Journal of Science and Technology ***54*** *(4B) (2016) 56-63*

EVALUATION OF THE IMPACT OF DYKE ON THE PRACTICE OF USING PLANT PROTECTION CHEMICALS AND THE ENVIRONMENT IMPACT QUOTATION INDEX OF RICE CULTIVATION AREAS IN THAP MUOI, DONG THAP PROVINCE

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Received: 15 August 2016; Accepted for publication: 10 November 2016

ABSTRACT

This report presents the result of a survey to evaluate the use of crop protection chemicals (pesticides – HCBVTV) in rice-growing areas with dyke, semi-dyke and no embankment based on interview result with 112 interviewers such as farmers, agricultural specialists, and pesticide dealers in Thap Muoi District, Dong Thap Province and pesticide usage data recorded by three selected framers in 3 different dyke systems. It showed that dyke practice affects the use of pesticides of farmers. After dykes constructed, the pesticides used were more diverse, with higher dosage compared to before having embankments. The report also evaluates the risk of using pesticides through Environmental Impact Quotient (EIQ) index. It showed that areas with dyke and semi-dyke have much higher EIQ index than areas without embankment, 167, 145 and 54, respectively.

Keywords: dyke, environmental impact quotient, pesticide, non- embankment, Vietnam.

1. BACKGROUNDS

Dong Thap is a province located in the Southwest region of Vietnam, Mekong Delta. Thanks to its tropical climate and fertile land with alluvial from Tien and Hau River, Dong Thap is able to produce a lot of food and many agricultural and aquatic products with high export value, becoming the national granary. However, due to low geographic characteristics, each year Dong Thap is flooded for 3-4 months during rainy season. To overcome such natural condition as well as improving crop yields, dyke system is built in some communes in Dong Thap. Dyke system was established with a purpose to control, discharge flood and improve productivity. However, afterward, cultivation with closed-dyke system has shown some weaknesses such as limiting alluvium from the rivers, create conditions for disease development, and the accumulation of chemicals toxic, especially the use of pesticides to prevent pests. In fact, pesticides were used with more diversity and higher dosage in these areas. Many studies have proved the impacts of pesticides on human health [1,2,3] and environment [4,5]. The question raised is, did dyke practice affect people's use of pesticides? Whether the use of surplus pesticides creates risk and propose threat toward human health and the environment or not? And how to reduce and limit those risks?

This study was conducted to evaluate how the dyke system affects people's pesticide practice. On that base we will calculate potential risk to human and environment at My Dong, PhuDien, and Truong Xuan town in Thap Muoi District, Dong Thap Province through Environmental Impact Quotient (EIQ) indicators. From there we will offer solutions to minimize the risks from pesticides to human and environment in Thap Muoi District, Dong Thap Province.

2. RESEARCH METHODS

2.1. Research area

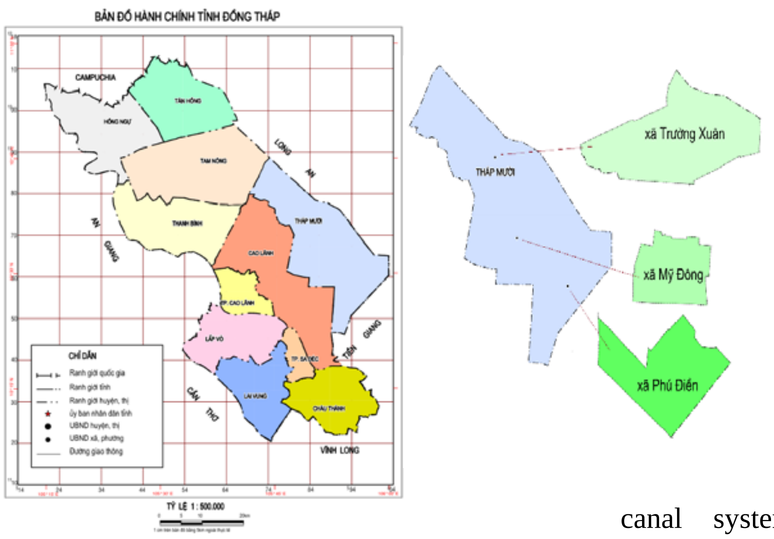

Figure 1. Location map of studied areas in Thap Muoi District, Dong Thap Province.

