

Research article

MATHEMATICAL MODEL TO PREDICT THE TRANSPORT OF E. COLI IN PHREATIC AQUIFER: AN INHIBITION FROM CADMIUM AT ELEME; RIVERS STATE OF NIGERIA.

Eluozo, S. N¹. Ademiluyi, J. O². And Ukpaka, P. C³.

¹Department of Civil Engineering, Faculty of Engineering, University of Nigeria Nsukka.
E-mail: solomoneluozo2000@yahoo.com

³Department of Chemical/Petrochemical Engineering, Faculty of Engineering, Rivers State University of Science and Technology, Port Harcourt, Nigeria.

Abstract

This paper explain the level of transport of E-coli under progressive phase condition in phreatic aquifer, this model where compared with the experimental result to see the level of its behaviour in the system and the level of inhibition from cadmium, from the study it shows that the concentration of E-coli increased in an oscillation form to a point where an optimum value where observed at nine metres at thirty days and suddenly decreased with distance in a fluctuation form to thirty metres at the period of hundred days ,while that of theoretical values express gradually increase to a point where an optimum value where recorded at eighteen metres at seventy days and suddenly decrease down to thirty metres at hundred days,. Comparing both results to the World Health Organization standard, both specification meet up the WHO standard, therefore the level of the concentration at those aquiferous zone is insignificant and harmless to human, in this condition without any regeneration, quality water in those aquiferous zone can be abstracted for human consumption. **Copyright © IJACSR, all rights reserved.**

Keywords: cadmium, E-coli, aquiferous zone, consumption

1. Introduction

Although water is a renewable resource and we use little more than 10% of the total precipitation surplus for public water-supply, irrigation, and industrial processes, its availability is restricted through an uneven distribution, both in time and space. In this respect, there is no essential difference between ancient times and the present day; society has always experienced problems with water: too little, too much, too variable too polluted. Over more than 6000 years mankind has tried to manage these water problems: by intervening in its natural courses through redistribution, storage, and regulation, to accommodate their Requirements for irrigation, drainage, flood protection, drinking water, sanitation, and power generation. Management and exploitation resulted in systematic knowledge of behavior of water under more or less controlled conditions. Gradually, from the Renaissance onwards, this empirical knowledge merged (Jacques 2007). Eleme in Rivers is state part of the Niger delta that the deposition is Benin formation with alluvium deposit, its stratum are homogeneous formation with a very high porosity, the permeability coefficient is an average of 0.042 (Eluozo, 2006). The settlements are privileged to be an industrialized area, this has definitely generated a lots man made activities, and the negative impact of it is pollution generated from all this companies. Past years trace petroleum product was found to have contaminated the soil and ground water aquifers, this resulted to serious pollution and affect the health of the people because the geological formation confound to be shallow aquifer, this condition has generated the rapid level of this contaminant. For this reason, there should further investigation to be thoroughly carried out other contaminant assessment that may have caused other ground water pollution in the study area. Displacement and leaching of trace metals may occur in the soil profile and contaminate the groundwater. The presence of heavy metals in surface and groundwater is usually the result of man's cultural activities. Vertical obviously, because of possible influence on the human food chain, environmental contamination by heavy metals is a global concern nowadays. Therefore, it is worthwhile to estimate the spatial distribution of heavy metal concentrations in the agricultural wells of a region (e.g. the Shiraz area). Groundwater pollution, often due to contaminant seepage from the disposal sites, is a big problem in many countries (Sharma and Busaidi, 2001). Industries such as plating, ceramics, glass, mining and battery manufacturing are considered the main sources of heavy metals in local water streams, which will cause the contamination of groundwater with heavy metals. Besides, heavy metals which are commonly found in high concentrations in landfill leach ate are also a potential source of pollution for groundwater (Aziz et al, 2004). In peri-urban areas of developing countries, e.g. China, sewage irrigation may affect heavy metal content in groundwater in the long term. The elevated level of heavy metals in the groundwater poses a substantial risk to local resource users and to the natural environment potentially. In China, the removal of heavy metals from groundwater has more and more captured the interest of the public and government (Yimin et al, 2006). Current research indicates that heavy metals cause two types of unfavorable processes in biological systems. Heavy metals inactivate several enzymes, including catalase, by binding to their SH-groups (sulfhydryl group) interfering with the tertiary and quaternary level of protein structure and denaturing the enzymes (Maleeka, 2001). Secondly, along with other heavy metals, lead can interfere with the cells ability to remove reactive oxygen species (ROS) and thus interfere with normal metabolism and vital cellular functions like electron transport chain (crucial to both mitochondrial and chloroplast function). Additionally, lead can decrease the number of mitochondrial cristae which in turn decreases oxidative phosphorylation and ATP synthesis. (Maleeka, 2001). Researchers indicates that the synergistic effects of lead, cadmium and manganese are poorly understood (Hensley, Kenneth, et al, 2004). Although zinc is a normal plant and animal system so-factor in trace amounts, the effects of zinc in combination with lead are still under investigation. The heavy metals investigated in this study have been implicated for various human health problems even at trace levels. The analyzed standard samples show recovery values ranging from 88–93% of the prepared standard (Ogundiran and Afolabi, 2008). Cadmium ranks 64th in order of abundance in the earth's crust, with an average concentration of 0.2ppm, which is less than that of zinc, copper, lead and chromium. Cadmium also occurs in various other natural materials such as magnetic rocks, shale's, sandstones, limestone and sediments in varying amounts. Cadmium levels ranging from 0.01 ppb to 0.4 ppb have also been reported in natural unpolluted fresh waters. Cadmium concentration up to 0.003 ppm, < 0.003 ppm, <0.025 ppm and 0.005ppm have also been reported in rivers of North America, Asia, Europe and UK respectively by UNEP in the year 1987. Cadmium concentrations ranging from 0.00008 ppm to 0.01 ppm have also been reported in selected rivers of various OECD countries which include rivers from Canada, Australia, France, Germany, Netherlands, and Switzerland. The average concentrations of cadmium in water from public water supplies in many large cities of the European communities were 0.0011 ppm. The concentration has, however, been found to vary between 0.0002 and 0.004 ppm. Cadmium concentrations varying from < 0.001 to 0.05 ppm has been reported in 480 water samples from Belgium. Cadmium levels varying from 0.04 ppm to 0.84 ppm

