Automatic Risk Detection System for Farmer’s Health Monitoring Based on Behavior of Pesticide Use

Maya Silvi Lydia\(^1\), Indra Aulia\(^2\), Eka Lestari Mahyuni\(^3\), and Ainul Hizriadi\(^1\)

\(^1\)Department of Computer Science, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan 20155, Indonesia
\(^2\),\(^4\)Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan 20155, Indonesia
\(^3\)Department of Public Health Sciences, Faculty of Public Health, Universitas Sumatera Utara, Medan 20155, Indonesia

E-mail: maya.silvi@usu.ac.id\(^1\), indraaulia@usu.ac.id\(^2\), eka.mahyuni@gmail.com\(^3\), ainul.hizriadi@usu.ac.id\(^4\)

Abstract. The Indonesian farmers usually use the agrochemical technology (i.e. pesticide) to prevent or control not only pests but also weeds. Unfortunately, this technique is often applied without adhering to the Occupational Health and Safety (OHS) standards, so that the risks to the pesticide exposure cannot be avoided. Nowadays, the stakeholder has the difficulties for detecting the risks. The current detection system is still performed manually by involving the related experts to assess the farmers’ behavior of pesticide use. This process often spends more times, so that it is impacted on late awareness of the pesticide exposure risk. Due to this, this paper proposed the automatic early detection (ArDeFarm) system with applying Certainty Factor method. This system uses the certainty values acquired from the related experts in order to generate the percentage of the pesticide exposure risk based on the farmers’ behavior in the pesticide mixing, loading and application. It is tested by using farmers’ behavior data collected from 100 orange farmers in Karo District. Based on the experiment, it is able to identify the pesticide exposure risk faced on farmers in the form of the risk percentage automatically, without relying on the experts. Besides, the result shows that it has been appropriate to the expert assessment.

1. Introduction

Recently, most of the Indonesian farmers utilize the agricultural intensification programs through various modern technologies [1, 2]. One of the technologies is the agrochemical use, such as a pesticide. The pesticide is widely used to improve the quality of agricultural products by preventing or controlling pests, weeds and other plant pathogens [3, 4, 5, 4]. Therefore, it can be considered as the tool of pest management, which is an economic, labor-saving, and efficient, in boosting productivity significantly.

Behind the benefits of pesticide, the pesticide remains toxic substances that its exposure can provide the risks to the organism non-target, such as the public, the environment and the farmers[5, 6]. It can generate the risks when it is over-applied, and used without following
the Occupational Health and Safety (OHS) standard [2, 7]. The common risk to the farmers’ health is the pesticide poisoning, which can also cause the unintended consequence, such as death. Therefore, an early detection system is indispensable by stakeholders (e.g. Department of Agricultural and Department of Health) for controlling the risk.

Nowadays, the early detection system is based on the farmers’ behavior data in using the pesticide [8], which is divided into three tasks (i) mixing, (ii) loading, and (iii) Application. The data is acquired by means of the direct interview between farmer and operator. The operator will then forward to the related expert to be analyzed, so that the pesticide exposure risk can be identified early enough. Unfortunately, this process is still performed manually by operator and expert. It often spends more time indeed. Therefore, a system which is able to detect the risks automatically is needed. By this system, stakeholders can determine the appropriate and fast actions for controlling and minimizing the risks that arise from the exposure pesticide.

Due to the limitation of the current system, this paper proposed an automatic early detection system, which is called as ArDeFarm. ArDeFarm generates the percentage of the exposure pesticide risk based on the farmers’ behavior in using the pesticide, including mixing, loading, and application. It has been designed and implemented by using the Certainty Factor Method.

2. Related Work
The certainty-factor (CF) method is a method for managing uncertainty in rule-based systems. The technique was first used in 1975 for the development of MYCIN, an expert system for the diagnosis and treatment of meningitis and infections of the blood. Since then there were many kinds of research on the expert system developed. In the health sector, the expert systems are mostly used to diagnose diseases from symptoms experienced by patients using certainty factors.

Findawati et al [9] performed a research on the development of an expert system that could diagnose the type of dermatitis disease based on the symptoms felt by users using Certainty Factor approach. Their proposed system provides not only the disease type but also the disease description and solution to overcome the disease. Based on the experiment, it has been considered capable of achieving the system goal with good accuracy.

