Review on pesticide residue on rice

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N Asiah[1], W David[1*], Ardiansyah[1] and S Madonna[2]

[1]Department of Food Science and Technology, Universitas Bakrie, Indonesia
[2]Department of Environmental Engineering, Universitas Bakrie, Indonesia

* Email: wahyudi.david@bakrie.ac.id

Abstract. Pesticide residue in rice has been investigated since the growing of demand of food safe. The determination of pesticide residues in food is becomes an essential requirement for consumers, producers and authorities responsible for food quality control. This study is aiming to show the information regarding agrochemical residue in rice from meta-analysis. This study showed that there are three major of agrochemical has been use as Pesticide, Fungicide, Herbicide and Insecticide. Effect of processing (milling) may decrease the pesticide contamination. Pesticide residue is adverse effect on human health problems.

1. Introduction

Rice as one of staple food in the world is one of the most important food product. Rice content a very important source of carbohydrates, protein and nutrients. In modern agriculture, agrichemical or pesticides are used globally in farming sector to control pest population [1]. The term of pesticide related with insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others [2]. In Developing country, the use of pesticides in agricultural products has significant impact for increasing yield product and improving product quality to meet the growing food demand [3]. In many cases, pests comes close to harvest time, when it is happen there will be product loss. In other hand, contamination from pesticides proved to be unsustainable, cost ineffective, has negative affect for human health and evironments such as soil, atmosphere, and aquatic system[4] [4][5]. It is important to know the presence of pesticide residues in food (both fresh and industrialized) to guarantee food safety.

Pesticides in the food chain is one of major public health concern, where several studies have analysed pesticide residues content in rice grains [6]. The consumption of pesticed-contaminated food product may becomes potential health risk for human body. Recently, study of cumulative risk assesment the posibility of multiple pesticides exposure that could cause unanticipated adverse effects on human helath is crusial issues in many area [7]. Furthermore, the detection of pesticide-contaminated product is also important to protect ecosystem. One of negative effects of the synthetic pesticides, especially organochlorinated and organophosphorus (OP) pesticides is contamination on food [8]. In the 1970s and the early 1980s, the high toxicity and high residue of pesticides used in crops were major concern where dominated by organochlorines (OC) and organophosphates (OP) [9]. OC are persistent and toxic chemicals and belonging to the group of persistent organic pollutants. A variety of carcinogenic, reproductive, neurological, immunological, and other adverse effects have been reported linked with the exposure of humans and other lives to these chemicals [10] [11].

Several methods of analysis have been used to assess the potential risk of pesticides to human health and the environment. Reduction of using pesticides for benefitial reason and try to minimize the risk to human health and the environment is challenging and still a worthwhile goal to pursue [12]. It is

important to see the correlation of reducing pesticide with reduction of the possible adverse effects of pesticides on human health and the environment [13].

Due to widely used of pesticides has risen over in agricultural practice, it becomes food safety issue. The study of pesticides residues in rice is very important to protect consumer's health. This study assesses review on pesticide contamination on rice. The paper aim to show information about pesticides used in rice crops, pesticide residues on rice, effect of primary processing on pesticide residue, human health risk assesment and awarness of pesticide contamination on rice that will be necessary in order to avoid negative effect for human.

2. Method

Meta-analysis is a method to analyze collected data from previous research articles, to form a new conclusion or fill the gap between previous research. Meta-analysis comprises of collecting, summarizing, analyzing, and reviewing data from previous research literature, in order to get a novel findings. Review on pesticide contamination on rice was done by conducting meta-analysis concept on previous typical research articles. After collecting research articles that comply with criteria of this study, screening was conducted to obtain desired articles. The flow of screening is presented in Figure 1.

