DISCOVERY

58(319), July 2022

Demonstration of Biokinetics Coefficient of Total Petroleum Hydrocarbon Degradation in Stagnant Water: The concept of LineWeaver Burk Plot

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To Cite:
Ukpaka CP, Okirie FU. Demonstration of Biokinetics Coefficient of Total Petroleum Hydrocarbon Degradation in Stagnant Water: The concept of LineWeaver Burk Plot. *Discovery*, 2022, 58(319), 824-827

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Peer-Review History
Received: 15 May 2022
Reviewed & Revised: 20/May/2022 to 23/June/2022
Accepted: 24 June 2022
Published: July 2022

Peer-Review Model
External peer-review was done through double-blind method.

ABSTRACT

The biokinectics of total petroleum hydrocarbon was illustrated in relationship with the LineWeaver Burk Plot concept of the Micheal's Menten and Monod's model for salt and fresh water media in a stagnant water sedimentation. The maximum specific substrate rate and the equilibrium or dissociation constant of substrate was demonstrated in this investigation for sampling points of PT1, PT2 and PT3. The equation of the linear curve was established revealing the values of slope and intercept, which was expressed in terms of $1/U_m$ equated to intercept and km/ U_m equated to slope. The reliability of the root of the best fit is within the range of 63% to 91%, with the highest percentage of acceptable value in salt water in total petroleum hydrocarbon degradation.

Key words: Demonstration, biokinetics coefficient, total petroleum hydrocarbon, degradation, stagnant water, LineWeaver Burk Plot.

1. INTRODUCTION

The application of LineWeaver Burk Plot in the evaluation of the functional parameters bas been investigated by different research groups [1-5]. Indeed, the mechanism and the concept is not new, but the uniqueness of the application in handling and determination of the rate of contaminants degradation is widely acceptable as research uses the general solution in evaluating the parameters that matters [6-7].

The substrate degradation of the contaminants in any given environment is possible only if the microbes make use of substrate as source of food for energy deriving and the process releasing substance that environmentally friendly [8-10]. Investigation on the characteristics of the substrate reveals that in most cases the substrate inhibits the active site of the microorganism, hereby mitigating the rate of contaminants degradation as well as resulting to microbial decline [11-15].

In most cases, continuous lag phase may be uncounted when the process experience environmental challenges and these influences could be variation in the physicochemical parameters [16]. Indeed, investigation by various researchers

has shown the tremendous effect of these physicochemical properties in mitigating the microbial activities in bioremediation processes [17]. The toxic nature of the contaminants also influence the microbial action and the rate of microbial growth during remediation processes.

2. MATERIAL AND METHODS

Sample Separation and Detection

The Agilent 6890N Gas Chromatograph-Flame Ionization Detector (GC-FID) equipment was used to separate and identify chemicals in fresh and salt water samples. A GC vial was filled with 3µl of concentrated sample eluted from the column. Before collecting the sample for analysis, the blank DCM was injected into the GC micro-syringe three times to clean the syringe. The material was then washed out of the micro-syringe. The sample was then injected into the column for separation of the sample's constituents. The chemicals were separated and then put via a flame ionisation detector. The chemicals in the sample are detected using FID. The level of TPH was measured in milligrammes per litre (mg/l) at each chromatogram.

Michael's Menten and Monod's Equation

The rate of TPH degradation is expressed according to Michael's Menten or Monod equation as follows:

$$R_i(C) = \frac{U_m C_{TPH}}{K_m + C_{TPH}} \quad (1)$$

where:

C_{TPH} = Concentration of TPH (ppm)

k_d = First order degradation rate constant (day^{-1})

U_m = Maximum rate constant (mg/l.day)

K_m = Monod constant (ppm or mg/l)

3. RESULTS AND DISCUSSION

The predicting the coefficients of the LineWeaver Burk Plot of the Total Petroleum Hydrocarbon degradation in stagnant water media was investigation and the effect of sedimentation as a controlling are presented in Figure 1 and 2.

