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RISK ASSESSMENT OF PESTICIDES USED IN BANGLADESH

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ABSTRACT : The use of pesticides can result in hazards to human and other non-target species directly and also through the contamination of environment. The present human exposure level (0.02) mg/kg/day) of pesticides in Bangladesh is much higher than that of expected level (0.005 mg/kg/day). So, there exists a significant risk of exposure hazards of pesticides in Bangladesh. Runoff, spillage, washing of pesticide containers in water sources contribute pesticide residues to ground and surface water in Bangladesh. About 45 ppb of DDT entered into water course from adjacent rice field through drains and soil. 10 ppb to 35 ppb of DDT and 0.23 ppb and 0.2 ppb of heptachlor in water samples at different locations of Bangladesh exceed acceptable limits (which is 2 ppb in case of DDT and 0.03 ppb in case of heptachlor). Thus the use of pesticides under certain condition could pose serious water pollution problems. In this study, attempt is also made to identify different management options to minimize environmental degradation due to pesticides uses.

KEY WORDS : Risk assessment, pesticide residue, risk management exposure assessment, environmental degradation.

INTRODUCTION

Pesticide is a general term used for insecticide, herbicide, rodenticide etc., comprise mostly of organic chemicals. These are mainly classified into organochlorine, organophosphorus and carbonate based on their chemical nature. These chemicals are present in the components of environment through human activities and food chain in living organisms to harmful levels. The presence of these chemicals due to excessive and indiscriminate use poses a serious risk because of their accumulation in the food chain in concentrations sufficient to reduce reproduction and to affect the offspring.

Risk assessment of pesticides includes exposure assessment, hazard identification and the risk evaluation. The assessment of exposure of hazardous chemicals to the environment is related to the degrading capacity of the ecosystem. Based on the evaluation of the mobilities and degradabilities of such chemicals, the possibilities of the exposure of the

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non-target species can be estimated. Pest management is an integral part of modern agriculture. Many kinds of chemicals as pesticides and insecticides are being used extensively worldwide for pest management. Most of such type of chemicals are less biodegradable i.e. a portion of the chemicals remains undecomposed and gradually accumulates in the ecosystem creating a great imbalance. They are environmentally mobile. They are highly toxic and hazardous and extremely damaging to habitats. They are also transported geographically into different biota.

The consumption of insecticides herbicides and fungicides is increasing every year in Bangladesh. Pesticide was first introduced in Bangladesh in 1951. About 2 tons of pesticides were imported in 1956-57 and the quantity was raised to about 8,000 metric ton in 1993 (Table 1). The use to these chemicals as pesticides is increasing in Bangladesh with time. It has been reported that about 25% of halogenated hydrocarbons, carbonates and other toxic agro-chemicals used in Bangladesh may reach the coastal water (ESCAP, 1987). The uncontrolled use of these chemicals, use of unauthorized chemicals may cause irreparable damage to the Bangladesh environment. Those chemicals being less biodegradable can exists in ecosystem for a long time and get attached with food chain. Their high presence in ecosystem make the system warm. The implication of use of pesticides and its environmental effects in the ecosystem have been studied in this paper.

Table 1. Pesticide Consumption from 1984 to 1993 in Bangladesh (metric ton)

Year	Insecticide			Fungicide	Herbicide	Rodentcide
	granular	liquid	powder			
1984	1977	809	104	32	62	1.2
1986	2228	672	159	35	86	3.7
1986	2993	857	262	107	57	13
1987	3098	600	244	46	61	4.0
1988	3520	523	121	21	80	8.4
1989	3967	779	168	110	62	4.9
1992	5601	1045	79	440	90	42
1993	5819	1004	84	566	111	57

RISK ASSESSMENT

The risk assessment process followed in this section comprises of three stages :

* Hazard Identification
* Hazard Accounting
* Risk Evaluation

Hazard Identification: The purpose of hazard identification is to identify hazards events which may occur due to use and misuse/abuse of

pesticides. The hazard identification matrix proposed by Zapponi (1990) is modified and presented in Table 2.

Table 2. Hazard Identification Matrix

Item	Description
Name and Code	Identification number
Acute Toxicity	LD_{50} and toxicity ranking
Subchronic Toxicity	LD_{50} and toxicity ranking
Chronic Toxicity	LD_{50} and toxicity ranking
Persistence	Half life, degradation rates
Mobility	Value of Koc
Bio-accumulation	Bio-accumulation factors potential in aquatic organisms

Hazard Accounting : Account hazards of pesticides following their flow cycle from beginning to the end (formulation plant, storage, transportation, field application and disposal of pesticides container or unused portion).

