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Use of pesticides in Bangladesh and associated risk assessment

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Abstract

Indiscriminate and over use of pesticide imposes severe long-term risk to human beings. The exposure level (0.018 mg/kg/day) of pesticides in Bangladesh is much higher than that of expected (0.005 mg/kg/day). Runoff, spillage and leaching of pesticides from agricultural fields contribute pesticide residues in surface and ground water. Ground water and surface water vulnerability in the case of DDT and Atrazine were carried out. Application of 1 to 1.12 kg/ha for Atrazine in low land rice field areas imposes moderate risk on ground water. Adulteration of pesticides in ponds, drainage from irrigation project causes toxicity to fish species and vegetables. Considerable amount of organochlorine insecticides were found in water samples of depressions near rice fields, which indicate lack of control mechanisms. Presence of significant amount of pesticide residue in food, dry fish etc. are matter of concern. The residue of pesticide in human body due to consumption of rice and wheat was estimated to be 0.62×10^{-5} mg/day/person. Shetu Pesticide Formulation Ltd., Savar has been observed as a case study and the concept of Pollution Prevention Program (PPP) (EPA, 1982) has been reviewed for the management of industrial waste.

Keywords: Pesticide, Risk assessment, Vulnerability, Pollution prevention program

Introduction

Pesticides, which include insecticides, herbicides, fungicides etc, comprise mostly of organic chemicals. They are considered as a critical aid to improve agricultural production by increasing soil nutrients and preventing crop losses. Annual consumption of pesticides as formulated products for agricultural purposes in Bangladesh was 7,800 ton in 1993, which was estimated to be more than 9,000 ton in 1996. In Bangladesh, about 80% pesticides are used in rice field. Moreover per hector consumption for crop protection was found to be gradually increased from 0.35 kg/ha in 1984 to 0.57 kg/ha in 1989 (Bangladesh Pesticide Association). As the environment of rice fields of Bangladesh are suitable for the growth of insects attack, frequency of pesticide application may be required to increase in growing season of crops. In Bangladesh, Carbofuran, Atrazine and DDT etc. are widely used in agricultural fields. Although a number of persistent organochlorine compounds including DDT are not permitted for using in agriculture, however these insecticides are available in black market because of irregular inspection. Furthermore DDT has also been used for drying purposes of fish.

Risk assessment is a complex phenomenon of uncertainty and damage/loss. It is necessary when there is a potential for hazardous changes to occur. Risk assessment is usually used to quantify uncertainties associated with the indiscriminate use of pesticides or such chemicals. The process of risk assessment arising from indiscriminate use of pesticides can be carried out in three parts.

1. Hazard Identification based on hazard identification matrix developed by Zapponi (1990)
2. Hazard Assessment from pesticide's flow cycle
3. Risk Assessment

In this paper an attempt has been taken to present the risk associated with pesticide use in Bangladesh.

Methodology

Standard methods (APHA-AWWA-WPCF, 1989) were adopted for the analysis of various water quality parameters. Gas Chromatograph (GC-14A, Shimadzu, Japan) was used for the measurement of pesticide's concentration on sample. Electron Capture Detector (^{63}Ni) with 5% OV-17 stainless steel poropak packed column was used. The column was of 3m length and 3.18 mm (1/8") of diameter. Temperature for column, injector and detector was maintained at 180^{0}C, 190^{0}C, and 210^{0}C for carbofuran; 195^{0}C, 250^{0}C and 300^{0}C for malathion, while 215^{0}C, 220^0 C and 265^0 C were kept for atrazine. Carrier gas was nitrogen (99.9% purity) at a flow rate of 80-90 ml/min for atrazine while 50-60 ml/min for malathion and carbofuran.

Result and Discussion

Vulnerability of Ground Water Pollution due to use of Atrazine

Atrazine is used in wide scale in low land rice fields. The half-life of atrazine in soil is 365 days (Crafts, 1973). At the rate of 2.00 kg/ha, in order to reach 0.1-mg/l concentrations in the ground water, about 150 days are required (Alam, 1996). According to Hollis, attenuation factor is the indicator of vulnerability of ground water due to application of pesticides in agricultural fields. Attenuation factors were calculated on the basis of Hollis's equation and found 0.752, 0.305 and 0.593 for the application rate of 2 kg/ha, 0.5 kg/ha and 1.12 kg/ha respectively. From the above calculation, it was evident that vulnerability of ground water pollution at normal application rate (1.12 kg/ha) is moderate. This result was checked by Ground Water Screening Index (GWSI) developed by Bishop (1985).

$$GSI = \ln (S^*(t_{1/2}^* K_{OW}))$$

Where, S is the solubility
$T_{1/2}$ is the half life
K_{OW} is the Octanol/Water Coefficient

For atrazine, GSI value was calculated and found to be 3.12. According to Bishop (1985), vulnerability of ground water pollution is high due to application of atrazine at the rate more than 1 kg/ha. But it is found from the field survey that the general application rate of atrazine is 1.12 kg/ha.