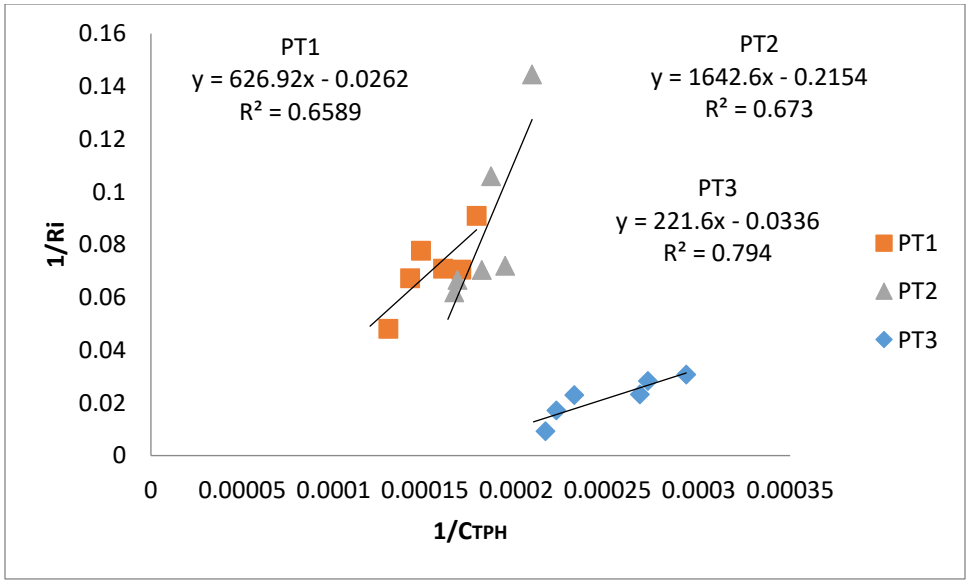

Figure 1: Line Waver-Burke Plots for Determination of Rate Constant used for Fresh Water

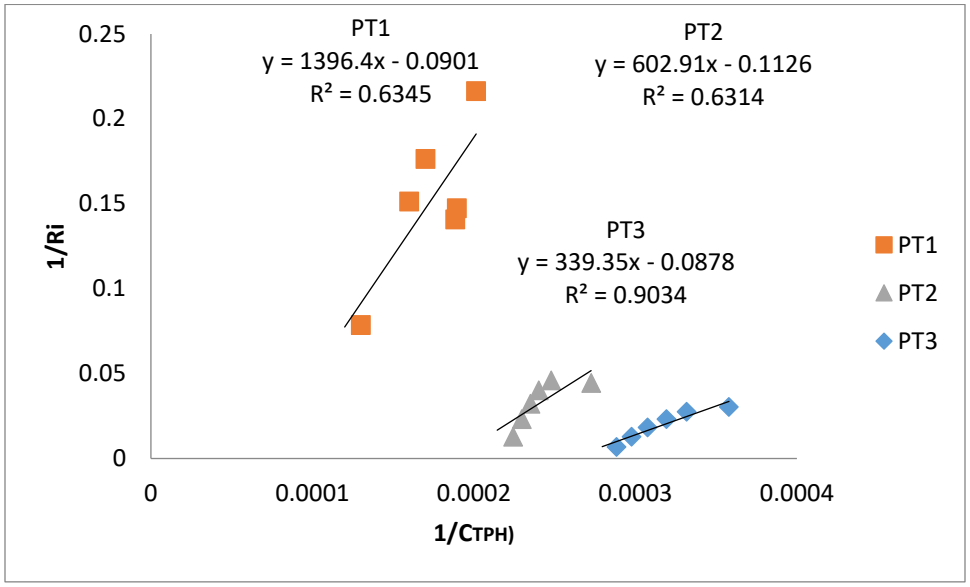

Figure 2: Line Waver-Burke Plots for Determination of Rate Constant used for Salt Water

Figures 1 show the plots used in determining the first order rate constant for freshwater and saltwater media respectively. From the linear equations in Figure 1, the rate constant was evaluated as 0.0029, 0.0030 and 0.0043day^{-1} at PT1, PT2 and PT3 respectively, which averaged 0.0034day^{-1} for fresh water. Also, from the linear equations in Figure 2, the rate constant was evaluated as 0.0011, 0.0025 and 0.0028day^{-1} at PT1, PT2 and PT3 respectively, which averaged 0.00213day^{-1}.

Similarly, Figures 2 show the plots used in determining the Monod constants for freshwater and saltwater media respectively. From the linear equations in Figure 3, the maximum specific rate constant, U_m was evaluated as 38.1679, 4.6424 and 29.7619mg/l.day at PT1, PT2 and PT3 respectively, which averaged 24.1908mg/l for fresh water. The Monod rate constant for fresh water was evaluated as 23928.2, 7625.81 and 6595.24mg/l, which averaged 12716.43mg/l. For salt water, the maximum specific rate constant, U_m was evaluated as 11.0988, 8.8810 and 11.3895mg/l.day at PT1, PT2 and PT3 respectively, which averaged 10.4564mg/l, while the Monod constant was evaluated as 15498.3, 5354.44 and 3869.03mg/l, which averaged 8239.27mg/l.

4. CONCLUSION

The significance of the LineWeaver Burk Plot in demonstrating the process for determination of the functional parameter is well described in this investigation and the contributions is as highlighted below:

i. The LineWeaver Burk Plot approach as developed by Micheal's Menten for substrate degradation and Monod's model is found useful in the determination of the maximiun specific rate of substrate degradation and growth rate of microbes as well as the equilibrium or the dissociation constant of substrates and microbes
ii. The research reveals that the functional parameters can be evaluated using the established equation of the linear curve and relating to the intercept and slope
iii. The determination of the functional coefficients is found useful for simulating the rate of reaction or degradation of the substrate.

Funding

This study has not received any external funding.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

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ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS