# SUBSTITUTES OF PERSISTENT ORGANIC POLLUTANT (POP) PESTICIDES IN BANGLADESH AND THE NEED FOR A SUSTAINABLE SUBSTITUTION PROCESS

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## Introduction

Bangladesh, with more than 160 million people in an area of 147,570 km$^2$ and with agriculture (Crops and horticulture) contributing with about 11.16% to the national GDP (BBS 2010)[1], is located in the north eastern part of South Asia between 20°34' and 26°38' north latitude and 88°01' and 92°41' east longitude. Bangladesh enjoys a subtropical monsoon climate with a temperature range from a minimum of 7°C-13°C to average of 24°C-31°C and up to 40°C in winter, autumn and summer seasons respectively. Rice is the most important crop grown in three seasons almost year-round. Further important crops include other cereals (wheat, maize), Solanaceae (e.g. eggplant, potato, tomato, okra), Leguminosae (e.g. country bean, mungbean, blackgram, chickpea, yard long bean), Cucurbitaceae (e.g. pumpkin, cucumber, bitter gourd, snake gourd, ribbed gourd, sponge gourd and pointed gourd, and Cruciferaceae (e.g. mustard, radish). Other cash crops include jute, sugarcane, tea (grown in some specialized areas only) and cotton. Besides, the major fruit crops include banana, mango, pineapple, jackfruit, guava and jujube. All these crops are seriously damaged by insect pests and diseases. Under farmers' field conditions, in certain years and places, yield losses range from 35% to 80% – Up to 100% loss has been recorded due to a single insect or disease, especially in the case of rice. Similar estimates apply to wheat, jute, sugarcane, pulses, oilseeds, vegetables and fruits. Therefore, the use of pesticides in Bangladesh has increased over the last 4 decades (Figure 1). Among the insect pests, cutworm, termite, mole cricket, white grub, grasshopper etc., are major soil insect pests of many crops. All these necessitated the use of pesticides formally including persistent organic pollutant (POPs) like aldrin, dieldrin, heptachlor, chlordane, etc. For storage pests HCH/lindane was used. Moreover, vector-borne diseases, particularly malaria, were a serious problem in Bangladesh. Malaria is still a serious problem in some areas. This necessitated the use of DDT. But in compliance with the WHO specifications as well as other relevant multilateral environmental agreements like the Stockholm Convention, Rotterdam Convention and Montreal Protocol, Bangladesh banned and/or discontinued the use of the most hazardous pesticides including POPs by 1998. The only exception was DDT allowed for restricted use in case of emergency against mosquito, the vector of malaria. The most important consequence of such ban and/or discontinuation of the POPs and other hazardous pesticides has been the predominant use of other classes of pesticides like organophosphates, carbamates, synthetic pyrethroids, neonicotinoids, avermectin, spinosad etc. due to the absence of adequately effective integrated pest management (IPM) packages with or without insecticides.

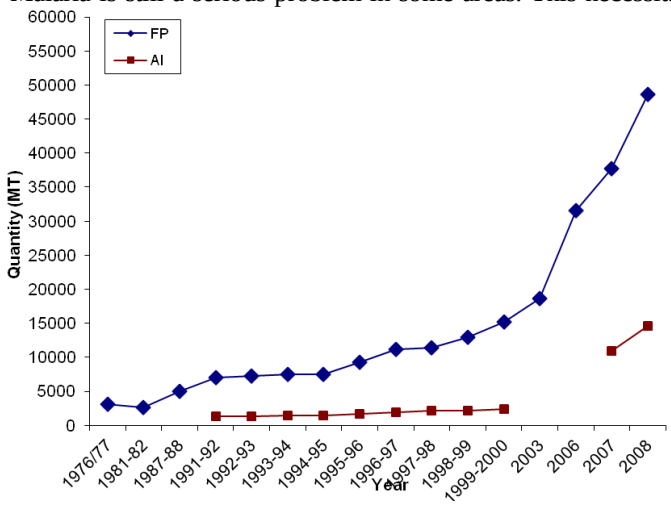


**Figure 1.** Pesticide consumption trend Bangladesh (1976 to 2008)[2] (FP: formulation product, AI: active ingredient)

**Materials and methods**

The article has been prepared based on information on past and current pesticide use in Bangladesh collected from regulatory authority, students research work for MS/PhD theses/ dissertation, association of pesticides companies and data collections from some sample farmers.

