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To cite this article: Fatima Chaseb Bader and Alaa Hassan Al-Farttoosy 2024 *IOP Conf. Ser.: Earth Environ. Sci.* **1371** 022028

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Beltanol Sorption Modelling in the Soil Column using High Performance Liquid Chromatography Technique

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Abstract. The Fungicide adsorption process is a major factor that results in failure of pest control. The results revealed that Beltanol sorption is subjected to first order reaction soil sorption, achieving a rate constant 0.013 min^{-1}. This reaction revealed that Beltanol behaviour is not influenced by soil factors. The Kd of Beltanol was 0.152 mL g^{-1}, resulting in less distribution under soil column condition. The Beltanol power function was not linear fitting well, scoring 0.788. Thomas model was estimated KTh = 0.0189 mL g^{-1} min^{-1}, this indicating that model was fitting to express on its less mobility in the soil. In general, plants can receive a reasonable amount of protection from Beltanol due to its sluggish rate of dissipation.

Keywords. Beltanol, Distribution Coefficient, First-order kinetic, Leachate, Power function.

1. Introduction

The adsorption process is a limited factor to the success or failure of pest control. Beltanol is one of the fungicides, consisting of 8-hydroxyquinoline sulfate. It is used to control many diseases that affect cucumber seedling death [1]. The process of soil particle surface sorption allows chemicals to be taken up by living things and released from soils into surface and ground waters. The mechanisms of chemical sorption include precipitation onto mineral surfaces and inner- and outer-sphere adsorption [2]. Many studies have reported that Beltanol is applied through a drip irrigation system at a concentration of 4.0 l/ha, for both Solanaceae and Cucurbitaceous family crops [3]. Since it contains 8-hydroxyquinoline, it can act as a chelating agent that binds to metal ions in the pathogen cells, preventing multiplication and inhibiting the growth of fungi [4].
Moreover, there is a strong probability that Beltanol residues can be adhesive or even leaching through the soil column, resulting in loss of chemical control against the pathogens.
Once Beltanol reaches the soil, it undergoes an adsorption process. This process allows pesticide molecules to bind to soil particles, reducing their availability and movement in the soil. Moreover, the adsorption operation depends on several factors, such as time, soil pH, soil organic matter, and iron and aluminum oxides [5].
Therefore, the main goal in the recent study is to determine the Beltanol behaviour according to the real data resulting from the soil column condition using High Performance Liquid Letter (HPLC).

IOP Conf. Series: Earth and Environmental Science **1371** (2024) 022028 doi:10.1088/1755-1315/1371/2/022028

2. Materials and Methods

2.1. Chemicals

Beltanol is a type of bactericidal fungicide that works by stopping bacteria. The composition was 8-Hydroxyquinoline 37.5% (Sulphate) w/v. Number of enrollment: 25.492 Formulation Soluble Concentrated (SL) one such chemical group is quinolin. 1 L and 5 L are displayed. The purpose of Beltanol was to protect the crop's vascular system from illness.

2.2. Beltanol Sorption Soil Column

The protocol has been used based on [6]. This experiment was conducted using the batch equilibrium approach using a dirt column. Three times, for fifteen minutes at 121°c, the soil was autoclaved to guarantee the eradication of all microorganisms. There was filter paper at the bottom, 4.5 diameters, 70 g of dry soil, and a 20-centimeter plastic column packed inside. 50 mL of 0.01M $CaCl_2$ was added to the soil in order to allow it to achieve its maximum capacity (saturating = 1.6 mmol g $^{-1}$). After that, the soil was left for a full day to reach balance. The soil columns were placed in the incubator shaker's holder and firmly tipped for 24 hours at 30°C and 120 RPM. 50 milligrams L^{-1} in 50 milliliters following equilibrium.

To quantify the concentration of Bethanol, 1 mL of the effluent was taken using beakers every 30 minutes and then put into an Eppendorf tube. The eluted underwent a 15-minute centrifugation at 14,000 rpm and was filtered using a 0.22 µm syringe prior to HPLC analysis.

2.3. Analysis of Beltanol Using HPLC

The Beltanol concentrations were analysed using the HPLC in Science and Technology Ministry-Baghdad according to the procedure in [7].

2.4. Modelling and Computes Statistic

The data was analysed using a number of models, including linear and kinetic models i.e. the first-order and second-order, the distribution coefficient Kd, Thomas model, and power function. These estimations have been performed based on the following equations.

The first and second order reaction kinetic were applied according to [8].

