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Research article

DEVELOPMENT OF MATHEMATICAL MODELTO PREDICT THE EFFECT OF CHROMIUM ON E.COLI GROWTH RATE ON GROUNDWATER AT OMOKU TOWN IN NIGER DELTA AREA OF NIGERIA.

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Abstract

Mathematical model to predict and monitor the effect of chromium on E-coli growth rate in groundwater at Omoku town in Niger Delta Area of Nigeria has been expressed. Comparative analysis of theoretical and experimental values of chromium results were analyze, the developed model results has its optimum concentration at thirty metres, while that of the experimental result developed similar condition thus experienced slight variations fluctuating from its optimum level at twenty four metres and suddenly observed decrease at thirty metres. This explains the behaviour of the theoretical and experimental values including one location that express best fit. The study also express the level of inhibition from heavy metal chromium influencing microbial growth in the study location, this can be attributed to environmental factors, some parameters express low concentration in some locations where E-Coli deposited 0.00mg/l at thirty metres and chromium is 0.00mg/l, those formation express the deposition quality groundwater aquifers, while in some formations that experienced high concentration between twelve and 80.00 at thirty metres should be avoided, good quality water can only be abstracted in those depths that its concentration is zero, as compared to the permitted level of world health organization for chromium which is 0.05 and E.coli 0.00mg/l since, the study area predominantly deposited shallow aquifers, but for those location that aquiferous zone is at thirty metres which high concentration deposit 80.00mgl of E.coli and chromium, it implies that those locations need thoroughly ground design and treatment plant before the water can be allowed for human consumption, because of the deposition high level of concentration that is more than the permitted level of world health organization standards for quality groundwater and quality assurance.

Keywords: Mathematical model effect of chromium, E.coli growth rate and groundwater

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1. Introduction

Groundwater are contaminated through a lot of influence, either man made activities or natural origin. Omoku in Ogba/Egbema/Ndoni Local Government Area of Rivers State, geological formation is alluvium deposit from Benin formation that transit to sombrero on the deltaic environment of the Niger Delta, the aquiferous zone is a shallow aquifer between fifteen to thirty metres in most locations, but are contaminated by lot of influence, which chromium and E-coli plays a major role contaminating this deposited aquifer. Because the geological formation is very porous, that is why extraction of quality water needs a serious attention and thorough experts that will apply the required standard due to those contaminants.

Therefore, for the benefit of the people settling in the study area, this research was carried out by developing a model to predict the effect of chromium on E-coli growth rate on ground water. Since either increase or decrease in chromium concentration favour the growth of e-coli in progressive phase. The increase or decrease in chromium is the significant factor on e-coli concentration in ground water as well as determined the quality of ground water for human utilization. Base on this fact, it is necessary to develop a mathematical model that can predict the growth rate of E-coli in Omoku town as a way forward to advise the public on the possible factors that influencing the ground water in that zone. In this model mathematical model was developed in view to compare the experimental data obtained from the analysis. The result will advise the public the best method abstract quality water zone free from contaminant and other area, contaminated; advise the best method to prevent such contaminant from those horizons. Overall toxic effects of heavy metals to soil microorganisms depend on their bioavailability. Although, heavy metal bioavailability is mainly dependent on the soil properties (pH and organic matter), Bacteria can also directly influence the solubility of heavy metals, by altering their chemical properties. (Okpokwasili; 2005). Investigation conducted revealed that microorganisms have developed several mechanisms which can immobilize, mobilize or transform heavy metals from one regionto another. These processes include extracellular precipitation, intracellular accumulation, oxidation and reduction reactions, methylation and demethylation, and extracellular binding and complexation. The exploitation of these bacterial properties for the remediation of heavy metal-contaminated sites has been shown to be a promising bioremediation alternative. However, at high concentrations, bioavailable heavy metals are toxic for a great number of soil microorganisms and soil microbial processes which in turn will result in severe ecosystem disturbance (Rabia, 2007).

The deleterious effects of heavy metals on microbe-mediated processes have been discussed in detail in several publications. Generally, a decrease in carbon mineralization and fixation, in nitrogen transformation, soil enzyme activities and litter decomposition can be observed. Other typical effects of heavy metal contamination are a decrease in the microbial numbers (CFU), biomass, or an increase of the frequency of heavy metal resistant bacteria (Fablemne, 2003).

However, measuring these parameters is not suitable for the determination of changes in the entire structure of soil communities exposed to pollutants. Since many of the microbiological and biochemical techniques used to study the effects of heavy metals on soil bacteria are cultivation dependent, they do not provide detailed information on the non-cultivable bacteria, neglecting thus the major part of the soil microbial community.

Consequently, soil microbial communities are treated as a black box (Gikas et al; 2009). These limitations have been overcome by the recent advances in molecular fingerprinting methods. Based on the analyses of signature biomarkers such as phospholipids fatty acids or nucleic acids, the fingerprinting techniques have been used as reported by (Fablemne, 2003). Chromium is found in many environments, including air, water, soil and all biota. It ranks 21st among the elements in crustal abundance (Ahmed et al; 2003). The average concentration of chromium in the continental crust has been reported as 125 mg/kg (National Academy of Science (NAS), 1974). Concentrations in freshwater generally range from 0.1 to 6.0 µg/L with an average of 1.0 µg/L, while values for seawater average 0.3 µg/L and range from 0.2 to 50 µg/L (Bowen, 1979). Freshwater chromium concentrations are dependent on soil chromium levels in the surrounding watershed areas. In addition, drainage water from irrigated agricultural areas with elevated amounts of soil chromium levels can have high chromium concentrations (as high as 800 µg/L), as observed at various locations within San Joaquin Valley (Deveral et al; 1984; Gaines, 1988).

Chromium is extracted from chromite ore [(Fe, Mg)O(Cr, Al, Fe)$_2$O$_3$] that has largest deposits in South Africa, the Philippines, Southern Zimbabwe, and Turkey (Rathnayake et al; 2010). The major users of chromium are the metallurgical, chemical, and refractory brick industries. Other industries that employ chromium include pigment manufacture, metal finishing, corrosion inhibition, organic synthesis, leather tanning, and wood preservation. Extensive industrial usage of chromium leads to generation of large volumes of chromium-containing wastes that are discharged into the environment. In addition to this waste, leakage due to improper handling and faulty storage containers also adds to the accumulation of chromium in the environment. Chromium is one of those heavy metals the concentration of which is steadily increasing due to industrial growth, especially the development of metal, chemical and tanning industries.

