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Studies on the Impact of Agrochemicals used on the Croplands of Jagatsinghpur District of Odisha, India

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ABSTRACT

Chemical fertilizers are utilized significantly in cutting edge agriculture as an approach for improving crop productivity. Some potential pesticides generally are generally utilized to decrease the crop loss due to deterioration by microorganisms and pests. In any, case sizable utilization of agrochemicals can cause extreme worries to the surroundings and human health. These chemicals also increase several heavy metals in the soil like chromium, cadmium, copper, arsenic, lead, zinc, and cadmium. Heavy metallic contamination withinside the soil is a chief environmental situation that negatively impacts large parts of the globe. The current research work is an investigation of the utilization of agrochemicals in the Jagatsinghpur district of Odisha and their adverse impact on the environment and human well-being. During the study, a detailed survey was conducted among the farmers of Jagatsinghpur district regarding the use of agrochemicals. Soil samples from distinct regions had been gathered for heavy metal and microflora analysis. The end result revealed that a few agrochemicals boom crop productiveness and concurrently damage the environment, and their long-time period use may be catastrophic. Besides the utilization of chemical products, biological products could be substituted for a cleaner and healthier environment and good human health.

***Key words*:** *Agrochemical, Biological, Environment, Heavy metal, Microorganisms*

Introduction

Agriculture is the primary source of Indian economy and plays a crucial role in its socioeconomic conditions. The green revolution started using different fertilisers and agrochemicals for the increase in the production of food crops. The Green Revolution contributed greatly to the Indian economy by providing food adequacy and enhanced rural welfare. These products are also used for purposes, such as maintaining non-agricultural areas like urban green areas and sports fields. The green revolution also resulted in the advancement of Indian agriculture (Borthakur and Singh, 2012).

Utilization of agrochemicals and chemical fertilizers in horticulture has a few favorable circumstances that fluctuate from yield increment of agrarian harvests and soil fertility to pest management and crop security. Cultivated crops are tested with numerous organic phenomena (weed, insect, and pest pervasion) and abiotic stresses (decreased soil fertility) that are overseen by the serious utilization of agrochemicals (Majeed, 2018). The huge amount in agrochemicals' application has made soil fertility

at a top position and managed insect with subsequent crop yielding fields from the last 40 years (Lamichhane *et al.*, 2016). Conventional agrochemicals (i.e., solely agrochemicals synthesized by the agrochemical corporations and not those used for hundreds of years, like sulfur and copper) provide various advantages (Cooper and Hans, 2007) Agrochemicals are the substances used widely across the globe to manage various agents, like arthropods, insects, animal disease transmitters, plants, and microbial pathogens. This merchandise is utilized in farming as well as in crop systems to control weeds and insects, on livestock for controlling pests and within the health sector to manage vectors borne diseases. Agrochemicals are usually sold out worldwide and utilized at industrial and domestic level (Dadaby and Tulk, 2017).

The use of typical agrochemicals past few decades has led to several issues in the agriculture, human health and environment. Agrochemicals will have numerous unfavorable ecological effects like industriousness in the soil. It will cause rich soil unusable for cultivating, bioaccumulation will crash living beings and food, spillover and groundwater penetration will cause spoilage of water (Watson, 2014).

Broad utilization of agrochemicals inside the horticultural fields is among the first reservoir of water pollution (Singh *et al.*, 2004). Nowadays, at any place on the planet, individuals are sensibly aware of the criticallity of sterilization and food safety and have been interested in agriculture sustainability, decreasing the detrimental impact on the earth. Numerous combinations of substances known as POPs ("Persistent Organic Pollutants") under the Stockholm Convention being utilized in farming and industry end up in adverse human health and ecological outcomes (Wang'ombe, 2014). The pesticide resistance leads to pest evolution, which is an important factor causing a need to reduce our dependency on conventional pesticides (Lamichhane *et al.*, 2016).

The current research aims to study the farmer's knowledge, attitude, and practices on applying agrochemicals in crop cultivation. Helps to analyze the source from where the farmers collect information regarding the use of agrochemicals. This will determine the types and number of agrochemicals used by the farmers in crop productivity. It will help to identify the environmental and human health issues associated with agrochemical usage and also to know the heavy metals accumulated as a result of the utilization of agrochemicals.

