Vol. 1 No. 3 September 2020 Pages 47-52 e-ISSN 2708-5694

Journal of Agriculture, Food and Environment (JAFE)

Journal Homepage: http://journal.safebd.org/index.php/jafe

http://doi.org/10.47440/JAFE.2020.1307

Original Article

Ubiquitous use of agricultural pesticides in six agro-based districts of Bangladesh and its impact on public health and environment

M. A. Kobir[1], I. Hasan[1], M. A. Rahman[1], M. Pervin[2], F. Farzana[3], M. R. Karim[1]*

[1]Department of Anatomy and Histology, Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
[2]Department of Pathology, Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
[3]Department of Soil, Water and Environment, University of Dhaka-1000, Bangladesh.

Article History

Received: 18 July 2020

Revised: 19 August 2020

Accepted: 22 August 2020

Published online: 06 September 2020

***Corresponding Author**

Dr. Mohammad Rabiul Karim, Professor and Head, Department of Anatomy and Histology, Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh. E-mail: mrabiulkarim@bau.edu.bd, Mobile: +88 01730721613; Phone office: +880-91-66016-18 (6313)

Keywords

Agricultural pesticides, public health, environment, Bangladesh

A B S T R A C T

Effects of pesticide exposure on public health are monitored in developed countries, which is rare in the least developed countries like Bangladesh. Here, a surveillance study was conducted to investigate the farmer's knowledge and perception toward pesticide use and the impact of occupational exposure as well as an environmental hazard in six agro-based districts (Gazipur, Khulna, Manikganj, Naogaon, Mymensingh and Tangail) in Bangladesh. A questionnaire was designed for a face to face interview of the farmers (at least 100 farmers in each district), and the data was collected. The farmer during cultivations used pesticides as single, double or several times in a single crop cycle. Among different types of pesticides, insecticides were highly used (38%), whereas Imidacloprid, and Lamda cyhalothrin insecticide was top used by the farmers. Weedicides or herbicide, fungicides and rodenticides were used 11%, 48%, and 0.5%, respectively. The knowledge and perception of the farmers towards pesticide usage are minimum, whereas the environmental pollution aspect is deficient. The knowledge of using personal protective equipment is the least. Eighty five percent of farmers use pesticides by spraying in the field. Thirty nine percent of farmers suffered from sneezing, burning sensation on face, conjunctivitis, dizziness and headache during pesticide application, and 3% suffered from skin rash of long time exposed with pesticide. The exposure of pesticides is widespread in the professional life of a farmer in Bangladesh. So, it is essential to ensure different training and awareness building program for the farmers to cope the adverse situation.

Introduction

Pesticides are double wedged weapons. It has been used in agriculture to enhance food production, and their use also causes severe environmental and health hazards to organisms (Tuzmen *et al.*, 2008). Pesticides are widely used to protect crops from pest damage. Different chemicals pesticide groups, such as organochlorin substances, organophosphates, carbamates, pyrethroid and heterocyclic pesticides, nitro compounds and amides are commonly used for the cultivation of vegetables, fruits and crops (Mavrikou *et al.*, 2008). There is widespread evidence that most of the crop, vegetable and fruit farmers in Bangladesh misuse pesticides (Miah *et al.*, 2014). Therefore, pesticides or toxic chemicals have become a part of our food chain, but it is tough to escape its exposure, especially in occupational life exposure. The unregulated use and its aerial application over large agricultural and urban areas have caused a serious threat to public health (Al-Saleh, 1994).