Chromium is designated by the U.S. Environmental Protection Agency (USEPA) as a priority pollutant due to its ability to cause genetic mutations and cancer. Chromium is unique among regulated toxic elements in the environment because different species of chromium, specifically Cr (III) and Cr (VI), are regulated in different ways. Relying on the chemical, toxicological, and epidemiological evidence, regulation of Cr (VI) concentration is different from that of Cr (III). Trivalent chromium is the nutritionally useful form, while the Hexavalent form is toxic and mutagenic. Cr (VI) is both a powerful epithelial irritant and confirmed human carcinogen. On the contrary, Cr (III) is an essential element in animal physiology and plays a role in glucose and lipid metabolism (Kanika, 2002). Hexavalent chromium is toxic and mutagenic to most bacteria. Among the visible effects reported in bacteria are cell elongations, cell enlargement, and inhibited cell division, which eventually leads to cell growth inhibition. Changes in morphologies of gram-positive and gram-negative bacteria were also observed by Bondarenko et al (Bopp et al; 1983). Few colonies of bacterial species such as Staphylococcus aureus, S. epidermidis, Bacillus cereus, and Bacillus subtilis were formed with degenerate cells that were reduced in size (Bondarenko and Ctarodoobova, 1981). Cr (VI) concentrations of 10-12 ppm were inhibitory to most soil bacteria in liquid media and, in general, gram-negative bacteria were more sensitive to Cr (VI) than were gram-positive bacteria (Ross et al; 1981). Increased content of Cr (VI) in soil was toxic to saprophytic and nitrifying bacteria. Lowered microbial biomass in soil was observed in the presence of high Cr (VI) in soil when it was determined using adenosine triphosphate (ATP) method. Other bacteria such as E. coli, Serratia

marcescens and Enterobacter aerogenes were unable to grow in Cr (VI) concentrations of 1 mM. (Arnold et al; 1988).

Metabolic effects of Cr (VI) on bacteria were evident by the observed changes in electron transport system. Cr (VI) has been shown to cause mutagenic effects in Escherichia coli, Bacillus subtilis, and Salmonella typhimurium the mutagenic effects of chromium are effective only when chromium crosses the cell membrane. Cr (VI) can easily diffuse across the cell membranes, unlike Cr (III) which can do so only under extreme conditions such as long incubations and high concentrations. Cell culture studies have shown that cellular uptake of chromate is at least 10 times greater than that of Cr(III) from equimolar solution. However, once inside the cell, most of Cr(VI) is reduced to Cr(III) by several reducing agents such as ascorbic acid, sodium sulfite, glutathione, NADPH and NADH. Based on several studies, it was concluded that trivalent chromium causes DNA-strand breaks. Cr (VI) causes genotoxic effects on bacterial cells, including frameshift mutations and base pair substitutions. (DeFlora et al; 1984) rep unbalanced nucleotide pools. These studies suggest that although Cr (III) form is the major agent responsible for molecular events leading to mutagenicity, it is Cr (VI) that poses the greater risk to human life due to its ability to easily enter the cell.

Chromium can exist in oxidation states ranging from 0 to 6^{+}. The various chemical and biological changes that chromium undergoes in the environment depend on the conditions that govern its speciation and other activities. Heavy metal contamination in the environment has become a serious problem due to the increase in the addition of these metals to the environment. Natural sources as well as the anthropogenic sources account for this contamination, which has become a threat to public health. Cadmium, copper and zinc are among those heavy metals that are being released to the environment (Wyzkoska, 2002). These heavy metals influence the microbial population by affecting their growth, morphology, biochemical activities and ultimately resulting in decreased biomass and diversity. The ability of an organism to survive in an environment with high metal concentration or its capacity to accumulate high concentration of heavy metal without dying reflects its capacity to tolerate metals (Azza et al; 2009). Heavy metals have been reported to be powerful inhibitors of biodegradation activities (El. Deeb and Altalhi, 2009). Hence, their presence may hinder or affect the rate of glyphosate degradation in soil and water. Pollution of the biosphere by heavy metals due to industrial, agricultural and domestic activities has created a serious problem for the safe and rational utilization of soils (Igwe et al; 2005) Under stress conditions caused by adverse anthropogenic effects such as dissemination of chemical pollutants, the development and biochemical activities of soil micro-organisms undergo several alterations. To prevent negative ecological consequences, microbiologically-related parameters should be involved in the indication of soil quality (Anyanwu and Ugwu, 2010).

Metal contaminants are commonly found in soils, sediments, and water. Metal pollutants can be produced through industrial processes such as mining, refining, and electroplating. Metals are not biodegradable but can be transformed through sorption, methylation, and complexation, and changes in valence state. These transformations affect the mobility and bioavailability of metals. At low concentrations, metals can serve as important components in life processes, often serving important functions in enzyme productivity. However, above certain threshold concentrations, metals can become toxic to many species. Fortunately, microorganisms can affect the reactivity and mobility of metals. Microorganisms that affect the reactivity and mobility of metals can be used to detoxify some metals and prevent further metal contamination (Smejkalovs et al; 2003). The

main aim of the study is to compare the theoretical model result with the experiment result of E. coli growth rate upon the influence of chromium as well as characteristics of E.coli concentration by monitoring the behavior of chromium influence on the micro organism migration in each of the soil formation. Secondly, to compare both parameters result and determine their level of concentration against borehole construction and water quality at the study area.

2. Materials and Method

2.1 Sample Collection

The method of sample collection was insitu method of sample collection from a point source discharge into a drain at Omoku Town in Niger Delta Area of Nigeria.

2. Equipment used for this study

Equipment is column equipment. The method of sample is in-situ method of sample collection on the aquifer material use for bacteriological analysis passing through the column experiment applied to determine the transport of microbes in a physical process. The equipments use to collect the aquifer material are as follows tripod stand, drilling stems, chain tone pipe range drilling bit, clamp, mud pump, casing pipe, Tangit gum, drilling fluid, marine rope, 3/8 gravel, and mud pit.