Risk Associated with Rice field due to Use of Carbofuran

Pesticide can reach the aquatic environment through the three main ways, spillage, runoff and leaching. There is evident that organochlorine pesticide is less mobile than the organophosphate pesticide. Presence of organic carbon is the indicator of mobility of pesticide.

Carbofuran is a systematic carbamate insecticide. Physically it is white crystalline substance, odorless when pure. Hazards identification matrix for carbofuran is developed based on identification matrix shown in Table 1.

Table 1. Carbofuran identification matrix

Item	Description	Remark
Name: Carbofuran		
Toxicity	LD_{50} = 8.2 –14.1 mg/kg LC_{50} = 0.043-0.053 mg/l tested on rat	Extremely toxic (WHO, 1982)
Persistence	Half life = 273 days	Very persistent
Mobility	K_{OC} = 3000/sqrt (S) = 3000 to 492	Slight to moderately mobile

(Source: Alam,1996)

It is evident from the above table that though carbofuran is an effective insecticide; it is an extremely toxic chemical. It is very persistent according to Hollis classification. The toxicity of its metabolites is less than carbofuran but still considerable because the value of LD_{50} is 17.9 mg/kg tested on rats, which is extremely toxic according to WHO, 1982. Moreover it is moderately mobile as K_{OC} value is 492 according to Hollis classification. So, there is a risk of ground water pollution due to indiscriminate use of this chemical.

Pesticides in Water, Food and Environment in Bangladesh and Associated Risk

Table 2 shows the presence of carbofuran and other pesticides in surface and ground water near to the rice fields.

Maximum limit of pesticides in drinking water is 0 mg/l (DOE). But surface water of Begumganj area contains 1900 ng/l of malathion. The possible way of contamination of surface water are over and indiscriminate use of pesticides; and soil erosion.

Pesticide residues were found in food samples. Table 3 shows the presence of DDT in rice and vegetables collected from different markets (Kawran Bazar, Mohammadpur and Malibag) of Dhaka.

Table 2. Pesticides in water samples

Location	Carbofuran	Atrazine	Malathion
Baman Danga (beel)	--	0.64 ppb	1.50 ppb
Hand Tubewell (Nayarhot)	--	Traces	Traces
Deep tubewell	--	--	--
Niger beel (Comilla)	0.1 ppb	--	0.006 ppb
Begumganj	0.46 ppb	--	19.00 ppb

Source: Alam (1996)

Table 3. Pesticide residues in Food

Sample	Total DDT equivalent (ppm)
Rice	0.2887
	0.2041
	0.3611
Vegetables	0.0331
	0.0102
	0.011
	0.08

Source: Alam (1996)

Pesticide residues due to eating above contaminated vegetables and rices

$C_b = \alpha^*\beta^*d^*\exp(a - kt)$

Where

α = 1 – DDT removed by cooking and washing (26.6%) [Bevenue A and Yeo C. Y, 1976]

d = 0.20 kg/day [Tuyen, 1989)

β = 50% [Assumed; Tuyen, 1989]

C = exp(a –kt) = 0.3941 mg/kg

$C_b = 10.5 \times 10^{-3}$ mg/day

Food storage (Y) reduces the percentage of pesticide residues. Pesticide remains in the body after digestion and metabolism of the food; the above equation has been modified as

$C_b = Y^*\alpha^*\beta^*d^*\exp(a - kt)$

Where, Y = Percentage of pesticide remains in food after storage

Effect of cooking and washing on residue level of pesticide in Rice (treated with 14C-DDT) is given in the Table 4.

Table 4. Effect of cooking and washing on residue level of pesticide in rice

Type	Total activity before cooking & washing (d/m/g)	Terminal activity after cooking & washing (d/m/g)
Rice	81.79	20.74

Source: Alam (1996)

After 240 days, due to dissipation and degradation of pesticide, it was found that, Y (for rice) = 0.40x0.21 = 0.084 (Saifullah, 1994)

α = 25.4%
C = exp (a –kt) = 81.79 dpm/g = 0.0038 mg/kg
C_b = 0.0038 x 0.254 x 0.1529 x 0.50 x 0.084
= **0.62×10^{-5} mg/day/person**
(Data are taken from Tuyen, 1989 and Saifullah, 1994)

Application of Pollution Prevention Program (PPP) for Reducing Risk in Pesticide Formulation Plant – A Case Study

Pollution prevention is a process that reduces the creation of wastes at the sources. It includes processes that reduce the use of hazardous as well as non-hazardous materials. It also includes other processes that protect natural resources through adequate and efficient management and conversion.

A pollution prevention program (PPP) is an ongoing and comprehensive operational activity at the source level with goal of minimizing wastes. An effective pollution prevention will (i) reduce risk, (ii) reduce operational cost, (iii) increase employees commitment to serve the industry (iv) improve healthy and effective workable environment and (v) protect public health and environment.

