International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 3, Issue 2 (February 2014), PP.54-59

Kinetics of Bioremediation of Lake Gerio in Jimeta-Yola Using *Pseudomonas aerigunosa*

* Luka Y.,* Usman F. O.,** Tya T. S. K.,*C. Joseph

**Department of Chemical Engineering, Modibbo Adama University of Technology Yola, Adamawa State, Nigeria.*

***Department of Agricultural and Environmental Engineering, Modibbo Adama University of Technology Yola, Adamawa State, Nigeria.*

Abstract:- The kinetic of bioremediation of Lake Gerio water was carried out using bioreactor. Water sample from Lake Gerio was collected for analyses with indigenous bacteria called control sample. *Pseudomonas aerigunosa* was isolated from the Lake Gerio water which was later introduced into some portion of the water obtained from Lake Gerio Known as bioaugmented sample. The substrate reduction was recorded at an interval of two days for twenty four days. *Pseudomonas aerigunosa* was able to remediate the pollutant in Lake Gerio water from from 51.02 mg/l to 17.51mg/l for control sample and from 51.02 mg/l to 16.53 for bioaugmented sample. The kinetic models for substrate reduction obtained are: $= 51.02 + 0.976$ (Zero Order control); $= 51.02 + 1.117$ (Zero Order bioaugmented); $= 39.51^{-0.063}$ (First Order control); $= 37.52^{-0.065}$ (First Order bioaugmented). The result obtained show that *Pseudomonas aerigunosa* is effective in bioremediation of Lake Gerio water using bioreactor.

Keywords:- Bioremediation, *Pseudomonas aerigunosa,* Kinetics, Lake Gerio

I. INTRODUCTION

Bioremediation requires the use of microorganism to remove or reduce the contaminants from polluted site without further disruption to the local environment (Puyate and Yelebe, 2010; Mukred et al., 2008; Basharudin, 2008). Researchers have shown that bioremediation is effective, environmentally friendly as well as the technology of the future because physical and chemical treatment are costly and may caused additional production of toxic substance. Bioremediation can be effective only where environmental conditions permit microbial growth and activity (Sudipta and Somnath, 2010; Mukred et al., 2008; Crawford and Crawford, 1996; Akpor and Muchie, 2010).

Biodegradation involves the conversion of chemical compounds by microorganisms into energy, cell mass and biological products (Basharudin, 2008). Organic pollutant which contains significant amount of biodegradable substance can be removed under aerobic environments. Microorganisms react under aerobic environments to give stable product, water, and a mixture of carbon dioxide and some gases (Reynolds and Richards, 1996).

In this research bioremediation is measured by increase in biomass growth and reduction in substrate concentrations (Hamza et al., 2009). Biodegradation is used to obtain concentrations of chemical substances remaining at a given time during ex situ and in situ bioremediation. The main focus is always on decrease in pollutant concentration (Okpokwasilli and Nweke, 2005; Kareem et al., 2011).Organic pollutant can be known in water using Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Chemical oxygen demand (COD) and Total organic carbon (TOC) (Tchobanoglous et al., 2003).

Lake Gerio is located very close to River Benue in Jimeta-Yola. The activities occurring in the lake can also affect the river because when the lake is filled or flooded during raining season the water is channeled into the river and vice versa. These activities end up polluting the water in the lake and river which eventually affect the inhabitant of the area (Luka et al., 2013).

Lake Gerio is used for irrigation, rearing of animals, aquatic life and washing by the inhabitants of Jimeta-Yola especially the Jambutu resident. There is the need to know how microorganism isolated from Lake Gerio can be used to remediate the water to save the life of people using the water.

The aim of this research is to determine how effective is *Pseudomonas aerigunosa in* degradation of organic pollutant in Lake Gerio under aerobic environment using Bioreactor. In addition, Kinetics parameters for the rate of degradation or reduction of COD (substrate) with time as well as biomass growth were obtained.

II. MATERIALS AND METHODS

Water samples for bioremediation were collected from Lake Gerio using Sterilized plastic containers and were preserved in line with standard method (Standard Methods, 1998). Ten-fold serial dilution method of

analysis was used to enumerate and isolate *Pseudomonas aerigunosa* from the water samples. Then a broth culture was prepared for bioaugmentation. About 1 l of water samples were poured into each of the two suspended growth plastic bioreactor of volume 3 l. The first bioreactor was labeled bioaugmented and the second bioreactor was named control (non-bioaugmented). Thirty six ml of the prepared broth pure cultures of *Pseudomonas aerigunosa* was inoculated into the bioaugmented bioreactor making the total volume to be 1 l. The research was conducted at room temperature (26 ℃) and the substrate removal was measured by recording the COD reduction at the interval of two days (Hamza et al., 2009; Kareem et al., 2011).