Risk Evaluation: Based on above information, the risk due to pesticide use can be evaluated.

In the risk assessment process proper attention has to be given to identify, account and evaluate the following hazards to human and environment which may be imposed by the use of pesticides;

* intoxication of workers in formulating plants/agricultural field,
* intoxication of involved persons during accident,
* impact of applied pesticide on ecosystem,
* residue in foods/drinks.
* intoxication of persons due to consumption of pesticides contaminated foods, drinks and inhalation of polluted air.

RISK ASSOCIATE WITH USE OF PESTICIDES

The use of pesticides can directly results in hazards to human and other non-target species and also through the contamination of environment. It is estimated that there are 5,00,000 cases of poisoning in all over the world with about 9,200 deaths and about 2,50,000 cases with 6,700 deaths in developing countries every year (Bull, 1982). Information about the correct use of pesticides, low living standard and low level of education among people in developing countries impose more risk. In Philippines, the ratios of persons intoxicated by pesticide poisoning over the period from 1961 to 1971 are 1.84 and 1.64 persons per 1,000 persons for rural and urban areas respectively but during 1972 to 1984 these figures increased in rural areas (2.38 per 1,000 population) decreased in urban areas (1.03 per 1,000 population) (Loevinsohn, 1987). In Sri Lanka, there were 2,101 depth among 16,649 cases of pesticides poisoning in

1983 and 2,250 deaths among 16,085 cases in 1984. There may be 1,000 to 2,000 pesticide fatalities each year not recorded by hospitals (Wanigasundara, 1987). In Thailand, the depth number from 1980 to 1984 were 1,574; 1,340; 1,063; 1,219 and 1,089 persons respectively (Tuyen, 1989). In 1987, more than 100 farmers in India's prime cotton growing area of Prakasan district in Andhra Pradesh committed suicide by consuming pesticide because debts incurred for pesticide purchase. Farm labours employed for spraying operations are the worst affected as they get exposed for longer periods by working continuously during the week. In India, the pesticides consumption was 80,000 metric ton in 1982-83 (Pandey and Carney, 1989) and it is estimated that India will require about 1,44,000 ton of pesticide by the year 2,000.

For agricultural workers who have come close exposure to pesticide application are the worst affected. Some fatalities occur every year in the US where workers may get a sudden accidental exposure to high concentrations of pesticide dusts. There is some recent evidence that continued exposure to pesticides produces chronic disease. Over long term, certain pesticide residues in the human body may cause genetic effects by damage to DNA molecules(Charles, 1972) and nervous system.

Consumption of pesticide chemicals is still low in Bangladesh as compared to other countries in region. However, problems arise from weak control mechanism and lack of knowledge of farmers about effects of pesticides which may result in rampant misuses and overdosing. About 39 insecticides, 21 fungicides, 10 herbicides,7 acricides and 2 rodenticides are being used in Bangladesh in agriculture and public health sector (Sattef,1985). The use of pesticide is not effectively controlled in Bangladesh and toxic persistent pesticides such as DDT; although banned for agricultural use, are reported to be imported illegally and are being used for the protection of rice crops. Interviews with farmer reveal that a huge amount of pesticides, mainly organophosphates is being applied to protect the crops during December to April. During this period, temperature of soil is less which lead to volatilization of pestiides. There will be minimum volatilization if the soil is less moist, but there is a risk of upward mass transfer of organophosphate from dry soil. Fish moralities are being reported in the beels resulting from pesticide use in adjacent rice fields during the survey work. Most of the organophosphates used in Bangladesh are toxic according to WHO classification. Organophosphates are known for chronic and acute poisoning. In California every year the largest number of reported acute systemic illness or poisoning is caused by the exposure to organophosphate residues (UBINIG, 1985).Therefore indiscriminate use of those pesticides in Bangladesh definitely causes damage to nerve system of the population exposed to organophosphates residue.

DDT has been used in Bangladesh over a long period of time. Again carbofuran has also been used at large scale in rice field. Therefore, in