have also been reported in 72 sediment samples collected from various unpolluted lakes from South Africa, Africa and Australia. In air, the natural background cadmium levels lie below 0.1 mg/m^3 . (Sharmar2006). Cadmium is mainly used in industries involved in electroplating, nickel cadmium battery manufacture, pigment manufacture, galvanizing, plastic manufacture, alloy manufacture and glass manufacture. Cadmium enters air, water, soils, sediments, land application of sewage and terrestrial organism via atmosphere, water, suspended sediments, land application of sewage material and phosphate fertilizer and by waste dumping. The cadmium levels in atmosphere because of emissions from various sources may increase significantly. In urban areas have an average of $2, \text{ ng/m}^3$ has actually been determined and this is about 20 times above the natural background level. In sediments, the cadmium levels may exceed the base line levels of 0.04 to 0.84 ppm by several order of magnitude. Similarly, the concentration of cadmium in polluted fresh water may exceed the baseline levels of 0.01 to 0.04 ppm by several orders of magnitude. Cadmium may also be bio-accumulated in fresh water biota. In the case of aquatic plants cadmium has been found to be less toxic than invertebrates or fish. However, chronic effect may take place even at concentrations as low as 0.001 ppm. The toxicity of cadmium to algae may be reduced by the presence of natural organic compounds in the water, probably because of complexing of a part of cadmium and thereby reducing the concentration of the toxic forms. It has also been found that cadmium toxicity was reduced to chlorella in the presence of selenium. A major portion of Cd ingested into our body is trapped in the kidneys and eliminated. A small fraction is bound most effectively by the body proteins, metallothionein, present in the kidneys. The rest of the cadmium is stored in the body and gradually accumulates with age. Excessive amounts of Cd^{2+} ingested may replace Zn^{2+} at important enzymatic sites and hence cause metabolic disorders. (Sharmar2006). Heavy metal ions such as Hg^{2+} , Pb^{2+} and Cd^{2+} act as effective enzyme inhibitors. They have a great affinity for sulphur containing species (ligands) such as $-\text{SH}$ and $-\text{SCH}_3$ (in cysteine and methionine amino acids, which are part of the enzyme structure). Metalloenzymes contain metals in their structures. When one metal ion of a metalloenzyme is replaced by another metal ion of similar charge and size, the action of enzyme is inhibited. Cadmium has a strong inhibitory effect on metalloenzymes such as zinc-containing enzymes like alkaline phosphatase, thermolysin or copper-containing enzymes like ceruloplasmin. These enzymes do not function when zinc or copper of the metalloenzyme is replaced by cadmium. Carboxy peptidase, a zinc-containing metalloenzyme has peptidase and esterase activity. When cadmium replaces zinc, peptidase activity is abolished whereas esterase activity is retained. Thus the specificity of the enzyme is altered. (Sharmar,2006). The acute toxicity of cadmium for freshwater species was found to vary from 0.0018 ppm to 126 ppm. It has been found that acute toxicity of cadmium to fish is mainly caused due to gill damage, enabling the fish to obtain oxygen from water and results due to anoxia. It has also been reported that cadmium inhibits the action of acetyl cholinesterase causing death through paralysis of the respiratory muscles and/or depression of respiratory system. According to another view, the damage to the ion regulating mechanism in fish rather than respiratory impairment or damage to the nervous system is more likely to be the cause of death. The development stages and time of exposure can play a significant role in determining the cadmium toxicity. Growth and development stages are often being used as a basis for determining the maximum acceptable toxicant concentration (MATC). Australian Water Resources Council has reported MATC to vary from 0.0007 ppm to $> 0.087 \text{ ppm}$ for several species of fish. Several studies have also been carried out on the impact of cadmium on biochemical, histological, hematological and behavioral responses of fish. It has been found that there is a decrease in liver and kidney enzyme activities in rainbow trout following a chronic exposure to cadmium. The toxicity of the metal to fresh water fish depends upon the species, age, weight, water quality and presence of other toxicants. According to EPA (1980), ingestion of large amounts of cadmium e.g., 13 to 15 $\mu\text{g/g}$, leads to nausea, diarrhea, abdominal pain, muscular rheumatism and weakness. The acute lethal dose by ingestion has been estimated to be 5 to 50 $\mu\text{g/g}$ of body weight. Chronic cadmium poisoning was first recognized in industrial workers and mostly involved kidney damage and obstructive lung disease. Tubular proteinuria, the earlier symptoms of kidney damage has frequently been reported in industrial workers. (Sharmar, 2006). Cadmium builds up in the man's body over a prolonged period. An American may accumulate about 30 mg of Cd of which 33% is deposits in kidneys, 14% in liver, 3% in pancreas, 2% in lungs and the rest is distributed in other parts of body, viz., adrenals, postate, testes and thyroid. Cadmium, like other toxic metals, has a high affinity for sulphur containing ligands, e.g., $-\text{SCH}_3$ or $-\text{SH}$ in methionine and cysteine, the amino acids of many proteins. It inhibits action of certain enzymes like adenosine triphosphate, aldolase, cholinesterase, glucose- 6-p-dehydrogenase, glutamine oxaloactive transaminase, catalase, succinic dehydrogenase, S-ALA synthetase, lipomide dehydrogenase, tryptophan, oxygenase, leucine amino peptidase and succinic dehydrogenase of rat kidney. Hypertension in man is also said to be associated with high levels of cadmium or zinc in kidneys. Respiratory and pulmonary damage is reported to occur from the breathing of cadmium vapours. Since cadmium cannot create an adverse effect on central nervous system, so it cannot cross the placental barrier. Therefore, infants are normally quite free of cadmium. It accumulates with age until a maximum