III. RESULTS AND DISCUSSION

The results are presented in Figures 1-8. Growth profiles of biomass for control and bioaugmented samples are presented in Figures 1 and 2, respectively. Figures 3 and 4 depicted Substrate Reduction by *Pseudomonas aerigunosa* for control and bioaugmented samples in the order presented. Kinetic of Bioremediation are presented in Figures 5, 6, 7, and 8 for Zero Order and First Order testing. Figures 5 and 6 represented the kinetics for Zero Order testing by substrate reduction for control and bioaugmented samples, respectively. While those for the First Order testing for both control and bioaugmented samples the results are shown in Figures 7 and 8, chronologically.

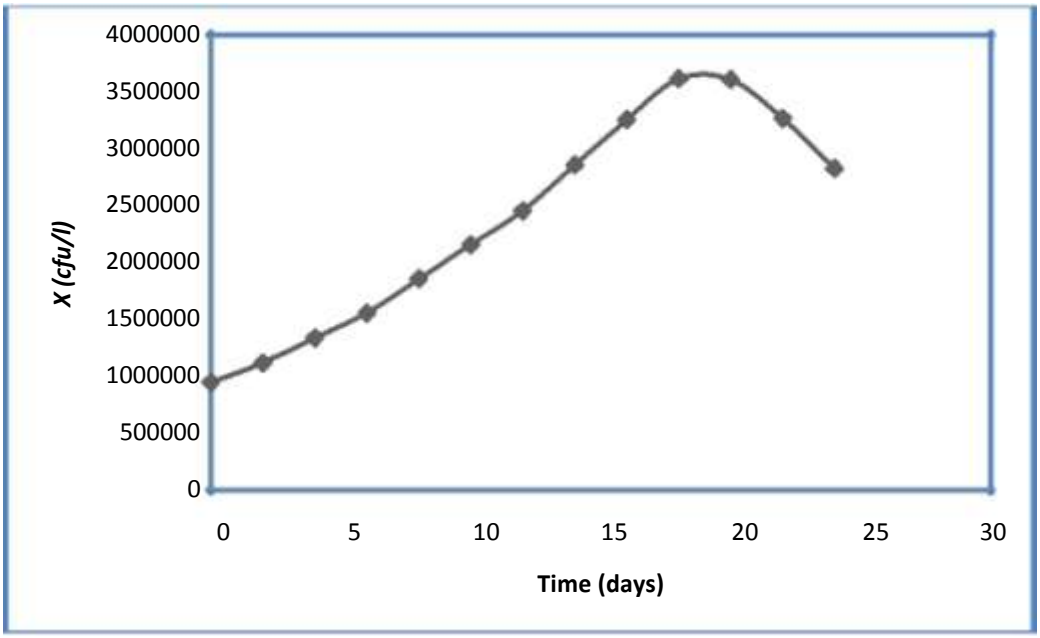

Figure1: Growth Profile of Biomass for Control Sample

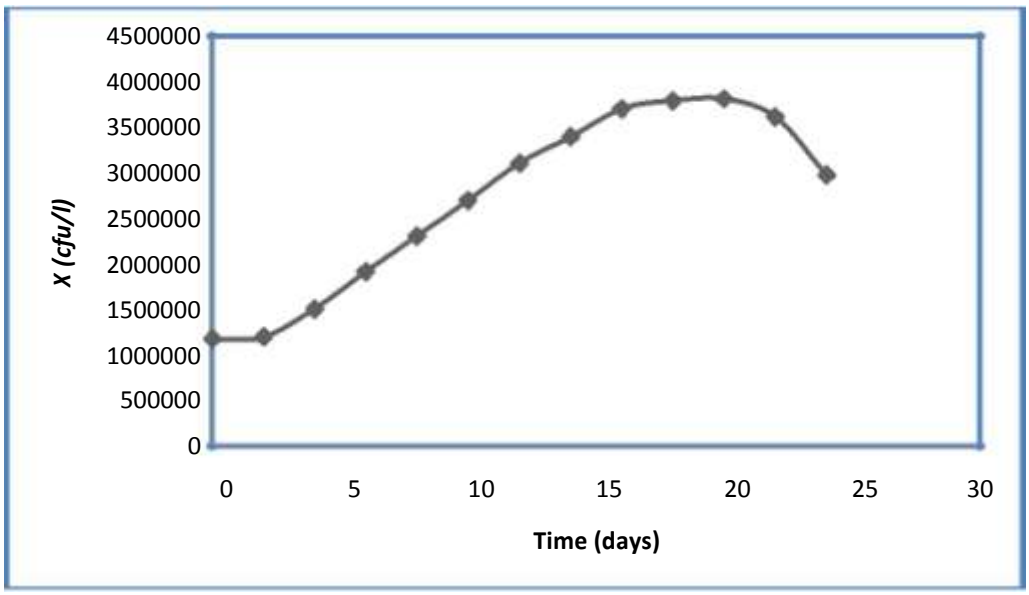