2.3 Chromium Analysis

Mathematical model where developed to predict the effect of chromium on e-coli growth rate in ground water at Omoku in Niger Delta Area of Nigeria considering the dependent of velocity, time, and distance, for chromium concentration base on the condition stated above.

2.3.2 **Microbial Analysis**

Bacteriological Methodology: Membrane filtration. **Testing Of Water**

(WHO, 1993, 1996, 1998)

Principle of Method: A 100ml water sample was filtered through membrane filters. The membranes, with the coliform organism (*E. coli*) on it, are then cultured on a pad of sterile selective broth containing lactose and an indicator. After incubation, the number of colonies of coliform (*E. coli*) were counted. This gives the presumptive number of *E. coli* in the 100ml water sample.

Choice of Technique: The method is recommended for its accuracy, speed of result, and because it can be performed in the field.

Required:

1. Sterile filtration unit for holding 47mm diameter membrane filters with suction device (wagteck international)
2. Sterile grid membrane filters of 47mm diameter with a pore size of 0.45um (oxoid).
3. Sterile 47mm diameter cellulose pads (both culture medium to be added just before use).
4. Sterile Petri dishes 50-60mm diameter
5. Sterile membrane lauryl sulphate broth (lactose sodium lauryl sulphate broth)
6. Autoclaving unit, blunt ended forceps, sterile bottles, grease pencil, incubator at 44^{o}c, Bunsen burner, Petri-dish holders and oblique light source.

Procedure:

a. **Assembling the Filtration Unit:** The sterile broth is aseptically added to the cellulose pad in a Petri-dish. The membrane filter is aseptically removed from the sterile pack using a flame sterilized blunt forceps and placed on the filter base with the grid-side uppermost and centrally. Next, the filter lid was screwed into place.

b. **Suction Filtration of water sample:** 100ml of the different water samples were thoroughly mixed by inverting the bottles several times and gently poured into the assembled filtration unit.

- The water was drawn into the filter membrane by suction using the hand held pressure pump.
- A blunt-ended forceps was sterilized by naked Bunsen flame, cooled and the membranes were aseptically removed from the filtration unit after unscrewing the lid of the filtration unit.
- The membranes were placed, grid-side uppermost, on the culture medium pads in the Petri-dishes, ensuring there were no air bubbles trapped under the membranes.
- The Petri-dishes were closed and the top of the lids were labeled with the code numbers of the water samples and volumes of water used using a grease pencil.

Incubation of Samples:

- The Petri-dishes were packed in a Petri dish holder with lids uppermost and placed inside the incubator at 44^{o}c for 12 – 16 hours.

Examination, count and calculation of *E.coli* colonies:

- Following incubation and using oblique lighting, the membranes were examined one after the other for yellow lactose fermenting colonies, 1-3mm in diameter. The number of colonies if any was counted. Any plink and small colonies less than 1mm in diameter were ignored. Number of colonies too numerous to count were reported as “too numerous to count” (indicative of gross contamination).
- To calculate the presumptive *E. coli* count/100ml water sample, the number of colonies counted per membrane was multiplied by 1.

3. Developed Model of E.coli under Progressive Condition in Groundwater

The mathematical model was developed by considering the E. coli growth rate function to be dependent of velocity, time, distance and chromium concentration. Based on these conditions as stated above a general mathematical expression can be written as:

Nomenclature

C(x)	-	Concentration of Chromium ML^{-3}
D_A	-	Dispersion Number
V^2	-	Velocity LT^{-1}
X	-	Distance L
T of t	-	Time T

S
$S_{(o)}$ -
$T_{(s)}$ -
} Laplace sign

$$C(x)\frac{\partial v(x)}{\partial t} - D\,V^2\frac{\partial C(x)}{\partial x} = \frac{V\partial C(x)}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$ML^{-2}\,T^{-2}$ $ML^{-2}\,T^{-2}$

The equation (1) is non-homogenous process and can be written as

$$C_{(x)}\frac{\partial v(x)}{\partial t} - D_A v^2\frac{\partial c(x)}{\partial x} = \frac{V\partial c(x)}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1a)$$

If equation (1a) is time dependent only, the equation reduces to:

$$C_{(x)}\frac{\partial v(x)}{\partial t} = \frac{V\partial c(x)}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Considering when the system is at steady state the above equation (1) can be rewritten as

$$D_A v^2\frac{\partial c(x)}{\partial x} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

For simplicity of solving equation (1), the following assumption is considered such as, let

$$C(x)\frac{\partial v(x)}{\partial t} = \beta \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3a)$$

Therefore, substituting equation (3a) into equation (1) becomes

$$\frac{V\partial c(x)}{\partial t} + D_A v^2\frac{\partial c(x)}{\partial x} = \beta \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3b)$$

Equation (3b) can be rewritten as

$$\frac{V\partial c(x)}{\partial t} = -D_A v^2\frac{\partial c(x)}{\partial x} + \beta \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Equation (4) obtained can be resolved using mathematical application. In this research work the mathematical tools known as separation of variable was used in positive real number of λ^2 condition. Thus, let

$$C(x) = Tx \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4a)$$

Since $C(x) = f(Tx)$ therefore, differentiating (4a) with respect to time and distance yields the following mathematical expression

$$\frac{\partial c(x)}{\partial x} = T^1 x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4b)$$

It can be obtained from separation of variables

$$\frac{\partial c(x)}{\partial x} = Tx^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4c)$$

Therefore, substituting equation (4b) and (4c) into equation (4a) and further expression by substituting equation (3a) into the obtained equation yields

$$V\left(T^1 x\right) = D_A v^2\ Tx^1 - Tx\frac{\partial v(x)}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Expanding further we get

$$VT^1 x = D_A v^2\ Tx^1 - Tx\frac{\partial v(x)}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Dividing equation (6) by *Tx* we have

$$\frac{VT^1 x}{Tx} = D_A v^2\ \frac{Tx^1}{Tx} - \frac{Tx}{Tx}\ \frac{\partial v(x)}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Thus, equation (7) can be written as

$$\frac{VT^1}{T} = D_A v^2\ \frac{x^1}{x} = \frac{\partial v(x)}{\partial t} = \lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

Equation (8) having taking the shape of separate of variable application as a mathematical tools used in solving complex problems of this kind.