level of 20 to 30 mg, is reached at the age of 50 years. When excessive amounts of Cd^{2+} are ingested, it replaces Zn^{2+} at key enzymatic sites, bringing about several metabolic disorders. Symptoms like bone pains, rheumatism and neuritis are also due to high dose of Cd^{2+} . Acute poisoning leads to vomiting, abdominal cramps and general weakness. (Sharmar, 2006). A recent study conducted in 1997 at the Indian Council for Medical Research (ICMR), Institute of Pathology in Safdarjang Hospital, New Delhi, has found alarming levels of toxic metals such as lead and cadmium in several placental tissues. This has sharply highlighted the hazardous of air pollution because these metals are both toxic and often, are the cause of many irreversible health effects. The study involved 101 women who delivered at the hospital's department of obstetrics and gynaecology. In the 82 samples analyzed so far, the average value of lead was 2.35 ppm and that of cadmium was 0.40ppm. These have been considered alarming because they are significantly higher than maximum acceptable limit. Strangely, arsenic was also found in high levels in quite a few samples. The researchers accuse vehicles running on leaded fuels as the main cause as far as presence of lead in the women's body is concerned. As for the formidable cadmium levels, they say that women were either smokers themselves or were clear victims of passive smoking. Other elements analysed were copper, zinc, nickel, manganese, cobalt, chromium and molybdenum. Levels of these elements, however, were more or less comparable to their amounts normally present in the human body. According to WHO, the acceptable weekly intake of cadmium should not be greater than 0.007 $\mu\text{g/g}$. If taken continuously and over a long period of time, cadmium accumulates in the kidney and liver causing extensive damage to these organs. And the fact that cadmium has long biological half life- cadmium levels in the body take a long time to go down through the processes of natural elimination-is no comfort either. Cadmium also affects the normal functions of plants. It can affect photosynthesis in several ways. It acutely affects biosynthesis of biomembranes and of the photosynthetic pigments, especially chlorophyll by inactivating the necessary enzymes. National and International regulating agencies have recommended that the total cadmium concentration should not exceed the maximum of 0.01 ppm in drinking water supply. These agencies include WHO, United States Public Health Service, India Council of Medical Research (ICMR), United States Environmental Protection Agency (EPA) and Indian Standards Institution (ISI). The Ministry of National Health and Welfare, Canada has recommended a maximum Cd concentration of 0.05 ppm in raw water. A maximum concentration of 2.0 ppm has been recommended for the discharge of cadmium containing effluents on inland surface waters by Indian Standards Institute (1981). United States Environmental Protection Agency had recommended maximum permissible concentration of 0.004 ppm and 0.002 ppm for the protection of aquatic life such as fresh water fish in Canadian and American waters respectively.