Setiabudi et al [10] develop a system which is able to diagnose the dental disease using Certainty Factor approach. The system will refer to the symptoms provided by patients in order to diagnose the dental disease. In this research, the disease which can be diagnosed consists of ten types of dental disease. The system performance in the case of the system accuracy has been evaluated by evolving 20 patients. By this evaluating, this paper concluded that the system accuracy reaches 95%, where only one patient which has the inappropriate result.

Another research by Munandar et al [12] focused on an expert system for helping Banten medical personnel in knowing the related disease based on the symptoms felt by patients, so that medical personnel can determine the appropriate handling. The system applied the Certainty Factor approach using multiple premise rules.

The research which is performed by Findawati et al, Setiabudi et al, and Munandar et al is based on the user’s disease symptoms because the nature the symptoms are usually uncertain. The expert system will facilitate the user with the questions regarding the signs and concluded the provided symptoms to the appropriate conclusion according to experts experience and knowledge.

Other than that, the expert system was also used in the environmental field as a system to monitor the water quality in the construction site so as not to violate government regulations [13]. In the Agricultural field, experts system was also used in the early Diagnosis of Red Chili Peppers Diseases [14] and diagnosing the broiler disease [15].

The difference of this research with the previous research works is that in this study we implement Certainty Factor approach to identify the pesticide exposure risk using the multiple premise rules based on non-risky farmers’ behavior in mixing, loading, and applying the pesticide.
The expected output of this system is the percentage of pesticide exposure risk, so that the percentage can be used to determine the appropriate solution in controlling and minimizing the pesticide exposure to farmers.

3. Methodology
This paper proposed the automatic early detection system, called as ArDeFarm, for overcoming the limitation as explained in Section 1. The basic concept of ArDeFarm can be depicted as in Figure 1.

![Figure 1: The Basic Concept of ArDeFarm System](image)

According to Figure 1, ArDeFarm System will generate the percentage of the pesticide exposure risk by identifying the farmers’ behavior when mixing, loading and applying the pesticide. The farmers’ behavior data is inputted to system by means of interview between operator and farmer using the structured questions. ArDeFarm System adopts the concept of expert system, so that the success of system performance depends on the expert knowledge embedded to the system for identifying the pesticide exposure risk in the form of the appropriate risk percentage. Therefore, this paper elaborated the Figure 1 into the general architecture of ArDeFarm as shown on Figure 2.

![Figure 2: The General Architecture of ArDeFarm System](image)

3.1. Input
The input to ArDeFarm System is a set of farmers’ answers, where the answers refer to the farmers behavior in using the pesticide. The farmers behavior which will be explored is related to three farmers’ tasks, including the pesticide mixing, loading and application. It can be acquired by using the structured questions. These questions have been formulated by experts based on the related theory and their experience.

3.1.1. The Pesticide Mixing and Loading
Farmers often perform the preparation stage before applying the pesticide to their farm field. The preparation consists of two tasks, which are the
pesticide mixing and loading. These tasks must be the important consideration when we want to identify the pesticide exposure risk [6, 8, 16]. This is because farmers will interact directly to the measured concentrated pesticide and quantities of pesticides involved and accidental releases of pesticides at these tasks. Therefore, these tasks can indeed provide the potential exposure risk to farmers, let alone when farmers get used to behavior, which do not follow the standard of Occupational Health and Safety (OHS).

In order to acquire the farmers' behavior related to the pesticide mixing and loading, this paper proposed the structured questions that cover how farmers mix and load pesticide?, where farmers mix and load pesticide? and what protective equipment is used by farmers when performing these tasks?. These questions are as shown in Table 1.