Figure 2: Growth Profile of Biomass for Bioaugmented Sample

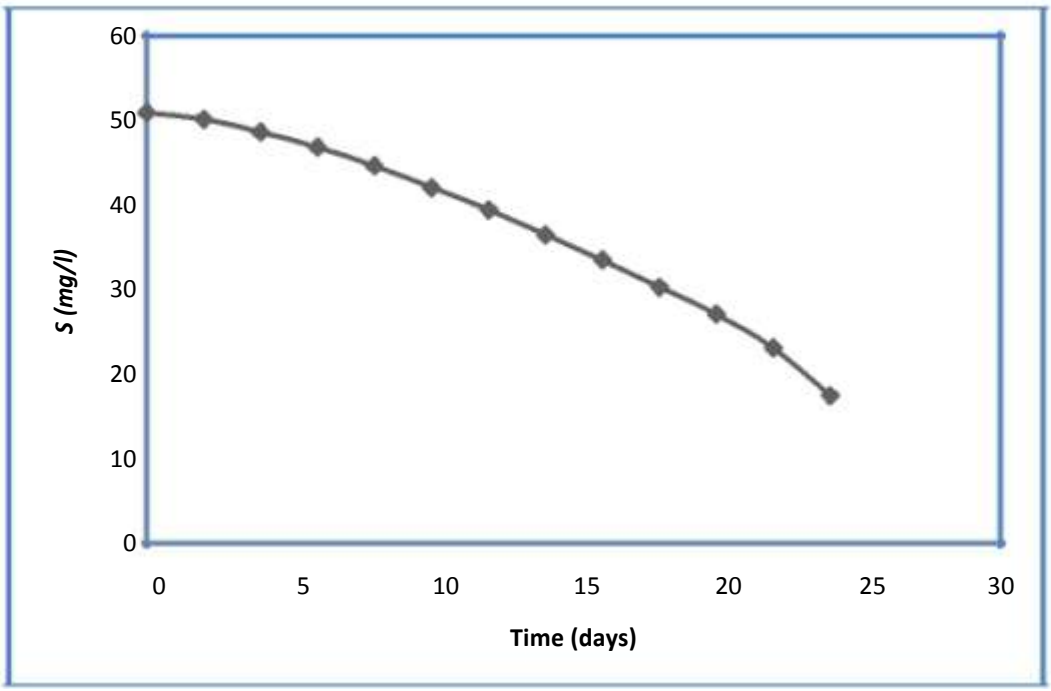

Figure 3: Substrate Reduction by *Pseudomonas aerigunosa* for Control Sample

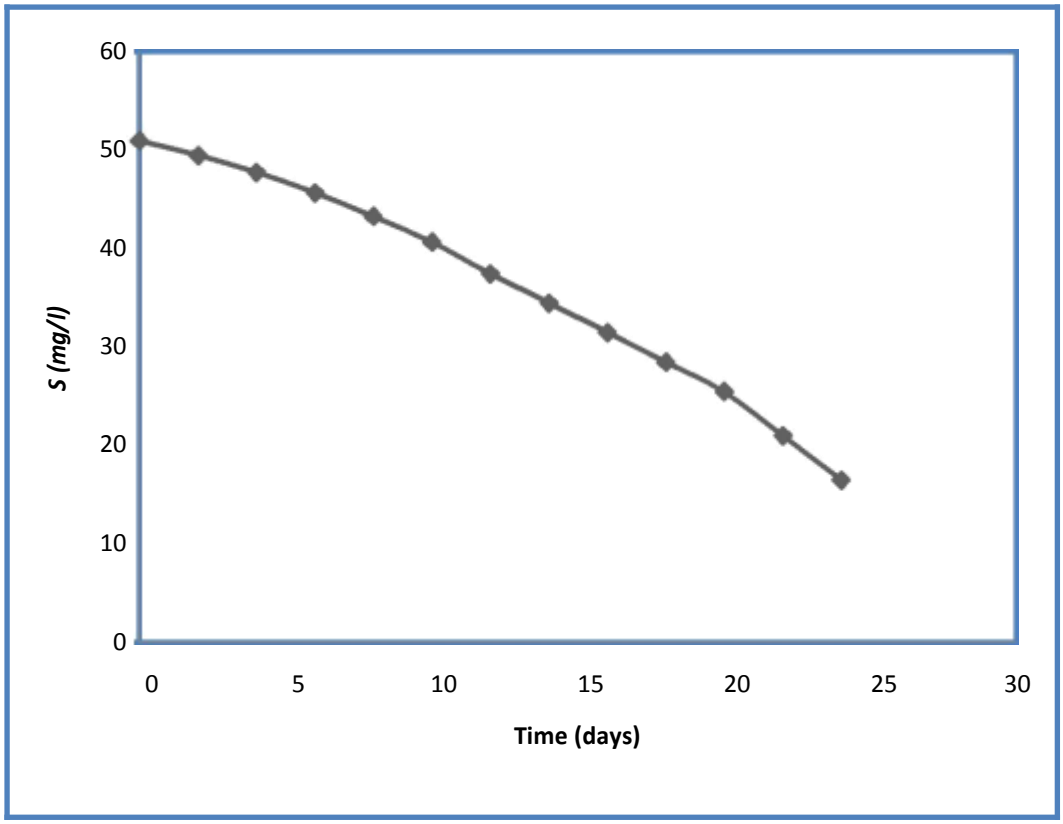

Figure 4: Substrate Reduction by *Pseudomonas aerigunosa* for Bioaugmented Sample

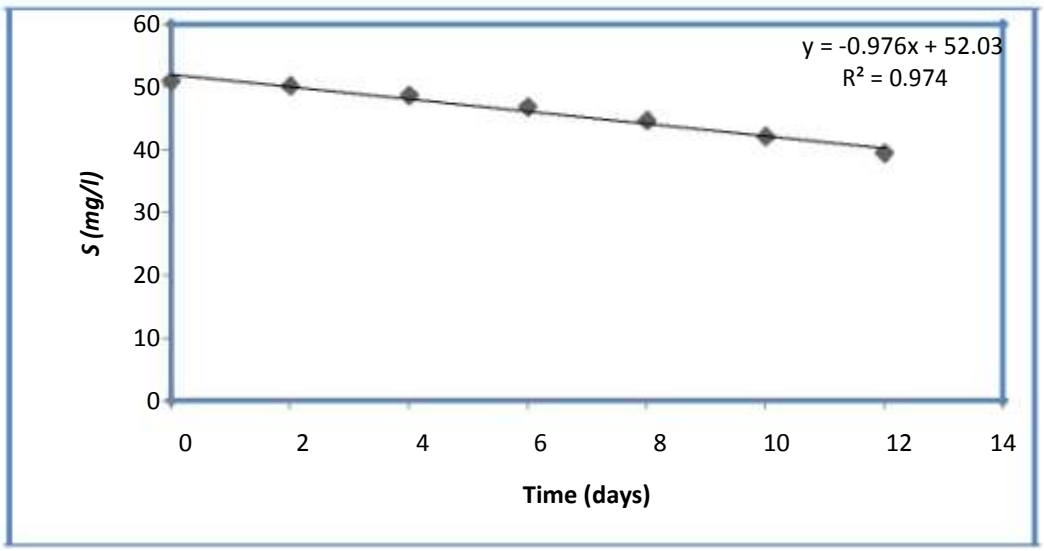

Figure 5: Testing Zero Order Kinetics for Substrate Reduction by *Pseudomonas aerigunosa* for Control Sample