Materials and Methodology

Study area

Out of thirty Districts in Odisha, Jagatsinghpur (ancient name - Hariharapur) is one of the districts that lies on the eastern coast of India (MSME, 2016). On 1 April 1993, it has become a new District being separated from the Cuttack District. Jagatsinghapur is at 20.27°N 86.17°E (Fig.1). It has an average elevation of 15 meters (49 feet).

Study site

The sites for the study are the five panchayats of Jagatsinghpur District, which includes 34 villages. These villages have very high diversity in agriculture, with more than 5,000 numbers of farmers. In this survey, farmers of four villages, namely Sainto,

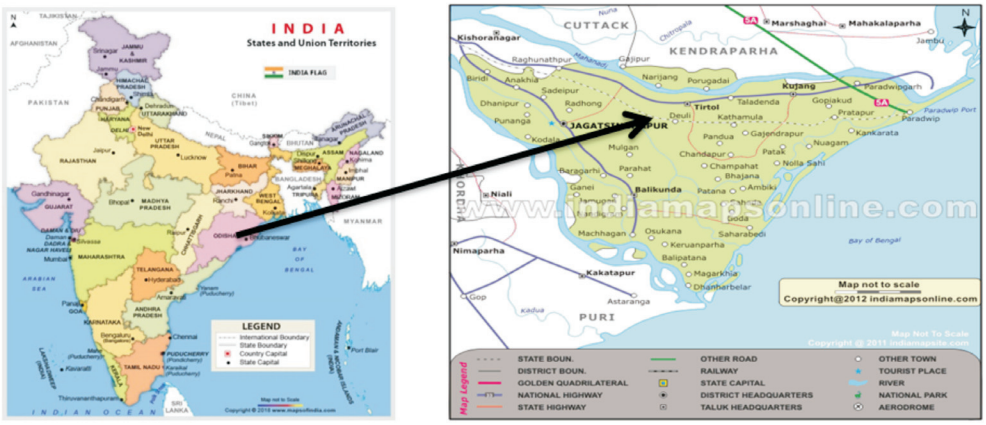


Fig. 1. Study area map (https://www.mapsofindia.com)

Haldia, Mahira, Patilo and Agar were counseled.

Data recording

The complete information regarding the cultivated plants and agrochemicals were studied and recorded in standard questionnaires. The farmers and local dealers were counselled who have utilized these agrochemicals in the crop fields. During the study, interviews of about 50 farmers and 10 local dealers in the town were completed. The doctors were also counselled to know the influence of agrochemicals on human health. The questions were asked to different farmers and local dealers (Wang'ombe, 2014).

Soil Sample collection and pH analysis

Soil samples were collected from two villages (Sainto, Patilo) of Jagatsinghpur District. Four soil samples were collected from two agricultural fields (0-30 cm depth) and two non-agricultural fields. The soil samples were kept in sterile plastic zipper packed

XRF analysis

The soil samples were properly dried, thoroughly homogenized, and sieved at 250 ìm particle size. XRF analysis was carried out at the Advanced Testing and Calibration Llaboratory in Centurion University of Technology and Management using a handheld XRF spectrometer. Each of the soil samples was analyzed for five times for about 240 sec using two X-ray filters, one for elements from potassium to copper and second for elements from zinc to antimony (Ene *et al.,* 2010).

Microbial analysis

Media preparation

Culture media is an artificial environment that is generally used to cultivate microbes in laboratory which contain nutrients such as carbon source, nitrogen source, phosphorous, potassium, magnesium, calcium and sodium for their exuberant growth provides nutrient for growth and multiplication of microbes in laboratory. The media were prepared in double distilled water using commercially prepared ingredients and autoclaved at 15 lb pressure per square inch with 121^{0}C temperature for 15 min (Frankland *et al.,* 1995; Behera and Mahalik, 2022).

