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Bacteria on Salt Water Medium Evaluation: The Conceptual Impacts of Temperature

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Abstract

The potential impact of temperature on bacteria on salt water medium for crude oil degradation in an aerated lagoon system was simulated using MATLAB Simulation software. The specific rate of bacteria obtained revealed maximum at temperature of less than 35oC with the order of 90°C (11 cfu/ml) > 60°C (40 cfu/ml) > 45°C (35 cfu/ml) > 30°C (28 cfu/ml). Most of the microorganism's presence in the salt water medium under the condition of aerated system was found to survive at temperature above 90oC and this shows that super thermophilic organisms were not present in the salt water medium. Indeed, the increase in temperature either inhibit or activate the microbial growth activities in the aerated lagoon. The specific rate of microbes (bacteria) in this case revealed high value in terms of inhibition compared to the activation value. Also, above temperature of 35°C at each stage the specific rate of microbes (bacteria) remains constant and this was attributed that the microorganism presence in the aerated lagoon is more of mesophilic organisms. The conceptual impact of temperature was observed on the mesophilic organisms as simulated by using the developed model presented in this research. This research has significantly revealed the potential of temperature on crude oil degradation as well as its inhibiting characteristics on microbial growth activity. The model of temperature as an inhibitor and activation on correlation with Michael's mention equation was established in relationship to the enzyme substrate complex interaction. Findings of the outcomes of this investigation are demonstrated in the conclusion of this research.

Keywords: Bacteria, salt, water, medium, evaluation, conceptual, temperature

INTRODUCTION

Efforts were made in the early twentieth century to obtain a pure enzyme and to mathematically define its activities [1–3]. In separate studies Harri and Brown independently suggested the enzyme substrate complex formation as an intermediate in the metabolic sequence [4, 5]. Based on this background, various mathematical equations were developed to express the kinetic properties of these enzymes [6–8]. Among the early investigators was Henri who developed an equation expressing the effect of substrate concentration, while Sorensen in 1909, developed his model taking into consideration the effect of pH. More models were proposed by Henri, Michaelis-Menten equation [8–11].

Researches introduced the steady state concept to enzymes kinetics and in 1902, the steady state of enzyme kinetics was studied [12–15]. They studied the rate of hydrolysis of sucrose by water to yield glucose and its structural isomer [16]. Also, investigation on the same area showed that when the

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sucrose concentration was much greater than the enzyme concentration, the reaction is zero order in sucrose concentration [17–20].

Sucrose + H20 —> Glucose + Fructose
Rate = K [Sucrosel = K if [sucrose) > [enzyme

One of the earliest investigators was Henri, on bases of which Michaelis and Menten developed the famous enzyme kinetic model. Henri kinetic study was based on certain assumptions:

That enzyme substrate complex dissociates to form free enzyme and product.

- That the rate of reaction depends on the dissociation of the enzyme substrate complex.
- That the substrate concentration is very high

Micro-organisms can withstand a range of salt concentrations when these changes are introduced slowly. The range of salt concentrations can vary as a result of the organisms' ability to adjust their internal molarity so it exceeds that of their environment. Organisms have the ability to adapt to stressful changing environmental conditions. In some cases, they acquire new gene functions; many protect their cells by changes in the cell membrane. For example, methane osarlinathermophia has a heterophony saccharine layer that its losses when grown in a high salt level nutrient deficient environment. This also requires the organism to metabolize compounds with a net-higher energy yield [21–23].

Both free and dissolved oxygen levels in the immediate environment are important to microbial degradation. Rate of hydrocarbon degradation decreases with decreasing oxygen reduction potential reported by various research groups in most biodegradation of hydrocarbon [24].

Although microorganisms obtain energy by different metabolism modes, they all have the same functions which is the generation of energy for biosynthesis results in an immense range of nutritional requirements. Some need only sunlight, carbon dioxide, water and inorganic nitrogen to grow carbon is one basic element of all living materials. It forms the skeleton upon which most compounds found in cells are built. In addition to carbon, cells are mainly composed of the elements of hydrogen, oxygen and nitrogen, Micro-organisms must get all their nutrients necessary for growth from the environment. The microbial requirements of nutrients are approximately the same as the composition of their cells [25].