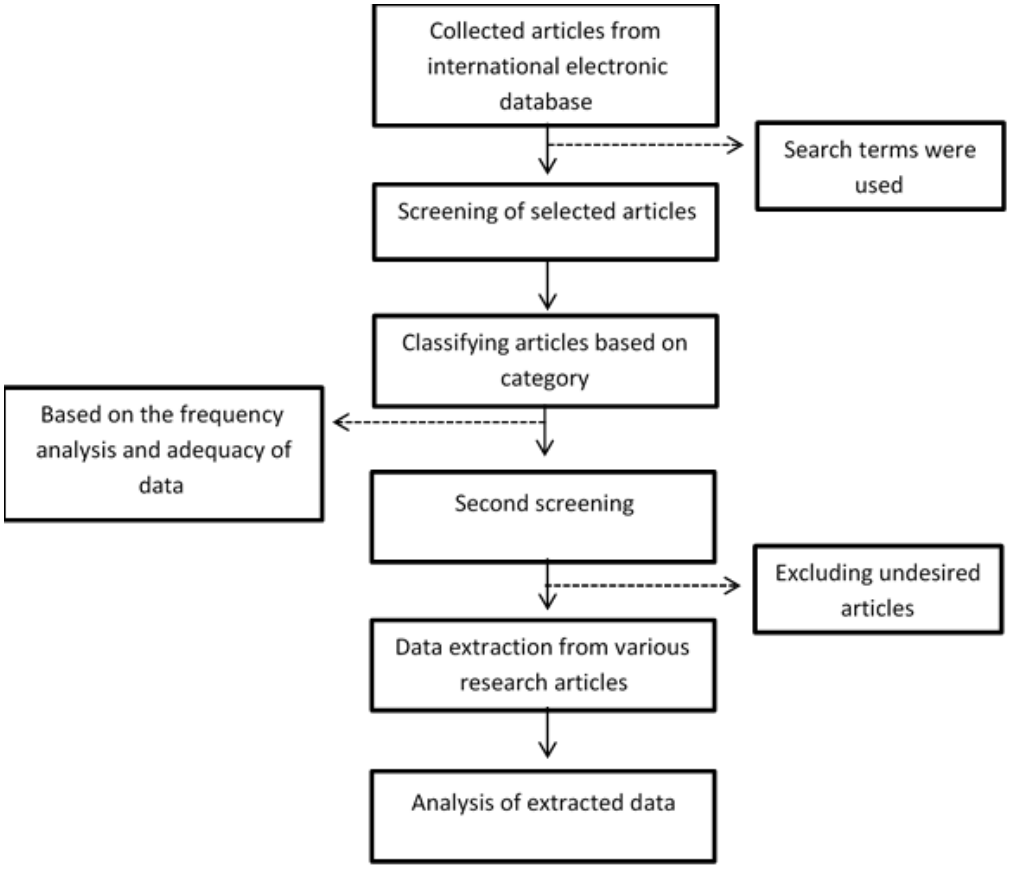

Figure 1. Data Collection

The literature used in this study as many as 80% comes from several international electronic databases, such as: High Reputation International Indexers (PubMed, SCOPUS, Thomson Web of Science), Directory of Open Access Journals (DOAJ), Center for Agriculture and Bioscience International (CABI), EBSCO, Proquest, and Gale). In addition, as much as 20% of the total literature used comes from book sources, references that have ISSNs and ISBNs, or official government and international organizations websites.

Narrowing in searching and collecting literature was done by looking at the time of publication of the literature. The literature obtained is literature that has a limit or deadline of the last 10 years. This research was conducted in 2018, therefore the yearly limit of literature that can be used is from 2008 to 2018. The yearly limit of publication in this literature aims to provide the most recent data or results related to research, so that the results of the meta-analysis research will be more accurate.

In conducting a literature or journal search, the search terms are used. Search terms are keywords related to research topics. The function of the search terms is the optimization of journal searches in order to be able to obtain journals that match the criteria of the research topic and at the same time narrow down the search for journals. Through the topic of these search terms, the search terms emerged which were the result of a combination of these topics. There are 5 topics of search terms used in searching journals or articles, each of which has terminology. The function of the existence of this terminology is as a benchmark for the search for journals or articles to fit the criteria or research objectives. The search terms are pesticide residues on rice, pesticide-contaminated rice products, the effect of primary processing on pesticide residue, and the awareness of pesticide contamination on rice.