2. Materials and Method

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.

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 (oxide).
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°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°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. Heavy Metals Determination (AAS):

A measured quantity of the samples were transferred into a Kjeldahl flask; 20ml of concentrated nitric acid (HNO₃) was added and the sample pre-digested by heating gently for 20mins. More acid was thereafter added and digestion was continued for 30-40mins. Digestion was stopped when a clear digest was obtained. The flask was cooled and the content transferred into a 50ml volumetric flask and made to the mark with distilled water. The equipment was conditioned by auto-zeroing it with distilled water and with 2% HNO₃. The pre-treated sample was analyzed for heavy metals using the appropriate hollow cathode element of each metal of interest at the appropriate wavelength, lamp current, band-pass, and background correction.

4. Developed Model of E-coli for phreatic Aquifer at progressive phase condition

Derived model equation as presented below

$$C(x) \frac{\partial v(x)}{\partial t} - D_{A1} V^2 \frac{\partial C(x)}{\partial x} = \frac{V \partial C(x)}{\partial t}$$

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

C = Concentration [ML⁻³]

V = Velocity [LT⁻¹]

D_A = Dispersion number

T = Time [T]

X = Distance L

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

If $\frac{\partial x}{\partial t} = \frac{vc(x)}{\partial t}$

and $C_{(x)} \frac{\partial v(x)}{\partial t} = \beta \dots\dots\dots (2)$

We have $\frac{V \partial c(x)}{\partial t} + D_A v^2 \frac{\partial c(x)}{\partial x} = \beta \dots\dots\dots (3)$

Such that

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

By transformation of (4) we have

$$C_{(x)} = T_x$$

It then implies that $\frac{\partial c(x)}{\partial x} = T_x^1$

It can be obtained from separation of variables

$$\frac{\partial c(x)}{\partial x} = T_x^1$$

Substituting in (4) we have

$$V(T_x^1) = D_A v^2 T_x^1 - T_x \frac{\partial v(x)}{\partial t} \quad \dots\dots\dots (5)$$

Expanding further we get

$$VT_x^1 = D_A v^2 T_x^1 - T_x \frac{\partial v(x)}{\partial t} \quad \dots\dots\dots (6)$$

Dividing equation (6) by T_x we have

$$\frac{VT_x^1}{T_x} = D_A v^2 \frac{T_x^1}{T_x} - T_x \frac{\partial v(x)}{\partial t} \quad \dots\dots\dots (7)$$

Then it implies that

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

If $\frac{v\partial c(x)}{\partial t} = \lambda^2$

We have

$$\frac{VT^1}{T} = D_A v^2 \frac{x^1}{x} - \frac{\partial v(x)}{\partial t} = \lambda^2 \quad \dots\dots\dots (9)$$

Solving term by term, we have

$$\frac{VT^1}{T} = \lambda^2 \dots\dots\dots (10)$$

$$VT^1 = \lambda^2 T \dots\dots\dots (11)$$

Let $T_{(o)} = 0$

$$V(ST_{(s)} - T_{(o)}) - \lambda^2 T_{(s)} = 0 \dots\dots\dots (12)$$

Considering the boundary condition, we have

$$T_{(o)} = C_1$$

Where C_1 is the initial concentration?