Isolation

Soil samples of 1 g were dissolved with 10ml of distilled water to make test suspension. Samples up to 10^3 dilutions were made by sequential dilution strategy and the suspension was spread over sterilized media with the assistance of a sterile glass spreader in an aseptic condition (Singh *et al.,* 2004, Sahu *et al.,* 2020). The spread plates were allowed to incubate at 37 °C temperature for 24 hrs for bacteria and 28 °C for 72 hrs for the growth of fungi. The streaked plates were inverted and incubated. The CFU (colony forming units) per gram dry soil were calculated.

$$CFU/g = \frac{\text{Average no. of colonies x Dilution factor} \times \text{volume of dilution amount}}{\text{Gram dry soil}}$$

Results and Discussion

The study sought to establish the proportions of farmers growing various horticultural crops. For the farmers to get good returns from the small land parcels, intensive growing of high value crops like vegetables is important. However, horticultural crops are prone to many pests and diseases that require using of pesticides for control. The agrochemicals and pesticides, if used injudiciously, could lead to adverse human health and environmental effects. A total of 33 agrochemicals were used by the farmers. Table 1 revealed that among 33, 15 chemicals were found to be chemical fertilizers with one bio-fertilizer. The other 18 agrochemicals were used as insecticides, pesticides, fungicides, and bactericides.

It was also noticed that a single bio-fertilizer, specifically zotobacter, along with three growth factors, and organic manure were used for growth and enhancing production by the farmers in the four blocks of Jagatsinghpur District. Azotobacter is distributed to the farmer by the government agencies and used as a bio-fertilizer. Granulated bio-extract of organic manure with a brand name as Phytozymewas was also used as manure in these blocks.

Most chemical fertilizers, insecticides, and pesticides were reported from Paradeep Phosphate Limited (PPL), followed by Indian Phosphate Limited (IPL). It was reported that chloropyriphous with the name of Dhanvan-20 and Tricel was used by the farmers as pesticides. Among those 33 agrochemicals, 15 were used as fertilizer to enhance growths which were applied in different doses/hectare (Table 1).

Three types of plant growth regulators were used for enhancing the yield. Humic acid is known for its

decomposing capacity of dead organic plants and animals, and as a result, humus is formed through the decomposition process by the microorganisms. The porosity of soil or the water holding capacity will be increased. This humification process enriches the soil inducing higher yield. Triacontanol is known for inducing better producing ability, was used by the farmers. Nitrobenzene 40% w/w is known for inducing growth and increase in yield and is used as a foliar spray that controls pest infestation.

The other 17 agrochemicals were used as pesticides and insecticides. Among these chemicals, Chloropyriphos was used as an insecticide to control several insects, viz, cutworms, cut rootworms, flea beetles and termites, etc. Though Emamectin benzoate is a naturally derived pesticide produced by the bacterium *Streptomyces avermitilis*, it is used in agriculture to control insects, nematodes, arthropods, and several other pests in a variety of crops.

Table 2 shows six fungicides viz. tricyclazole 75%, copper oxychloride 50% wp, metalaxy l8% with 64% wpmancozeb, hexaconazole, propineb 70%, and emamectin benzoate were used by the farmers to control various fungal diseases in rice fields. Different fungicides were used for controlling different types of fungal growth. Tricyclazole is a systematic and protective fungicide that comes under the brand name Teem and is generally used to control *Magnoporthe grisea,* which is the causal organism of blast diseases of rice. Copper oxychloride is a widely known used copper fungicide. It has low aqueous solubility and volatility, and it will not degrade in the environment as it is a heavy metal.

The farmers used metalaxyl as a foliar spray to control fungal diseases and specially oomycetes fungi. Hexaconazole is used by the farmers as a foliar spray while they used metalaxyl to control seed borne diseases especially, to control blast and sheath blight of rice. Propineb was used by the farmers to control fungal diseases, basically fungi belonging to the group oomycetes, acomycetes, basidiomycetes, and fungi imperfectii. Another agrochemical mancozeb was used to control fungal disease and insects. It was found to be used both as an insecti-

Table 1. Important fertilizers, pesticides and plant growth regulators used in five panchayats of Jagatsinghpur District of Odisha, India

