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# Modelling the effect of moringa seed shell on crude oil polluted soils for remediation purposes

**Uku Eruni Philip[1], Ekperi Nelson Ibezim[2]**

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**Author Affiliation:**
[1]Lecture, Chemical Engineering Department, Federal University, Otuoke, Bayelsa State, Nigeria
[2]PhD Researcher, Chemical/Petrochemical Department, Rivers State University, Port Harcourt, Rivers State, Nigeria

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DISCOVERY
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## ABSTRACT

The results obtained were utilized to calculate the highest specific rates, the disassociation constant and the kinetic values in terms of first and second order kinetics. The use of the Lineweaver Buck plot was taken into consideration for the different reactors and the maximum specific rate of substrate degradation and disassociation constant were evaluated and determined for both the powdered forms of the moringa seed shell, in the Loamy soil. According to the research, crude oil degraded more quickly in reactors that contained a mixture of yeast, NPK and powdered swamp soil (moringa oleifera) from moringa seeds. The total number of bacteria rose in all of the treatment reactors, with the fastest growth rate occurring at 56 days (during the progressive or exponential phase), before each reactor reached its full substrate (crude oil) usage capacity and entered the stationary and decline phases. In the model evaluation, the Michalis-Menten model's correlation coefficient values (R2) were greater than those of the first and second order degradation rate models. Therefore, the first order degradation rate R2 value ranges are from 0.9063 to 0.9894, the second order degradation rate ranges from 0.8004 to 0.9396 and the Michalis-Menten Equation ranges from 0.9639 to 0.9979. So, compared to the first and second order degradation rate models, the Michalis-Menten Equation provided a more accurate prediction of the residual TPH.

**Keywords:** Modelling, moringa seed, remediation, uku, soil, ekperi, clean up

## 1. INTRODUCTION

The amount of environmental deterioration being experienced in the world today is causing an increase in concern, with a large portion of it being caused by the increased production and consumption of fossil fuels. Oil exploration and use endangers the wellbeing of the ecosystem and all living things, including humans, on all continents (Silva-Castro et al., 2015). An oil spill is the environmental release of a petroleum hydrocarbon. Oil spills can result from crude oil releases from tankers, offshore platforms, drilling rigs and wells as well as refined petroleum products (like gasoline and diesel) and their by-products, heavier fuels used by big ships like bunker fuel or the spill of any oily waste or refuse (Singh et al., 2010; Smith, 1968).

Natural ecosystems have been harmed by the spills of crude oil and refined petroleum in numerous locations across the world, including Alaska, the Gulf of Mexico, the Galapagos Islands, France, the Niger Delta region of Nigeria and many more (Srivastava et al., 2014). A few hundred tons to several hundred thousand tons of oil have been released during catastrophes, such as the Deepwater Horizon Oil Spill, the Atlantic Empress and the Amoco Cadiz (Sui and Li, 2011). Because of the remoteness of the sites or the bottlenecks impeding emergency environmental responses, smaller spills have been shown to have a significant impact on ecosystems (Sutherland et al., 1995). An example of this is the spills that occurred in the Nigerian Niger Delta region. Oil pollution has severe consequences.

The money made from the exploration of crude oil has been crucial to the advancement of the modern world. The end results of processing crude oil can also be viewed as the source of a great number of inventions and discoveries of additional useful items (Svobodová et al., 2016). Chemical methods were initially used to clean up the contaminated environment at the polluted site. However, the most undesirable products are the crude oil spill, resulting from processing have a negative impact on the environment since they are dangerous. When compared to biological mechanisms, the expense of cleaning up a polluted site with a chemical technique is substantial (Swannel et al., 1996).

In most cases, the chemicals utilized improved remediation in the first stage; however, research has shown that chemicals also have a harmful impact on the environment. Based on this observation, it was determined that the bioremediation trend of technology, whose end products are environmentally benign, is the ideal one to adopt to improve remedying a contaminated environment (Talha et al., 2019). The bioremediants are derived from plants and animals and they are raised to receive the necessary energy to enable them to catalyze the reaction process by breaking down the hazardous and contained into less harmful product for the environment (Tekere, 2019), having an understanding of the significance of plant extracts that include beneficial nutrients as well as the existence of microorganisms. In order to effectively use these creatures and the nutrients present in those plants to address environmental issues, it is required to do research on their features. Moringa seed shell in powdered form was chosen for this study to examine their significance in addressing contaminated soil environments with crude oil (Tekere, 2019).