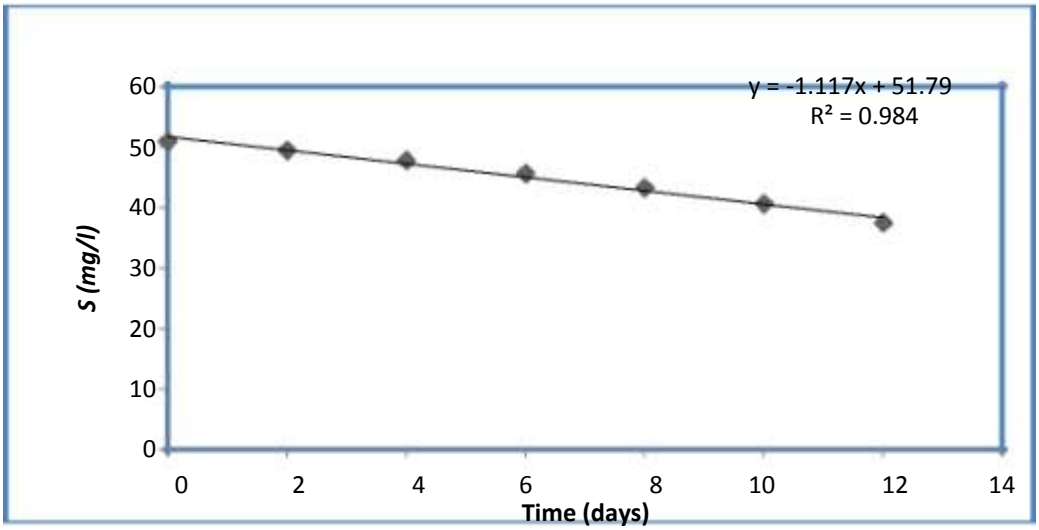

Figure 6: Testing Zero Order Kinetics for Substrate Reduction by Pseudomonas aerigunosa for Bioaugmented Sample

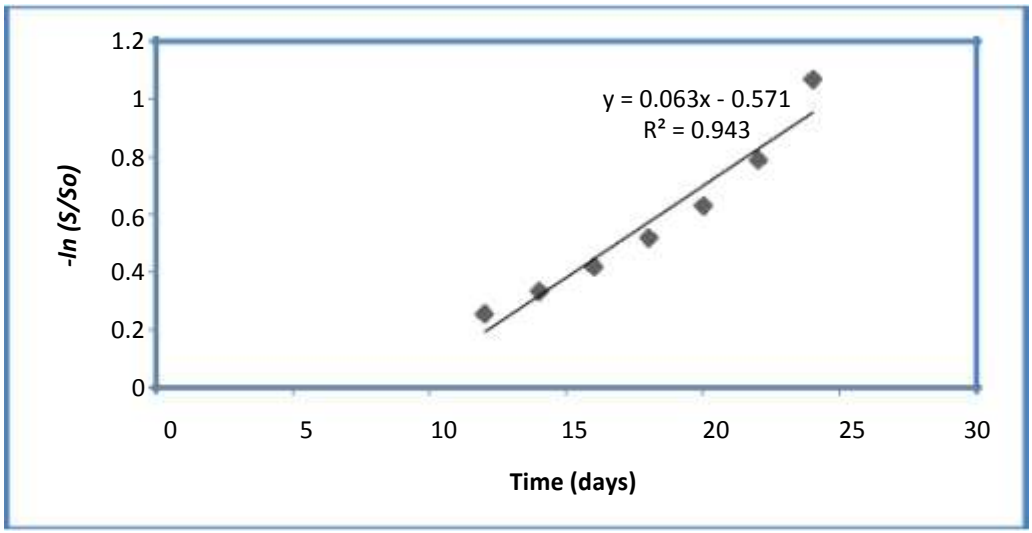

Figure 7: Testing First Order Kinetics for Substrate Reduction by *Pseudomonas aerigunosa* for Control Sample