Thap Muoi District is toward the East of Cao Lanh, located on N2 Highway, linking the city with Ho Chi Minh city, the rice economy axis – a very favorable location to develop economic exchanges. The soil is majorly alluvial, well-fertile, with relatively flat terrain suitable for production and irrigation system layout. The land is heavily divided with a rich canal system. Total agricultural area occupies around 43.672 ha (82.7 % natural area), in which 98 % is agricultural land and 2 % is used for aquaculture. Annual planted area occurs a relatively high proportion (85.35 % total area), including more than 38.000 ha for rice and crop rotation, distributed across all the communes, other shallow planting crops occupy around 960 ha [6].

Different types of dyke in study area were fairly well-established long time ago; the earliest one was built in 1984 in My Dong commune and most recently, Truong Xuan town in 2008. My Dong was one of the earliest communes to practice embankment in Dong Thap Province with 100 % area within bounded box. PhuDien mainly cultivates with semi-dyke. Truong Xuan was one of the communes that cultivates without embankment. However, some parts of Truong Xuan now practice embankment during its third cultivation season.

2.2. Research Methods

2.2.1. Collecting data

The data used in this study was collected from actual investigation with residents from My Dong, Phu Dien and Truong Xuan in Thap Muoi District, Dong Thap Province. These are 3 typical communes with dyke, semi-dyke and no embankment. We surveyed 84 farming families about their use of pesticides, dosage, spraying rate in one season, most commonly used brand each season before and after embankment construction in studied areas. Moreover, we also interviewed with agricultural specialists (10 interviewers), pesticide dealers (11 interviewers), and pumping station specialists (7 interviewers) to collect more information on the use of pesticide and irrigation regimes in researched areas. The interviewing data of pesticide usage were cross-checked with the recording data from three selected framers in three different dyke systems.

Data after collected was analyzed and sorted with Excel program. Experiment and sample collecting was conducted at 3/84 sample acre of three communes. The result was calculated as representable average value of all three communes.

2.2.2. Calculating EIQ index

Environmental Impact Quotient (EIQ) is an indicator used to quantify potential environmental threat and risk of pesticide toward human health and the ecology; it was created and developed by scientists of Cornell University (US) in 1992 [6]. There are 2 EIQs, EIQ Theory and EIQ Practical on site. EIQ Theory proposes the potential intoxication of pesticides, while EIQ Practical reflects possible risk on fields when farmer uses pesticides. EIQ Theory of a pesticide is calculated based on its chemical components, including 11 targets related to possible threat to human and the environment of field ecology [8] as shown in Table 1.

Table 1. Standard classification of EIQ Pesticide active ingredients.

Possibilities	**Symbol**	**Standard testing**		
		1	**3**	**5**
Chronic toxicity	C	Little to none	Possible	Yes
Dermal toxicity LD50 in rats/rabbits mg/kg	DT	2000 mg/kg	200 – 2000 mg/kg	0 – 200 mg/kg
Bird toxicity (8 days LD50)	D	1000 ppm	100 – 1000ppm	1 – 100 ppm
Bee toxicity	Z	Not poisonous	Medium poisonous	Highly poisonous
Beneficial arthropod toxicity	B	Little consequence	Medium consequence	Severe consequence
Fish toxicity (96 LC50)	F	10 ppm	1-10 ppm	< 1 ppm
Plant surface half-life	P	1 – 2 weeks	2 – 4 weeks	4 weeks
Soil half-life	S	< 30 days	3 – 10 days	100 days

Systemicity	SY	None and other herbicides	Autoclaved	
Leaching potential (Aquatic half-life, absorption, …)	L	Small	Medium	Large
Surface loss potential (Aquatic half-life, absorption, …)	R	Small	Medium	Large

Those points were then organized to show the environmental impacts on 3 subjects: producer, consumer, and environment. In conclusion, EIQ Theory of a substance is the average of the there impacts on the subjects mentioned above (Table 2).

Table 2. Equation for determining EIQ values on subjects, environment, and total EIQ.