this study, attempt has been made to review the related literatures with an emphasis on the process of the assessment of the risks of different pesticides/insecticides in general and carbofuran and DDT in particular. Carbofuran and malathion are used in wide scale in rice field in Bangladesh. Matrix present in Table 2 has been used for hazard identification. It is important to recognize what elements of information are missing and consider a possible postponement of subsequent phases of risk assessment process until the data is available. Most of farmers of Bangladesh applied malathion and carbofuran at dose of 3G 1.5 kg/ha and 3G 20 kg/ha (recommended rate = 16.8 kg/ha, BARC, 1994) respectively. The corresponding concentrations in the rice field are 75 ppb and 1000 ppb which are toxic to fish because of their accumulation ability into fish (LD_{50} = 80 ppb, for fish). This will increase reduced reproductively of fishes, birds and other organisms, reduced pollination, soil sterilization and algae growth. This is also evident from the study of Hoque (1994) who found residue of pesticides in the tissue of fishes. Carbofuran generally does not accumulate in fish but its usual application dose (1000 ppb) in the rice field immediately after application impose a risk to fish and other non-target aquatic lives. In 1985 the Transport Research Board, UK reported about 74% of all accident involving hazardous materials are related to road transport. In Bangladesh main mode of transportation of pesticides are road, therefore accident hazards is also one of the main concern to minimize the risk of spillage during transportation.The prediction of pollution concentration (454-gu/m^3 which is higher than 160 ug/m^3, allowable concentration) in air by Guassian model indicates the risk of pollution of air in Bangladesh for the use of carbofuran (Alam, 1996). However, this requires further experimental verification.

Assessment of surface water vulnerability due to application of DDT in rice field is made by Alam (1996). This indicates that about 45 ppb of DDT enter into water course from adjacent rice field through drains and soil. A considerable amount of DDT, dieldrin, heptachlor, etc. (Tables 3, 4,5 and 6) have been found in water samples, dried fishes and milk samples. Presence of heptachlor (0.2 ppb and 0.23 ppb) in water samples is the matter of concern for fish population. Although levels of heptachlor residues are within WHO guide line value (30 ppb) but this is likely to be bio-magnified in the food chain. Again endrin is quite toxic to bluegills with LD_{50} value being 6 ppb. Hence presence of endrin in water sample is also a matter of concern as water from these source are also used for drinking, bathing and washing purposes. DDT and its metabolites are highly toxic to fish. The presence of DDT in water samples (10 ppb to 35 ppb) which is not registered for marketing indicates slight to moderate pollution from organochlorine residues in different pats of Bangladesh. Runoff and soil erosion are two major sources of DDT

contamination of water bodies. It is evident from Table 5 that a very high concentration of DDT and DDE residue present in dried fish samples collected from Dhaka New market. It is estimated that about 0.096 mg/day amount DDT residue is stimulated by eating contaminated fish of New market (Alam, 1996). The daily intake by this contaminated fish (0.0014 mg/kg/day considering the body weight of 70 kg person in Bangladesh) is much higher than that of Western World (0.0007 mg/kg/day, Millanby, 1992). It is also alarming that milk samples (Table 6) collected from Tangail area are contaminated by DDT and DDE residues. Residues of Endrin, Dieldrin, Lindane, DDT, DDD, BHE etc have been also found in the fishes of the Bay of Bengal. This indicates the environmental pollution of coastal areas and Bay of Bengal. In the salt-water environment, low concentration of DDT may cause 20% mortality of fish of small species. From this residue, birds and other non-target organisms are also effected. Moreover DDE, a by product of DDT, is less biodegradable and chemically stable and is not burned up and is eliminated from body very slowly. According to ESCAP (1987) 25% of total used pesticides reaches coastal water, so about 500 tons of organophosphorous pesticides and 250 tons of DDT have been reached into sea water in 1984-85.This amount is being increasing every year. Assessment of pesticide residues in wider scale and regulatory vigilance are needed in Bangladesh to protect the quality of water and environment.

Table 3. Residues of Pesticides in Water Samples (ppb)

Locations	DDT	DDE	Endrin	Heptachlor
BIT, Khulna	19.5	0	0	0.20
Kittonkhola, Barisal	35	0	0	0.20
Anowara,Chittagong	0	0	75	0
Amin Bazar, Dhaka	0	10	14	0.23

Table 4. Pesticide Residues in Water Sample (ppb)

Sample collected from	p,p'-DDE	Dieldrin	p,p'-DDT
Baman Danga Beel	-	0.64	1.50
Hand Tubewel (Nayerhat, Dhaka)	-	Traces	Traces
Niger bell (Comilla)	0.10	-	0.006
Begumgonj, Sylhet	0.46	-	19.00

Table 5. DDT Residue in Dried Fish Samples (Dhaka Newmarket) (mg/kg)

	p,p'DDE	p,p'-DDD	o,p'DDT	p,p-DDT	Total
sample-1	0.06	0.04	0.04	0.15	0.29
sample-2	0.04	0.05	0.18	0.07	0.34
sample-3	0.25	7.65	11.50	76.00	96.15
sample-4	0.47	2.83	5.00	17.33	25.63

Table 6. DDT Residue in Milk Samles (ppb)

p,p'-DDE	p,p'-DDT	Remark
16.9	44.4	Residue found at different retention time (min.)
4.5	39.7	
5.8	18.8	

Considering storage loss of pesticide residue, pesticide remains in the body after digestion and metabolism of food is estimate by the model developed by Tuyen (1989) and modified by Alam (1996). The residue of pesticide in human body due to consumption of rice and wheat in Bangladesh is 1.7×10^{-5} mg/day/person. Although the concentration of pesticide residue in human body in Bangladesh is still low as compared to other developing countries but may cause long term effects. However, this estimate does not consider the consumption of the foods, drinks and inhalation of air.