3. Result and Discussion

3.1. Pesticides Used in Rice Crops

The aiming of pesticides used in rice crops is to control weeds and pest during cropping stages and for pest management post harvest and to prevent pests from attacking grains in order to preserve the crops. The type of agrochemicals mostly used by farmers is insecticides, then followed by herbicides (Figure 2). The type and amount of agrochemicals applied in various countries may differ depending on the crop system, the climate condition and farmers practices. For example, Japan receive more than two herbicide applications, while in Philippines only about half the rice area is treated and in Bangladesh there is little herbicide use because their rural labor is relatively inexpensive [14].

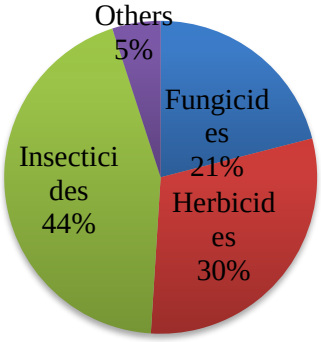

Figure 2. Persence of agrochemicals mostly used by farmers [2]

The fact that using pesticide have some advantages must be considered again by considering it negative side (Table 1). The application of pesticides should be in compliance with good agricultural practices. Pesticides will remain a tool for modern agriculture and therefore it is important to reduce the use of chemical pesticides by applying pest control strategy. Rational pesticide use (RPU), considered as a 'subset' of Integrated Pest Management (IPM), is a strategy to maximize efficacy with minimize health and environmental impact, and with minimum food residues. The ways for minimum use of chemical pesticides can be done by doing accurate diagnosis of pest problems; forecasting of outbreaks; optimized timing of interventions for maximum longterm efficiency and minimum pesticide use; selection of a pesticide with minimum impact on nontarget organisms and the operator; improved application of the selected pesticide for maximum dose transfer to the biological target, reduced pesticide costs, minimum contamination of the environment and the operator, and minimum residues on food crops [15].

Table 1. Positive and negative used of pesticide in food product

Positive	Negative
Improving productivity	Food residue
Protection of crop losses/yield reduction	Environment polution
Vector disease control	Resistance of pests
Increase food quality	High cost
Prolong shelf life	Not suitable
Other areas – transport, sport complex, building	Disturbing ecosystem

3.2. Pesticide Residues On Rice

The applications of pesticide during the period close to harvest may be associated with low or almost zero mobility of photoassimilates in the plant due to natural senescence. While, reduction of respiration in the caryopsis acts as a barrier to absorp of the insecticide by the plant. Organophosphorus pesticide (OP) have several adverse effects. OP have anticholinesterase activity in the nervous system which lead to an accumulation of the neurotransmitter, acetylcholine, at nerve terminals, causing subtle and long lasting neurobehavioral impairments in humans. The OP residue may cause abdominal cramps, nausea, diarrhoea, saliva-tion, miosis, dizziness, tremor, anxiety and confusions [7]. Organophosphorus pesticides (OP) have replaced organochlorine pesticide (OCPs) in agricultural activities due to OP have high lipophilic nature that can accumulate and tend to surpass in the animal tissues and resulted health problem. Organochlorine pesticide (OCPs) are still applied widely especially in rice paddies production due to it ability to increas productivity, but it also causes risk to human health [16]. OCPs are persistent and toxic chemical, they have ability for bio-accumulation in the food crops and animal tissues [17]. The Maximum Residue Limit (MRL) of rice grains among different countries varies according to the legislation of each administrative organization. MRL are not exceeded when the pesticides are applied according to Good Agricultural Practices (GAP) [5] Table 2 shows the pest management in rice worldwide.