<table>
<tr><td>EI Applicator effects: C*(DT*5)</td><td rowspan="2">EI Producer = EI Applicator + EI Picker effects</td><td rowspan="8">EIQ = (EI Producer + EI Consumer + EI Ecology)/3</td></tr>
<tr><td>EI Picker effects: C*(DT*P)</td></tr>
<tr><td>EI Consumer effects: C*((S+P)/2)*SY</td><td rowspan="2">EI Consumer = EI Consumer + EI Water source</td></tr>
<tr><td>EI Water source: L</td></tr>
<tr><td>EI Aquatic animals (fish): F*R</td><td rowspan="4">EI Ecology = EI fish + EI bird + EI Honeybee + EI Beneficial arthropod</td></tr>
<tr><td>EI bird: D*((S+P)/2)*3</td></tr>
<tr><td>EI Honeybee: Z*P*3</td></tr>
<tr><td>EI Beneficial arthropod: B*P*5</td></tr>
</table>

From the EIQ Equation, Cornell University scientists were able to establish the standard list of EIQ values called the EIQ Theory values, and then to calculate EIQ on fields (EIQ Practical) based on this equation:

$$\text{EIQ Practical on field} = \text{EIQ}*\%\ \text{a.i.}*\text{Dosage (kg/ha)} \qquad (1)$$

of which: EIQ: Environmental Impact Quotation Theory of Active Ingredients (a.i.) of that pesticide; % a.i.: Percentage of active ingredients; Dosage: Amount of pesticide used (kg/ha).

If farmer used many kind of pesticide, then EIQ Practical is the sum of EIQs of all pesticides used. An alternative way to evaluate the environmental effects of integrated pest management is use of pesticide risk indicators [9]. These indicators are: the synoptic evaluation model for plant protection agents (SYNOPS) indicator from Germany, the multi-attribute toxicity from the United States and the environmental impact quotation from the United States.

3. RESULT – DISCUSSION

3.1. The situation of pesticide usage before and after embankment

According to the result of surveying and collecting information from farmers within studied area, before the dyke system in two seasons: Winter-Spring and Summer-Fall. Between October and February is the flood season so they couldn’t cultivate crop. After using dyke, farmers can work an extra season, Fall-Winter, to increase family income. For farmer with years of experience, rice productivity after embankment is majorly higher than before, 54/63 families earn higher productivity, occupying 85.71 % total, while the others lose their productivity after embankment. Moreover, the introduction of dyke system also changes the habit of using pesticides in study area (Figure 2).

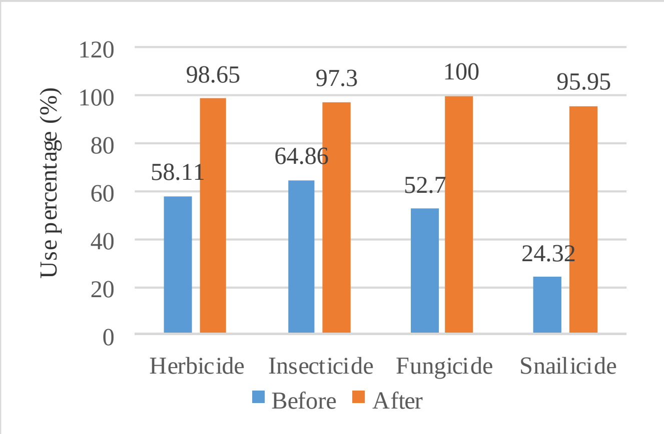

Figure 2. Comparison of pesticide use before and after dyke.

The percentage of pesticide usage after embankment almost doubled compare to before. To be specific, herbicide increases by 40.54 %, insecticide by 32.44 %, and fungicide by 47.3 %, especially snailicide increases the most by 71 %.

Looking at the chart, before embankment, the amount of insecticide was higher than other pesticides (64.86 %). After using dyke, 100 % farmers use fungicides and 97.3 % insecticide.

Perhaps it is because of the climate change that has affected and changed the weather in a negative direction, causing more disease. Another reason is when having dyke, it is more difficult for water and pesticide to leave the soil after entering, giving opportunity for pests to grow. The pesticides used during cultivation also change according to Table 3 and 4: Increasing dosage, use percentage and its types than ever. In before, most farmers prefer manual weeding but after using dyke, they switched to herbicides such as Sofit 300EC (Pretilachlor), Dietmam 360EC (Pretilachlor), Topshop, etc.. Not only herbicide but other crop protection chemicals also have significant change after the use of dyke system. Insecticides like 1.8EC, 3.6EC, Chief, now in favor of farmers, are widely used instead of Basudin, Monitor, etc. Other snailicide also increases its use percentage: Toxbait (21.62 %) to (47.23 %), Bolis 12GB (5.41%) to (18.92 %).