Thomas model was estimated by applying the equation (1). By Plotting ln ($C0\ /Ct - 1$) vs time (t) allows for the linear least square regression analysis of Eq. 1 to get the Thomas constant KTh (L min^{-1} mg^{-1}) and q0.

$$\text{Ln}\ (C0/\ Ct - 1) = KThq0\ M\ Q/- KThC0t \qquad (1)$$

Where: - KTh = Thomas rate constant (mL min^{-1} mg^{-1}),
q0 = equilibrium Beltanol adsorbed per g of soil (mg.g^{-1}),
C0 = initial Beltanol concentration (mg.L^{-1}),
Ct= Beltanol concentration at time t (mg L $^{-1}$),
M= mass of soil (g),
Q= filtration velocity mL.min-1 and t= time (min),
In addition, V= the flow rate (mL min^{-1}).
By applying the equation (2),

$$C0\ /Ct = 1\ 1{+}e\ (Kth\ )\ (qmm{-}Ci\ Vef) \qquad (2)$$

A nonlinear plot can be generated through the plotting of ($C0/Ct$) vs time (t).

While the Power Function and Distribution Coefficient Kd were computed using the formula given in [9].

3. Results and Discussion

3.1. Kinetic Reaction Examination of Beltanol

To distinguish between the kinetic reactions of Beltanol in the soil column, the first-order and second-order kinetic were estimated. The data in Figure (1) show that Beltanol reaction is subjected to the first-order rather than the second-order. This depends on the value of the R^2. The highest value was registered in the case of the First -order, reaching 0.90. While it scored 0.75 in the second-order. According to this result, Beltanol remains in the soil approximately (DT_{50}= 50.22 mins and 990.21 mins) respectively. This means Beltanol will provide plant protection from the infection by *Rhizoctonia* and *Fusarium* pathogenesis during this period. This resulted from the slow rate of dissipation in the soil. The rate of Beltanol dissipation constant is 0.013 min^{-1}. Thus, the importance of the kinetic study is due to the loss of pesticide control. Hence, the determination of these environmental parameters enables a suitable time to plant-disease fungus control.

In line with this study, the current study was agreed with many laboratory examinations that have been conducted. For example, [9] reported that Diethyl methyl phosphonate (DEMP) pollutant was undergoing the first-order model in the soil column.

In contrast, this study also differs from a study by [10] reported that the diazinon insecticide was subjected to the second-order reaction. In contrast, this study also differs from a study by Al-Farttoosy (2021) reported that the diazinon insecticide was subjected to the second-order reaction. While its concurede with many studies mentioned that many pesticides, for instance, fungicides or even insecticides, and herbicides were subjected to the first order kinetic. Hence, [11] illustrated that carbendazim behaves as first order and [12] reported that glyphosate is subjected to the same order. In addition, [13] find out that three insecticides were decreasing based on the first reaction, including indoxacarb, imidacloprid, and lambda-cyhalothrin, while chlorantraniliprole was undergoes the second order.

The importance of this experiment is to determine the remaining time that Beltanol is available and effective against the plant pathogens. Moreover, it can be used to detect the time required to reach non-effective concentration toward the pathogens in the soil.

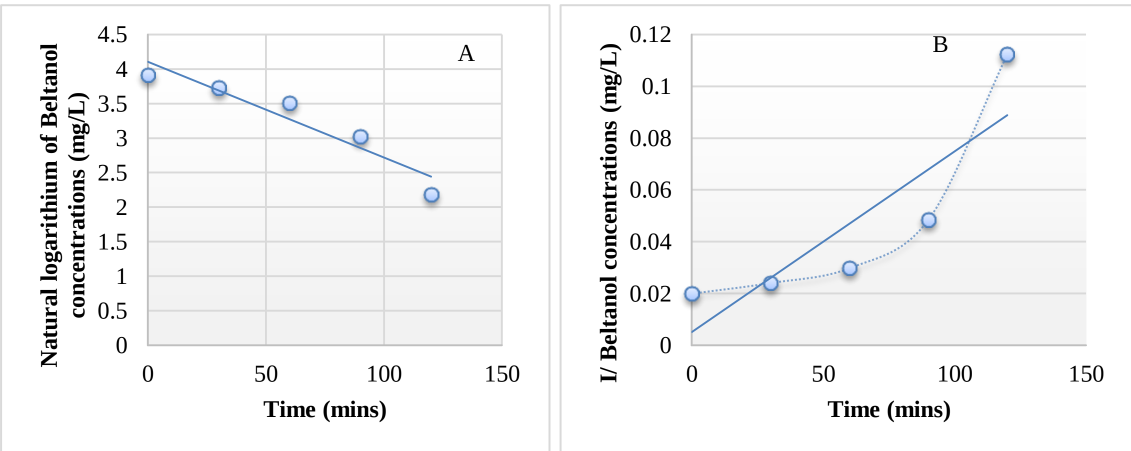

Figure 1. Kinetic reaction of Beltanol in the Soil. A) First & B) second-order.