It is also evident from field survey (Table 7) that skin and respiratory diseases are common among the workers exposed to pesticide processing/application process in tea garden. Most of the work in pesticide processing/application is done manually in developing countries in general and Bangladesh in particular. This scenarios are also common in formulating plants. In most cases the workers/farmers do not have protective clothing. Even if available, protective clothing is generally not worn while handling the pesticides on account of hot and humid condition.

Table 7. Health Effect of Pesticide Exposure

Disease	Non-exposed member	Exposed member
skin	0	80
respiratory	10	70
eye	10	40

Present exposure of pesticides due to consumption pesticides contaminated foods, drinks and inhalation of polluted air is estimated by Alam (1996) to be 0.02 mg/kg/day in Bangladesh is much higher than the expectable level (0.005 mg/kg/day). This definitely have short-term and/or long term effects as cancerogenic or teratogens to humans and other non-target species. Therefore, proper assessment and controlled use of those chemical is one of the main concern to minimize overall environment degradation.

RISK MANAGEMENT

Most of the work which is handled mechanically in advanced countries, is done manually in developing countries. So risk management in developing countries means sound management of pesticide use/application and safe handling theses chemicals in various phase of their flow cycle. This includes formulating plants, storage facilities, transportation, field applications and final disposal. Thus the health hazards of the workers/farmers can be minimize with the following preventive measures:

* There should have proper facilities for removing fugitive dust and pesticide odor in the storage areas.
* There should have safe storage facilities at properly ventilated places.
* Availability of proper mask for the workers/farmers working in this sectors.
* Periodic medical checkup of workers/farmers involved in this sectors in required.
* Availability of different posters in the working areas with warning contents about toxicity of pesticides at various manufacturing/application phases.
* Upgrading of the quality of national transport system for transporting pesticides.
* There should have labeling system on the pesticide containers.
* There should have training program for the workers/farmer involved in various pesticide processing and application process.
* The agencies involved in manufacturing, processing and supplying the pesticides should have the responsibility of community education about hazards of pesticides and also of demonstrating the proper methods of application.
* Public awareness program through mass media is essential.
* National monitoring system should have to be established.

The development of a strategy for pesticide management in Bangladesh is urgently needed to reduce soil, water and air pollution. Thus to improve overall pesticide management system in Bangladesh, it

is essential that the different agencies involved in pesticide manufacturing/processing/application process and in monitoring and controlling the Bangladesh environment should recognize the problem for the development of pollution control legislation and standards.

CONCLUSIONS

On critical examination of the existing pesticide management system in Bangladesh and the discussion presented in the foregoing section the following conclusions can be drawn in this paper:

* The exposure level (0.02 mg/kg/day) of pesticides due to cosumption of pesticides contaminated foods, drinks and inhalation of polluted air in Bangladesh is much higher than that of expected level (0.005 mg/kg/day). So, there is a significant risk of exposure hazards of pesticides to human and other non target species in Bangladesh.
* Runoff, spillage, washing of pesticides' containers in water sources contribute pesticide residues to ground and surface water in Bangladesh. 45 ppb of DDT entered into water course from adjacent rice field though drains and soil. 10 ppb to 35 ppb of DDT and 0.23 ppb and 0.2 ppb of heptachlor in water samples at different locations of Bangladesh exceed acceptable limits (which is 2 ppb in case of DDT and 0.03 ppb in case of heptachlor). So, there is a significant risk of pollution water bodies in Bangladesh for the use of DDT and heptachlor.
* The prediction of pollution concentration (454 ug/m^3 which is higher than 160 ug/m^3, allowable concentration) in air by Guassian model indicates the risk of pollution of air in Bangladesh for the use of carbofuran.
* To improve overall pesticide management system in Bangladesh, it is essential that the different agencies involved in pesticide manufacturing/processing/application process and in monitoring and controlling the Bangladesh environment should recognize the problem for the development of pollution control legislation and standards.

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