**Results and discussions**

***POPs Pesticides history in Bangladesh***

Three tons of endrin were received through barter and applied in modern rice cultivation in around 1957/58 land marked the use of pesticides in Bangladesh (former East Pakistan). The use of endrin continued for 10 years. Meanwhile, other POP pesticides like aldrin, dieldrin, chlordane, BHC/lindane and heptachlor were largely imported and used for agricultural purposes. DDT was received initially through WHO, then was imported, and from 1972 was manufactured locally. DDT was used exclusively for mosquito control for preventing/combating malaria. But in compliance with its legislation supported by WHO and MEAs, Bangladesh started discontinuing, banning, deregistering extremely hazardous pesticides in the 70's, and lastly banned heptachlor in 1998. The POPs pesticides, which have been discontinued, banned or deregistered include endrin and HCH/lindane (1970), aldrin (1975), chlordane (1985), dieldrin (1997), and heptachlor (1998)[3]. The government imposed only restricted use permission for DDT in 2005. Other POPs pesticides such as toxaphene and mirex were never imported and used in Bangladesh. However endosulfan is produced in Bangladesh by two producers and is still the most commonly used insecticide for different crops.

***Substitutes of POPs Pesticides***

With the exception of endosulfan, no POP pesticide has been imported or produced in Bangladesh since 1998. A very limited quantity of DDT is received through WHO and/or imported under the malaria control program. Therefore, the total consumption of pesticides in Bangladesh since 2000 shown in Figure 1 truly reflects the consumption of non-POP pesticides, which include 2,443 active ingredients (AIs) and 15,160 formulated products (FP) marketed (BCPA 2010)[2]. This total quantity includes the POPs' substitutes registered for specific crops in addition to the quantity used for crops other than for which they are basically registered. The crops, their target pests, substituted POPs pesticides, their POPs pesticides substitutes and adoption are shown in Table 1. In addition, Table 2 shows the consumption of the three most common POPs substitutes listed in Table 1, namely carbosulfan, chlorpyrifos, and imidacloprid (a neonicotinoid).

Table 2 shows the quantity of the use of newer pesticides, such as imidacloprid as a substitute of POPs with possibly increasing trends for imidacloprid and carbosulfan. They are applied at different crop stages including flowering stage, when pollinators including bees visit the crop. There is a high risk of bee decline, since imidacloprid has been proven to be highly toxic to bees[6] (Table 3). Moreover, imidacloprid is persistent in soil and water, and has high leaching potential[6]. Imidacloprid may be washed out of the soil into water bodies and groundwater[7]. The chemical is then further distributed into the environment.

Imidacloprid is absorbed by and translocated through the plant system and is poisonous to pollinating insects[5-11] through contamination of nectar and pollen. In Bangladesh, *Apis melifera* is a very common and efficient commercially cultivated pollinator collecting pollen and nectar from different flowering crops including mustard, rapeseed, linseed, mungbean, cucurbits etc. for which imidacloprid-containing formulations are registered for aphid and white fly control.