Solving equation (8) term by term, we have

$$\frac{VT^1}{T} = \lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

$$VT^1 = \lambda^2 T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

Applying the theory of Laplace transformation into equation (10) becomes

$$V(ST_{(s)} - T(o) - \lambda^2 T_{(s)} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Considering the boundary condition as follows

At T = 0

$$T(o) = C_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Therefore, substituting the boundary condition of equation (12) with equation (11) becomes

$$VST_{(s)} - VC_1 - \lambda^2 T_{(s)} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

$$VST_{(s)} - VC_1 - \lambda^2 T_{(s)} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

$$VST_{(s)} - \lambda^2 T_{(s)} = VC_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

$$(Vs - \lambda^2)\, T_{(s)} = VC_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

Then $\dfrac{VC_1}{VS - \lambda^2}$ $\ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$

Therefore the Laplace inversion of equation (17) can be written as

$$T_{(t)} = VC_1\, \ell \frac{\lambda^2}{V} t$$

From equation (8) we have

$$D_A V^2 \frac{x^1}{x^1} = \lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

Applying the same mathematical approach of Laplace transformation and considering the boundary condition at

$$X = 0$$

$$X(o) = C_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

Resolving the equation (19) by substituting the necessary boundary condition and using the mathematical equation as stated above given a general solution of

$$X_{(t)} = D_A V^2 C_2\, \ell \frac{\lambda^2}{D_A v^2} t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

$$\frac{\partial v(x)}{\partial t} = \lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$$

Integrating the initial concentration for which $V = 0,\ V(o) = C_3$

$$SV_s - C_3 = \lambda^2 \quad \text{..... (23)}$$

$$SV_s = \lambda^2 + C_3 \quad \text{..... (24)}$$

Making V_s the subject relation gives

$$V_s = \frac{\lambda^2 + C_3}{S} \quad \text{..... (25)}$$

Using Laplace inverse we obtain

$$V_t = \lambda^2 + C_3$$

$$\lambda^2 = V_t - C_3 \quad \text{..... (26)}$$

Therefore, from equation (18) where

$$T_{(t)} = VC_1 \ell^{\frac{\lambda^2}{V}t} \quad \text{..... (27)}$$

Therefore, substituting equation (26) into equation (18) becomes

$$T_{(t)} = VC_1 \ell^{\frac{V_{(t)} - C_3}{V}t} \quad \text{..... (28)}$$

Similarly, substituting equation (26) into equation (21) becomes

$$X_{(t)} = D_A V^2 C_2 \ell \frac{V_{(t)} - C_3}{D_A V^2} t \quad \text{..... (29)}$$

But $C(x) = TX = VC_1 \ell^{\frac{V_{(t)} - C_3}{V}t}$

Therefore

$$C_{(t)} = VC_1 \ell^{\frac{V_{(t)} - C_3}{V}t} \bullet D_A V^2 C_2 \ell^{\frac{V_{(t)} - C_3}{D_A V^2}t} \quad \text{..... (30)}$$

But $V = \frac{\partial}{t}$

Therefore, $t = \frac{\partial}{V}$, thus equation (30) can be written as

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$$C(x)_d = VC_1 \ell^{\frac{V_t - C_3}{V} \bullet \frac{d}{V}} \bullet D_A V^2 C_2 \ell^{\frac{V_{(t)} - C_3}{D_A V^2} \bullet \frac{d}{V}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

Equation (31) is the general equation used in monitoring and predicting the chromium concentration in different soil level in Omoku town in Niger Delta Area of Nigeria. The general solution obtained was resolved using computer programme known as visual software as presented in this paper.

4. Results and Discussion

The result obtained from the investigation are presented in tables and in figures the data obtained illustrate the behaviour of the system upon influence of environmental factors

Table 1: Chromium concentration at various distances

Distance	Theoretical Result of Chromium mg /l
3	38.97
6	7.29E-05
9	37.2
12	3.72E-05
15	37.24
18	3.84E+01
21	38.8
24	4.27E+01
27	39.57
30	8.82E+01

Table 2: Chromium concentration at various distances

Time	Theoretical Result of Chromium mg /l
10	38.97
20	7.29E-05
30	37.2
40	3.72E-05

50	37.24
18	3.84E+01
70	38.8
80	4.27E+01
90	39.57
100	8.82E+01

Table 3: chromium concentration at various times

Time	Theoretical Result of Chromium mg /l
10	38.97
20	7.29E-05
30	37.2
40	3.72E-05
50	37.24
60	3.84E+01
70	38.8
80	4.27E+01
90	39.57
100	8.82E+01

Table 4: Comparison of theoretical values at various times

Time	Theoretical Result of Chromium mg /l
10	38.97
20	7.49E-05
30	37.2
40	3.72E-05
50	37.24
60	3.81E+01
70	37.8
80	4.17E+01
90	39.44
100	0.01

Table 5: Comparison of experimental and theoretical values obtained from investigation upon the influence of distance

Distance	Exp Result Conc. Mg/L. Chromium	Theoretical Result of Chromium mg /L
3	38.88	38.97
6	7.15E-05	7.29E-05
9	37.5	37.2
12	3.70E-05	3.72E-05
15	37.05	37.24
18	3.81+01	3.84E+01
21	38 45	38.8
24	4.18E+01	4.27E+01
27	39.44	39.57
30	0.01	8.82E+01

Table 6: Comparison of experimental and theoretical values obtained from investigation upon the influence of Distance

Distance	Exp Result E-Coli conc. Mg/L	Theoretical Result of Chromium mg /l
3	.38.56	38.97
6	7.45E-05	7.29E-05
9	38.5	37.2
12	3.60E-05	3.72E-05
15	37.75	37.24
18	3.77E+01	3.84E+01
21	38.65	38.8
24	4.33E+01	4.27E+01
27	39.44	39.57
30	0.0015	8.82E+01

Table 7: Comparison of experimental and theoretical values obtained from investigation upon the influence of Distance

Time	Exp Result E-Coli conc. Mg/L	Theoretical Result of Chromium mg /l
10	.38.56	38.97
20	7.45E-05	7.29E-05
30	38.5	37.2
40	3.60E-05	3.72E-05
50	37.75	37.24
60	3.77E+01	3.84E+01

