



# Using Agrochemicals in Farming and Its Ecological Impact in Rural Areas in Eastern Bankura of West Bengal

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author MDG designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FHR and KM managed the analyses of the study. Authors AD and SD managed the literature searches. All authors read and approved the final manuscript.*

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## **ABSTRACT**

United Nations Hunger Task Force listed eight goals and conservation of nature and protection of environment is one of them. Different practices involved in use of agrochemicals like mishandling, indiscriminate use, disposal could have adverse health and environmental impact. This experiment was done in eight selected villages of Sonamukhi block in Bankura district of West Bengal with the main objectives of assessing the knowledge and practices regarding agrochemicals stewardship role performed at the end user level i.e. farmers; exploring the farmers perceptions of agrochemical use and its potential adverse effects on health and identifying socioeconomic variables which

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influence this role and perception. Two types of Methodology involved in this study among which participatory types are cross sectional survey, focus group discussions, key informant interviews along with descriptive statistics and Pearson Correlation Analysis. Pesticides which are highly hazardous according to WHO report, are very much in use for different purposes in the study area. All total of 300 farmers were interviewed, among them 20% stored agrochemicals in their homes prior to usage. Eighty percent of the respondents do not use anything to mix the chemicals and they do it bare hand, Unsafe dispose of empty sacs or containers of agrochemicals found in 40% of the respondents and whereas almost 25% of the respondents reused containers/sacks to store materials at homes. A minimal number of them *i.e.* only 5% of the respondents used sufficient personal protective equipment during application of agrochemicals. Participatory and bottom-up approaches like focus group discussion and key informant interviews divulged that awareness and perception regarding adverse effects of agrochemicals is moderate among the participants. The practice of handling of agrochemicals without proper protection and unsafe disposal of pesticide containers appears to be widely prevalent in the study villages. It was found the though respondent possess moderate knowledge of health and environmental hazard but the implementation of this perceived knowledge is very low. Among the different socioeconomic variables age and size of land holding has negative but significant, whereas education has shown positive and significant correlation with the use of Personal Protective Equipment. A holistic program for increasing awareness for safe management, handling and disposal of pesticides among both users and agricultural input dealers is required to address this important health and environmental problem.

*Keywords: Agrochemicals; practices; ecological impact; Bankura.*

## 1. INTRODUCTION

Agriculture remains the principle sources of livelihood for most of the rural population in India [1]. United Nations Hunger Task Force listed eight goals and conservation of nature and protection of environment is one of them [2]. As part of the green revolution use of synthetic fertilizers and chemical pesticides in agriculture has increased since 1960s in India [3]. During last five decades synthetic fertilizers consumption has drastically increased several folds and India is now one of the leading producers of agrochemicals in the world [4,5]. Agro-chemicals specially pesticides are specifically formulated which are toxic to living organisms and they are equally hazardous to human. This adverse impact of pesticides on the environment is alarming [6]. Total area under arable land in India is 170 Mha with average pesticide consumption of 0.5 kg/ha. In terms of total consumption of pesticides, India is placed tenth in the world [7]. However, this present level should not be taken with low risk to health and environment, given the prevalence and increased use of toxic pesticides allowed in India. As there is always scope for more pesticide consumption in India in the coming decades owing to the growing population coupled with high demand for food grains and intensification of agriculture under fast changing ecological set up[8]. Plant Protection Chemicals in present days is use at about 30% of the total cultivated area in India, of

which insecticide is 61.39%, followed by fungicides (19.06%), herbicides (16.75%) and other (2.80%) [9]. The green revolution became reality in India due to application of only a few chemical pesticides and fertilizers, particularly Northern States like Punjab and Haryana, and this had led to serious problems in quality and quantity of soil-water. Now there are more than 200 registered pesticides (majority of them are toxic insecticides and fungicides) available for the Indian farmers. It has been seen that developed countries use more herbicides than insecticides and fungicides, whereas Indian farmers apply more insecticides and fungicides [8]. Most of the chemical pesticides can have harmful effects on human beings either as acute or chronic toxicity [10]. Acute exposure to pesticides maybe fatal or adverse health complication may be observed [11]. About 355,000 people die around the world each year due to unintentional acute poisonings [12]. Stewardship role on the part of farmers, good management practices in terms of use, and disposal of agrochemicals is an important health and environment issue in developing countries [13]. Safe handling of pesticide is essential for the well-being of all those involved with using pesticides. To find the degree of total exposure of a person to pesticides sum of all the exposures resulting during different working situations like mixing, applying, storing or disposing the chemicals were taken into account [14]. Exposure to agrochemicals and its health

