0491-x>
- 12 Panuwet, P., Siri Wong, W., Prapamontol, T., Ryan, P. B., Fiedler, N., Robson, M. G., & Barr, D. B. (2012). Agricultural Pesticide Management in Thailand: Situation and Population Health Risk. *Environmental Science & Policy*, 17, 72-81. <http://doi.org/10.1016/j.envsci.2011.12.005>
- 13 Meticulous Market Research Pvt. Ltd. (2017, November 21). Glyphosate Market trends detailed in new research report by Meticulous Research™. Retrieved from <https://globenewswire.com/news-release/2017/11/21/1198054/0/en/Glyphosate-Market-trends-detailed-in-new-research-report-by-Meticulous-Research.html>
- 14 Sammons, R. D., & Gaines, T. A. (2014). Glyphosate resistance: state of knowledge. *Pest Management Science*, 70(9), 1367-1377. <http://doi.org/10.1002/ps.3743>
- 15 Kamel, F., & Hoppin, J. A. (2004). Association of Pesticide Exposure with Neurologic Dysfunction and Disease. *Environmental Health Perspectives*, 112(9), 950-958. <http://doi.org/10.1289/ehp.7135>
- 16 Apilux, A., Isarankura-Na-Ayudhya, C., Tantimongcolwat, T., & Prachayasittikul, V. (2015). Paper-based acetylcholinesterase inhibition assay combining a wet system for organophosphate and carbamate pesticides detection. *EXCLI Journal*, 14, 307-319. <http://doi.org/10.17179/excli2014-684>
18. Information Update - Helath Canada advises Canadians to avoid homemade craft and pesticide recipes using boric acid. (2016, July 22)
- The Field Alliance partners are the Agriculture Technology Services Association, Cambodia, Rural Development Sole, Co., Ltd., Laos, Thai Education Foundation, Thailand and Initiatives for Community Empowerment and Rural Development, Vietnam.