Recently, the agricultural system in Bangladesh is being diversified from the most traditional way of three-season crop production to higher-value crops such as vegetables and fruits (Shammi *et al.*, 2020). Pesticides are quite often risky to farmers, who often find themselves ignoring the risks associated with these compounds and who lack sufficient health measures to work with pesticides. Exposure to pesticides can increase the risk of cancer in a person's lifetime and affect the nervous and immune systems. Some pesticides may also produce mild to severe neurological and respiratory damage or act as genotoxic and cancerous agents (Hayat *et al.*, 2011). As a limited landed agricultural nation with an

immense population to feed, dependent on increased agricultural production is also increasing. Because of the high demand for crops, farmers are heading extensively on pesticide usage to maximize agricultural productivity in a developing country (Shammi *et al.,* 2020). According to Bangladesh Crop Protection Association, Bangladesh imported more than 15,106 tons of active ingredients to formulate 37,187 tons of pesticide products in 2017, which is 6% higher compared to the immediately previous year (Imran, 2018). Most of the farmers in Bangladesh are not concerned about the requirement and effectiveness of a particular pesticide towards a particular pest attack.

Furthermore, they not only use pesticides in the field but also during harvesting and before marketing (Bhuiyan *et al.,* 2009). Nevertheless, pesticides spread very speedy through water and air and thus get easily incorporated with our food chain. Indiscriminate and widespread use of pesticides in Bangladesh cause a serious threat to all living organisms, including human beings and the environment. The toxic metabolites of pesticides accumulate and persist longer with their hazardous features in the different organs of the body. It is reported that reactive compounds or free radicals play an essential role in the toxicity of pesticides and environmental chemicals. Pesticide chemicals (insecticides) may induce oxidative stress leading to the generation of free radicals and alterations in antioxidants or free radical scavenging enzyme systems (Duzguner and Erdogan, 2010). However, the impact of this indiscriminate use of pesticide are regularly monitored and controlled in a developed country but hardly seen in a developing country like Bangladesh (Bhattacharjee *et al.,* 2013). Besides this, there is an alarming number of acute and chronic health effects because of exposure to those pesticides are being recorded (Chitra *et al.,* 2006). Unfortunately, the related study and database regarding pesticide usage are very few in Bangladesh. Therefore, the present study was designed to investigate the farmer's knowledge and perception toward pesticide use and the impact of occupational exposure in popularly known six agro-based districts in Bangladesh.

Materials and Methods

Study area

To make a list of pesticides used in the different agro-based areas in Bangladesh in addition to knowing the farmer's attitude towards the use of agricultural pesticides, a surveillance study was performed. The six agro-based districts in Bangladesh, namely Gazipur, Khulna, Manikganj, Mymensingh, Naogaon, and Tangail were selected for the surveillance study (Figure 1). The selection of these six districts was based on higher crop/vegetables/fruits production areas in Bangladesh. In brief, four types, namely, insecticides, weedicides or herbicides, fungicides and different additives, were used for crop/vegetable/fruits (cabbage, lady's finger, potato, tomato, eggplant, cauliflower and cucumber, mango, banana) production in the selected areas of Bangladesh. The surveillance study in the selected districts of Bangladesh was performed based on a well-prepared questionnaire on farmer's knowledge, behavior and experience towards pesticide application, health problems and environmental hazard associated perception (Table 1).

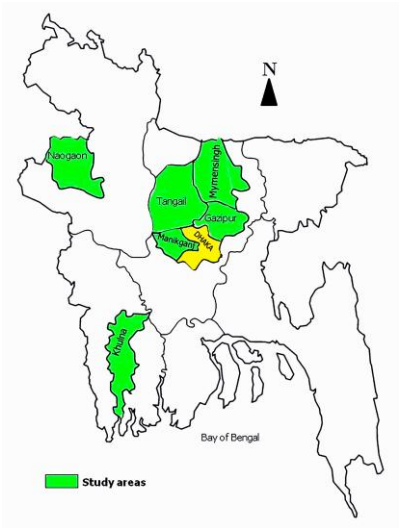

Figure 1. The figure showing the agro-based areas of surveying the six districts of Bangladesh.