A moisture content of about 80 percent field capacity or about 15 percent water on weight basis has been reported as optimum for petroleum hydrocarbon degradation in soil. Inadequate moisture less than 40 percent is reported to significantly reduce the rate of petroleum hydrocarbon degradation [26]. Moisture contents affect the availability of contaminants, the transfer of gases, the effective toxicity level of contaminants, the movement and growth stage of micro-organisms and species distribution. Low moisture levels restrict bacteria activity by limiting cellular movement and metabolic reactions [27]. The competitive advantage between bacteria and fungi level in soil changes markedly with moisture levels and the degree of contact between the water and the hydrocarbon particles determines partially the rate of utilization of hydrocarbons by the micro-organisms.

MATERIALS AND METHODS

Microbial Growth Kinetics

The population of microbes increases because the pollutants support the growth of microorganisms;

$$\frac{dx}{dt} = \mu x \tag{1}$$

Where x = cell mass per unit culture volume
μ = specific growth rate of the biomass

- t = time

In the growth of microorganisms, the concentration of nutrient, constituent variation could lead to different growth behavior and the rate of growth μ is a function of the availability of nutrient.

$$\frac{dx}{d} = \mu dt$$

$$\int_{xo}^{x} \frac{dx}{x} = \int_{o}^{t} \mu dt$$

$$\text{Log } e_{1/10} = e\mu \tag{2}$$

$$:x = xo\ e_{\mu}$$

Where xo is the initial concentration of cell and x is the cell concentration at time t.

The specific growth base on the essential component of growth was proposed by Monod as

$$\mu = \mu_{\max} \frac{[S]}{K_m + [S]} \tag{3}$$

Where μ = specific growth rate of the biomass

μ_{max} = maximum cell growth rate which corresponds to the situation when the pollutant is present in excess

- S = substrate concentration at time t
- Km = dissociation constant of enzyme substrate complex

Rearrangement of equation (3) gives;

$$\frac{K_m}{\mu_{\max}} + \frac{[S]}{[S]} = \frac{1}{\mu}$$

$$\frac{1}{\mu_{\max}} + \left[\frac{K_m + [S]}{[S]} \right] = \frac{1}{\mu}$$

$$\frac{1}{\mu_{\max}} + \left[\frac{K_m}{[S]} + \frac{[S]}{[S]} \right] = \frac{1}{\mu}$$

$$\frac{K_m}{\mu_{\max}} \frac{1}{[S]} + \frac{1}{\mu_{ma}s} = \frac{1}{\mu} \tag{4}$$

Progressive Phase Model for Substrate

The progressive degradation of the substrate was postulated by Michael's Menten and the obtained expressed is given as

$$[V] = \frac{[V]_{\max}[S]}{Ks + [S\}} \tag{5}$$

Where V is the specific rate of substrate degradation Vmax is the maximum specific rate of substrate degradation, [S] is substrate concentration Ks is the equilibrium or dissociation constant.

Considering when the rate of substrate degradation is directly proportional to time, therefore

$$\frac{d[S]}{dt} = \psi[S] \tag{6}$$

Rearranging equation (6), we have

$$\int_{[s]}^{[s]} \frac{d[S]}{[S]} = \int_{o}^{t} \psi dt \tag{7}$$

Resolving equation (7) we have

$$[S] = [S_o] + e^{\psi t} \tag{8}$$

$$[S] = [S_o]\ e^{\psi t} \tag{9}$$

Model of Temperature as an Inhibitor or Activator on Correlation with Michael's Menten Equation

For Case 1

The Michael's Menten Equation is expressed to ascertain the relationship between the effect of temperature acting as an inhibitor on substrate degradation in a bioreactor. The mathematical expression is given as

$$[V] = \frac{[V]_{\max}\ [S]}{Ks + [S]} \cdot [I] \tag{10}$$

Were I is an inhibitor (temperature) therefore

$$[I] = [T] \tag{11}$$

Where T = temperature inside the bioreactor equation (10) can be written as

$$[V] = \frac{[V \max [S]}{Ks + [S]} \cdot [T] \tag{12}$$

Equation (12) can be considered as an activator because the temperature favours the microbial activities as well as substrate degradation