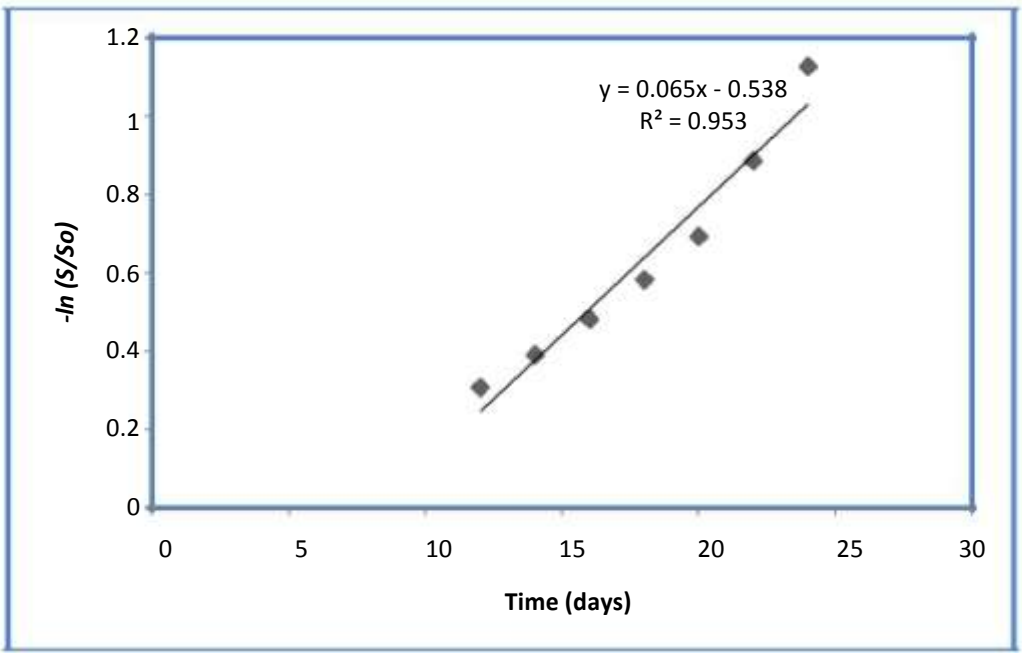

Figure 8: Testing First Order Kinetics for Substrate Reduction by *Pseudomonas aerigunosa* for Bioaugmented Sample

Growth profile of biomass were shown in Figures 1and 2 for the control and bioaugmented samples, respectively. There was no lag time observed in the microbial growth. This might be due to the fact that the bacteria in the water are not exposed to entirely new environment before being excavated and kept in the bioreactor which is in line with Levenspiel, 1999. After 18 days, the bacterial stopped growing with the highest value 3620000 cfu/l for control sample whereas at 20 days the bacteria stopped growing with the highest value 3820000 cfu/l for bioaugmented sample which marked the beginning of death phase for the two different samples.

Figures 3 and 4 give a picture of substrate reduction which indicates the potential of *Pseudomonas aerigunosa* in remediating the pollutant in Lake Gerio from 51.02 mg/l to 17.51 and from 51.02 mg/l to 16.53 mg/l for the control and the bioaugmented samples, respectively. These are in line with Okpokwasilli and Nweke, 2005 and Kareem et al., 2011. Better results are obtained with bioaugmented sample compare to indigenous bacteria (control sample). Higher remediation might be achieved if the sample was biosimulated and bioaugmented simultaneously (Puyate and Yelebe, 2010).

The results obtained were tested using Zero Order and First Order kinetic models. The rates of substrate reduction at high concentration are considered to be Zero Order and First Order at moderate to low concentration (Levenspiel, 1999; Okpokwasilli et al., 2005; Hamza et al., 2009; Kareem et al., 2011). Figures 5 and 6 shows substrate reduction fit Zero Order from 51.02 mg/l to 39.51 mg/l with rate of -0.976 for the control sample and from 51.02 mg/l to 37.52 mg/l with rate of -1.117 for bioaugmented sample, respectively. Concerning, First Order Kinetic model Figures 7 and 8 depicted from 39.51 mg/l to 17.51mg/l with rate 0.063 for control and from 37.52 mg/l to 16.53 mg/l with rate 0.065 for bioaugmented respectively. Putting the results obtained for rate constant (k) and initial substrate concentration (So) into the integrated rate expression for Zero Order (Equation 1) and First Order (Equation 2) give as (Levenspiel, 1999):

(1)

(2)

The kinetic models for substrate reduction in Lake Gerio using *Pseudomonas aerigunosa* and are represented by Equations 3-6:

For Zero Order control

(3)

For Zero Order bioaugmented

(4)

For First Order control

(5)

For First Order bioaugmented

(6)

The results trend exhibit Zero Order at high substrate concentration because every site of *Pseudomonas aerigunosa* is saturated with the substrate that made the rate constant. While, as the substrate concentration decreases with time only few available sites of *Pseudomonas aerigunosa* were covered and that made the rate of remediation to be proportional to the substrate concentration for First Order kinetic model (Levenspiel, 1999; Okpokwasilli and Nweke, 2005; Hamza et al., 2009).