impacts can be regressed at community level by appropriate and judicious use of the same. There are some recommended methods of mixing, applying, storing, disposing and practicing use of proper personal protective equipment(PPE) which must be adopted at end user level [15,16]. The objective of the experiment was to acquire baseline information and study the knowledge and practices regarding handling of routinely used pesticides and agrochemicals and identification of socio-economic variables which significantly influence these practices. The farmers awareness and perceptions of agrochemical use and health effects were also explored.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Place

The study was done in eight villages viz; Kochdihi, Dhulai, Manikbazar, Rangamati, Hamirhati, Kalyanpur, Churamonipur, Nachanhati of Sonamukhi block of Bankura district, West Bengal, selected for its application of agrochemicals on crops or non-application and time and resource availability of the research person.

### 2.2 Sampling Procedure

The sampling procedure is shown on the below chart (Chart 1) and the respondents' selection is presented in Table 1.

### 2.3 Methodology

Methodology of the present experiment included cross sectional survey, focus group discussion,



Chart 1. Sampling procedure

Table 1. Respondents were selected through proportionate random sampling method

Villages	Populations		Sample
	Number of villagers	Proportion in each village (%)	Number of farmers selected
Kochdihi	3296	0.28	84
Dhulai	2607	0.23	69
Manikbazar	1757	0.15	45
Rangamati	1037	0.09	27
Hamirhati	955	0.08	24
Kalyanpur	951	0.08	24
Churamonipur	462	0.04	12
Nachanhati	423	0.05	15

key informant interviews, Pearson correlation analysis.

### 2.4 Cross Sectional Survey

Across-sectional survey can be defined as a process of collection of data to make inferences about a population possessing the attributes of the study (universe) at one point in time. Cross-sectional surveys have been described by many as snapshots of the populations about which they gather data. Cross-sectional designs are used for population-based surveys.

### 2.5 Focus Group Discussion

This method is appropriate for discussing specific topic in detail. A small group of people, who are knowledgeable or who are interested in the topic are invited to participate actively in then focus group discussion. A facilitator is chosen to ensure that the discussion does not diverge too far from the original topic and that no participant dominates the discussion. Each and every item observed and being said must be recorded and interviewer must not mix his or her own interpretation with it.

### 2.6 Key Informant Interviews

A key informant is anyone who has special knowledge on a particular topic. Key informants are expected to be able to answer questions about the knowledge and behavior of others and especially about the operations of the broader systems.

## 2.7 Pearson Product-Moment Correlation Analysis

When an increase and decrease in one variant is accompanied by an increase or decrease in the other variant, the two are said to be correlated and the phenomenon is known as Correlation. Correlation coefficient ( $r$ ) is a statistical measure of the relationship between two variables which are at the interval or ratio level of measurement and are linearly related. In the present study it has been calculated using software SPSS 12.

The Interview schedule of the present study included basic socio-economic information, commonly used pesticides and fertilizers, practice of mixing, storing and disposal of chemicals, re-use of containers, sacks and use of personal protective equipments; the questionnaire was translated into vernacular, back translated and piloted, modifications made before use. Farmers from all the villages were selected through proportionate random sampling and interviewed at feasible places according to them mostly at their home using the interview schedule.