### Table 1: The Questions related to Pesticide Mixing and Loading

| Question                                                                 | Frequency |
|-------------------------------------------------------------------------|-----------|
| Q.A1 Mencampur dan memuat pestisida di luar ruangan                      | AFSSORN   |
| Mixing and loading is performed outdoor                                 |           |
| Q.A2 Mencampur dan memuat pestisida ketika tidak berangin               | AFSSORN   |
| Mixing and loading is performed when no windy                          |           |
| Q.A3 Berdiri melawan angin                                              | AFSSORN   |
| Standing upwind                                                        |           |
| Q.A4 Menuangkan pestisida di bawah ketinggian mata                       | AFSSORN   |
| Pouring pesticide below eye level                                       |           |
| Q.A5 Menggunakan kacamata pelindung khusus                             | AFSSORN   |
| Using goggles                                                          |           |
| Q.A6 Menggunakan respirator atau masker khusus                          | AFSSORN   |
| Using respiratory mask                                                 |           |
| Q.A7 Menggunakan topi pelindung khusus                                 | AFSSORN   |
| Using waterproof Hat                                                    |           |
| Q.A8 Menggunakan sarung tangan panjang khusus                           | AFSSORN   |
| Using long rubber gloves                                               |           |
| Q.A9 Menggunakan apron khusus                                           | AFSSORN   |
| Using Apron                                                            |           |
| Q.A10 Menggunakan baju pelindung khusus                                | AFSSORN   |
| Using coveralls or chemical resistant suit                             |           |
| Q.A11 Menggunakan baju berlengan panjang                               | AFSSORN   |
| Using long-sleeved shirt                                                |           |
| Q.A12 Menggunakan celana panjang pelindung                             | AFSSORN   |
| Using long pants over boots                                            |           |
| Q.A13 Menggunakan sepatu boots khusus                                   | AFSSORN   |
| Using rubber boots                                                     |           |
| Q.A14 Tidak makan ketika mencampur dan memuat pestisida                 | AFSSORN   |
| Not eating when mixing and loading                                      |           |
| Q.A15 Tidak minum ketika mencampur dan memuat pestisida                 | AFSSORN   |
| Not drinking when mixing and loading                                    |           |
| Q.A16 Tidak merokok ketika mencampur dan memuat pestisida               | AFSSORN   |
| Not smoking when mixing and loading                                     |           |

Where A = All The Time; F = Frequently; S = Sometimes; O = Occasionally; R = Rarely; N = Never
3.1.2. The Pesticide Application  
After mixing and loading, farmers will spray the pesticide to their farm field using the application equipment[16]. This task is similar to the pesticide mixing and loading. It can increase the pesticide exposure risk because it will take more time than the previous tasks [8].

This paper proposed the questions, which aimed at exploring the farmers’ behavior in the pesticide application. The questions refer to the spraying and protective equipment used by farmers, as well as the way spraying of pesticide. These questions are as shown in Table 2.

| Question (Q.B)  | Action Description                                                                 | Frequency |
|-----------------|------------------------------------------------------------------------------------|-----------|
| Q.B1            | Tidak menyemprot lebih dari 4 jam sehari                                           | Not spraying more than four hours per day |
| Q.B2            | Menyemprot ketika angin tidak kencang                                             | Spraying when the wind is not strong |
| Q.B3            | Berjalan mundur saat menyemprot pestisida                                           | Walking backward while spraying |
| Q.B4            | Menyemprot pestisida searah angin spraying in the direction of the wind           | Not repairing the nozzle (tip of the sprayer) with mouth or hands (without protection) |
| Q.B5            | Tidak memperbaiki nozzle (ujung alat semprot) dengan mulut atau tangan (tanpa pelindung) | Not repairing the nozzle (tip of the sprayer) with mouth or hands (without protection) |
| Q.B6            | Menggunakan kacamata pelindung khusus                                             | Using goggles |
| Q.B7            | Menggunakan sarung tangan panjang khusus                                          | Using long rubber gloves |
| Q.B8            | Menggunakan apron khusus                                                           | Using Apron |
| Q.B9            | Menggunakan baju pelindung khusus                                                  | Using coveralls or chemical resistant suit |
| Q.B11           | Menggunakan baju bertengan panjang                                                 | Using long-sleeved shirt |
| Q.B11           | Menggunakan celana panjang pelindung                                               | Using long pants over boots |
| Q.B12           | Menggunakan respirator atau masker khusus                                         | Using respiratory mask |
| Q.B13           | Menggunakan topi pelindung khusus                                                   | Using waterproof Hat |
| Q.B14           | Menggunakan sepatu boots khusus                                                    | Using rubber boots |
| Q.B15           | Tidak makan ketika menyemprot pestisida                                             | Not eating when mixing and loading |
| Q.B16           | Tidak minum ketika menyemprot pestisida                                             | Not drinking when mixing and loading |
| Q.B17           | Tidak merokok ketika menyemprot pestisida                                           | Not smoking when mixing and loading |

Where A = All The Time; F = Frequently; S = Sometimes; O = Occasionally; R = Rarely; N = Never
3.2. User Certainty Determination

User Certainty Determination is responsible to determine the certainty value for each fact which will be given by user. The facts are acquired by ArDeFarm system using the structured questions. They are the user’s answers referring to how often do farmers engage in the behavior of pesticide use which is not risky. This paper proposed 6 (six) of the behavior frequency with the certainty value as shown in Table 3.

| User Answer | Certainty Value |
|-------------|-----------------|
| All The time | 1.0             |
| Frequently   | 0.8             |
| Sometimes    | 0.6             |
| Occasionally | 0.4             |
| Rarely       | 0.2             |
| Never        | 0.0             |

According to Table 3, value of 0 means that farmers never perform non-risky behavior in using the pesticide. Meanwhile, farmers who always engage non-risky behavior when mixing, loading and applying pesticide, the certainty value will be assigned by value of 1.