## 2. METHODOLOGY

**Application of Model Equations**

***The Michaelis-Menten Biodegradation Rate Model***

Similarly, the degradation rate of TPH was tested with the Michaelis-Menten biodegradation rate and it is expressed as:

$$r_{TPH} = \frac{\mu_{\max} C_{TPH(t)}}{K_s + C_{TPH(t)}} \tag{1}$$

Upon linearization, equation (1) becomes:

$$-\frac{1}{r_{TPH}} = -\frac{dC_{TPH(t)}}{dt} = \frac{1}{\mu_{\max}} + \frac{K_s}{\mu_{\max}}\left(\frac{1}{C_{TPH(t)}}\right) \tag{2}$$

Where: $\mu_{\max}$ is the maximum specific degradation rate, $C_{TPH(t)}$ is TPH concentration with time *t*, $K_s$ is the degradation rate constant relating to Michaelis-Menten.

A plot of $\frac{1}{r_{TPH}}$ against $\frac{1}{C_{TPH(t)}}$ gives the slope as $\frac{K_s}{\mu_{\max}}$ and $\frac{1}{\mu_{\max}}$ as intercept.

## 3. RESULTS AND DISCUSSION

**Michaelis-Menten Model**

Similarly, to the maximum specific rate constant and the constant relating to Michaelis-Menten as containing the Michaelis-Menten model expressed in equation as shown below;