Sl. No.		Agrochemicals	Brand Mode of use
1	Urea	IIFCO	25 kg in one acre used directly in soil
2	Grommer	IPL	50 kg in one acre used directly to soil
3	Murate of potash	IPL, PPL	12.5 kg in one acre used directly into the soil
4	Triple super phosphate	PPL	25 kg in one acre directly into the soil
5	N.P.K	Navratna	Used directly into the soil
6	Manganese sulphate	-	8-10 g per acre
7	Calcium ammonium nitrate	PPL	8-10g per acre
8	Nitro phosphate	IPL, PPL	8-10g per acre
9	Potassium sulphate	Koromondal	10-12g per acre
10	Diammonium phosphate	PPL	25g per acre
11	Zinc	-	8-10g per acre
12	Boron	Lithobor	8-10g per acre
13	Single super phosphate	PPL	25g per acre
14	Azotobacter	Provided by government	-
15	Granulated bioextract of organic manure	Phytozyme	-
Plant Growth Regulator			
1	Triacontanol	Miraculan	0.5-1 mg / kg of liquid triacontanol soaking 12-24 hours before planting
2	Humic acid	Hima gold	Dilute at rates between 1:10 (100ml per L of water) for soil application, and 1:50 (20ml per L) or weaker for foliar spraying. Shake well before diluting
3	Nitrobenzene 40% w/w	Flora max	2-3 ml calibre in 1 litre of water

cide as well as a fungicide.

Thiamethoxam is a broadspectrum systemic insecticide used in the field in the brand name Teem. Cartapis was used for controlling chewing and sucking pests to kill them. This insecticide has been categorized for its low toxicity, high effectiveness, and low pesticide residue used in the rice field. Imidacloprid is an insecticide that mimics nicotine. Nicotine naturally occurs in plants such as tobacco, and it is highly toxic to insects and pests. Imidacloprid is used to control termites, soil insects, sucking insects, and fleas and ticks on pets. Prfenofos and cypermethrin 4% ec insecticide was used for protecting the plants from insects. Streptomycin sulphate is used as bacteriocide (Table 2) for controlling bacterial disease in plants. Streptomycin sulphate is sold under the brand name Plantomycin.

Elemental analysis of soil

The concentration of different compounds presents in the fertilizer treated soil and control soil. The fertilizer treated soil showed an increase in a trace amount of heavy metal compounds like As, Ga, Re, Yb, Eu, Th, Nb, Zr, Y, Rb, Cr, V, Ti, Si, Cu, etc. These compounds are present in higher concentration in agrochemical treated soil as compared to control soil.

Heavy metals are a major source of soil pollution. They not only affect the plant yield but also affect the soil biochemical parameters (Speir *et al*., 1999). Heavy metals obliquely act on soil enzymatic behavior by varying microorganism frequency, which synthesizes different metabolites (Huang *et al.*, 2009 Heavy metals display the poisonous outcome of soil microbiota by affecting essential microbial load and diminishing the count and activities of soil microbes. Few heavy metals such as Pb, Cd, As, Se or Hg are not necessary for plant growth and development, since they don't achieve any comprehended physi-

Table 2. List of fungicides, insecticides and bacteriocides used in five panchayats of Jagatsinghpur District of Odisha, India.