$$V(ST_{(s)} - VC_1) - \lambda^2 T_{(s)} = 0 \dots\dots\dots (13)$$

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

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

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

Then $T_{(s)} = \frac{VC_1}{VC_1} - \lambda^2 \dots\dots\dots (17)$

$$Vs - \lambda^2 = 0 \dots\dots\dots (18)$$

$$Vs = \lambda^2$$

$$S = \frac{\lambda^2}{V} \dots\dots\dots (19)$$

$T_{(s)} = VC_1 e^{\frac{\lambda^2 t}{V}}$

 $\dots\dots\dots (20)$

$$D_A v^2 \frac{x^1}{x^1} = \lambda^2 \dots\dots\dots (21)$$

Where $X_{(o)} = C_2$

$$\boxed{X_{(t)} = D_A v^2 C_2 e^{\frac{\lambda^2}{D_A v^2 t}}}$$
 (22)

$$\frac{\partial v(x)}{\partial t} = \lambda^2$$
 (23)

$$S V_{(s)} - V_{(o)} = \lambda^2$$

Integrating the initial concentration for which $V_{(o)} = C_3$

$$S V_s - C_3 = \lambda^2$$
 (24)

$$S V_s = \lambda^2 + C_3$$
 (25)

Making V_s the subject relation gives

$$V_s = \frac{\lambda^2 + C_3}{S}$$
 (26)

Using Laplace inverse we obtain

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

$$\lambda^2 = \frac{Vt}{C_3}$$
 (27)

$$\text{If } \frac{VT^1}{T} = D_A v^2 \frac{x^1}{x} = - \frac{\partial v(x)}{\partial t} = \lambda^2$$
 (28)

If we let $C_{(s)} = T_{(x)}$ we have

$$\frac{VT^1}{T} = D_A v^2 \frac{x^1}{x} - \frac{\partial v(x)}{\partial t}$$
 (29)

Integrating both sides gives

$$VC_1 \ell^{\frac{\lambda^2}{v}t} = D_A v^2 C_2 = \ell^{\frac{\lambda^2}{D_A v^2}t} \quad \dots\dots\dots (30)$$

$$C_{(x)} = VC_1 \ell^{\frac{\lambda^2}{v}t} = D_A v^2 C_2 \ell^{\frac{\lambda^2}{D_A v^2}t} \quad \dots\dots\dots (31)$$

If $\lambda^2 = \frac{Vt}{C_3}$

We get

$$C_{(x)} VC_1 \ell^{\frac{\lambda^2 t}{v}} = D_A v^2 C_2 \ell^{\frac{v t^2}{C_2}} \quad \dots\dots\dots (32)$$

$$C_{(x)} = T_{(x)} T_{(t)} X_{(t)}$$

$$C_{(x)} = VC_1 \ell^{\left(\frac{\lambda^2 t}{v}\right)} \left(D_A v^2 C_2 \ell^{\frac{\lambda^2 t}{D_A v^2}} \right) \quad \dots\dots\dots (33)$$

Given the constraints below

Since $t = 0, X = 0 = C_m$

$$C_m = C_1 C_2$$

Such that $C_1 = \frac{C_m}{C_2} \quad \dots\dots\dots (34)$

$$C_{(x)} = \left(\frac{VC_m}{C_2} \ell^{\frac{\lambda^2 t}{v}} \right) \left(D_A v^2 \ell^{\frac{\lambda^2 t}{D_A v^2}} \right) \quad \dots\dots\dots (35)$$

By indices, it simplifies ts

$$C_{(x)} = V^3 D_A C_m \ell \left(\frac{\lambda^2 t}{v} + \frac{\lambda^2 t}{D_A v^2} \right) \dots\dots\dots (36)$$

Table 1: Concentration of E.coli at various Distances

Distance	Theoretical Value E-coli Conc.
3	9.60E-08
6	4.20E-08
9	3.37E-07
12	1.72E-07
15	3.20E-06
18	2.42E-04
21	4.76E-07
24	9.60E-07
27	2.88E-06
30	1.00E-05

Table 2: Concentration of E.coli at various Times

Time	Theoretical Value E-coli Conc.
10	9.60E-08
20	4.20E-08
30	3.37E-07
40	1.72E-07
50	3.20E-06
60	2.42E-04
70	4.76E-07
80	9.60E-07
90	2.88E-06
100	1.00E-05

Table 3: Comparison of theoretical value with experimental result of Cadmium versus Distance

Distance	Theoretical Value E-coli Conc.	Experimental Result of cadmium
3	9.60E-08	9.65E-06
6	4.20E-08	4.14E-08
9	3.37E-07	3.38E-04
12	1.72E-07	1.68E-06
15	3.20E-06	3.15E-04
18	2.42E-04	2.38E-05
21	4.76E-07	4.69E-07
24	9.60E-07	9.54E-06
27	2.88E-06	2.78E-05
30	1.00E-05	1.00E-06

Table 4: Comparison of theoretical value with experimental result of Cadmium versus time