Eight numbers of focus group discussion (FGD) and key informant interviews were conducted. A focus group advisory was developed, the key themes for FGDs were identified as commonly used agrochemical in that region, reasons behind using it, adverse effects of these chemicals and ways to reduce the harmful effects. One number of FGD was conducted in each of the village with farmers who were currently engaged in agriculture. FGDs were conducted at the villages itself and the sites were chosen according to feasibility of the participants. All of the eight FGDs were conducted and moderated by single researcher, to ensure that each item on the agenda was fully discussed and that all the respondents had sufficient opportunity to express their views. The objectives of the study and implications of participation were explained to the group at the beginning. Socio-economic information such as age and experience in agriculture were collected from the participants. FGD was analyzed on the vary day in which it was conducted. Components were divided into different attributes and parameters of pesticide stewardship role play by the respondent and rationale for using it, harmful effects, ways of using it, precautions taken to minimize adverse effects and were coded with different alphabets. Repeated together, accumulated and synthesized. Components which evoked spontaneous discussions, which had more time

spent on them and those associated with strong emotional cues were verbatim. The Key informant interviews were conducted with aged and experienced farmer and with the Agri-input dealers in the agricultural village. The interview focused on commonly used agrochemicals in the villages and trends in its usage and years.

## 2.8 Statistical Analysis

Data was analyzed with the use of software SPSS 12 (SPSS Inc., 1989-2003) for windows. SPSS or Statistical Package for the Social Sciences is among the most widely used programmes for statistical analysis in social science. In the present experiment SPSS was used in Pearson product moment correlation analysis.

## 3. RESULTS AND DISCUSSION

A total of 300 farmers were interviewed; 84 from Kochdhi, 69 from Dhulai, 45 from Mankbazar, 27 from Rangamati, 24 from Hamirhati, 24 from Kalyanpur, 12 from Churamonipur and 15 from Nachanhati. The Socio-economic characteristics of the farmers interviewed obtained by cross sectional survey method has been shown in Table 2. The socio-economic characteristics were analyzed to find the mean of the scores and it was found that, mean age (SD) of the farmers interviewed was 45.02 years. Among them 4.6 % were illiterate and 34.9% possessed less than one acre of land. Use of synthetic fertilizers and chemical pesticides for cultivation is very common practice among the respondent. Among 300 farmers interviewed, 20% said they stored agrochemicals prior to use while a majority of them would buy the chemicals only before use. Storing of agrochemicals before and after use has been found among 8.2% of the respondent and also 35.7% of the respondents follow the practice of mixing chemicals at their household premises before taking it to the field for application. Among them, 80% mixed chemicals with bare hands while 15.7% used a stick or ladle for mixing. Of those interviewed, 40% dispose or threw away the empty sacks or tins of pesticides or fertilizers once empty, while 25% reused it to store things; 11.2% found to bury the empty sacs after use. The usual practices on the handling of chemicals obtained by cross sectional survey are summarized and presented in Table 3. A majority of 65.5% responses were negative in terms of bathing or cleaning themselves with water immediately after applying pesticides. Personal protective equipment (more than one measure) was used by 5% while 23% did not use any

protective equipment. In Pearson correlation analysis it has been found that age and account of land has shown negative but significant correlation with number of PPE but education has shown positive and significant correlation with number of PPE which has been shown in Table 4. The pesticides which are mostly in use in the study villages were Monocrotophos, Carbofuran, Triazophos, Deltamehrin, Cypermethrin, Dithane M 45. The classification of the above-mentioned pesticides according to the World Health Organization (WHO) based on hazard is shown in Table 5. The important findings from the eight Focuss Group Discussions and Key informants interview depicted that the habit of using chemicals in agriculture has begun in all the villages on an average of thirty years ago. Most of the people did not have adequate knowledge regarding the recommended doses of pesticides or fertilizers to be used. The local agri-input dealers advised most of the farmers on the type and quantity of the chemicals to be used. Farm output in terms of biological and commercial attributes were increased upon using agrochemical was a statement agreed by all the respondents. Most of the respondents who buy chemicals just prior to application stated that reason behind this is to avoid deliberate self-harm and to keep it away from the reach of children. While the average response of the farmers showed comprehensive awareness regarding the effects of chemicals in causing chronic toxicity was poor. Many of the respondents agreed that infertility among domestic cattle has increased due to pesticide application in agricultural crops. Some focus group discussion and key informants' interviews laid emphasis on impairment of soil and water quality due to pesticide application. According to the respondents use of biological pesticides showed much delayed effect and that is too mild or in some cases not so effective. Organic farming as an option can be adopted only when the entire peasant in a cluster practices the same otherwise pests from chemical farm move to organic farm and causes yield loss. Some of Key Informants showed much higher knowledge in terms of agrichemicals application as to avoid spraying during rainy seasons, cattle should not be allowed to graze immediately after spraying, storing pesticides at home should be avoided as much as possible. This knowledge gap among the farmers was contributed to the degree of personal cosmopolitaness the knowledgeable respondents possess. The use Personal protective equipment was negative as some said they are not habituated with the same and for