**Example 1.** Suppose farmer 1 provided answers for Q.A1 to Q.A16, namely A, F, S, R, A, A, R, A, S, O, R, A, F, S, and A. Based on these answers, User Certainty Determination will determines the certainty factor, namely 1.0, 0.8, 0.6, 0.2, 1.0, 1.0, 0.2, 1.0, 0.6, 0.4, 0.2, 0.2, 1.0, 0.8, 0.6, and 1.0.

3.3. Expert Rule Certainty Determination

Expert Rule Certainty Determination aimed at determining the measurement of belief to conclusion or decision, which is obtained from the formulated rules. Experts gave the belief and disbelief value for each rule. Based on these values, the expert’s certainty value can be calculated by using Equation 1.

\[ CF_{rule}[h, e] = MB[h, e] - MD[h, e] \]  

where:
- \( CF_{rule}[h, e] \) is the certainty factor in the hypothesis \( h \) due to evidence \( e \)
- \( MB[h, e] \) is the measure of increased belief in \( h \) due to \( e \)
- \( MD[h, e] \) is the measure of increase disbelief in \( h \) due to \( e \)

This paper proposed the measure of expert’s belief for each conclusion or decision into 6 (six) choices. These choices have the value of the measure of belief as shown in Table 4.

| Expert’s Belief | Value |
|-----------------|-------|
| Definitely Sure | 1.0   |
| Sure            | 0.8   |
| Pretty Sure     | 0.6   |
| Quite Sure      | 0.4   |
| Fairly Sure     | 0.2   |
| Not Sure        | 0.0   |
Based on theory and expert’s experience, experts have provided the measure of expert’s belief for the hypothesis of this paper. The formulated hypothesis is “not potentially exposed to pesticide (no risk)” for each provided evidence. This hypothesis will be called as \( h_{\text{thisstudy}} \) and evidence will be represented by question id, as presented in Table 5.

### Table 5: Value of Expert Rule Certainty Factor

| Rule Id | Expert’s Rules | \( MB[h, e] \) | \( MD[h, e] \) | \( CF_{\text{rule}}[h, e] \) |
|---------|----------------|----------------|----------------|-----------------|
| R1      | \( e_{Q.A1} \) AND (\( e_{Q.A2} \) OR \( e_{Q.A3} \)) AND \( e_{Q.A4} \) \( h_{\text{thisstudy}} \) THEN \( 0.9 \) | \( 0.2 \) | \( 0.7 \) |
| R2      | \( e_{Q.A5} \) AND \( e_{Q.A6} \) AND \( e_{Q.A7} \) AND \( e_{Q.A8} \) AND \( e_{Q.A9} \) AND \( e_{Q.A10} \) AND \( e_{Q.A11} \) AND \( e_{Q.A12} \) AND \( e_{Q.A13} \) \( h_{\text{thisstudy}} \) THEN \( 1.0 \) | \( 0.1 \) | \( 0.9 \) |
| R3      | \( e_{Q.A14} \) OR \( e_{Q.A15} \) OR \( e_{Q.A16} \) THEN \( h_{\text{thisstudy}} \) \( 0.7 \) | \( 0.1 \) | \( 0.6 \) |
| R4      | \( e_{Q.B1} \) and \( e_{Q.B2} \) AND (\( e_{Q.B3} \) OR \( e_{Q.B4} \)) AND \( e_{Q.B5} \) \( h_{\text{thisstudy}} \) THEN \( 0.8 \) | \( 0.1 \) | \( 0.7 \) |
| R5      | \( e_{Q.B5} \) AND \( e_{Q.B6} \) AND \( e_{Q.B7} \) AND \( e_{Q.B8} \) AND \( e_{Q.B9} \) AND \( e_{Q.B10} \) AND \( e_{Q.B11} \) AND \( e_{Q.B12} \) AND \( e_{Q.B13} \) AND \( e_{Q.B14} \) THEN \( h_{\text{thisstudy}} \) \( 1.0 \) | \( 0.1 \) | \( 0.9 \) |
| R6      | \( e_{Q.B15} \) OR \( e_{Q.B16} \) OR \( e_{Q.B17} \) THEN \( h_{\text{thisstudy}} \) \( 0.7 \) | \( 0.1 \) | \( 0.6 \) |