A total of nineteen questions contained ~~a~~ survey sheet (Table 1) was filled with the response of vegetables, fruits and paddy farmers of targeted six areas of Bangladesh. Total 600 (six hundred; one hundred from each district) people who are directly or indirectly involved with agricultural practices and related to pesticide handling were interviewed face to face. For an interview, the questionnaire was divided into four sections composed of introductory conversation, perception of the farmers toward pesticides, perception of the farmers regarding health issues, and perception of the farmers about the effects of pesticides on public health as well as the environment. The study period was September 2018 to December 2019.

Table 1. A list of questionnaires to assess prevailing pesticides and farmers attitudes toward pesticides in the field.

1. Introductory conversation:
• Name of the farmers, Address, Age, Sex, Crop pattern:
• Process of crop/ vegetables/ fruits protection:
2. Perception of the farmers toward pesticides:
• Types of pesticide used: • Effect on production: increase / decrease • Way of application: Application/ spray • Time of application: morning/ noon/ afternoon • Frequency of pesticide application per crop/ vegetables/ fruits: • Last use of pesticide before harvesting: • Whether wash or not wash before marketing:
3. Perception of the farmers regarding health issues:
• Application by: Self/ others • Any protective equipment used during application: yes/ no (specification) • Experience of any health problem during or after application: yes/ no (specification) • Washing process of equipment used
4. Perception of the farmers about the effects of pesticide on public health as well as the environment:
• Experience with soil health: whether production increase /decrease: • Water pollution concept: • Air pollution concept: • Overall profit: increase/ decrease: • Effect on human health: beneficial/ harmful

To make the data collection process more convenient to the local people, the questionnaire was translated into Bengali and, in some cases, used the dialects familiar to the local peoples. Farmers who are directly related to agriculture, pesticide shopkeepers, and pesticide dealers were selected for an interview as the primary source of data. The opinion of experienced, educated people, school teachers, and local people were also considered during data collection in the field.

Data analysis

Data were collected, stored, tabulated and evaluated on various parameters. The data were scrutinized and edited before putting the obtained data into the sheet analysis. Data were then analyzed using MS Excel software, and the results were expressed as mean ± standard deviation.

Results

Among the toxic chemicals, insecticides were highly used (38%). Weedicides or herbicide, fungicides and rodenticides were used 11%, 48%, 0.5%, respectively (Figure 2A). The rest 2.5% includes different additives like sulfur, phosphorus, zinc, murate of potash, and growth promoters etc. At least 25 different types of pesticides were found to supply these pesticides to farmers for crop/vegetable/fruit production. Among these varieties of pesticides, imidacloprid (a chloro-nicotinyl insecticide), lamda-cyhalothrin, carbofuran, cypermethrin and chlorpyrifos mixture, dimethoate, synthetic pyrethroid and cartap plus acetaprimid mixture were the highest used insecticides and herbicides by farmers, in the studied areas of Bangladesh (Figure 2B). Among fungicides carbendazim, mancozeb and carbendazim mixture, mancozeb and metalaxyl mixture, fipronyl and foxim mixture, hexaconazole, azoxistrabin and difenokonazole mixture were mostly used.

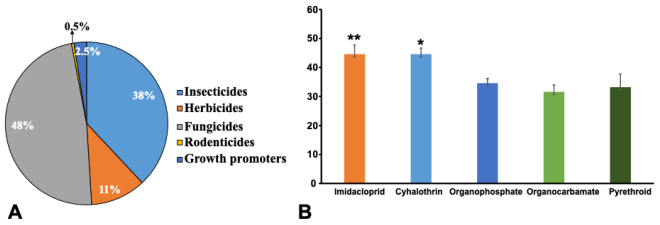

Figure 2A-B: A. Prevalence of pesticides used in the studied areas in Bangladesh. B. Top used insecticides in the studied areas in Bangladesh. Student t-test, *the p-values of ≤0.05 were considered to be statistically significant, **p-values of ≤0.01 showing highly significant.