3.2. The Beltanol Behavior Based on Thomas Model

The most interesting aspect of this study is investigating the Thomas model. This model interests the pollutant breakthrough in the soil column. Therefore, in Figure (2-A) there is a clear trend of Beltanol curve graphs shown. Nevertheless, the linear graph of Thomas' model was not linear fitting well. But given that the value of the coefficient of determination (R^2) derived from the experimental results is greater than 0.75 (0.968) Figure (2-B), indicating that both internal and external diffusion have no effect on the actual adsorption process, the Thomas Model is suitable to describe the kinetics of the adsorption column [14].

The current Thomas model result concurs with [15] findings. They verified that each adsorbent's adsorption capacity is inversely proportional to the derived Thomas constant. It is noteworthy that the adsorption flow rate constant (Kth) = 0.0189 mL mg^{-1} min $^{-1}$ and adsorption capacity (qo = 0.013 mg g^{-1}) were determined using the Thomas model.

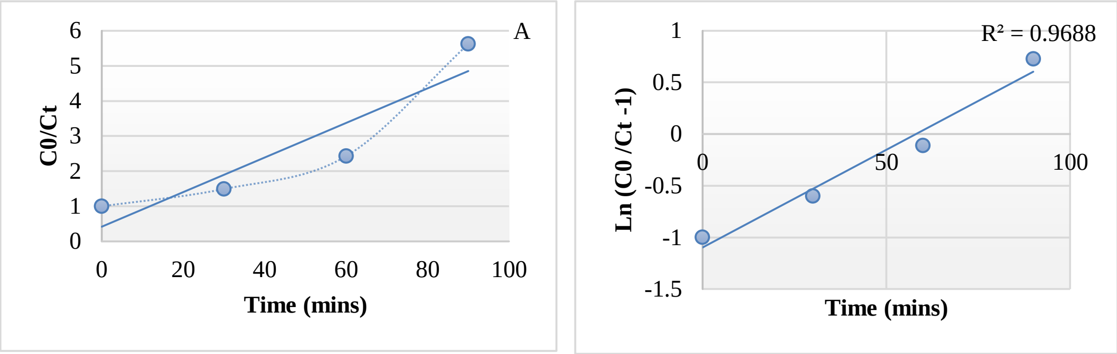

Figure 2. Breakthrough of Beltanol concentration based on Tomas model A) curve and B) linear.

3.3. The Beltanol Kd and Power Function

The distribution coefficient (Kd) of pollutants, which is the ratio of their concentrations in sediments to water. Therefore, The Kd value calculated was 0.152 mL g^{-1} min^{-1}. Consequently, it indicates that Beltanol has less distribution under the soil column condition. The less vertical movement of Beltanol concentration through the soil at the application, indicating the success of pathogens control. This success belongs to the remaining of Beltanol in the soil for a long time, achieving close contact with the pathogens like *Rhizoctonia* solani and even *Fusarium* spp. and then its availability.
To confirm the capability of Beltanol leachate in the soil column, such a further analysis showed that Beltanol concentrations were leachate as a function of a time. Thus, the Beltanol has fast decreasing concentrations of the Beltanol analysis using HPLC technique can be seen in Figure (3).

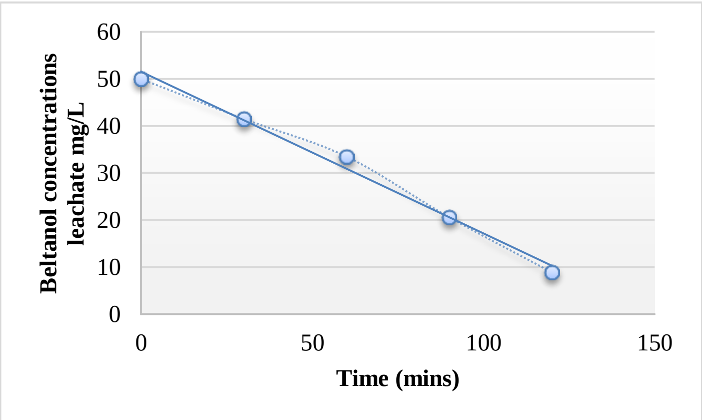

Figure 3. Beltanol leachate in the soil column.

