Research Open Journal of Environmental Engineering and Management
Vol. 1, No. 1, October 2013, PP: 01 - 12
Available online at http://scitecpub.com/Journals.php

Research article

PREDICTIVE MODEL TO EVALUATE PHYSIOCHEMICAL INFLUENCE ON THERMOTOLERANT TRANSPORT IN HOMOGENEOUS COARSE AND GRAVEL FORMATION PRESSURED BY DISPERSION USING COLLOID FILTRATION METHOD IN COASTAL AREA OF BAYELSA STATE, NIGER DELTA OF NIGERIA.

Eluozo, S. N.

Subaka Nigeria Limited Port Harcourt Rivers State of Nigeria
Director and principal consultant Civil and Environmental Engineering, Research and Development
E-mail: Soloeluozo2013@hotmail.com
E-mail: solomoneluozo2000@yahoo.com

Abstract

Predictive model to evaluate physiochemical influence on Thermotolerant transport in homogeneous coarse and gravel formation has been expressed, The pressured by dispersion using colloid filtration method were accessed, this generated a model in phases to monitor the behaviour of the microbes under the influence of physiochemical deposition in soil, characteristics of physiochemical properties in soil were confirm to develop some reaction with Thermotolerant contaminants in soil and water environment, this condition developed some influences on the contaminant migration in the strata, the study were able to developed a conceptual frame work that will be useful to experts to determine the strata that generate high percentage of Thermotolerant contaminant in coastal area of Bayelsa state.

Keywords: predictive model, physiochemical influence, Thermotolerant transport, and coarse and gravel

1. Introduction

Development of Groundwater the main basis of potable water supply for domestic has been express as the major man utilization of human. The application of agricultural uses in the southern part of Nigeria especially the Niger Delta express long retention time and natural due to filtration capacity of aquifers (Odukoya et al., 2002; Agbalagba et al., 2011; Ehirim and Ofor, 2011). Ground Water that is protected for drinking, satisfying in taste, and proper for domestic purposes is designated as drinkable water and must not restrain any substance or biological contamination (Horsfall and Spiff, 1998). Pollution of groundwater has steadily been enhanced particularly in our cities with lots of industrial activities, population growth, poor sanitation, land use for commercial agriculture and other factors accountable for ecological degradation (Egila and Terhemen, 2004). The concentration of pollutants in groundwater depends on the state and category of fundamentals introduced to naturally or by human activities and disseminated through the geological stratification of the area. Studies carried out said that petroleum refining contributes solid, liquid, and gaseous wastes in the surroundings (Ogbuagu, et al., 2011). Most of these wastes could include toxic components such as the polynuclear aromatic hydrocarbons (PAHs), these products have been reported to be the real contaminants of oil and most plentiful of hydrocarbons found in the crude oil mixture (El-Deeb and Emara, 2005). At any point it is introduced in the environment, PAHs could be stable for as short as 48 hours (e.g. naphthalene) or as long as 400 days (e.g. fluoranthene) in soils (Martens and Frankenberger, 1995). They thus, resist degradation and, remain persistent in sediments and when in organisms, could accumulate in adipose tissues and further transferred up the trophic chain or web (Decker, 1981; Boehm et al., 1981).