#### 3.4. Premise Certainty Factor Calculation
This step is responsible to calculate the certainty factor for multiple premise rule based on the certainty factor of evidence and rules, acquired from the previous processes. This certainty factor is calculated by using Equation 2.

\[
CF[h, e] = CF[e] \times CF[\text{rule}] = CF(\text{user}) \times CF(\text{expert})
\]  

(2)

where:
- \( \text{IF } e_i \text{ AND } e_{i+1} = \min(CF[e_i], CF[e_{i+1}]) \)
- \( \text{IF } e_i \text{ OR } e_{i+1} = \max(CF[e_i], CF[e_{i+1}]) \)

**Example 2.** Based on Example 1, Premise Certainty Factor Calculation will be calculated based on evidences and rules in Table 5, such as:

\[
\text{CF}_{R1} = \min(1.0, \max(0.8, 0.6), 0.2) \times 0.7 = 0.14 \\
\text{CF}_{R2} = \min(1.0, 1.0, 0.2, 1.0, 0.6, 0.4, 0.2, 0.2, 1.0) \times 0.9 = 0.18 \\
\text{CF}_{R3} = \max(0.8, 0.6, 1.0) \times 0.6 = 0.6
\]

#### 3.5. Certainty Factor Combination Calculation
After getting the certainty factor for multiple premises, the next step is Certainty Factor Combination Calculation. This step will calculate the certainty factor of the hypothesis using a set of certainty factor multiple premises. It uses the formulation of the combining function as presented in Equation 3.
CF_{\text{combine}}(CF_1, CF_2) = \begin{cases} 
CF_1 + CF_2 \times (1 - CF_1), & \text{if } Both > 0 \\
\frac{CF_1 + CF_2}{1 - \min(|CF_1|, |CF_2|)}, & \text{one < 0} \\
CF_1 + CF_2 \times (1 + CF_1), & \text{if } Both < 0 
\end{cases} \tag{3}

**Example 3.** Certainty factor of non-risky behavior will be calculated by Certainty Factor Combination Calculation based on Example 2, such as:

\[ CF_{(CF_{R1}, CF_{R2})} = 0.14 + 0.18 \times (1 - 0.14) = 0.295 \]

\[ CF_{((CF_{R1}, CF_{R2}), CF_{R3})} = 0.718 \]

3.6. **Output**

The output of ArDeFarm system is a numeric representation in the form of the percentage of the pesticide exposure risk. In the current implementation, this percentage refers to the risk percentage for 3 (three) tasks of the pesticide use. It will be a consideration basis to stakeholders in determining the appropriate and fast actions to control and minimize the risks that arise from the exposure pesticide. For generating the risk percentage, this paper uses the formulation as presented in Equation 4.

\[ \text{Percentage of Exposure Risk} = (1 - CF_{\text{combine}}) \times 100\% \tag{4} \]

Based on the result of Example 3, behavior which is performed by farmer in mixing and loading pesticide is 28% at risk to exposure pesticide.

4. **Result and Discussion**

Based on the objective of this paper, the experiment scenario is to evaluate the system performance based on the efficiency of the ArDeFarm in identifying the pesticide exposure risk and the accuracy of ArDeFarm in generating the appropriate percentage of the pesticide exposure risk.

![Figure 3: Output Result of ArDeFarm](image)

ArDeFarm system aimed at generating the percentage of the pesticide exposure risk based on the farmers’ behavior in mixing, loading and applying the pesticide as depicted in Figure 3. ArDeFarm system was tested by using the behavior data of 100 orange farmers in 4 sub-district of Karo District.
4.1. Efficiency
Inference Engine is a part of ArDeFarm system, which is able to identify the exposure pesticide exposure based on the farmers’ behavior in the form of the appropriate percentage. It is embedded the expert knowledge into a set of rules. Therefore, it can be applied to arise the system automation.

In this paper, the system efficiency was evaluated by deleting the core part, that support the system automation, which is Inference Engine. By applying this experiment, this paper cannot generate the percentage of pesticide exposure risk as expected (see Figure 3). The example of this experiment can be seen in Figure 4.