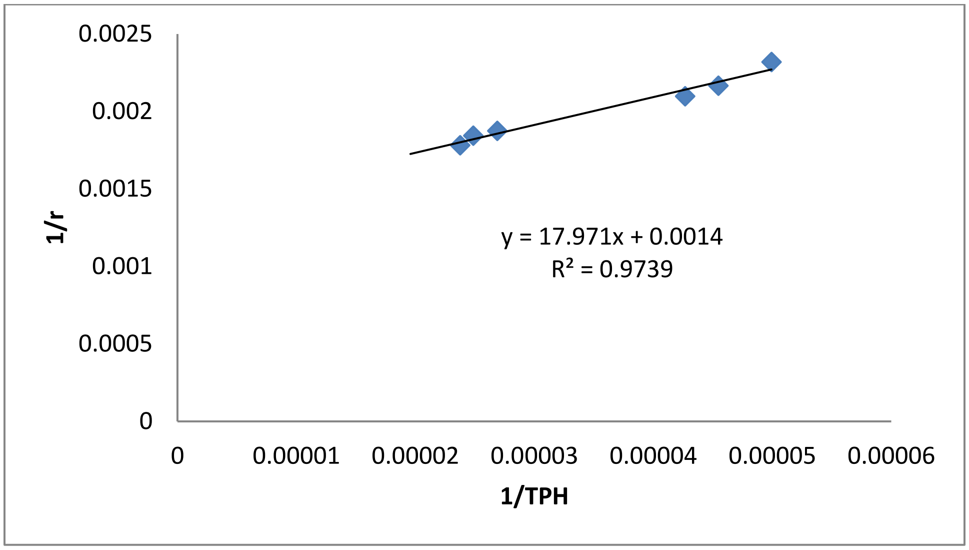


**Figure 1** Line Waver-Burke Plot for Swampy Soil with 20g Moringa Seed Shell in Powdered Form

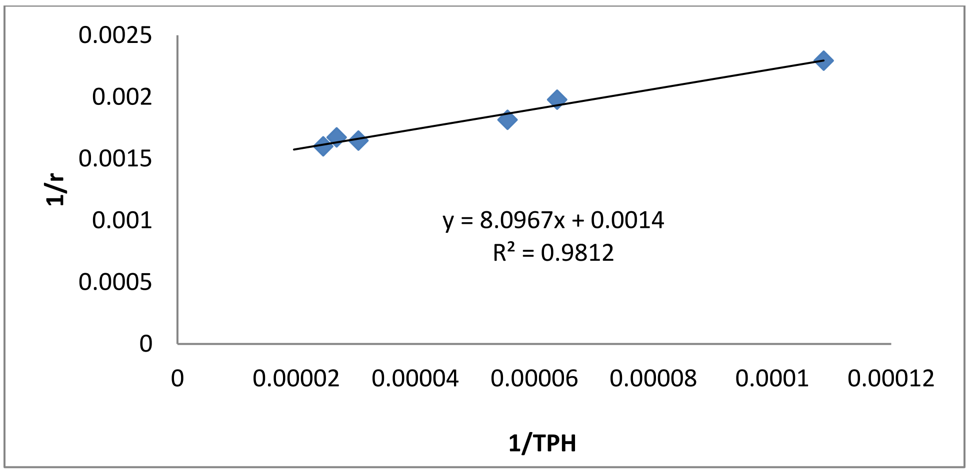


**Figure 2** Line Waver-Burke Plot for Swampy Soil with 40g Moringa Seed Shell in Powdered Form

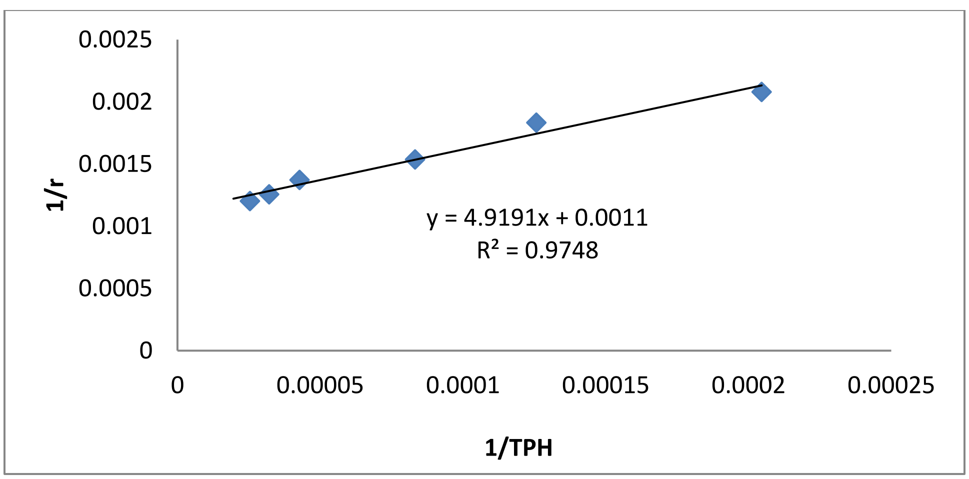


**Figure 3** Line Waver-Burke Plot for Swampy Soil with 60g Moringa Seed Shell in Powdered Form

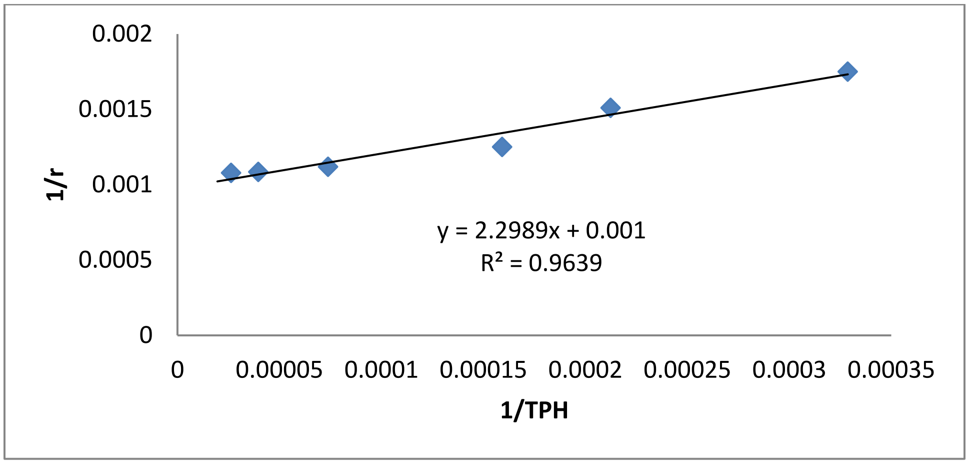


**Figure 4** Line Waver-Burke Plot for Swampy Soil with 80g Moringa Seed Shell in Powdered Form

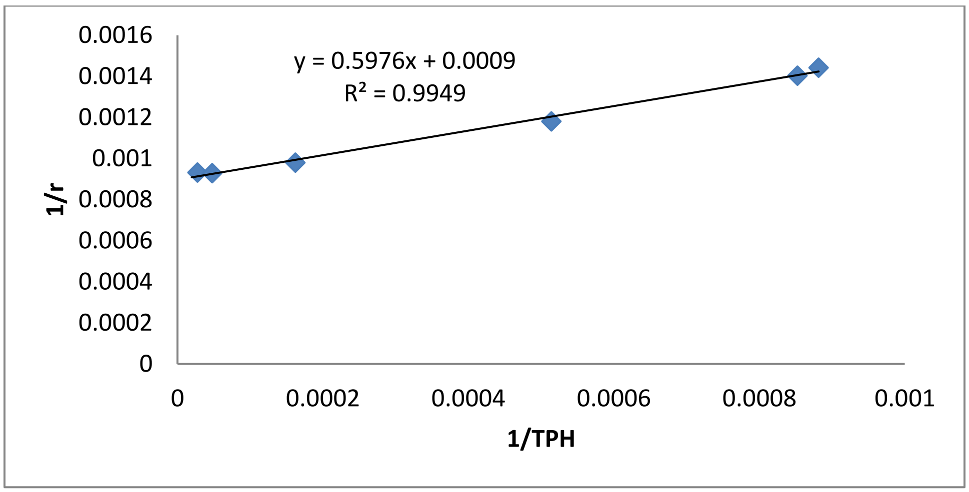


**Figure 5** Line Waver-Burke Plot for Swampy Soil with 100g Moringa Seed Shell in Powdered Form

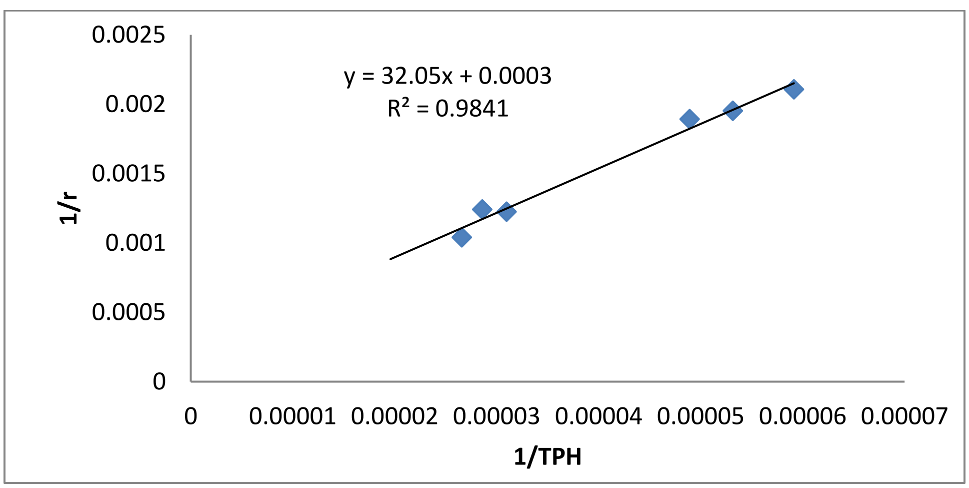


**Figure 6** Line Waver-Burke Plot for Clay Soil with 20g Moringa Seed Shell in Powdered Form

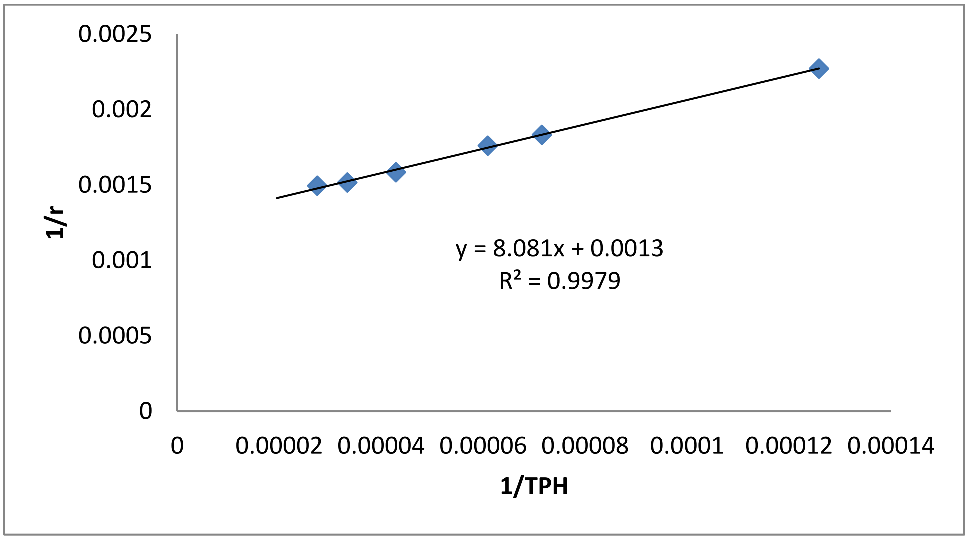