some respondents it is difficult to work in field with this equipment. Some of the important verbatim accounts from the FGDs are shown in Box 1.

The health and development of living beings has been affected as indiscriminate and excessive application of pesticides damaged not only the environment and agriculture but also has entered into the food chain. Prevention and control of insect pests and diseases in the field crops was the main objective of introduction of pesticides and at the beginning very positively the use of pesticides reduced pest attack and it played a vital role in increasing the crop yield as expected. Regulation of import, registration process, manufacturing, selling, transportation, distribution and handling of insecticides and pesticides comes under the Insecticides Act, 1968 and Insecticides Rules, 1971 with a vision of risk prevention to human beings or animals and for all involved in these matters, throughout our country [17]. Use of chemical pesticides more than the recommended doses (as found in focus group discussion most of respondent do not have the knowledge of recommended dose) has attributed to environmental degradation mostly as contamination and the impact on the society in long run are found to be many. It has been found that not only in India but also in other country lack of perception among the farming community has lead to bad to worst situation as they keep on applying agrochemicals indiscriminately and excessively [18]. However, number of act or welfare scheme has been formulated for the agricultural workers but unfortunately they are unable to adequately protect and safeguard the interest of them. The present experiment divulged that awareness among the rural farming community is poor regarding safe use of agrochemicals. The pesticide stewardship role played by the farmers are very much negative as use of personal protective equipment (PPE) is very low as it has been found that only 5% of the sample respondents gave positive response towards use of PPE, unsafe disposal of empty pesticide containers are widely prevalent in the research areas. Degree of personal cosmopolitaness is also very low as the respondents mainly depend on local agri-input dealers for type and amount of agrochemicals to be used.

Adequate number of training, awareness programme, workshops and other necessary extension method need to be conducted to minimize the knowledge gap of the farmers and

also the agri-input dealers in terms of their present practices in pesticides and other chemicals handling and use with that of recommended one to get a grip on the issue of environmental and health problem [19]. Learning activities should lay much emphasis on

**Table 2. Characteristic of study population (n= 300)**

Characteristics	Categories	Numbers (%)
Age Groups	Below 30 years	12 (3.9%)
	30-45 years	144 (47.8%)
	46-60 years	127 (42.6%)
	Above 60 years	17 (5.7%)
Educational status	Not attended school	14 (4.6%)
	1-5 <sup>th</sup> standard	71 (3.5%)
	5 <sup>th</sup> - 10 <sup>th</sup> standard	197 (65.6%)
	Above 10 <sup>th</sup> standard	18 (6%)
Land owned	Less than 1 acre	105 (34.9%)
	1-5 acre	169 (56.4%)
	More than 5 acre	26 (8.7%)

*"For most the agrochemicals we do not know the recommended dose, even the exact name is also unknown in some cases.... the application method and quantity is mostly suggested by the local agri-input dealers...."*

*"Our grandfather were much more physically fit than us as they lived longer then our generation without much health problem and also could take more physical stress than us at their younger days.. This can be attributed to excessive use of agro- chemicals"*

*"Domestic cattle also show lower fertility than the previous days may be due to high rate chemical application in the field"*

*"Quality of soil has deteriorated because every year we are applying more number of chemical fertilizer than the previous to obtain the same yield but unfortunately sometimes get lesser than the last year."*