Model of Temperature as an Inhibitor or Activator on Correlation with Michael's Menten Equation

For Case 2

For considering when the increase in temperature in the bioreactor acts as an inhibitor, therefore equation (8) can be written as

$$[I] = \frac{1}{[T]} \tag{13}$$

Substituting equation (13) into equation (7) we have

$$[V] = \frac{[V]_{\max}\ [S]}{Ks\ + [S]} \tag{14}$$

Equation (14) is acceptable if the increase in the temperature of the bioreactor influences the microbial and substrate degradation negatively, hereby regarding the influence of the temperature as an inhibitor in the bioreactor

RESULTS AND DISCUSSION

The result on plot of specific rate of microbes (bacteria) on salt water medium and temperature on bacteria inhibition and activator is presented in Figure 4.128 to 4.129 as demonstrated:

Figure 1 shows the relationship of the computed rate of bacteria with changes on the temperature in a set bioreactor made of an aerated system and the system was simulated with application of MATLAB software. The specific rate computation demonstrates initial increase in the value of the rates at each operating temperature, before achieving a constant line of the curve of the expression. However, this trend of characteristics has shown and revealed that the possible microorganism's presence in the collected fresh water samples is identified to be mesophilic organisms. At temperature above 89oC no microbes trend was demonstrated in the simulation figure as showcased in Figure 1and this trend of behavior was experienced due to the inhibiting effect of the temperature variation in the system made of salt water medium Figure 2.

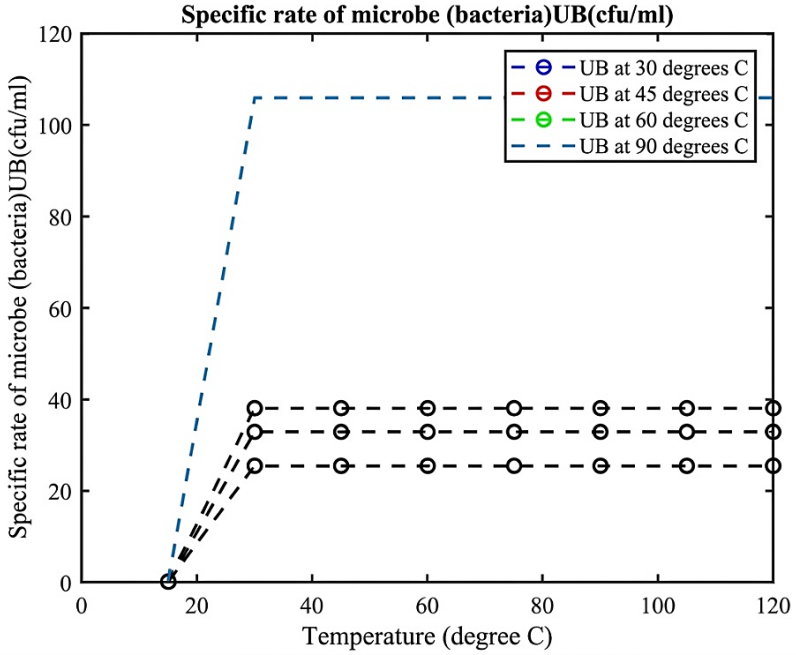

Figure 1. Specific rate of microbes (bacteria) on salt water medium versus temperature on bacteria inhibition.