**Figure 7** Line Waver-Burke Plot for Clay Soil with 40g Moringa Seed Shell in Powdered Form

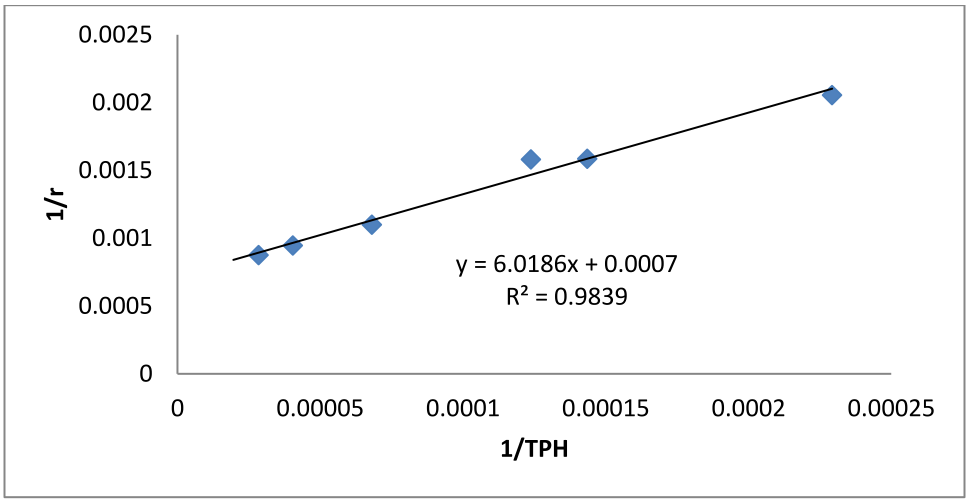


**Figure 8** Line Waver-Burke Plot for Clay Soil with 60g Moringa Seed Shell in Powdered Form

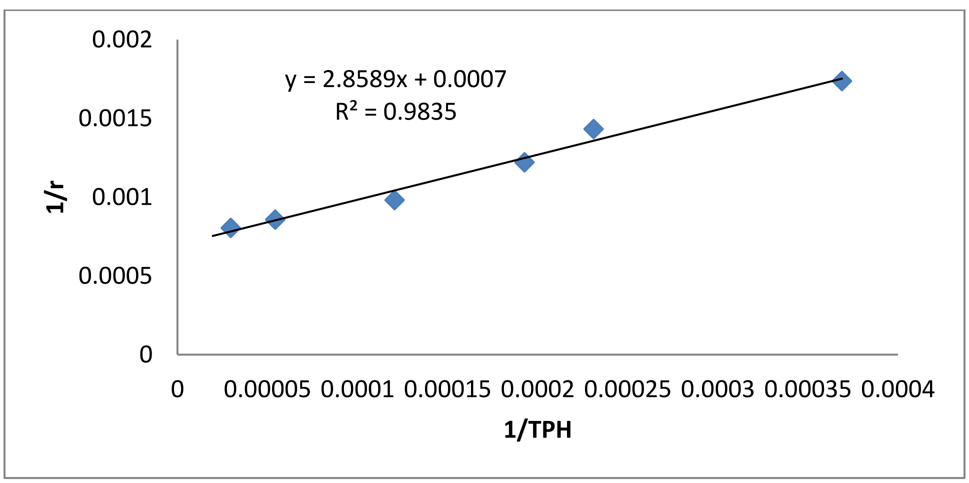


**Figure 9** Line Waver-Burke Plot for Clay Soil with 80g Moringa Seed Shell in Powdered Form

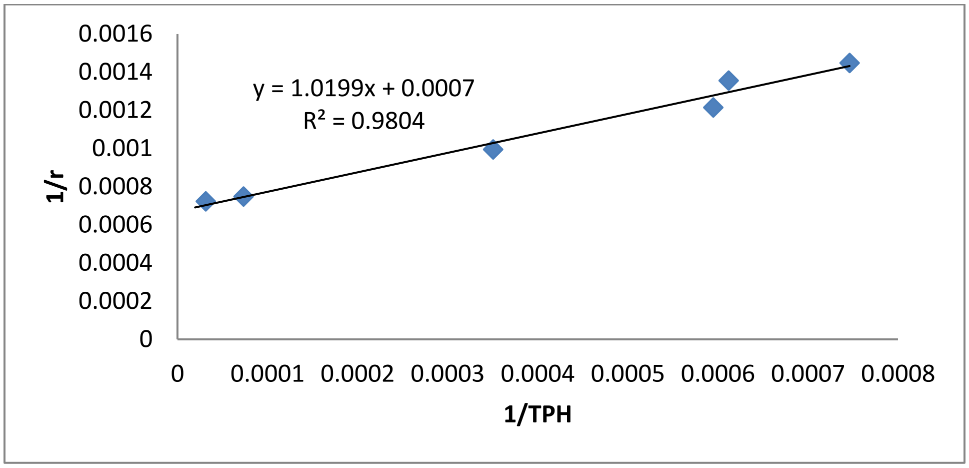


**Figure 10** Line Waver-Burke Plot for Clay Soil with 100g Moringa Seed Shell in Powdered Form

Figures 1 to 10 show the plots for estimation of the maximum TPH degradation specific rate constant, $U_m$ and the constant $K_s$ for the Michaelis-Menten rate kinetic model. Thus, from the regression equations on the plots, the constants were evaluated for the different weights of treatments. Again, as a demonstration of the applicability of the Michaelis-Menten model, the evaluated constants for swampy soil treated with moringa seed shell in powdered form were substituted into equation (2), which can then be used to predict TPH content in soil. The rate model at the respective treatment weights (Table 1).