As a result, the Beltanol leachate speed scored 0.34 mg L^{-1} min^{-1}, which is considered a little fast. It is logical to compare between the Kd and leachate behavior of Beltanol. Because the first parameter refers to the ability of the fungicide to distribute between the soil and its water. If the Kd was high, meaning the Beltanol does not leachate, tending to retain onto soil particles. While the outcome of this experiment has shown the less Kd, and the high-speed leachate.
However, the distribution coefficient, sometimes referred to as the partition coefficient, is one of the most crucial metrics for figuring out if a pollutant in the liquid phase exposed to suspended matter or sediment would migrate, according to [16] The quantitative distribution of an element or compound between sediments and the water column is described by this parameter.
It is likely that there is less mobility of pollutants in the soil due to the soil texture. In the current study, the soil characteristics are described in Table (1). This was the same reason to be glyphosate

less mobile in the soil because of soil properties. Therefore, this result is consistent with the study of [12]. They found out that the herbicide was less mobile and has a tendency to adsorb on soil particles, as indicated by the distribution coefficient of glyphosate between the soil and its solution, Kd, which was found to be 0.33 mL g^{-1}.

Table 1. Characteristics of Soil.

Type	EC ms/cm	pH (IU)	Total phosphorus (mg/l)	Total nitrogen (mg/l)	Total organic carbon (%)
The studied soil	10.8	7.95	0.064	5.6	3.29

However, other pesticides, such as lambda-cyhalothrin and chlorantraniliprole, have a lower dispersion, measuring 0.639 and 0.562 mL g^{-1}, respectively. These pesticides tend to have a higher distribution in similar soil conditions. However, the soil most likely no longer has any influence. This is due to the characteristics of the pesticides themselves; imidacloprid and indoxacarb, for instance, had scores of 5.25 and 1.30, respectively, indicating high-level dissemination [13].

Diethyl methyl phosphonate (DEMP) was shown to be less mobile in the study conducted by [17], which was attributed to a particular property of the soil. 3.36 mg kg^{-1} of the organic carbon was present in the soil, which led to significant adsorption and reduced dispersion.

In terms of Power Function, the decrease in the content of Beltanol in the soil column was shown in Figure (4). These data do not fit a basic linear model very well. R^2= 0.79 and the power function was rated at 0.788.

It has been concluded that Kd determination was an important parameter, not only in the essential data for evaluating risks, but also in the plant pathogens control monitoring.

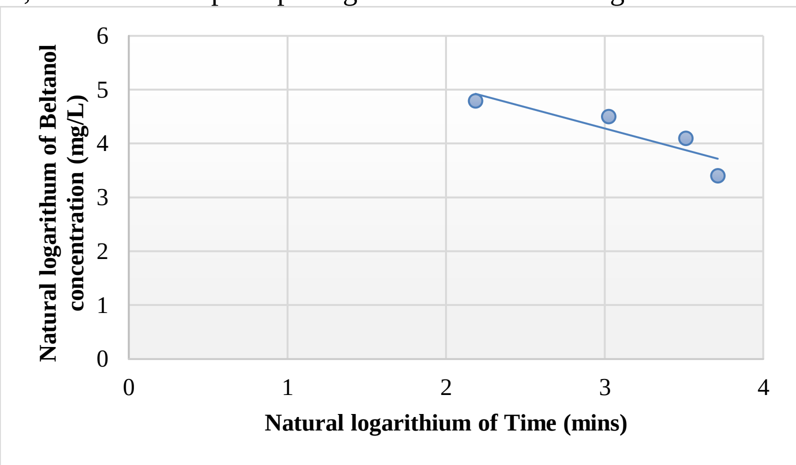

Figure 4. Power function of Beltanol behaviour in the Soil column.

Conclusion

This study set out to gain a better understanding of Beltanol behaviour in the soil column. One of the more significant findings to emerge from this study is that Beltanol undergoes the first-order reaction kinetic model rather than the second-order reaction. The distribution coefficient experiment confirmed that Beltanol had less distribution under soil column condition. In contrast, the power function of Beltanol was not linear fitting well. The findings of this study suggest that application of Beltanol can leachate from the soil relies on soil properties. Overall, the Beltanol can provide an acceptable protection to plants due to the slow rate of dissipation.

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