Time	Theoretical Value E.coli Conc.	Experimental Result of Cadmium
10	9.60E-08	9.65E-06
20	4.20E-08	4.14E-08
30	3.37E-07	3.38E-04
40	1.72E-07	1.68E-06
50	3.20E-06	3.15E-04
60	2.42E-04	2.38E-05
70	4.76E-07	4.69E-07
80	9.60E-07	9.54E-06
90	2.88E-06	2.78E-05
100	1.00E-05	1.00E-06

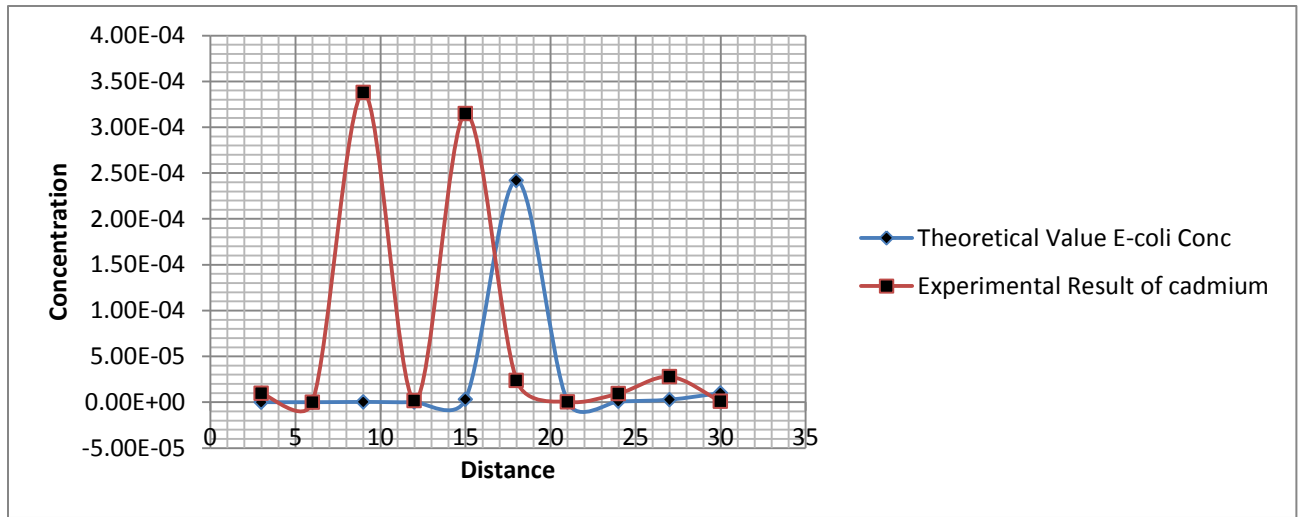


Figure 1: Comparison of experimental Data with theoretical value *E.coli* versus Distance

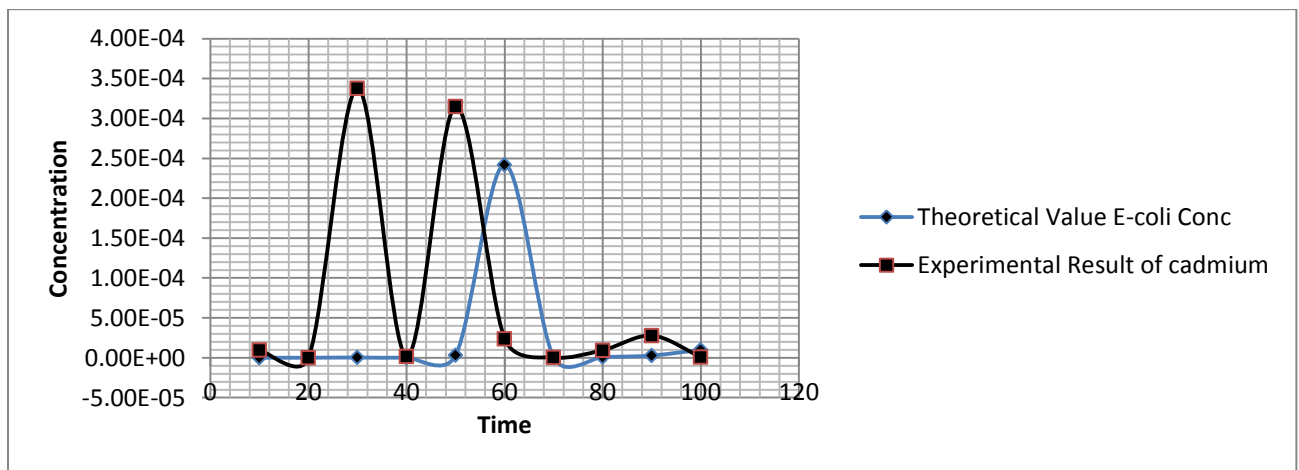


Figure 2: Comparisons of experimental Data with theoretical value *E-coli* versus time