Table 2. Pest management in rice worldwide

Insecticide	Application rate/ha	Fungicide	Application rate/ha	Herbicide	Application rate/ha
Carbofuran	10 – 20 kg	Hexaconazole	-	Bensulfuron methyl	0,05 kg
Etofenprox	4 L	Kresoxim methyl	1 – 1,25	Bentazone	1 – 2kg
Fenitrothion	0,1 – 0,2 L/ton rain	Trifloxystrobin	0,5 – 0,8 L	Bispyribac sodium	0,02 kg
Pirimiphos methyl	0,08 L/tograin	Carbendazim	-	Cyhalofop butyl	0,2 – 0,3 kg
Metiocarb	6 kg/ton seed	Tebuconazole	0,45 – 1 kg	Clomazone	0,4 kg
Diazinon	0,75 L	Tricyclazole	0,3 – 0,4 kg	Glyphosate	0,5 – 4 kg
Chlorpyrifos	0,06 – 0,15 L	Prochloraz	0,5 L	Molinate	2 – 4 kg
Trichlorfon	0,6 – 0,85 L	Thiphanate methyl	0,7 – 1 L	Pretilachlor	0,6 kg
Teflubenzuron	0,07 L	Isoprothiolane	1 – 1,5 L	Propanil	3 – 4 kg
Malathion	-	Carbaryl	1,2 L	Quinclorac	0,5 – 0,6 kg
		Propiconazole	0,5 – 0,7 L	Thiobencarb	2 – 3 kg

3.3. Effect of primary processing in pesticide residue

Refer to their chemical characteristics, the amount of pesticides and other biotic and abiotic conditions, these compounds may migrate into the grain. It can be understand that pesticides should only be present on the outer layer and should be eliminated during grain milling, mostly in coproducts such as bran and husk [18]. Food processing treatments such as milling, parboiling and storage lead to a significant reduction of pesticides residue (Table 3). Parboiling is precooking process of rice whitin the husk. This

process involves first hidrating paddy followed byheating to cook the rice and finally drying of the rice. Grains one of long term stored agricultural product (3-36 weeks) at ambient temperatures in bulk silos where insecticides may be added to reduce losses during storage pests. Removal of residues in food by processing is influenced by type of food, insecticide type and severity of processing prosedure used. Hence a combination of processing techniques would be potential option for food safety [19].

Table 3. Effect of Primary Processing on Pesticide Residue

Primary Processing	Effect on Pecticide Residue	References
Milling (de husking or hulling as well as the removal of bran layers or polishing)	Milling decrease the concentration of the most lipophilic pesticides, as these are usually found in the bran Most residues are present in the outer portions of the grain (residues are higher in the bran than in the wheat or flour) During milling, residues accumulated in thr bran fractions and were reduced in white flour Milling of wheat to flour decrease malathion residues about 95%	Pareja et al, 2011 [14] Kaushik et al, 2009 [19]
Soaking and steaming (parboiling or cooking) to produce parboiled rice	Reduce the pesticide content in rice due to inactivation or degradation of the pesticides during parboiling at high temperature (100C). Parboiling able to reduce 68% Lebaycid, 51% for Dursban and 49% for Ekalux.	Kaushik et al, 2009 [19]
Storage	Food grains and pulses are cross contaminated in storage my be by post harvest application on pesticide At storage condition 20 Oc and 50-70% Relative Humidity, After 32 weeks residuces litle drecrease	Jagadish et al, 2015 [20]

3.4. Human health risk of pesticide contamination on rice

The amount of pesticide residues in grains does not necessarily mean that it is hazardous, it depend on their toxicological properties, level of residues and degree of exposure of human beings to residues. To be toxic when the residues have to be present in quantities large enough and greater than Maximum Residue Limit [15]. Study has been done by [17] and revealed that there is a severe risk to the human population through consumption of contaminated cereal.. These studies indicate that milling processing may decrease the residue contaminant during cultivation. Furthermore, [7] revealed that Organophosporous pesticide residue in milled rice on the Chines market can be detected by investigating then occurrence of acetylcholinesterase (AChE) inhibition. Exposure of AChE-inhibiting pesticides for the population above 7 years old at P99.9 represented 52-94.5 % of the acceptable diary intake (ADI) expressed as methamidophos. [15] suggested that the current risk-reduced conventional pesticides and organophosphorus, the use of fungicides azoxystrobinand trifloxystrobin, the herbicides cyhalofop-

butyl, glufosinateammonium, imazethapyr and penoxsulam, and the insecticides gamma-cyhalothrin, zeta-cypermethrin, etofenprox and spinetoram can be an alternative[21].