**Box 1. Verbatim accounts from focus group discussion**

**Table 3. Pesticide stewardship parameters among the respondents (n= 300)**

Attributes	Parametrs	Number (%)
Storage of agrochemicals	Respondents who store pesticides/fertilizers	60 (20%)
Place of mixing chemicals	Respondents who mix chemicals at their house	107 (35.7%)
Method of mixing chemicals	Stick/ladle	47 (15.7%)
	Bare hand	240 (80%)
	Gloves	9 (3.1%)
	Others	4 (1.2%)
Disposal of empty sacs/tins	Store materials	75 (25%)
	Thrown away	120 (40%)
	Buried	34(11.2%)
	Burnt	23 (7.6%)
	Given to rag pickers	48 (16.2%)
Cleaning immediately after applying chemicals	Soap and water	27 (9.2%)
	Water	76 (25.3%)
	Will not do anything	196 (65.5%)
Personal protective equipment(PPE) used while applying chemicals	Gloves	46 (15.3%)
	Clothing	193 (64.5%)
	Mask	251 (83.6%)
	Shoes	74 (24.7%)
	All the four equipment	15 (5%)
Won't use anything	69 (23%)	

increasing awareness and perception regarding need for using proper personal protective measures among farmers and to play stewardship role. Line departments like Block agricultural offices, ATMA, KVK should take an active responsibility to monitor and evaluate the use of PPE among farmers.

According to WHO classification Monocrotophos, Carbofuran, Triazophos which are classified as highly hazardous and Deltamethrin, Cyprmethrin and Dithane M 45 which are moderately hazardous but has been found to be extensively in use in the study area[20]. Pesticides which comes under WHO Ib (Highly hazardous) and class II (Moderately hazardous) should be avoided for regular use as per FAO recommendations [21]. In the regulated industrialized world most of the class-I and II pesticides are banned or strictly controlled, but in our country, still class-I and II pesticides are produced and are freely available and moreover there are no resources to ensure safe use of pesticides [22]. The idea and facts reducing dependence on harmful chemical pesticides and promoting the use of non-chemical or organic alternatives and the less harmful pesticides and the use of pest-resistant, genetically modified seeds through community involvement in a bottom-up approach and active participation in decision making are needed to be promulgated. Also the civil and medical societies have a vital role to play in bringing evidence informed policy decisions [19].

Some of the issues regarding safe use of agrochemicals were stated in this paper, which may not be exhaustive due to time and resource constraints. Quantum of further research is needed in this aspect in micro level to gather data on ill effect of agrochemicals on health and environment. Also policy formulation at institution meanwhile can play a vital role to ensure safe use of agrochemicals by the farmers on farm as well as training on safe and right method agrochemicals application is the crying need of the present day.

**Table 4. Pearson correlation of significant independent variables with dependent variable PPE**

Independent Variables	Significant % at 0.01 level
Age	- 0.455**
Education	0.344**
Land owned	- 0.212**

**Table 5. WHO classification of commonly used pesticides in the study villages [17]**

Chemical name of pesticide	WHO classification by hazard
Monocrotophos	Ib (highly hazardous)
Carbofuran	Ib (highly hazardous)
Triazophos	Ib (highly hazardous)
Deltamethrin	II (moderately hazardous)
Cypermethrin	II (moderately hazardous)
Dithane M 45	II (moderately hazardous)

#### 4. CONCLUSION

Evolution of alternative strategies is a continuous process in pest and disease management, in spite of this pesticide, fungicides and other agrochemicals will continue to use in Indian farm. The negative pesticide stewardship role in terms of use of personal protection and disposal of pesticide containers appears to be widely prevalent in the experimental area. A holistic approach with a combination of different extension teaching and learning methods for creating awareness and stable perception for safe management, handling and disposal of pesticides among both farmers and agri-input dealers is required to combat this important health and environmental problem. Educating farmers and training them, especially regarding protection measures like using protective clothing, proper measuring techniques using appropriate devices, empty container recycling and disposal, are some of the important stairs identified to covert the concept of pesticide stewardship into reality. Also, improving label language and quality, pesticide drift management and involvement of line department in block level and district level, the input manufacturing companies in pesticide stewardship activities would play an important role in the sustainability of agro-ecosystems.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Department of Agriculture and Cooperation, Ministry of Agriculture. Annual Report, 2010-2011. New Delhi: Government of India; 2011.
2. Sanchez, P. A. and Swaminathan, M. S., Cutting world hunger to half. Science, 2005;307:357–359.