IV. CONCLUSION

After, 18 days the bacterial stopped growing with the highest value 3620000 cfu/l for the control sample. While the maximum growth profile of *Pseudomonas aerigunosa* value of 3820000 cfu/l for the bioaugmented sample was attained after 20 days.

Better results are obtained with bioaugmented sample compared to that of the existing *Pseudomonas aerigunosa* in the indigenous environment. The kinetic models agree with Monod equation (Okpokwasilli and Nweke, 2005). The bioremediation process will aid in reducing the level of pollutants in Lake Gerio if a bioreactor and the kinetic models are used at the site.

REFERENCES

[1]. Akpor, O. B. and Muchie, M. (2010). Bioremediation of Polluted Wastewater Influent: Phosphoruos and Nitrogen Removal. Scientific Research and Essays Vol. 5 (21), pp.3222, Available online at http://www.academicjournals.org/SRE.

[2]. Basharundin, H. B. (2008). Bioremediation of Oil Contaminated wastewater: Using Mixed Culture, Bachelor of Chemical Engineering (Biotechnology) Thesis, Universiti Malaysia Pahang, pp1-4.

[3]. Crawford, R. L. and Crawford, D. L. (1996). Bioremediation: Principles and Applications, pp 13-14, Cambridge University Press, New York, USA.

[4]. Hamza, U. D., Mohammed, I. A. and Ibrahim, S. (2009). Kinetics of Biological Reduction of Chemical Oxygen Demand from Petroleum Refinery Wastewater, Researcher,1(2), pp 17-22, Available online at http://www.sciencepub.net, sciencepub@gmail.com.

[5]. Kareem, S. A., Kefas, H. M. and Choir T. J. (2011). Kinetics of Fermentation by Enzymes: A Mathematical Approach, AU Journal of Technology 15(2), pp 110, Assumption University, Bangkok, Thailand

[6]. Levenspiel, O. (1999). Chemical Reaction Engineering, Third Edition, pp 38-60; 611-644, John Wiley and Sons, Delhi, India

[7]. Luka, Y., Onaji, P. B. and Chiroma, T. M. (2013). Extent of Pollution of River Benue in Jimeta-Yola from Bwaranji to Gerio, International Journal of Current Chemical Sciences Vol. 1(1) pp. 1-004, available online at http://www.bretj.com.

[8]. Mukred, A. M., Hamid, A.A., Hamzah, A. and Yusoff, W. M. W.(2008) .Development of Three Bacteria Consortium for the Bioremediation of Crude Petroleum-oil in Contaminated Water, Online Journal of Biological Sciences 8(4), pp 73-79.

[9]. Okpokwasili, G. C. and Nweke, C. O. (2005). Microbial Growth and Substrate Utilization: Kinetics, African Journal of Biotechnology Vol. 5(4), pp 305-314, available online at http://www .academicjournals.org/AJB.

[10]. Puyate, Y. T. and Yelebe, Z. R. (2010). Estimation of Monod Kinetic Parameters during Aerobic Digestion of Biodegradable Organic Waste, Part 1: Analysis based on substrate Utilization with effect of Bioaugmentation, Journal of the Nigerian Society of Chemical Engineers Vol. 25, pp 73-76, Nigerian Society of Chemical Engineers, IKeja, Lagos, Nigeria.

[11]. Reynolds, T. D. and Richards, P. A. (1996). Units Operations and Processes in Environmental Engineering, Second Edition, pp. 78-88, PWs Publishing Company, Boston, USA.

[12]. Standard Method (1998). Standard Methods for the Examination of Water and Waste water , 20th Edition.

[13]. Sudipta D. and Somnath M. (2010). Performance and Kinetic Evaluation of Phenol Biodegradation by Mixed Microbial culture in a Batch Reactor, International Journal of Water Resources and Environmental Engineering Vol. 2 (3), pp 40-47, Available online at http://www.academicjournals.org/ijwree.

[14]. Tchobanoglous, G., Burton, F. L. and Stensel, H. D. (2003). Wastewater Engineering: Treatment and Reuse, pp. 80-99; 580-88, Tata McGraw-Hill Publishing Company Limited, New Delhi india.