Risk assessment of pesticide impact on human health is not an easy and particularly accurate process due to some reasons. How long the periods and the levels of exposure, type of pesticides (regarding toxicity), mixtures or cocktails used in the field, and the geographic and meteorological characteristics of the agricultural areas where pesticides are applied. Table 4 and Table 5 show that acute Toxicity of pesticides according to the Environmental Protection Agency (EPA).The respective toxicity tests for human health risk assessments required by Environmental Protection Agency (EPA) are [13]: (1) the effects of short-term exposure to a single dose of pesticide (The acute toxicity test, which assesses oral, dermal, and inhalation exposure, eye irritation, skin irritation, skin sensitization, neurotoxicity); (2) the effects of intermediate repeated exposure (oral, dermal, inhalation, nerve system damage) over a longer period of time (30–90 days); (3) the effects of long-term repeated exposure lasting for most of the test animal's life span and intended to determine the effects of a pesticide product after prolonged and repeated exposures (e.g., chronic non-cancer and cancer effects); (4) The developmental and reproductive tests, which assess any potential effects in the fetus of an exposed pregnant female (i.e., birth defects) and how pesticide exposure may influence the ability of a test animal to reproduce successfully; (5) The mutagenicity test which assesses the potential of a pesticide to affect the genetic components of the cell, and (6) The hormone disruption test, which measures the pesticide potential to disrupt the endocrine system (consists of a set of glands and the hormones they produce that regulate the development, growth, reproduction, and behavior of animals including humans.

Table 4. Acute toxicity of pesticides according to the EPA classification (adapted from EPA [14]).

Class	Signal words	Acute toxicity to rat		
		Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Inhalation LD_{50} (mg/L)
I	DANGER	<50	<200	<0,2
II	WARNING	50-500	200-2000	0,2-2,0
III	CAUTION	500-5000	2000-20,000	2,0-20
IV	CAUTION (optional)	>5000	>20,000	>20

Table 5. Acute toxicity of pesticides (eye and skin effects) according to the EPA classification (adapted from EPA [13]).

Class	Signal words	Acute toxicity to rat	
		Eye effects	Skin effects
I	DANGER	Corneal opacity not reversible within 7 days	Corrosive
II	WARNING	Irritation persisting for 7 days	Severe Irritation at 72 hours
III	CAUTION	Irritation reversible within 7 days	Moderate irritation at 72 hours
IV	CAUTION (optional)	No Irritation	Mild or slight irritation at 72 hours

3.5. Awarness of pesticide contamination on rice

The overuse of pesticides in agriculture has generated increasing concerns about the negative effects of pesticides on human health and the environment. Understanding farmers' perceptions of risk of pesticides and the determinants of pesticide overuse is important to modifying their behavior towards reducing pesticide use [22]. The degree of farmers awarness about pesticide effect strongly influenced by their pest management methods. Implementation of alternative methods of pest control determined by farmers knowledge of pros (beneficial effects) and cons (harmful effects) of using pesticide. There are several variables that influenced their pest control strategies and pestcide use attitude. It quite

subjective and my depend on their socio-economic characteristic, farm characteristics, personal beliefs, tradition, perceptions, and preferences [3]. More educated farmers were more aware of the pesticide residue problem. Convincing farmers that their perceptions of the crop yield loss due to pest-related disease are over estimated and improving farmer's knowledge of pest management and pesticide safety are critical. Some socio-economic factors, such as education, training on pest management, regular information flow, extension services and credit are the pre-requisite to improve rice farmer's understandings about ecological hazards due to overuse use of pesticides to be consideration in formulating environmental policy for agricultural sector [23]. Table 6 show Factors influencing formers' knowledge on environmental pollution and Figure 3 describe the pesticide risk behaviors and factors influencing pesticide used.