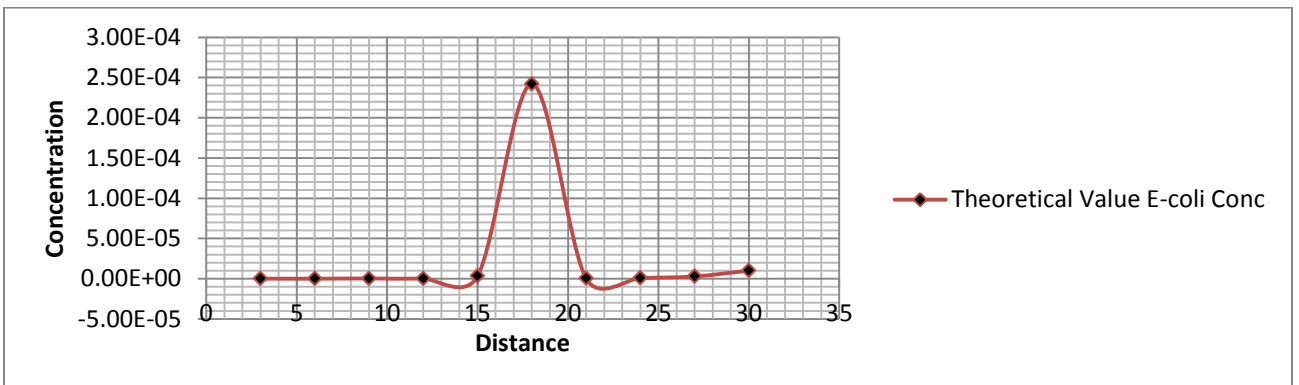


Figure 3: Concentration of *E.coli* at various times

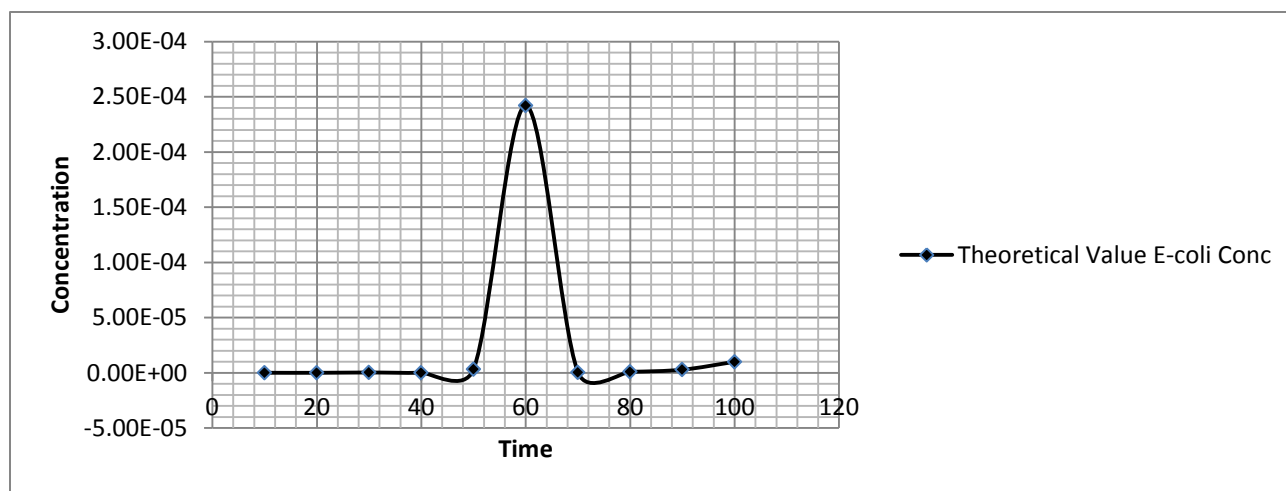


Figure 4: Concentration of E.coli at various times

The figure presented shows that the concentration gradually increase with distance to point where an optimum value were observed at eighteen metres, a sudden decrease with distance were recorded from twenty one metres to thirty metres, while that of experimental result generated an oscillation form of concentration where an optimum values were observed at nine metres fluctuating down to thirty metres. This explain the level of inhibition from cadmium inhibiting the microbes it was just at eighteen metres were the microbes find a favourable region and generate a higher microbial growth, but other region were inhibited by cadmium deposition. More so the effect on Distance may favour ground water quality in some condition, because in some deposition, at a certain level other influence may affect the level of migration through degradation and result to self purification, these can generate quality ground water. Figure 2 shows that the theoretical value gradually increase with distance were an optimum value was recorded at sixty days and suddenly decrease with time down to hundred days, while that of experimental result maintained a fluctuation form in its concentration, where an optimum value was recorded at nine days, and suddenly decrease in a fluctuation down to hundred days, this explain the level of inhibition with respect to time from cadmium, but the deposition reduced its concentration at ninety days and hundred days This predict the period when the microbes migrate to a region or stratum that is favourable for them. The model has predicted the time of migration and also defined the behaviour of the microbes in the system. This developed model definitely finds favour to the design of bore hole as a concept for design criteria, where Engineers can apply this standard as safety of factor that will produce a durable ground water engineering result for human utilization at every level for human consumption. figure three explain that the concentration increased with distance to a point where an optimum value were recorded at eighteen metres and suddenly decrease from twenty one to thirty metres with increase in distance, these shows that the rate of microbial transport from one aquifer to another soil formation where the microbes did not generate an increase in microbial population., it may be attributed to the level of porosity and geological depositions including environmental factors. While figure five presented shows that the concentration of E-coli uniformly increased with time to a point where an optimum value were achieved at eighteen metres, and suddenly

decrease with increase in time from seventy to hundred days, this explain the duration of microbes migration from one stratum to the other, their influence in these conditions may be attributed the level of geological depositions in the study area.

5. Conclusions