Table 3. Common pesticides used before dyke system.

No.	Herbicide		Insecticide		Fungicide		Snailicide	
	Name	**Use %**	**Name**	**Use %**	**Name**	**Use %**	**Name**	**Use %**
1	Manual	41.89	Takumi 20WG	10.81	Anvil 5SC	13.51	Toxbait	21.62
2	Sofit 300EC	33.78	Decis 2.5 EC	10.81	Filia 525SE	10.81	Bolis 12GB	5.41
3	Meco 60EC	13.51	Monitor 50EC	10.81	Benlats C 50WP	6.76	Anhead	1.35
4	Dietmam ADC	6.76	Bassa 50EC	9.46	Nativo 750 WG	6.76		
5	2, 4D	5.41	Chief	9.46	Antaco 500 ND	5.41		
6	Michelle 62EC	2.7	Vitaco 40WG	8.11	Fuan 40EC	5.41		
7	Damin 80 WP	1.35	Basudin 10D	5.41				

Table 4. Common pesticides used after dyke system.

No.	Herbicide		Insecticide		Fungicide		Snailicide	
	Name	Use %	Name	Use %	Name	Use %	Name	Use %
1	Sofit 300 EC	74.32	Takumi 20WG	47.3	Anvil 5SC	29.73	Toxbait	47.23
2	Germicide 360 EC	14.86	Chief 260 EC	32,43	Fuan 40EC	28.38	Cuu Chau	20.27
3	Topshop 60OD	12.16	Abakill 1.8EC	14.86	Filia 525SE	20.27	Bolis 12GB	18.92
4	2,4D	9.46	Abakill	8.11	Amistar Top 325SC	18.92	Tungsai 700 WP	9.46
5	Clincher	8.11	Pajero 30 WP	5.41	Vista 72.5 WP	14.86	Snailicide	2.7
6	Meco 60EC	6.76	Padan 50 SP	5.41	Bump 650 WP	9.46		

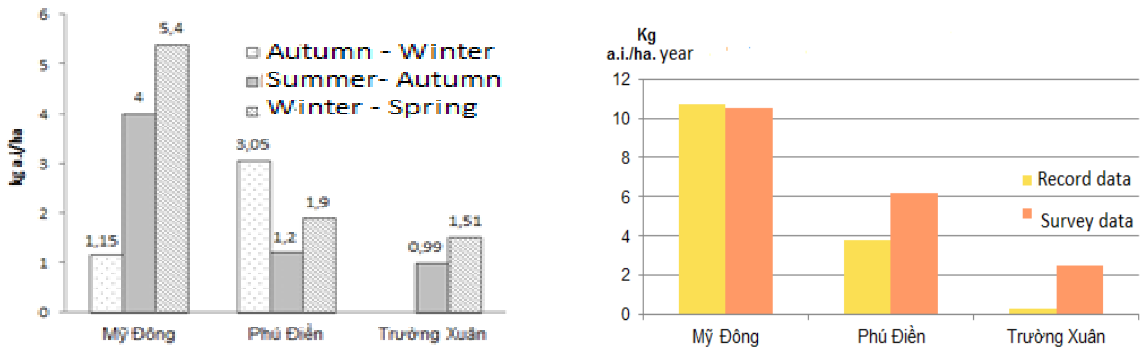

Figure 3. Comparison of pesticide usage dosage (a.i./kg) among communes v.s. crop. seasons.

Figure 3 showed that the farmers in close dyke use pesticide more than those in semi-dyke and non-embankment areas. The 1-year recording data indicates that farmers always change the pesticide types and dosages. Both interview and record data suggested that amount of pesticide used in close dyke area varied about 10 kg a.i./ha/year and in semi-dyke varied between 4 and 6 kg a.i./ha/year meanwhile less than 2 kg a.i./ha/year in non-embankement stutided area.

3.2. Evaluating pesticide risk through Environmental Impact Quotient (EIQ)

Through investigation, we learn that most farmers believe pesticide won't have any significant impact on environment so the habit of using pesticide more than recommended is a real concern in Thap Muoi District. To evaluate the impact level of pesticide on human and environment, our group use Environmental Impact Quotient (EIQ) to evaluate My Dong, Phu Dien, and Truong Xuan from Thap Muoi District, Dong Thap Province.