Among the farmers of six districts (one hundred from each), 100% of farmers believe that using of pesticides increase the production. Eighty five percent of the total farmers (510 ±5) use pesticides by spraying on the field, and the rest 15% (90±5) apply on their land in the form of powder, concentrate or granules (Table 2). The form of the pesticides (liquid, powder, concentrate or granules) depended on the pest attack and the availability on the nearby local market of the farmers. The time of pesticide application greatly varies from crop to crop. Around 78% (468±5) farmers prefer sunny weather to apply pesticides in their paddy field, and the rest of farmers 22% (132±5) choose afternoon to evening time (Table 2). This scenario was the opposite in the case of vegetable cultivation. The frequency of pesticide application also depends on the type of crops and vegetables.

Table 2. Perception of the farmers toward pesticides for crop/ vegetables/ fruits production in Bangladesh.

Questions	Variables	Response	
		Total = 600	Percentage (%)
1. **Pesticide used by farmer's:**		600	100
2. **Effect on production:**			
	Increase	600	100
	Decrease	0.00	0.00
3. **Way of application:**			
	Application by hand Spreading	90	15
	Spray	510	85
4. **Time of application:**			
	Morning	0.00	0.00
	Noon	468	78
	Afternoon/ Evening (vegetable farmer)	41	6.845
5. **Frequency of pesticide, fertilizer including growth promoter's application per crop/vegetable cycle:**			
	Paddy: 3-6 times	516	86
	Brinjal: 14times	37 (total 90)	41
	Tomato: 10-12 times	156 (total 200)	78
	Potato: 5-7 times	68 (total 100)	68
	Cabbage: at least 5 times	56 (total 700)	80
	Mango: 3-5 times till harvesting	285 (total 300)	95
	Cucumber: 8-10 times	48 (total 48)	100
6. **Last use of pesticide before harvesting:**			
	Paddy: 25-30 days before harvesting	516	86
	Brinjal: last day of harvesting	37 (total 90)	41
	Tomato: last day of harvesting	156 (total 200)	78
	Potato: 7-12 days before harvesting	68 (total 100)	68
	Cabbage: last day of harvesting	56 (total 700	80
	Mango:	285 (total 300)	95
(Pre- and post-harvesting and even prior to marketing)			
	Cucumber: 1-2 days before harvesting	48 (total 48)	100
7. **Whether wash or not wash before marketing:**			
	Wash	Vegetables farmer 258.75 (total 345)	75
	Do not wash	86.25	25

The last use of pesticides before harvesting was 20-30 days in case of paddy and a minimum of 2 days in case of vegetables. The majority of the farmers do not think that they need to wash the vegetables before marketing unless it was messed with clay. In case of fruits, the pesticide was used up to harvesting and even also during the marketing of the fruits, for example, some pesticides such as Contaff® (Hexaconazole), Shinkar® (Carbendazim), Cupravit® (Copper fungicide) etc. are used in the fruits to prevent post-harvesting rotting and spot. Few chemicals such as ethophen (promote® and tomtom®), liquid mixture of carbide, formalin were used for ripening of the immature banana. The 65% of farmers (390±5) depended on others to apply pesticides, whereas 35% (110±5) apply by themselves. During application of pesticides long sleeve shirt, trouser, and only the face mask are their protective equipment. Thirty nine percent of

(234±5) farmers suffered from sneezing, burning sensation on face, conjunctivitis, dizziness, and headache almost every time of pesticide application, and 3% (18±5) suffered from skin rash with a long time of exposure to pesticides. Equipment's used in distributing of pesticides is washed on the field by 89% (534±5) of farmers, whereas 11% (66±5) of farmers wash in the house yard, pond or others (Table 3).

Table 3. Perception of the farmers toward pesticides related health issues in Bangladesh.