70	38.65	38.8
80	4.33E+01	4.27E+01
90	39.44	39.57
100	0.0015	8.82E+01

Table 8: Comparison of experimental and theoretical values obtained from investigation upon the influence of Distance

Time	Exp Result E-Coli conc. Mg/L	Theoretical Result of Chromium mg /l
10	.38.56	38.97
20	7.45E-05	7.29E-05
30	38.5	37.2
40	3.60E-05	3.72E-05
50	37.75	37.24
60	3.77E+01	3.84E+01
70	38.65	38.8
80	4.33E+01	4.27E+01
90	39.44	39.57
100	0.0015	8.82E+01

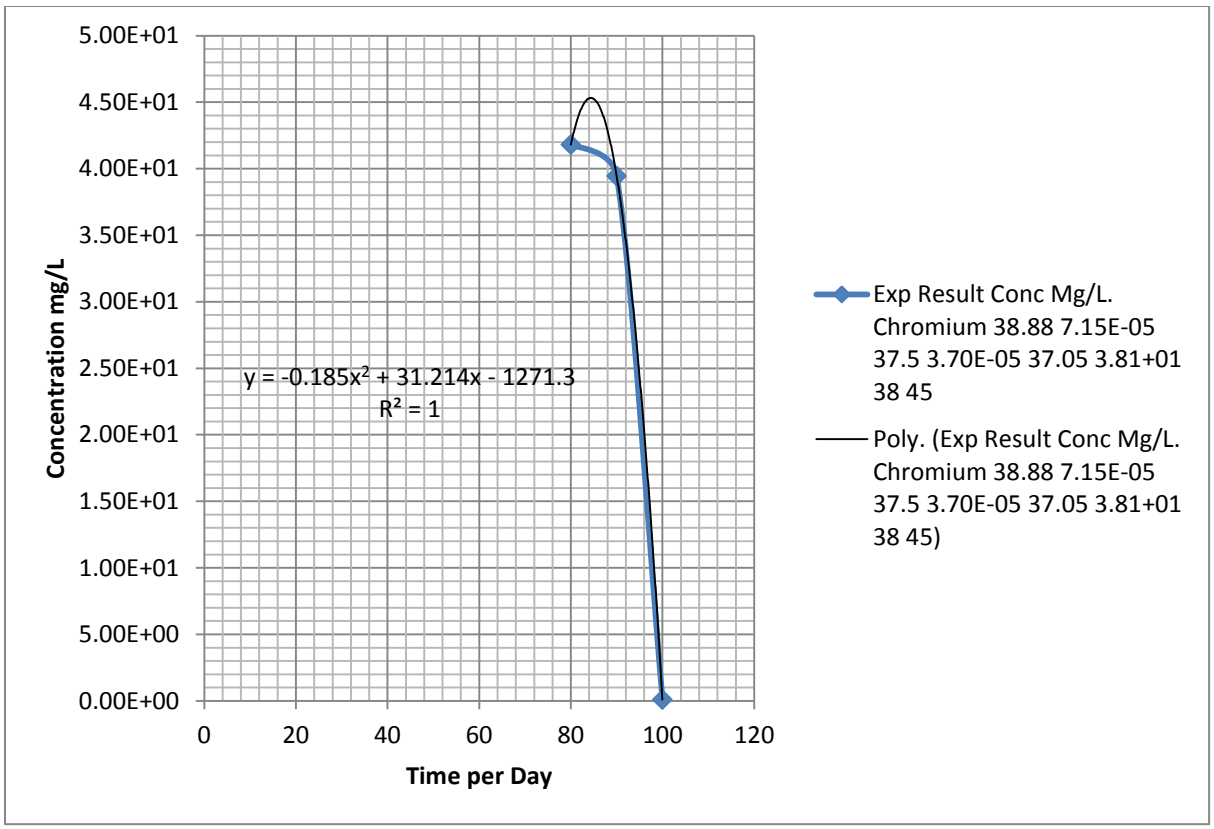

Figure 2: concentration of E-coli various Time

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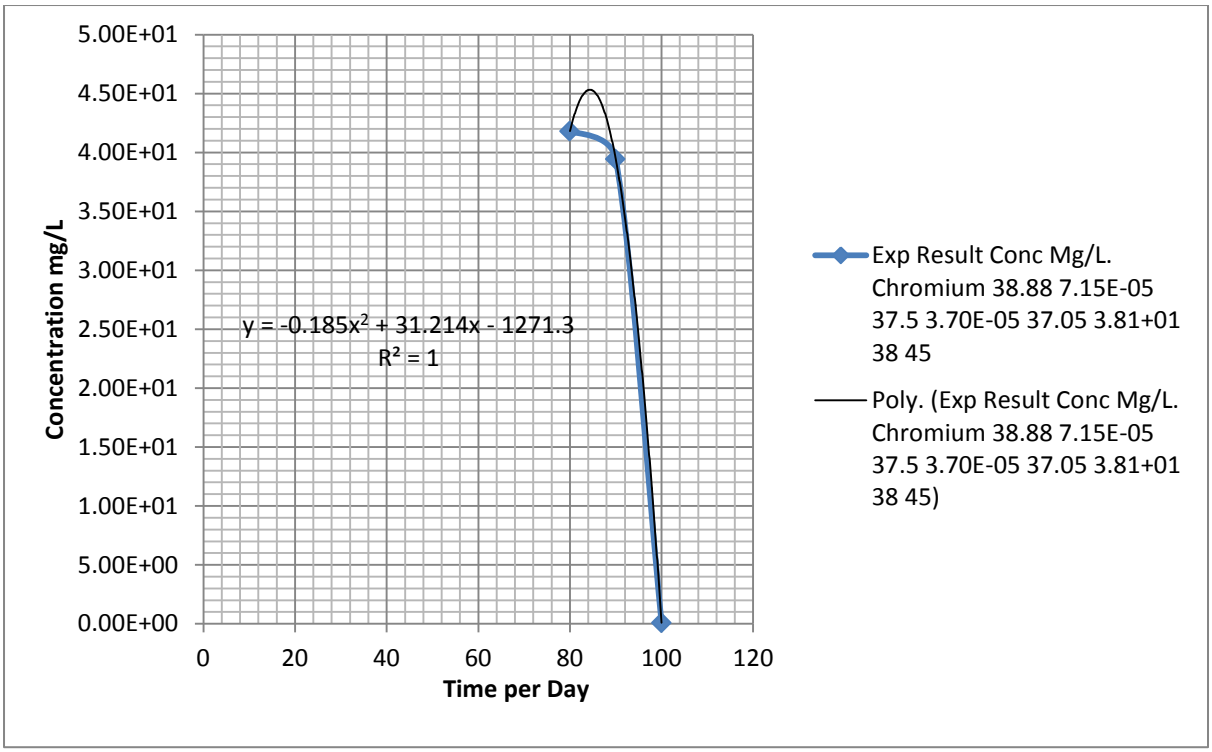