According to EIQ values list updated on Cornell University's website [9], we have collected and classified an EIQ Theory in study area as shown in Table 5. Among those pesticides used in Thap Muoi District, ingredient with the highest EIQ is Fipronil with EIQ total is 88.25 (EIQ Producer 60, EIQ Consumer 60, EIQ Ecology 193.75); the one with the lowest EIQ is Metaldehyde with EIQ total is 11.73 (EIQ Producer 6, EIQ Consumer 9, EIQ Ecology

20.2). In the study area, most pesticides have EIQ Theory less than 30 (48.3 %) between 30 and 45 (44.8 %) and less than 60 (3.4 %) since people use a lot of type I and II poisonous chemicals.

Table 5. EIQ Theory of active ingredients in insecticide and herbicide of Thap Muoi District.

No.	Active Ingredient	EIQ Theory	No.	Active Ingredient	EIQ Theory	No.	Active Ingredient	EIQ Theory
1	Fipronil	88.25	11	Buprofezin	34.97	21	Iprodione	24.25
2	Carbofuran 0.2	50.67	12	Dimethoate	33.49	22	Thiophanate-methyl	23.82
3	Diazinon	44.03	13	Thiamethoxam	33.3	23	Flubendiamide	19.36
4	Fenoxaprop	43.67	14	Propiconazole	31.63	24	Penoxsulam	18.72
5	Difenoconazol	41.5	15	chlorfluazuron	30.31	25	Chlorantraniliprole	18.34
6	Tebuconazole	40.33	16	Trifloxystrobin	29.78	26	Propineb	16.9
7	Methamidopho s	36.83	17	Permethrin	29.33	27	2,4 D	16.67
8	Imidacloprid	36.71	18	Deltamethrin	28.38	28	Ethoxysulfuron	12.67
9	MCPA	36.67	19	Azoxystrobin	26.92	29	Metaldehyde	11.73
10	Cypermethrin	36.35	20	Cyhalofop-butyl	25.2			

Using equation (1) with data collected through survey we can calculate EIQ Practical on fields of the 3 studied communes. The EIQ result shows that: My Dong (closed dyke) has EIQ value up to 167.02, Phu Dien (semi-dyke area) at 145.43, but Truong Xuan (non-embankment) is only 54.03, which indecates that the closed dyke and semi-dyke areas have EIQ much higher than non-embankment areas especially, the close dyke area has EIQ value over the safety limit set by Cornell University, 150. Such high EIQ Practical is considered unsafe for human health and environmental quality.

However, the EIQ has some limitation to indicates the impacts of pesticide based on single figures [10]. The results could be better if it was combined with risk index and pesticide residual modeling.

4. CONCLUSION AND PROPOSAL

4.1. Conclusion

Most experienced farmers since before embankment believe that pesticides won’t have a significant effect on environment, leading to the increasing amount of pesticide and fertilizer being used, which also contribute to the accelerating risk of pesticide residuals. Most farmers don’t use pesticides according to the advice of agricultural specialists. For their belief, extra use is better than enough so usually the amount is 2-10 times more than recommended dosage.

Dyking strongly influences farmer’s habit of using pesticide in study area. After having dykes, pesticide was used more often, more diverse and higher dosage. Therefore, using dyke for rice cultivation also affects the EIQ practical. For fields with closed full dyke system like My Dong, EIQ practical value was high than the suggested Cornell University’s safety limit, 150.

4.2. Proposal

Although the EIQ has some limitation [10], the study results has indicated that EIQ could be used for future research and for integrated pesticide management evaluative efforts that emphasize the environmental affects of pesticides. It is necessary to survey and evaluate pesticide residual in next few years to be able to reach accurate conclusion on the residual levels in closed-dyke paddy fields and estimate how the dyke system affects the environmental quality and human health by different approaches such as risk index and pesiticide residual modeling.

Authorities need to propagate to farmers cultivating in dyke areas about the harms of overly residual pesticide, so that they will sometimes allow flooding across the field during cultivation. The intensive training courses on how to use pesticide are needed to help raise awareness among farmers on the harms caused due to over use of pesticide.

Acknowledgement. Thanks to Vietnam Ministry of Natural Resources and Environment for funding this research and Ho Chi Minh City University of Natural Resurces and Enviornment and Dong Thap Province for supporting research conducts.

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