Questions	Variables	Response	
		Total = 600	Percentage (%)
1. **Application by:**			
	Self	210	35
	Using applicator by others	390	65
2. **Use of protective equipment during application with specification:**			
	For self-application:		
	Towel or other cloth to wrap the face region	210	35
	Full sleeve shirt		
	Pant		
	For Others:		
	Face mask	390	65
	Full sleeve shirt		
	Pant		
	Eye goggle		
3. **Experience of any health problem during or after application:**			
	Yes (Specification)		
	Burning sensation on face	234	39
	Dizziness		
	Headache		
	Skin rash and irritation	18	3
	No	348	58
4. **Washing process of equipment used:**			
	In the Field	534	89
	House yard	66	11
	Pond and other		

However, for all the six hundred farmers from the six districts, the perception of farmers about the effects of pesticides on public health as well as the environment is inferior. Eighty three percent (498±5) of farmers have no idea while questioning the experience with soil health, whereas 9% (54±5) believe decrease and 8% (40 ±5) confused with that role of pesticides. Only 31% (186±5) of farmers replied with an affirmative answer that they are well concerned with the air and water pollution effect on public health due to pesticides, whereas the large population, 69% (414±5) of people have no idea about air and water pollution caused by pesticides. However, interestingly, 91% (446±5) believes that the indiscriminate use of pesticide is harmful to human health (Table 4).

Table 4. Perception of farmers toward pesticide related public health as well as the environment.

Questions	Variables	Response	
		Total = 600	Percentage (%)
1. **Experience with soil health:**			
	Increase	0.00	0.00
	Decrease	54	9
	No idea	498	83
	Confuse about the role	48	8
2. **Water pollution concept:**			
	Yes	186	31
	No	0.00	0.00
	No idea	414	69
3. **Air pollution concept:**			
	Yes	186	31
	No	0.00	0.00
	No idea	414	69
4. **Overall profit:**			
	Increase	234	39
	Decrease	0.00	0.00
	Equal	366	61
5. **Effect on human health:**			
	Beneficial	0.00	0.00
	Harmful	546	91
	Confused/Not beneficial	54	9

Discussion

The use of pesticides has become an invincible part of crop/vegetables/fruits production in Bangladesh. The majority of farmers used pesticides that have not been registered in Bangladesh or restricted by WHO in underdeveloped countries (WHO 2004, Jors *et al.*, 2006 and Shetty *et al.*, 2011). Awareness about occupational exposure among farmers was not adequate. They did not read or follow the safety manual and had no training on the proper management for safe usage of pesticides (Dey, 2010). The vast majority of farmers cannot maintain personal hygiene (i.e., washing their hands with soap after application of pesticides) and smoke while spraying in the field. In India, similar behavioral trends are recorded (Devi, 2009).

In the present study, the age range of farmers was from 18 to 80 years. Among the six hundreds (600) of farmers of the selected districts, 96.33% were not well educated, and the rest (3.67%) were educated. Eighty five percent of the total farmers who use pesticides through spraying on the field depends mostly (65% farmers) on other people to spray, and the rest 15% apply on their land in the form of powder, concentrate or granules. Depending on vegetables and crops, farmers spray their vegetables 17-150 times per cycle (Ali *et al.*, 2002). The people or farmers who spray or apply the pesticides in the field are 99% illiterate. The majority of the spraying people are between 18 to 27 years old and who exceeding 50 years old is sporadic. Following Bhattacharjee *et al.*, 2013 it was found that the majority of the sprayer was 19–28 years of age, with only 5.9% older than 50 years. The time of pesticide application in the case of paddy farmers, 78% prefer the sunny weather. They believe that hot, humid and arid condition are more suitable for the pesticide to exert their action as rapid as possible. However, vegetable farmers prefer evening time. The study found that pesticide users are mostly unaware of protective coverings at the time of handling, transporting, storing and spraying. Hundred percent of the sprayers were found to handle pesticides with a bare hand during application. Around 40% of sprayers use a mask or

other cloth on the face as a protection from direct exposure. Studies show that wet cotton clothing and cotton masks increase the person's absorption rate of pesticides (Kishi *et al.,* 1995).