**Table 1** Michaelis-Menten TPH Degradation Rate Model

| Weight (g) | Predictive Model |
|---|---|
| 20 | $r_{TPH} = \dfrac{714.286C_{TPH}}{12836.489 + C_{TPH}}$ |
| 40 | $r_{TPH} = \dfrac{714.286C_{TPH}}{5783.357 + C_{TPH}}$ |
| 60 | $r_{TPH} = \dfrac{909.091C_{TPH}}{4471.909 + C_{TPH}}$ |
| 80 | $r_{TPH} = \dfrac{1000C_{TPH}}{2298.9 + C_{TPH}}$ |
| 100 | $r_{TPH} = \dfrac{1111.111C_{TPH}}{664 + C_{TPH}}$ |

## 4. CONCLUSION

This research showed that increasing the amount of treatment in polluted soil will also increase the percentage of TPH that would be eliminated from the soil over time, although the best TPH degradation efficiency across all treatment choices was reported at the 84th day of analysis. The treatment would be better applied between 60g and 100g, but economically, applying 60g weights of treatment would save more on the expense of getting the treatment. However, there was no significant difference between the 20g and 40g treatment alternatives and the control sample.

The control sample often performs the worst since the TPH naturally decayed in this environment. This was due to the absence of a source of nutrients, which prevented the hydrocarbon-degrading bacteria from having the energy they needed to assault the substrate. Applying the right amount of treatment to soil that has been contaminated by crude oil will thereby speed up the bioremediation process.

**Ethical issues**

Not applicable.

**Informed consent**
Not applicable.

**Funding**
This study has not received any external funding.

**Conflict of Interest**
The author declares that there are no conflicts of interests.

**Data and materials availability**
All data associated with this study are present in the paper.

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