Figure 3: concentration of E-coli various Time

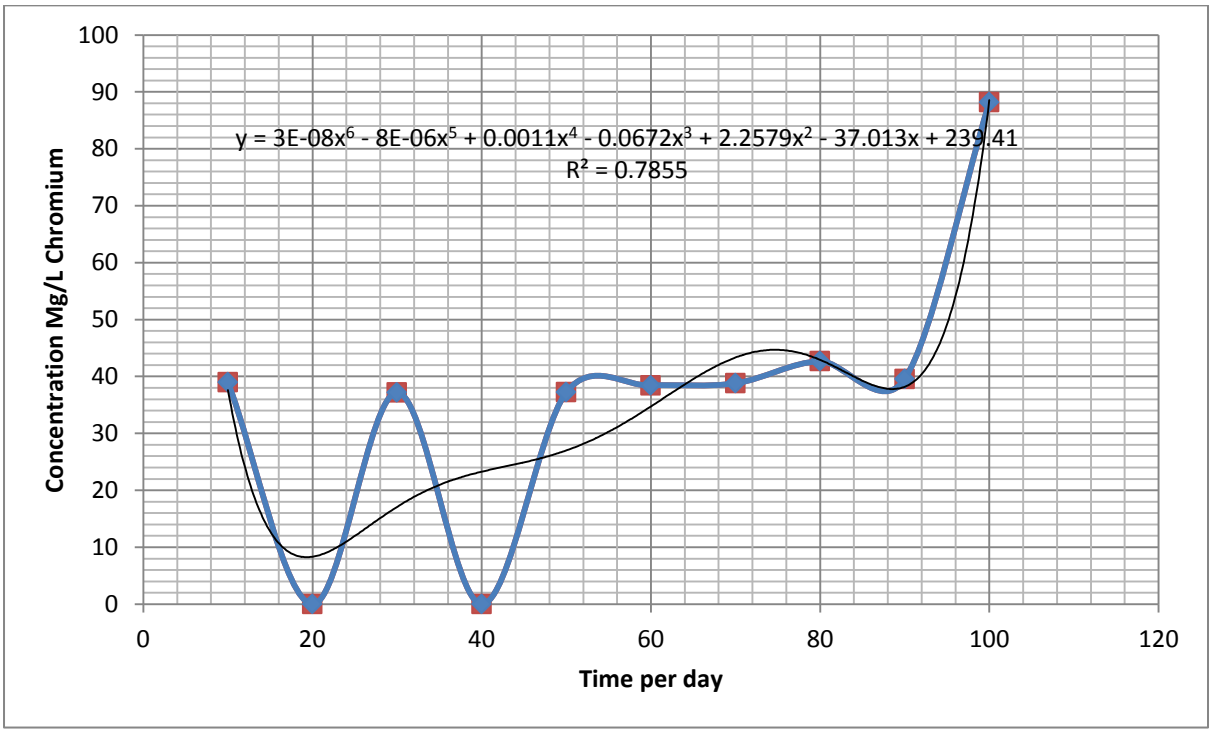

Figure 3: comparison of experimental result of E. coli with theoretical value of chromium versus time

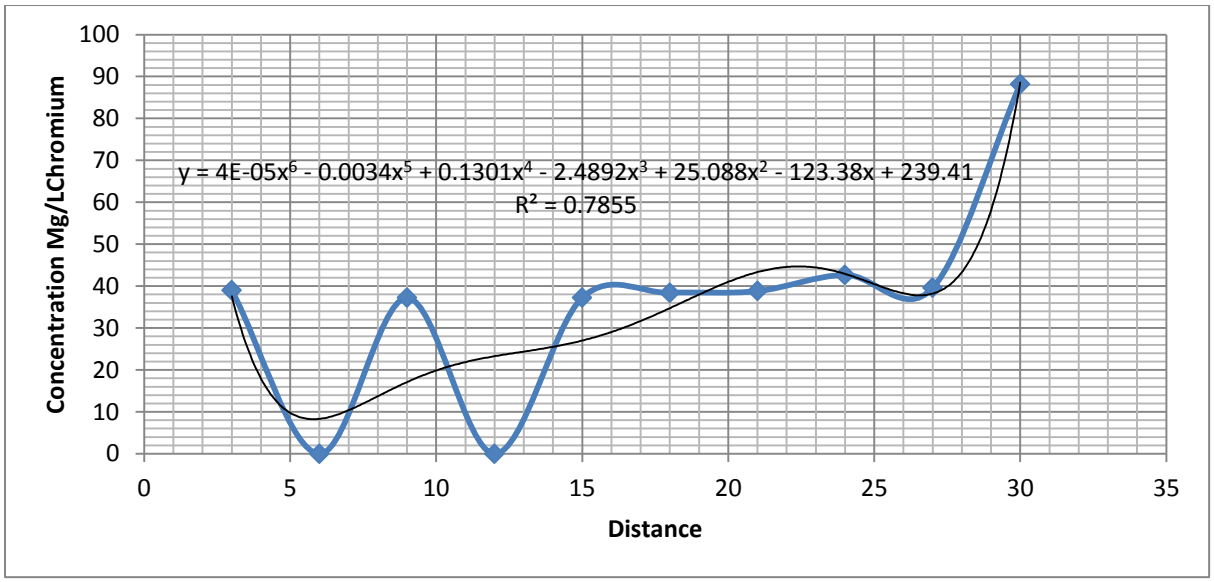

Figure 4: experimental result of E. coli with theoretical value of chromium versus depth