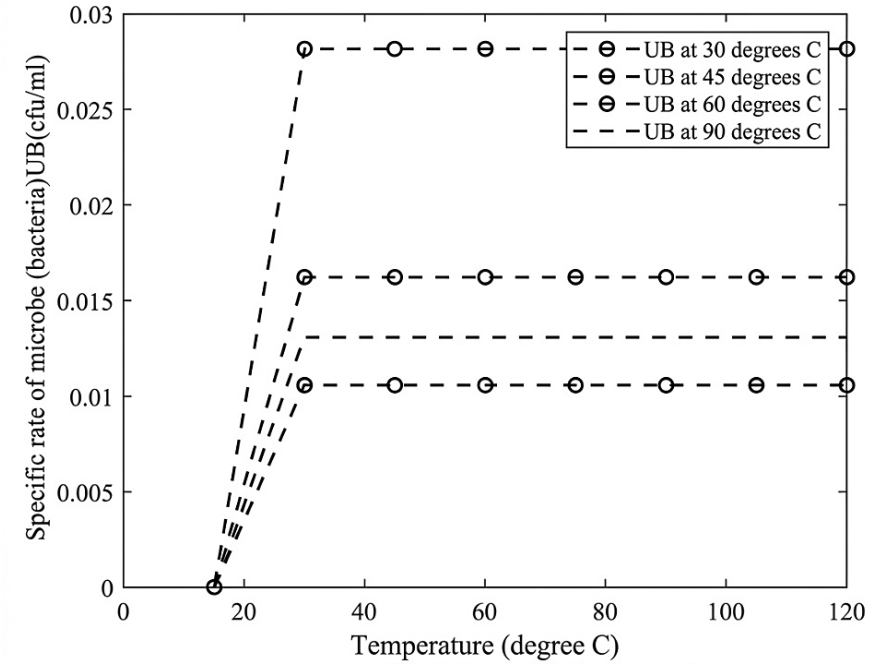

Figure 2. Specific rate of microbe (bacteria) on salt water medium versus temperature on bacteria activation.

Figure 1 shows the relationship of the computed rate of bacteria with changes on the temperature in a set bioreactor made of an aerated system and the system was simulated with application of MATLAB software. The specific rate computation demonstrates initial increase in the value of the rates at each operating temperature, before achieving a constant line of the curve of the expression. However, this trend of characteristics has shown and revealed that the possible microorganism's presence in the collected fresh water samples is identified to be mesophilic organisms. At temperature above 90°C no microbes trend was demonstrated in the simulation figure as showcased in Figure 1and this trend of behavior was experienced due to the inhibiting but the organisms were activated at lower temperature in the system made of salt water medium

CONCLUSION

This research is concluded based on the following

- The salt water medium sampled contain more of the mesophilic organisms and low population of thermophilic, because no organisms withstand temperature above 35oC.
- The microbial build-up was impacted by temperature
- Temperature functional role in an aerated lagoon shows both inhibition and activation of the microbes (bacteria) in the bioreactor.
- The degradation of the crude oil (substrate) and the microbial growth was impacted by the temperature variation in the bioreactor.
- The specific rate of the bacteria variation was attributed to the variation on the operation temperatures.

REFERENCES

1. Roberg S, Østerhus JI, Landfald B. Dynamics of bacterial community exposed to hydrocarbons and oleophilic fertilizer in high Arctic intertidal beach. Polar Biol. 2011;34(10):1455–1465.
2. Tarpgaard TH, Boetius A, Finster K. Desulfobacter psychrotolerans sp. nov., a new psychrotolerant sulfate-reducing bacterium and description of its physiological response to temperature changes. Antonie Van Leeuwenhoek. 2006;89(1):109–124.
3. Ukpaka CP. Studying the depuration time on changes in biomarkers profile on Nigeria crude oil. Appl Sci Rep. 2016;13(2):69–74.