**Table 1:** Substitutes of POPs Pesticides in Bangladesh (Source: PPW 2011)[4]

| **Crops/Public Health** | **Pests** | **Replaced POPs Pesticides** | **POPs Substitute Pesticides** | **Widely adopted Alternative to POPs pesticides** |
|---|---|---|---|---|
| Potato | Cutworm | Dieldrin, Heptachlor | Bifenthrin, Carbofuran, Cartap, Chlorpyrifos, Chlorpyrifos methyl, Lambda Cyhalothrin, Diazinon, Imidacloprid | Carbofuran, Chlorpyrifos, Lambda Cyhalothrin, Imidacloprid |
| Sugarcane | White Grub & termite | Heptachlor Dieldrin | Bifenthrin, Cadusafos, Carbofuran, Imidacloprid | Carbofuran, Imidacloprid |
| | Termite | Heptachlor, Dieldrin | Carbofuran, Chlorpyrifos, Chlorpyrifos + Alpha-Cypermethrin, Permethrin, Imidacloprid, Thiamethoxam | Carbofuran, Chlorpyrifos, Imidacloprid, Thiamethoxan |
| Tea | Termite | Chlordane Dieldrin | Bifenthrin, Chlorpyrifos, Permethrin, Imidacloprid, Thiamethoxam | |
| Maize | Cutworm | | Chlorpyrifos, Lambda Cyhalothrin, imidacloprid | Chlorpyrifos, Imidacloprid |
| Rice | Stored Grain insects | | Fenitrothion, Pirimiphos methyl, Aluminium Phosphide | |
| Public Health | Mosquito | DDT | Cypermethrin, Malathion, Malathion + Permethrin, Lambda Cyhalothrin, d-allethrin, Permethrin, Tetramethrin, Temephos, Phenthoate, Alpha Cypermethrin, Deltamethrin, S. Bioallethrin + Permethrin, d-transallethrin, Allethrin, Esbiothrin, S. Bioallethrin + permethrin + PBO, ETOC (Prallethrin), ETOC & Sumithrin (d-Pheothrin) | Bed nets Impregnated bed net Coils, Aerosols (Limited use) |

**Table 2.** Consumption of three pesticides used partly as POPs pesticide substitutes in 2009 and 2010 (Source: BCPA 2010)[2]

| Name of Insecticides | 2009 (metric tonne) | | 2010 (metric tonne) | |
|---|---|---|---|---|
| | FP* | AI** | FP* | AI** |
| Carbosulfan | 170.4 | 34.08 | 213.69 | 42.74 |
| Imidacloprid | 87.65 | 17.5 | 94.83 | 18.94 |
| Emamectin Benzoate | 13.58 | 0.68 | 10.72 | 0.54 |

***FP – Formulation Product **AI- Active Ingredient;**

**Table 3.** Properties of some pesticides replacing or having replaced POPs pesticides in Bangladesh

| Insecticide | Acute (48h) $LD_{50}$ honey bee (in nanogram per bee) | Soil degradation | Leaching potential |
|---|---|---|---|
| **Imidacloprid** | 3.7 (oral)* | **persistent** | **high** |
| Carbosulfan | 180 (oral) | non-persistent | low |
| Chlorpyrifos | 59 (contact) | moderately persistent | low |

* exposure route in parentheses

***Risk assessment need for substitutes of POPs pesticides***

The substitutes of POPs pesticides have been introduced in Bangladesh largely without a particular risk assessment. The main driver for the selection of a pesticide substitute was/is the cost of the pesticide and the effectiveness against the respective pest. However, of the three listed pesticides, imidacloprid is known to be highly toxic to bees[5-11] and considered as an important factor for the massive bee decline observed in the US and in Europe over the last 15 years threatening harvest yields of bee pollination-dependent crops. The decrease in bees and other pollinators have important economic implications[12,13]. In addition, very recent studies indicate that neonicotinoids may adversely affect human health, especially the developing brain[14]. It is in particular worrisome that main patents for imidacloprid have finished and therefore companies in particular in developing countries might increasingly produce this persistent and toxic neonicotinoid.

POPs pesticides have been banned in Bangladesh, but adequate information about the safety of their substitutes now in use have not been duly considered. Therefore, before the large-scale adoption of any substitute for POPs pesticides a proper investigation with respect to their safety for the ecosystem including bees and other pollinators and for human health aspects should be carried-out. International collaboration in this respect would be highly useful and urgently needed for Bangladesh and most probably also for other developing countries.

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