3. Roy BC, Chattopadhyay GN. Greenpeace India. Subsidising Food Crisis. [Internet]. Available:<http://www.greenpeaceindia>, [Accessed on January 20, 2012]
4. Food and Agricultural Organization, United Nations. Fertilizer use by crop in India. Rome: FAO; 2005. Chemical use in farming and its health and environmental implications in a rural setting isotherm ; 2005 Available:[www.iosrjournals.org](http://www.iosrjournals.org) 95 | Page
5. Corporate catalyst India. Surveys and Reports. Chemical and petrochemical industry; 2011. [Cited on Jan 2012]. Available:[http://www.cci.in/pdf/surveys\\_reports/chemical-petrochemical-industry.pdf](http://www.cci.in/pdf/surveys_reports/chemical-petrochemical-industry.pdf)
6. Litovitz TL, Smilkstein M, Felberg L. Annual Report of the American Association of Poison Control Center's Toxic Exposure Surveillance System. *Am. J. Emerg. Med.* 1996;15:447–500.
7. Hundal BS, Anand, Ramandeep Singh, Pesticide marketing: The Indian scenario. *Icfai J. Manage. Econ.* 2006;4:32–37.
8. Shetty PK, Murugan M, Sreeja. KG. Crop protection stewardship in India: Wanted or unwanted. *Current Science.* 2008;95(4).
9. Shetty PK. Socio-ecological implications of pesticide use in India. *Econ. Polit. Wkly.* 2004;39:5261–5267.
10. U.S. Environmental Protection Agency. Pesticides health and safety. Human health issues [Internet]; 2012. Available:<http://www.epa.gov/pesticides/health/human.htm>, [Accessed on January 21, 2012]
11. World Health Organization. Public health impact of pesticides used in agriculture. Geneva; 1990.
12. World Health Organization. The World health report 2003 - shaping the future. Geneva; 2003.
13. Health and Environment Linkage Initiative, WHO. Toxic hazards. [Internet]; 2012 [Cited on 2012 April 26]. Available:<http://www.who.int/heli/risks/toxic/chemicals/en/>
14. Fait Antonella, Iverson Bent, Tiramani Manuela, Vaisantin Sara, Marconi Macro. Preventing health risk from the use of pesticides in agriculture. Protecting workers health series. Geneva: World Health Organization; 2001.
15. World Health Organization Pesticide Evaluation Scheme. Technical guidance for management of public health pesticides. Geneva: WHO; 2010.
16. Food and Agricultural Organization How to Reduce Risks to Human Health and the Environment. [Internet]; 2010. [Cited on 2012 April 25] Available:<http://www.fao.org/ag/locusts-CCA/en/1102/1123/index.html>
17. Public law: Insecticide act 1968, Act No.46 of 1968 (2nd September 1968); 1968.
18. World Health Organization. The WHO recommended classification of pesticides by hazard and guidelines to classification. Geneva: WHO; 2004.
19. Rakesh PS, Ankita P, Annie M. Cherian, Ashutosh Masih, Edwin Mohan, Geethu Rachel, Goutham Sunny, Jayajiwan Simon, John T. George, Kevin John, Priyanka Schilling, Karpe M. Lombi, Reginald Alex, Vinohar Balraj, Venkata Raghava Mohan. Chemical use in farming and its health and environmental implications in a rural setting in southern India. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT).* 2013;5(5):90-95. [e-ISSN: 2319-2402] [p-ISSN: 2319-2399]
20. Conway GR. Strategic Models, in G R Conway (Ed.) *Pest and Pathogen Control: Strategic, Tactical and Policy Models*, International Series on Applied Systems Analysis, John Wiley and Sons; 1984.
21. Pesticide Action Network, United Kingdom: The list of Lists, 3rd ed. London: PANUK; 2009.
22. Mensah Robert, Vodouhe Davo, Sanfilippo Damien. A new tool for Africa's organic cotton growers. *Pesticides News.* 2008;79.

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