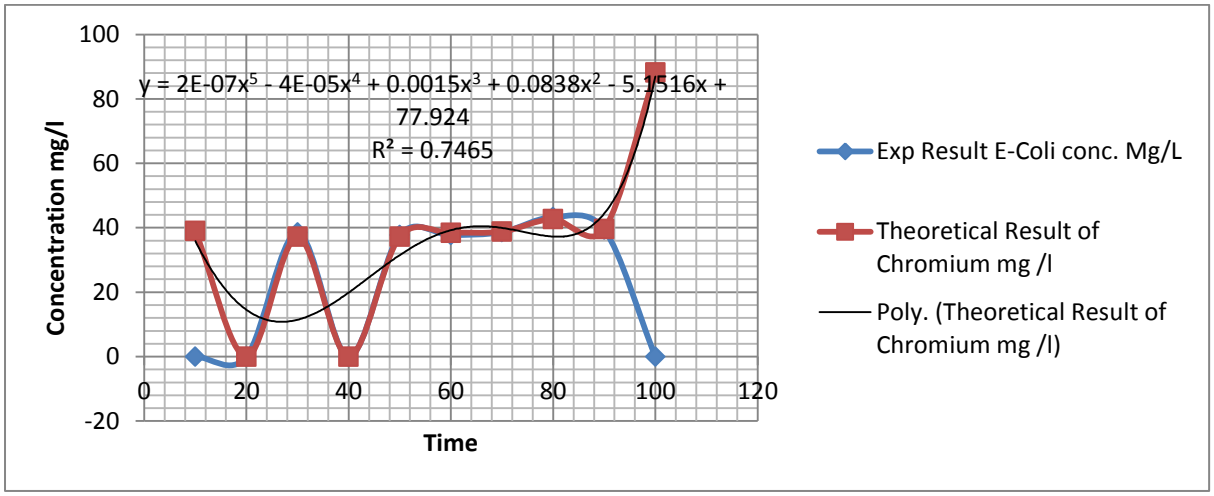

Figure 5: comparison of experimental result of E. coli with theoretical value of chromium versus time

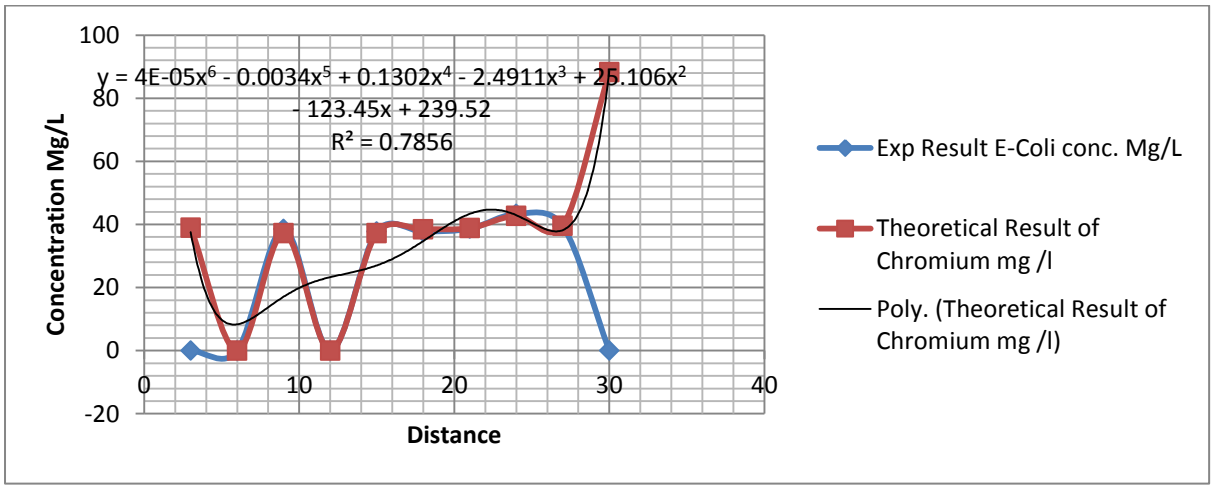

Figure 6: comparison of experimental result of E. coli with theoretical value of chromium versus time

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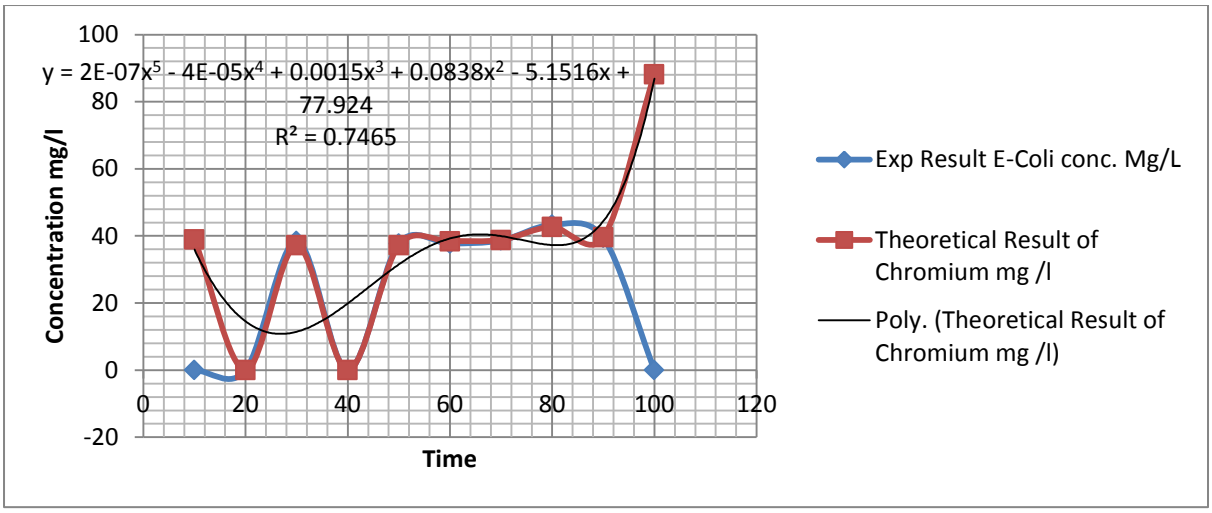

Figure 7: comparison of experimental result of E. coli with theoretical value of chromium versus time