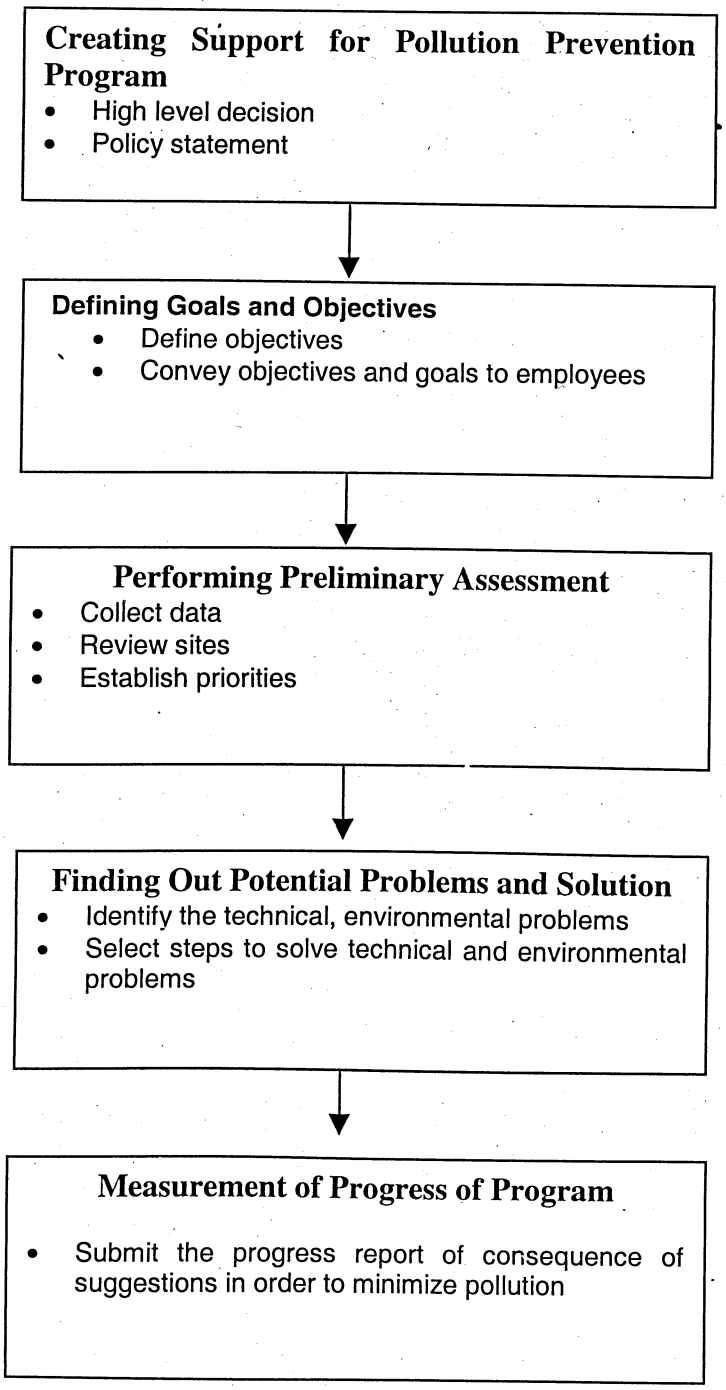

Fig. 1. Flow diagram for pollution prevention program (EPA, 1982)

The Shetu Pesticide Formulation Ltd, Savar discharged wastewater directly in the surface water. It causes toxicity and changes the physical properties of water. It was found that application of sedimentation tank, use of mask during formulation, incineration of drum containing ingredients, proper handling with residual parts of ingredients for recycling reduced waste generation, pollution and health risk (Alam, 1996). The total cost of existing treatment plant could not be able to provide by the local manager of Shatu Pesticide Formulation Ltd. But for maintaining ISO 14000 guideline, use of mask, storage facilities and hand cover will contribute to the incremental treatment cost. Total number of worker was found to be 200. Separation of ingredients from the waste will increase the cost of treatment, but it will reduce material cost. According to the local manager, every day around 200 kg ingredient is being lost during formulation process. The cost of 200kg of ingredients is around Tk. 20,000/-. Application of separator will reduce this cost every day. Investment cost of separator is around Tk. 10,00,000/-. Moreover application of landfill will be suitable method for handling hazardous materials. Incineration facilities are not up to the mark and establishment of new incineration unit will need lot of investment. The following conclusion has been proposed considering pollution prevention program

- Use of mask, hand cover and implementation of separator during formulation process will reduce health risk
- Reuse of empty pesticide drum reduces waste generations
- Use of wood charcoal for removal of color in treatment plant will remove the color and enhance reuse the water

Conclusion

The exposure level (0.018 mg/kg/day) of pesticides in Bangladesh is much higher than that of expected limit (0.005 mg/ka/day). Vulnerability of application of atrazine is moderate and there is a risk of ground water pollution due to indiscriminate use of atrazine.

Conscious efforts have been made in the constitution under the section on directive principles to assign the duties for the state and all citizens through Articles 48A and 51A. It stipulates that government should take proper steps to protect environment (Khan, 1996).

After the Stockholm conference in 1972 (EPA, 1982), environment movement really picked up in Bangladesh. In order to implement the recommendations of the conference, Government of Bangladesh brought environmental law. Yet due to various management and technical problems, environmental pollution is increasing. Moreover, small and medium size Industries have financial problem. Environmental pollution prevention program is intended to promote employee and can arise awareness of environmental –related activities by providing proper information, training.

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