Interestingly, 17% of sprayers were found to smoke during or before spray. Many farmers inform smoking cigarettes during pesticide application. However, many are unwilling to follow the necessary precautions, attributing their reluctance to non-availability and high cost of personal protection products, and the prevailing hot and humid weather conditions. These reasons were similar to those reported from other developing countries such as Indonesia (Fait *et al.,* 2001). Esechie and Ibitayo (2011) stated that personal protective equipment such as nose mask, overall and eye goggles were rarely found to be used by the farmer during pesticide application in Oman. Bhattacharjee *et al.,* 2013 investigated that one hundred seventy-four (47.2%) farmers mixed water with pesticides using bare hands and 21.1% of farmers smoked during the time of spraying pesticides. However, thirty nine percent of farmers suffered from sneezing, burning sensation on face, conjunctivitis, dizziness, and headache almost every time of pesticide application and 3% suffered from skin rash of long time exposed with pesticide is very alarming for sound health perspective of farmers in Bangladesh. Similar findings were also reported in the previous studies in India (Manachini *et al.,* 2005; Chitra *et al.,* 2006; Dey, 2010; Shetty *et al.,* 2011) in Indonesia (Kishi *et al.,* 1995) and Bangladesh (Rahman and Alam, 1997; Hossain *et al.,* 2004 and Shammi *et al.,* 2020). Ngowi *et al.,* (2007) reported that pesticide-related health problem includes skin problem and neurological disturbances. Ntow *et al., (*2009) reported in Ghana that weakness and headache are very common symptoms of pesticide exposure, and almost 97% of farmers exposed to pesticides had been experienced. FAO (2001) stated that pesticide exposure-related health problems are mimic and natural in the rural area, and the most common symptoms are headaches, dizziness and vomiting. In Oman, health symptoms because of pesticide exposure were skin irritation (70.3%), burning sensation (39.2%), headache (33.8%), vomiting (29.7%) and salivation (21.6%) as reported by Esechie and Ibitayo (2011). They also noted general weakness, among other symptoms related to pesticide exposure. In a similar study in Bangladesh, Miah *et al.,* (2014), reported that 55%, 53%, and 52% having experience of health hazards, i.e., eye irritation, headache and nausea, respectively, at the time of pesticide application. World Health Organization (WHO) reported that at least 20,000 workers die from exposure to pesticides every year (WHO, 2004). The use of agricultural pesticides not only causes human health disorders but also pollutes soil, air and water through leakage and easily incorporated with the food chain.

Referring to the Bangladesh Agricultural Research Institute (BARI) investigation study, Khandker and Hossain (2017) revealed that one-third of Bangladesh's pesticides used in crops, vegetables and fruit production was below the standard level for which the resistance of pests to a specific pesticide is significantly increasing. This indicates that farmers need to add more pesticides (10-15 times the required amount for fruit production and 8-10 times for vegetable growing). The unnecessary amount of pesticide causes the high cost of production, and their remaining residues cause the soil and ecosystem contamination. The residual poisonous chemicals retained in crops, vegetables and fruits that are endangering human health. Pesticide residues remain in the marketed vegetables due to not-maintenance of the pre-harvesting period. Beyond these, various pesticides are systematic. The systemic contaminants enter the fruit and vegetables, and by washing, it is tough to remove them. Interestingly only 25 farmers were concerned about it (Miah *et al.,* 2014).

Farmers' conception about soil, air and water pollution was astounding. Because 83% of farmers do not know about soil health due to extensive use of pesticides, 9% believe in decreasing and 8% are confused with the pesticide function. Approximately 31% of farmers responded with an affirmative response that they are well concerned about the effect of air and water pollution on public health because of pesticides, whereas 69% of the large population has no idea. However, 91% believe that indiscriminate pesticide use is detrimental to human health. Shammi *et al.,* (2020) reported that about 53.5% of farmers realized indiscriminate use of pesticides cause surface water pollution. Farmers were comparatively aware of some pesticide hazards on humans and non-target organisms, but knowledge of other pesticide hazards (e.g., water contamination) was low (Bondori *et al.,* 2018).