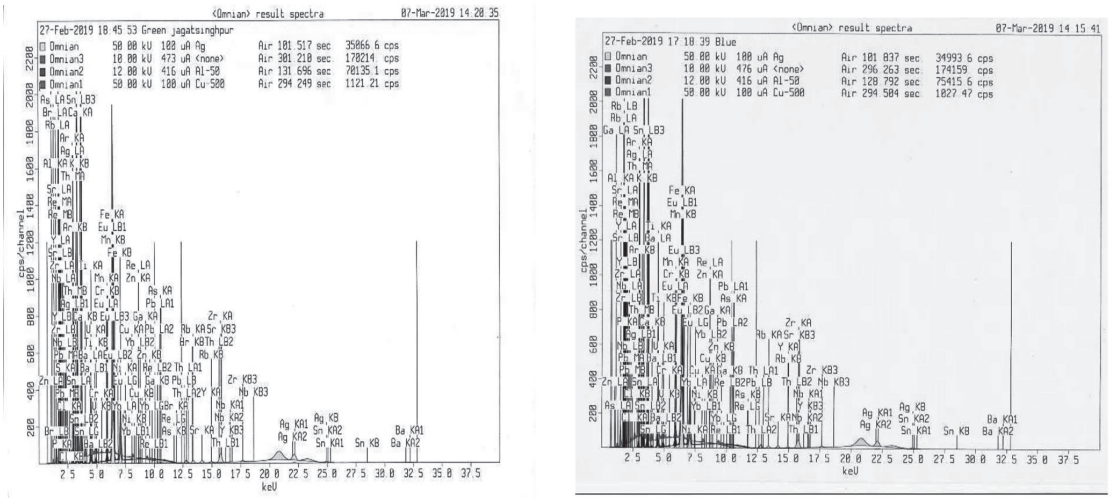
Sl. No.	Fungicides	Brand name	Mode of use
1	Tricyclazole 75%	Teem	Transplanted and direct-seeded rice, at 100 g/ha
2	Copper oxy chloride 50% wp	Unicop-500	Recommended dosage per hectare 0.600 kgs-7.500 Kgs % of formulation in dilution with 750-1000 liter of water or as being recom mended.
3	Metalaxy l8%+ mancozeb 64% wp	Magnet	2.5 kg per hectare
4	Hexaconazole	Mainex EC/ Krizole	50 g-75 g and 1000 ml -1500 ml dilution in 500l of water
5	Propineb 70 %	Sanipeb	0.3 or 0.5% or 300/500 g/100 l water
6	Emamectin benzoate	Mega claim	m per hectare
		Insecticides	
7	Thiamethoxam	Teem	Transplanted and direct-seeded rice, at 100 gm/ha
8	Cartap hydrochloride 4% g	Paratop	1 g in 1 liter of water
9	Cartap hydrochloride 50% sp	Boregan sp	1 g in 1 litre of water
10	Imidacloprid	Parador	ml in 1 litre of water
11	Traiazophos	Parashute	250-500/acre
12	Chlorpyriphos	Dhanvan-20/ Tricel	Mix 1 liter l-drint with 19 liter of water to make 1% a.I. Emulsion and to be applied
13	Profenofos40%+cypermethrin 4% ec	Ratinasuper	- 600 ml per acre
		Bactericides	
14	Streptomycin sulphate = 9% Tetracycline hydrochloride = 1% And adjuvants for better absorption and penetration of antibiotics	Plantomycin	2-3 gram in a liter of water

ological action in plant growth. Zn, Ni, Co, Fe, Cu, Mn, and Mo are necessary elements that are required for natural growth and metabolism of plants, yet these components can cause harm when used is more than ideal qualities (Garrido *et al.*, 2005; Rascio and Navari-Izzo, 2014). Thinking about the edible portion of the plant in several vegetable species, the transport of heavy metals from soil to people ought to be a topic of intrigue. Absorption of heavy metals by plants subsequently is hazardous to both animal and human health (Sprynskyy *et al.*, 2007). The retention by plant roots is one of the main courses of heavy metals in the food chain. Usage of food crops contaminated with heavy metals is a way through the food chain for introduction to humans. The development of such plants in contaminated soil shows a risk since the vegetal tissues can aggregate heavy metals (Jordao *et al.*, 2006). Heavy metal poisoning results in anoxia, anaemia, gastrointestinal problems, and fatigue. It can cause difficulties in blood pressure, muscle pain, joint pain, and pregnancy (Fig. 2.) (Odum, 2016).

Studies on soil micro flora

The study was accomplished for a brief period of one week and during this limited time, isolation of micro flora (bacteria, fungi) was made twice in a week. Four different soils were collected namely: S1,