![Figure 4: Output Result of Efficiency Experiment](image)

Based on Figure 4, this condition occurred because ArDeFarm do not have the related knowledge as core of identification system. This case is because Inference Engine is the heart of expert system containing the related knowledge, which is important to achieve a goal of expert system [17]. In other words, the functionality of ArDeFarm does not work properly without Inference Engine. Therefore, the results show that Inference Engine embedded to ArDeFarm system was able to reduce significantly the time taken to identify the pesticide exposure risk using the set of farmers’ answers for each task behavior.

4.2. Accuracy
The system accuracy was evaluated by using the assessment form through the appraisal conducted by related experts as primary assessor of the percentage of pesticide exposure risk generated by ArDeFarm. Based on expert evaluation, ArDeFarm has been assessed as having the ability to generate the appropriate percentage of pesticide exposure risk. This is based on the evaluation, where experts identified that there are 91 orange farmers have the risk to exposure the pesticide when applying their behavior in mixing, loading and application. The expert’s results are not slightly different to the results generated by ArDeFarm system in which ArDeFarm system identified 88 orange farmers is risky to exposure pesticide. These results of experts and system have the percentage of pesticide exposure risk that the average percentage difference reaches 11%.

5. Conclusion
Based on result and discussion, this paper concluded that the proposed system (ArDeFarm) can be used to generate the percentage of the pesticide exposure risk automatically based on
the farmers’ behavior in using the pesticide. The system result has been assessed by experts as the system which is able to be the early detection system in controlling and minimizing the pesticide exposure risk to farmers based on the percentage of pesticide exposure risk. This condition proved that the formulated rules in the proposed system can provide the appropriate risk result in a relatively short time. Therefore, the proposed system can work properly according to the objective of this paper.

This paper plans to further improve the reliability of ArDeFarm in the case of improving the system accuracy and generating the textual report consisting of the causes of the pesticide exposure risk and the appropriate suggestion in controlling and minimizing the pesticide exposure risk. Besides, future research is expected to consider the sophisticated and robust methods for improving the system reliability and intelligence, especially updating the expert knowledge simultaneously.

Acknowledgement
We would like to thank the Ministry of Research and Technology and Higher Education Republic of Indonesia who has supported and funded this research through the grant research of TALENTA Universitas Sumatera Utara (USU) 2018, Contract Number 2590/UN5.1.R/PPM/2018 on March 16, 2018.

References
[1] Prijanto T B, Nurjazuli N and Sulistiyani S 2009 Jurnal Kesehatan Lingkungan Indonesia 8 76–81
[2] Sheahan M, Barrett C B and Goldvale C 2016 African Development Bank Group Working Paper Series
[3] Damalas C A and Eleftherohorinos I G 2011 International journal of environmental research and public health 8 1402–1419
[4] Whithaus S M The Safe and Effective Use of Pesticides
[5] Understanding pesticide risks accessed: 2018-05-15 URL http://npic.orst.edu/health/risk.html
[6] DeMoranville C and Sandler H Pesticide mixing and loading recommended practices Handout URL http://www.umass.edu/cranberry/downloads/
[7] Pesticide health risk assessments accessed: 2018-05-25 URL https://www2.health.vic.gov.au/public-health/environmental-health/pesticide-use-and-pest-control/pesticides-safe-use/pesticide-health-risk-assessments
[8] Damalas C A and Koutroblas S D 2016 Farmers exposure to pesticides: toxicity types and ways of prevention
[9] Findawati Y and Afrina A 2018 IOP Conference Series: Materials Science and Engineering vol 403 (IOP Publishing) p 012068
[10] Setiabudi W U, Sugiharti E and Arini F Y 2017 Scientific Journal of Informatics 4 43–50
[11] Prihatini P M et al. 2012 TELKOMNIKA (Telecommunication Computing Electronics and Control) 10 825–836
[12] Munandar T A and Suherman S 2012 International Journal of Application or Innovation in Engineering & Management (IJAIE) 1 58–64
[13] Ooshaksaraie L and Basri N E A 2011 American Journal of Environmental Sciences 7 75–81
[14] Agus F, Wulandari H E and Astuti I F 2017 Journal of Applied Intelligent System 2 52–66
[15] Setyohadi D, Octavia R and Puspitasari T 2018 Journal of Physics: Conference Series vol 953 (IOP Publishing) p 012118
[16] Franklin C A and Worgan J P 2005 Occupational and residential exposure assessment for pesticides vol 9 (John Wiley & Sons)
[17] Nada Y A and Meshref H 2014 International Journal of Computer Applications 105