Conclusion

Farmers used pesticides indiscriminately during vegetable, fruits and crop cultivation in Bangladesh. Two top-used pesticides namely; imidacloprid and lamda cyhalothrin were recorded in the surveyed areas. The occupational exposure of pesticides in the study area was the most common finding in the occupational life of farmers but the farmers are reluctant to use any protective equipment during the handling and application of pesticides in their field. Due to a lack of proper knowledge regarding handling, application and storage of pesticides, farmers are suffering from different health disorders and financial crises in rural area. So building awareness among the farmers is the burning issue at this situation. Therefore, it is essential to ensure different training for farmers to cope with this situation.

Acknowledgment

The authors thank Md. Mizanur Rahman and Md. Ahasan Habib for data collection in Tangail and Manikganj districts. This work was supported by the Grant for Advance Research in Education (GARE), Bureau of Educational Information & Statistics (BANBEIS), Ministry of Education (MoE), Government of the People's Republic of Bangladesh, (Grant No: LS2018773; 2019/720/MoE) to MR Karim.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

MR Karim and M Pervin designed the experiment. MA Kobir wrote up the draft. MA Kobir undertook the experiment; MR Karim and MA Kobir interpreted the results putting efforts on statistical analysis with MA Rahman; MR Karim, MA Kobir, I Hasan, M Pervin and F Farzana checked the manuscript critically. All authors read and agreed on the final version of the manuscript.

References

Ali SM, Rahman MM, & Hossain AM (2002). Pesticide use and male fertility in Bangladesh. Bangladesh Environment.

Al-Saleh IA (1994). Pesticides: a review article. Journal of environmental pathology, toxicology and oncology: official organ of the International Society for Environmental Toxicology and Cancer 13(3):151-61.

Bhattacharjee S, Chowdhury MA, Fakhruddin AN, & Alam MK (2013). Impacts of pesticide exposure on paddy farmer's health. Jahangirnagar University Environmental Bulletin 5; 2:18-25.

Bhuiyan MH, Ali MS, & Molla MM (2009). Effects of using chemicals and hormones for cultivation and marketing of vegetables and banana. National Food Policy Capacity Strengthening Programme (NFPCSP), FAO Bangladesh.

Bondori A, Bagheri A, Damalas CA, & Allahyari MS (2018). Use of personal protective equipment towards pesticide exposure: Farmers' attitudes and determinants of behavior. Sci. Total Environ. 639, 1156–1163. https://doi.org/10.1016/j.

Chitra GA, Muraleedharan VR, Swaminathan T, & Veeraraghavan D (2006). Use of pesticides and its impact on health of farmers in South India. International journal of occupational and environmental health 1; 12(3):228-33.

Devi PI (2009). Health risk perceptions, awareness and handling behavior of pesticides by farm workers. Agricultural Economics Research Review 22:263-8.

Dey NC (2010). Use of pesticides in vegetable farms and its impact on health of farmers and environment. Environ. Sci. Technol 11:134-40.

Duzguner V, & Erdogan S (2010). Acute oxidant and inflammatory effects of imidacloprid on the mammalian central nervous system and liver in rats. Pest. Biochem. Physiol. 97 13–18.

Esechie JO, & Ibitayo OO (2011). Pesticide use and related health problems among greenhouse workers in Batinah Coastal Region of Oman. Journal of forensic and legal medicine 1; 18(5):198-203.

Fait A, Iversen B, Visentin S, Maroni M, & He F (2001). Preventing health risks from the use of pesticides in agriculture. Protecting Workers' health series n°l. International Centre for Pesticide Safety, WHO, Geneva, Switzerland.