Control soil



Fertilizer treated soil

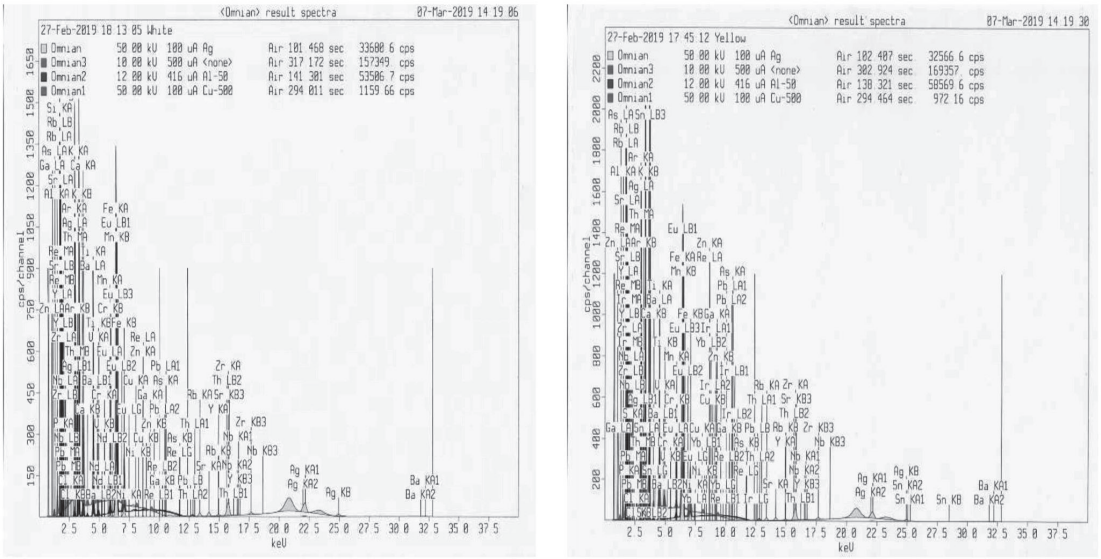


Fig. 2. XRF analysis of different soils of Jagatsinghpur District of Odisha, India

Table 3. CFU/g of bacteria and fungi isolated from different soil samples

Sl. No.	Soil Type	Bacteria (CFU/g)	Fungi (CFU/g)
1	Treated (S1)	22.5×10^3	62×10^3
2	Treated (S2)	32×10^3	44×10^3
3	Control (S3)	200×10^3	104×10^3
4	Control (S4)	60×10^3	132×10^3

*S1, S2, S3, S4 indicates soil samples collected from villages of Jagatsinghpur District.

S2, S3 and S4 (Table 3).

Considerable fluctuations in CFU's occurred between the four different soil types. The highest CFU for bacterial plates was found in control soil (S3 & S4), i.e. 200 x 10^3, followed by 60 x 10^3, respectively. Lower CFU/g was recorded as 22.5 x 10^3, followed by 32 x 10^3 in treated soil - S1 and S2 respectively (Fig. 3).

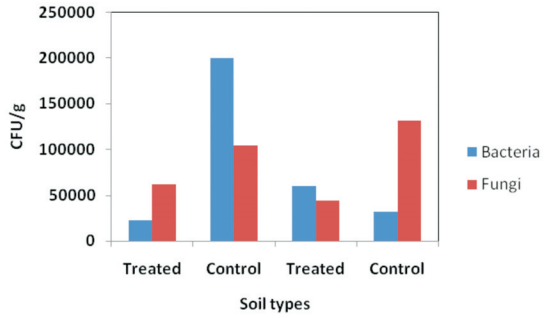


Fig. 3. CFU/g of bacteria and fungi isolated from different soil samples

Highest CFU/g in case of fungi was accorded to be 132 x 10^3 and 104 x 10^3 in control soil - S3 and S4 samples respectively. Lowest was found in case of treated soil sample (agrochemicals used soil) preparations which resulted to be 62 x 10^3 and 44 x 10^3 CFU/g of soil samples (S1 and S2) respectively.

These variations in CFU are due to the application of different pesticides upon the soil that resulted in a decrease in microflora growth and germination. High CFU indicates the normal growth, germination, and reproduction of the bacterial and fungal microbes that are resistant to particular chemicals. The detrimental effect of pesticides caused decreased by microflora.

Conclusion

The study revealed that farmers or agriculturists had insufficient knowledge, poorly developed attitudes, and practices with regard to the use of agrochemicals in crop cultivation that resulted in adverse environmental and human health effects. Among those 33 agrochemicals, 15 agrochemicals were used as fertilizers to enhance vegetative growth. The results show that pesticides have a negative effect on soil microflora as well as human health. The fertilizer treated soil showed an increase in a trace amount of heavy metal compounds like As, Ga, Re, Yb, Eu, Th, Nb, Zr, Y, Rb, Cr, V, Ti, Si, Cu, etc. These compounds are present in higher concentrations in agrochemicals treated soil compared with the control soil. Agrochemical used soil (treated) also showed less micro flora as compared to untreated soil. Production, use, storage, disposal, and packaging of pesticides are some important risk factors on human health and the environment which should be controlled. Farmers should be informed about the hazardous uses of non-purpose application errors such as protective clothes used during the application, compromising personal hygiene, chemical overdose, and some unnecessary duplication of agrochemicals, contact, and exposure to chemicals through few educational programs. Chemicals causing persistent organic pollutants needs to be banned for sustainable agricultural practices to make an eco-friendly environment and safeguard human as well as animal health.

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Conflict of Interest

Authors do not have any conflict of interest to declare.

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