Table 6. Factors influencing formers' knowledge on environmental pollution [23] (adapted by Parveen 2010)

Variabel	**Spearman's correlation (r_s)**
Formal schooling (oridinal)	0.48"
Rice cultivated area (ordinal)	0.373"
Training on pest management (nominal)	0.244'
Credit received (nominal)	0.363"
Exposure to television (ordinal)	0.399"
Contact with extention personel (nominal)	0.213'
Awarness of IPM (nominal)	0.497"

' and " indicate at 0.005 and 0.001 propability level (2-tailed) with 98 degree of freedom, (n =100)

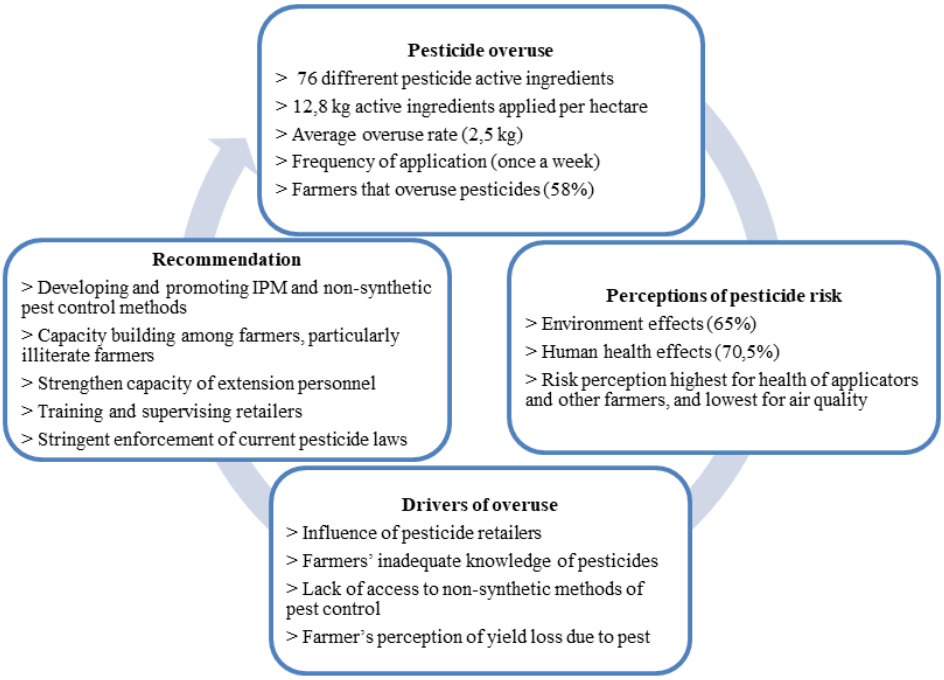

Figure 3. Pesticide risk behaviors and factors influencing pesticide used (Adapted from Jallow et al, [22]).

4. Conclusion

In conclusion, our study shows that: (a) Pesticide residue concentration can be affected during rice processing-with concentrations generally lower in the final product; (b) Pesticide residue on rice has been affected for human health includes non-cancer and cancer risk, hormone disruption, and mutagenicity. Further research could address the questions: (a) How to enhance knowledge about effect of different kind of pesticide can serve as an incentive for farmers to adopt technology that rely less on

pesticide use; (b)How to use an appropriate processing technology for minimizing of residue contaminant as well as keeping nutritional value of the grain.