FAO, 2001. Farmer self-surveillance of pesticide poisoning episodes: report on one-month pilot: FAO Programme for Community IPM in Asia, August 15-Sept 15.

Hayat K, Ashfaq M, Ashfaq U, Saleem & MA (2010). Determination of pesticide residues in blood samples of villagers involved in pesticide application at District Vehari (Punjab), Pakistan. African Journal of Environmental Science and Technology 4(10):666-84.

Hossain F, Pray CE, Lu Y, Huang J, Fan C & Hu R (2004). Genetically modified cotton and farmers' health in China. International Journal of Occupational and Environmental Health 1; 10(3):296-303.

Imran Hossain, 2018. Hazardous pesticides in wide use in Bangladesh. The new age newspaper Sep 14, (https://www.newagebd.net/credit/Emran Hossain).

Jørs E, Morant RC, Aguilar GC, Huici O, Lander F, Bælum J & Konradsen F (2006). Occupational pesticide intoxications among farmers in Bolivia: a cross-sectional study. Environmental Health 5, 1-9.

Khandker DS and Hossain ML (2017).Use of chemical pesticides in agriculture. The independent news, 29th December.

Kishi M, Hirschhorn N, Djajadisastra M, Satterlee LN, Strowman S, & Dilts R (1995). Relationship of pesticide spraying to signs and symptoms in Indonesian farmers. Scandinavian journal of work, environment & health 21:124-33.

Mancini F, Van Bruggen AH, Jiggins JL, Ambatipudi AC, & Murphy H (2005).Acute pesticide poisoning among female and male cotton growers in India. International journal of occupational and environmental health 1; 11(3):221-32.

Mavrikou S, Flampouri K, Moschopoulou G, Mangana O, Michaelides A, & Kintzios S (2008) Assessment of organophosphate and carbamate pesticide residues in cigarette tobacco with a novel cell biosensor. Sensors 8:2818–2832.

Miah SJ, Hoque A, Paul A, & Rahman A (2014). Unsafe use of pesticide and its impact on health of farmers: a case study in Burichong Upazila, Bangladesh. Cancer 21(3):22-30.

Ngowi AV, Mbise TJ, Ijani AS, London L, & Ajayi OC (2007). Pesticides use by smallholder farmers in vegetable production in Northern Tanzania. Crop Protection (Guildford, Surrey) 26(11): 1617–1624.

Ntow WJ, Tagoe LM, Drechsel P, Kelderman P, Nyarko E, & Gijzen HJ (2009). Occupational exposure to pesticides: blood cholinesterase activity in a farming community in Ghana. Archives of environmental contamination and toxicology 1; 56(3):623-630.

Rahman MH & Alam MJ (1997). Risk assessment of pesticides used in Bangladesh. Journal of civil engineering 25(1):97-106.

Shammi M, Sultana A, Hasan N, Rahman MM, Islam MS, Bodrud-Doza M, & Uddin MK (2020). Pesticide exposures towards health and environmental hazard in Bangladesh: A case study on farmers' perception. Journal of the Saudi Society of Agricultural Sciences 1; 19(2):161-73. https://doi.org/10.1016/j.jssas.2018.08.005

Shetty PK, Hiremath MB, Murugan M, & Nerli RB (2011). Farmer's health externalities in pesticide use predominant regions in India. World Journal of Science and Technology 1(4):1-1.

Tuzmen N, Candan N, Kaya E, & Demiryas N (2008). Biochemical effects of chlorpyrifos and deltamethrin on altered antioxidative defense mechanisms and lipid peroxidation in rat liver. Cell Biochemistry and Function 26(1). 119-124. doi:10.1002/cbf.1411

WHO, 2004. The WHO recommended classification of pesticides by hazard and guidelines to Classification. Available at: http://www.who.int/ipcs/publications /pesticides_hazard/en. Accessed on 12 March 2020.