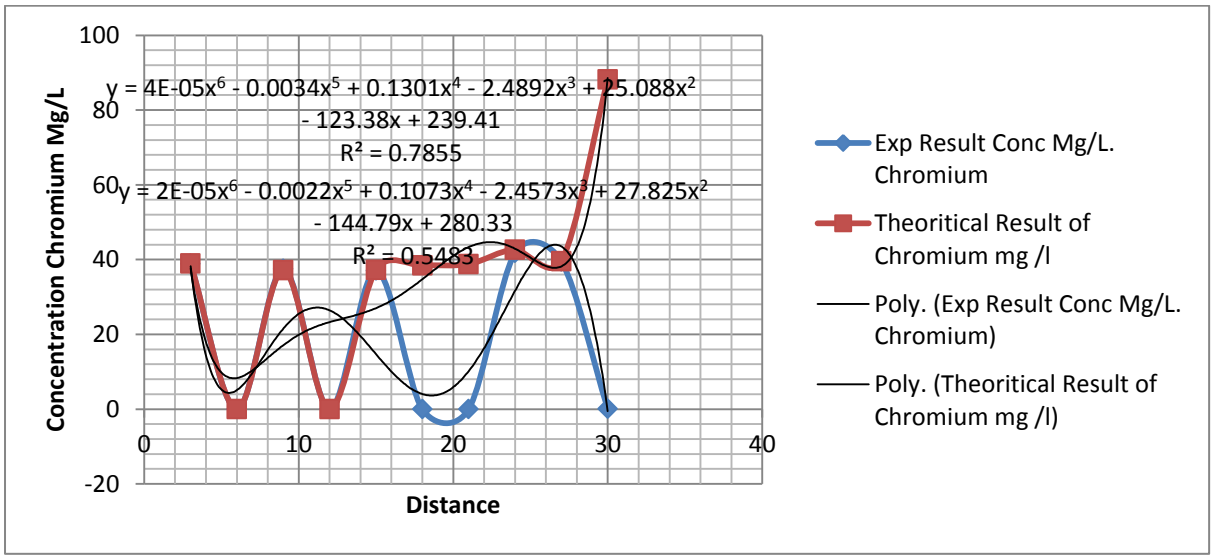

Figure 8: comparison of experimental result of E. coli with theoretical value of chromium versus time

Figure one illustrates the concentration increase with increase in distance to a point where its optimum value was obtain at eighteen metres and suddenly drop at thirty metres. This can be attributed to the level of it deposition including other influence either on activities of man or natural origin Figure 2 the concentration increase with increase in distance to a point where its optimum value was obtain at eighteen metres and suddenly drop at hundred days this can be attributed to the level of it deposition including other influence either on manmade activities or natural origin. It is seen that the experimental value has a good match with the theoretical value as shown in Figure 2. The variation in the concentration of chromium can be attributed to the variation in time. From figure 3 result the concentration were express in vacillation form, it increase with time to a point where an optimum value was obtained at hundred days This variation in chromium concentration can be attributed to the level of deposition of the inhibitors such that the level of deposition may being influenced by other environmental factors either man made activities or natural origin the result produced the best fit lines equation of $y=3E\text{-}08X^5 +0.004X^4\text{-}0.067X + 2.257X^2 - 37.01 + 239.4$ with it root of $R^2 = 0.785$. Figure 3, the

concentration were expressed in oscillation form, it increase with distance to a point where an optimum value was obtained at thirty metres. This can be attributed to the level of deposition of the inhibitors where by the level of deposition are influenced through the geology formation of the area. it may also being influenced by other environmental factors either man made activities or natural origin it produced the best line fit equation as presented in the figure, while in 4 Figure 5, it illustrates the concentration of E-coli in a vacillation form with increase in duration to a point where optimum values was obtained at ninety days and suddenly drop with time to hundred days. While that of theoretical value maintained express if behaviour rapidly thus increase with time, where it obtain it optimum value at thirty metres. This can be attributed to the level of depositions of the stratum whereby it may be heterogeneous formation, or high degrees of porosity may influence the level of migration of the solute. It produced the best fit line equation of $y=2E-07X^5-4E-05X+0{,}001X^3+0.83X^3-5115X+77.92$ with it root of $R^2 = 0.785$. Figure 6 illustrates the concentration of the theoretical result in a fluctuation form influences with increase in distance to where an optimum value was obtained at thirty metres, while that of experimental result in the same vein increase and also obtained it optimum value at twenty seven metres and suddenly decrease with distance at thirty metres. This implies that the inhibitors influence the microbial growth with a high percentage thus influences from the geological formation it produced the best fit line equation state on the graph. Figure 7 showcase the concentration in a fluctuation form it experience an increase with distance to a point where it obtain it optimum value at hundred days while that of experimental result of chromium in the same form fluctuate to obtain it optimum value, at seventy days, suddenly degradation were observed at hundred days. Finally Figure 8 shows that the concentration increase with distance in fluctuation form to a point where an optimum value was obtain at thirty metres, while that of chromium in the same vein maintained the same fluctuation form of concentration and obtained it optimum value at twenty seven metres and suddenly experienced degradation at thirty.

5. Conclusion

This research work gives an ideal on the characteristics of E- coli in different aquifer in ogba Egbema/Ndoni local government area of Nigeria. Therefore this work provides a guide on the characteristics of E-coli within the area under investigation. The level of growth has definitely shown the reality of hindrance and also shows the level of chromium concentration at the study area. comparing the level of concentration of chromium from the theoretical result compared to the World Health Organization standard for quality water, it shows that the chromium result is very high and that implies that groundwater exploitation should be designed based on design criteria by considering the model result from that study area, more so there should be a treatment plant if any ground water should be abstracted from that location. It is also seen that the mathematical model can be used to monitor and predict the effect of the physiochemical; parameter (chromium) of E.coli growth rate. The physiochemical parameter deposited generate a high concentration, the model was able to monitor this parameter level of deposition at every formation in the study area. The study gives an idea of the characteristics of E-coli at different deposition of aquifer in Ogba/Egbema /Ndoni local Government area of Rivers state, Nigeria. Therefore the work provide a guide on the characteristics of E-coli within the area under investigation, For certainty the migration of microbe E.coli are influenced by so many other minerals. This study considered the basic migration of microbes at very fast and slow conditions.

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