4. Roels JA. Application of macroscopic principles to microbial metabolism. Biotechnol Bioeng. 1982;22:2457.
5. Ukpaka CP. The effect of functional parameters on microbial characteristics in crude oil degradation. J Res Environ Sci Technol. 2012;1(4):66–90.
6. Othuropangat S, Castranova V. Oil spill. In: Encyclopedia of Toxicology. 3rd ed. 2014. p. 677–681.
7. Pandey OR, Rakesh KJ. Bacterial chemotaxis toward environmental pollutants. Appl Environ Microbiol. 2002;68:5789–5795.
8. Radwan SS, Hasan RH, Salamah S, Dabbous S. Bioremediation of oily seawater by bacteria immobilized in biofilms coating macroalgae. Int Biodeterior Biodegrad. 2002;50:55–59.
9. Ukpaka CP. The concept of chemical and biochemical oxygen demand in inhibiting crude oil degradation in fresh water pond system. Merit Res J Environ Sci Toxicol. 2013;1(7):136–146.
10. Ukpaka CP. Investigation into the effect of momentum transfer on de-oxygenation of wastewater treatment in pond system for wet seas. Int J Novel Res Eng Pharm Sci. 2015;2(4):85–106.
11. Teira E, Lekunberri I, Gasol JM, Nieto-Cid M, Alvarez-Salgado XA, Figueiras FG. Dynamics of the hydrocarbon-degrading Cycloclasticus bacteria during mesocosm simulated oil spills. Environ Microbiol. 2007;9(10):2551–2562.
12. Ukpaka CP. Comparison of degradation of benzene, toluene and phenol in both fresh and salt water media. Curr Sci Perspect. 2016;2(4):105–115.
13. Silk S. Biodegradation and transport of crude oil in sand and gravel beaches of Arctic Alaska. Coastal Marine Institute (CMI), Department of Civil and Environmental Engineering, University of Alaska Fairbanks; 2015. OCS Study BOEM 2015-041.
14. Ukpaka CP. BTX degradation: The concept of microbial integration. Chem Int. 2016;3(1):8–16.
15. Teramoto M, Suzuki M, Hatmanti A, Harayama S. The potential of Cycloclasticus and Altererythrobacter strains for use in bioremediation of petroleum aromatic contaminated tropical marine oil spills. J Biosci Bioeng. 2010;110(1):48–52.
16. Ukpaka CP. Examination of plant growth on improved soil environment polluted with crude oil bioremediation. Curr Sci Perspect. 2017;3(2):67–78.
17. Torstensson L, Fell M, Stenberg B. Need of a strategy for evaluation of arable soil quality. Ambio. 1998;27(1):4–7.
18. Ukpaka CP. Matlab techniques for evaluation of crude oil degradation at various functional parameters. Curr Sci Perspect. 2018;4(1):7–12.
19. Robador A, Brüchert V, Jørgensen BB. The impact of temperature change on the activity and community composition of sulfate-reducing bacteria in Arctic versus temperate marine sediments. Environ Microbiol. 2009;11(7):1692–1703.
20. Ukpaka CP. Comparison of theoretical and experimental approach to predict crude oil spreading rate in Niger Delta Area, Nigeria. Int J Chem Eng Process. 2018;4(2):27–37.
21. Radel SR, Navidi MH. Chemistry. 2nd ed. United States of America: West Publishing Company; 1994. p. 521–607.
22. Reuschenbach P, Pagga U, Strotmann U. A critical comparison of respirometric biodegradation tests based on OECD 301 and related test methods. Water Res. 2003;37(7):1571–1582.
23. Ukpaka CP, Otabiri B. Responses application to monitor and predict crude oil distillation rate using pneumatic control system on a furnace. J Eng Technol Res. 2013;5(7):217–229.
24. Steffan RJ, McClay K, Vainberg S, Condee CW, Zhang D. Biodegradation of the gasoline oxygenates methyl tert-butyl ether, ethyl tert-butyl ether and tert-amyl methyl ether by propane-oxidizing bacteria. Appl Environ Microbiol. 1997;63(11):4216–4222.
25. Ukpaka CP, Ogoni HA, Amadi AS, Adebayo TA. Mathematical modeling of the microbial growth and decay rate of Pseudomonas species on biodegradation of Bonny light oil. Glob J Pure Appl Sci. 2005;11(3):423–431.
26. Pandey K, Rüther A, Rowe RK, Poland JS. Remediation of hydrocarbon-contaminated soils in the Canadian Arctic by land farming. Cold Reg Sci Technol. 2008;53:102–114.
27. Park C, Marchland EA. Modeling salinity inhibition effects during biodegradation of perchlorate. J Appl Microbiol. 2006;101:222–233.