All homogenous formation in terms of geological formation has some other influence deposition on the study area. Therefore, the migration of microorganism and its behaviour in terms of growth is a subject matter of serious concern in terms of distance in groundwater deposition. Geological formation of the soil profile contributes to the characteristics of E.coli concentration at different aquifer. If the geological formation of the strata faviour the E.coli, a high population will be achieved in each day, but if the condition does not faviour the E.coli, they may die off. Therefore, the death rate depends on the type of geological formation, through their deposition, including other influences, which may contribute to any state they found themselves. This research work gives an ideal on the characteristics of E- coli in different aquifer in Tai Eleme 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 cadmium concentration at the study area. Comparing the level of concentration of cadmium from the theoretical result to the World Health Organization standard for quality water, it values proof insignificant.

References

- [1] Eluozo S. N (2006); Evaluationof Bore construction practice in Rivers State M.Eng Enviromental Engineering Thesis University of Port Harcourt p144
- [2] Yimin, A. (2008). Heavy metal-contaminated groundwater treatment by a novel nanofiber membrane, P. 4.
- [3] Yimin conference on Desalination and the Environment. Sponsored by the European Desalination Society and Center for Research and Technology Hellas (CERTH), 1993. Sani Resort, Halkidiki, Greece, P.3.
- [4] Sharma, R.S. and Al-Busaidi, T.S. (2001). Eng. Geol., 60 235–244.
- [5] Aziz, H.A. Yusoff, M.S. Adlan, M.N. Adnan N.H. and S. Alias (2004). Waste Manag., 24 353–358.
- [6] Gadd, G. M. and White, C. (1993).Trends Biotechnol., 11353–359.22–25, 20076
- [7] Jacques, W. D. (2007). Ground water engineering CRC Press Taylor & Francis Group 6000 Broken Sound Parkway NW, Suite 300Boca Raton, FL 33487-2742 by Taylor & Francis Group, LLC CRC Press is an imprint of Taylor & Francis group, an Informal business, p. 1.
- [8] Gadd, G.M. and White, C. (2007). Trends Biotechnology. 11353–359, pp. 22–25.
- [9] Hensley, K. (2004). “The Journal of Neuroscience” taken from “The Journal of Neuroscience. And conferences at the Oklahoma Medical Research Foundation. pp1-4

- [10] Hensley, K. (2006). "Grant Proposal to Study Tar Creek" Oklahoma Medical Research Foundation, pp 1-5
- [11] Maleeka, A. (2001). Antioxidative defense to lead stress in subcellular compartments of pea root cells. Acta Biochim Pol.48 (3):687-98(ISSN: 0001-527X)[Availableonline]<http://www.medscape.com/medline/abstract/11833777?prt=true>
- [12] O' Halloran, Thomas (2002). "Heavy Metals in Concert with Life". The Journal of Biological Chemistry. Vol. 274, 15041-15045.
- [13] Ogundira, O. O. and Afolabi, T.A. (2008). Assessment of the physicochemical parameters and heavy metals toxicity of leachates from municipal solid waste open dumpsite international journal of science and technology 5 (2), 243-2.