References

[1] Onojoh P K and Aliyu E W 2013 Determination of Residual contents of pesticides in Rice Plant and Rice Grains (Oriza Sativa) From Four different regions of Omala LGA , KOGI State , Nigeria . *Int. Journal's Res. J. Sci. IT Manag.* **2** 12–6
[2] Aktar M W, Sengupta D and Chowdhury A 2009 Impact of pesticides use in agriculture: their benefits and hazards. *Interdiscip. Toxicol.* **2** 1–12
[3] Abdollahzadeh G, Sharifzadeh M S and Damalas C A 2015 Perceptions of the beneficial and harmful effects of pesticides among Iranian rice farmers influence the adoption of biological control *Crop Prot.* **75** 124–31
[4] Berg H and Tam N T 2018 Decreased use of pesticides for increased yields of rice and fish-options for sustainable food production in the Mekong Delta *Sci. Total Environ.* **619–620** 319–27
[5] Kim G, Kwak J, Choi J and Park K 2012 Detection of Nutrient Elements and Contamination by Pesticides in Spinach and Rice Samples Using Laser-Induced Breakdown Spectroscopy (LIBS) *J. Agric. Food Chem.* **60** 718–24
[6] Teló G M, Marchesan E, Zanella R, Peixoto S C, Prestes O D and de Oliveira M L 2017 Resíduos de fungicidas e inseticidas em grãos de arroz *Acta Sci. - Agron.* **39** 9–15
[7] Chen C, Li Y, Chen M, Chen Z and Qian Y 2009 Organophosphorus pesticide residues in milled rice (Oryza sativa) on the Chinese market and dietary risk assessment *Food Addit. Contam. Part A* **26** 340–7
[8] Arjmandi R, Tavakol M and Shayeghi M 2010 Determination of organophosphorus insecticide residues in the rice paddies *Int. J. Environ. Sci. Technol.* **7** 175–82
[9] Huang J, Fangbin, Zhang L and Rozelle S 2016 Farm Pesticide, Rice Production, and Human Health *EEPSEA Res. Rep.*
[10] Sharma C M, Rosseland B O, Almvik M and Eklo O M 2009 Bioaccumulation of organochlorine pollutants in the fish community in Lake Årungen, Norway *Environ. Pollut.* **157** 2452–8
[11] Eqani S A-M-A-S, Malik R N, Katsoyiannis A, Zhang G, Chakraborty P, Mohammad A and Jones K C 2012 Distribution and risk assessment of organochlorine contaminants in surface water from River Chenab, Pakistan *J. Environ. Monit.* **14** 1645
[12] Rahman S and Chima C D 2018 Determinants of pesticide use in food crop production in Southeastern Nigeria *Agric.* **8** 1–14
[13] Damalas C A and Eleftherohorinos I G 2011 Pesticide Exposure, Safety Issues, and Risk Assessment Indicators *Int. J. Environ. Res. Public Health* **8** 1402–19
[14] Pareja L, Fernández-Alba A R, Cesio V and Heinzen H 2011 Analytical methods for pesticide residues in rice *TrAC Trends Anal. Chem.* **30** 270–91
[15] Ekström G and Ekbom B 2011 Pest Control in Agro-ecosystems: An Ecological Approach *CRC. Crit. Rev. Plant Sci.* **30** 74–94
[16] Chaiyarat R, Sookjam C, Eiam-Ampai K and Damrongphol P 2015 Organochlorine pesticide levels in the food web in rice paddies of Bueng Boraphet wetland, Thailand *Environ. Monit. Assess.* **187** 230
[17] Mahmood A, Malik R N, Li J and Zhang G 2014 Human health risk assessment and dietary intake of organochlorine pesticides through air, soil and food crops (wheat and rice) along two tributaries of river Chenab, Pakistan *Food Chem. Toxicol.* **71** 17–25
[18] Dors G C, Primel E G, Fagundes C A A, Mariot C H P and Badiale-Furlong E 2011 Distribution of pesticide residues in rice grain and in its coproducts *J. Braz. Chem. Soc.* **22** 1921–30
[19] Kaushik G, Satya S and Naik S N 2009 Food processing a tool to pesticide residue dissipation – A review *Food Res. Int.* **42** 26–40
[20] Jagadish G K, Jaylakshmi s. K and Sreeramulu K 2015 Evaluation of pesticide residue in rice , wheat and pulses of Bidar district Karnataka , India *Issues Biol. Sci. Pharm. Res.* **3** 100–6

[21] Selvaraj S, Basavaraj B and Hebsur N S 2014 Pesticides use and their residues in soil, grains and water of paddy ecosystem – A review *Agric. Rev.* **35** 50
[22] Jallow M F A, Awadh D G, Albaho M S, Devi V Y and Thomas B M 2017 Pesticide risk behaviors and factors influencing pesticide use among farmers in Kuwait *Sci. Total Environ.* **574** 490–8
[23] Parveen S 2010 Rice Farmers ' Knowledge About the Effects of Pesticides on Environmental Pollution in Bangladesh *Bangladesh Res. Publ. J.* **3** 1214–27