1. Introduction

The environment is one of the factors that must be maintained. In the industrial world, the use of a solvent must be studied for its impact on the environment. Conventional solvent methods can pollute the environment, so an eco friendly alternative is needed. One alternative that can be used is ionic liquid [1]. Ionic liquids are used in several industrial fields and their application has expanded mainly due to their structural tunability. The use of ionic liquids is seen in extraction, lubricants, liquid-liquid separation, fuel cells, and the production of basic materials, such as gels and membranes [2]. At first, ionic liquids were considered environmentally safe solvents, but some ionic liquids produced from non-renewable energy sources are difficult to biodegrade in the environment, undermining their eco-friendly character [3]. Due to the ionic liquid market expanding globally, the production of ionic liquid is increasing rapidly. The annual growth rate of ionic liquid is expected to exceed 22% and the market size is expected to exceed 50 thousand tons by 2022. The increase in the production and use of ionic liquid may harm the environment, such as the pollution of soil and aquatic ecosystems [4].

Ionic liquids have been widely studied due to their unique characteristics, such as low-vaporization, low flammability, High-temperature stability, and solvation ability, and easy recycling through separation from volatile compounds [2], [3].This characteristic of ionic liquid can indirectly cause atmospheric pollution and inhalation toxicity to humans or animals [2]. According to existing study, the ionic liquid can inhibit many enzymes. One of the enzymes that can be inhibited by the toxicity of ionic liquid is the enzyme acetylcholinesterase (AChE). The inhibitory effect of acetyl cholinesterase enzyme resulting in distortion of many neu rological processes can have harmful effects. It has been shown that pyridinium and imidazolium-based ionic liquids are responsible for inhibiting enzyme activity [6]. In the nervous system of fish, inhibition of the enzyme acetyl cholinesterase results in up to 70% mortality [2]. Therefore, acetylcholinesterase enzyme can be used as one of the toxicity indicators of ionic liquid.

The conventional method for measuring inhibition of the acetylcholinesterase enzyme is done using colorimetry. This method requires a lot of time and resources [2]. In addition, thousands of animals are sacrificed to obtain all toxicology results on chemicals through laboratory animals. [7]. Another alternative to detect the toxicity of ionic liquids is using in silico methods. In silico methods are methods that use computers such as using machine learning. There are several studies that have been conducted related to predicting the toxicity of ionic liquid to the enzyme acetylcholinesterase. In 2008, Torrecilla et al. conducted study using 3 methods namely Multilayer Perceptron (MLP), Radial-Basis function (RB), and Multiple Linear Regression (MLR). The results of the study MLP got R2 = 0.814, MLR got R2 = 0.973, and RB got R2 =0.842 [5], [8]. Yan et al. also conducted a similar study in 2012. This study uses the topological indexes method with an Extreme Learning Machine (ELM) model. The results of this study are R2 = 0.877 and RMSE = 0.212 [5], [9].

Further study was conducted in 2015 by Singh et al. who investigated the toxicity of various ionic liquids on the poten tial inhibition of acetylcholinesterase (AChE) enzyme using a Support Vector Machine (SVM) and Cascade Correlation Net work (CCN). Their results showed R2 = 0.910 and RMSE = 0.15 for SVM, while R2 = 0.922 and RMSE = 0.14 for CCN. This shows the success in predicting different toxicity classes and the exact toxicity endpoints of ionic liquid. In addition, this study also proved that the nonlinear model developed by the SVM algorithm is more reliable in predicting the toxicity of ionic liquid [5], [10]. Another study was conducted in 2019 by Zhu et al. using the MLP and ELM methods. The results obtained from the ELM model are R2 = 0.964 and RMSE = 0.096, while the results of the MLP model are R2 = 0.917 and RMSE = 0.145. From these results, the ELM model provides a higher R2 value than MLP and a lower RMSE value than MLP. This proves the superior performance of ELM for ionic liquid toxicity estimation [5].

Based on the study that has been conducted predicting the toxicity of ionic liquid to the enzyme acetylcholinesterase, the results are quite good. However, these results can be improved. The way that can be done is to use deep learning. One of the deep learning models that can be used is LSTM. A commonly used optimization method is the manual optimization method. The manual method requires a lot of experimenting so it takes a lot of time. An alternative to manual optimization method is using meta-heuristic method such as camel algorithm. Camel algorithm will look for parameters that produce the smallest validation loss. Camel will use a combination of exploration and exploitation strategies to perform the search. The Camel algorithm has a balance between exploration and exploitation so that the search for optimal parameters is efficient and accurate [14]. Using the camel algorithm, the search for the best parameters will be more effective.

The purpose of this study is to use the LSTM model optimized using camel algorithm to predict the toxicity of ionic liquid against acetylcholinesterase enzyme. By applying the Camel algorithm to optimize the

LSTM model parameters, this study aims to improve LSTM model to predict the toxicity of ionic liquids. Camel will use a combination of exploration and exploitation strategies to perform the search. Using the camel algorithm, the search for the best parameters will be more effective.