2. Theoretical background

Faecal directory microbes are non-pathogenic used to indicate the degree of faecal contamination. They are usually current in far superior numbers than pathogenic microorganisms and are easy to isolate, identify and enumerate. Faecal directory microbes include coliforms (total coliforms, Thermotolerant coliforms and *Escherichia coli*), intestinal enterococci Bacteriophages and clostridia. The existence of total coliforms, Thermotolerant coliforms, *E. coli* and intestinal enterococci in beach sand are subject to relation between their counts in beach sand and their counts in adjacent waters have comprised a significant area of research, with apparently contradictory results. Total coliforms, Thermotolerant coliforms and intestinal enterococci were secluded from exterior sand samples in Marseilles and Agde, France. Counts of intestinal enterococci, probably deriving from animals, were superior to counts of other index (Conseil Supérieur d'Hygiène Publique de France, 1990). High numbers of Thermotolerant coliforms and intestinal enterococci were isolated in beach sand along Taranto coastal waters in Italy (Signorile et al., 1992). Lesser numerical faecal index microbes were recorded in swimming areas in Tel Aviv, Israel, and in Barcelona, Spain (Figueras et al., 1992; Ghinsberg et al., 1994). Niger Delta water resources are found to be plentiful, but lack the quality for human consumption. Enlarged population is due to speedy growth in oil and gas industry instigated a raise in the demand for usable water. The stress is positioned on the operation of the groundwater resource. The area under concern in this study in the Niger Delta (Bayelsa State) suited within the Coastal alluvium, mangrove and fresh-water swamps hydrogeologic province. In this region, the Coastal Plain Sands which constitute the regional aquifer is highly lenticular and contains unequal lenses deposition of aquitard (Ekine and Osobonye, 1996). Various units region of aquifers are partially subdivided. Also, the trouble of high iron content is very important. Iron stains laundary, imparts abhorrent taste and colours food, corrodes casings, pipes and plumbing fixtures, and cooking utensils. Nevertheless, inspite of these tribulations, ground water exploitation are done indiscriminately without preliminary geological, geophysical and hydrogeological examination. Consequently produce water with high iron content from boreholes, seasonal or temporally efficient boreholes, and hence deserted hydrowells is ever-present in Bayelsa State. In order to progress the effectiveness of sitting high yield abstraction boreholes containing good quality water, predictable geophysics that offers remote and non-destructive methods for assessment of the subsurface should be employed.

The location lies between Longitudes 6º3! And 6º40! East and Latitudes 4º23.3! and 4º38.2! North and is situated in the Coastal area of the transitional surroundings of the previous Niger Delta (Fig. 1). The topography is invariably gentle. Average elevation stands at about 50 m above Sea level. 1700 mm/annum are known to be the average rainfall (Ako, 1982), adequate recharges are found to occur during the rainy season. There are a numeral of perennial streams and rivers found in area of survey. Network are formed these empties to the Atlantic Ocean. Consequently developed marshy terrain and in some cases form beaches. The study areas develop underlain Coastal Plain Sands (Benin Formation). The sediments of the Coastal Plain sands deposited during the Late Tertiary - Early Quaternary period, theses is about 2100 m thick (Abam, 1999) and it consists of enormous lenticular, unconsolidated coarse to medium - fine grained sands with localized clay/shale interbreeding in the formation. The sands are usually fairly sorted, poorly cemented, and angular in shape (Mbonu *et al*., 1991) .these has been recognized as fresh water bearing sands. Both confined and unconfined aquifers are encountered at varying depths. The deposition of is about 40-150 m thick overlying the Benin Formation through the superficial sediments making up the current day surface geomorphic zones in the delta, it consists of alternating sequences of sand, silt and clay with the latter becoming progressively more prominent seaward.

3. Governing Equation

Nomenclature

C	-	Concentration
P_b	-	Bulk density
θ	-	Porosity
S	-	Physiochemical
D	-	Dispersion
V		Velocity
X	-	Distance
T	-	Time

$$V\frac{\partial c}{\partial t} + \frac{P_b}{\theta} S \frac{\partial c}{\partial t} = D\frac{\partial^2 c}{\partial X^2} - V\frac{\partial c}{\partial X} \qquad \text{..................................} \qquad (1)$$

Applying physical splitting techniques on equation (1)

$$\frac{P_b}{\theta} S \frac{\partial c_1}{\partial t} = P_b \frac{\partial c_1}{\partial t} \qquad \text{..................................} \qquad (2)$$

$$\left.\begin{array}{l} t = 0, \quad x = 0 \\ C_{(o)} = 0 \\ \left.\frac{\partial c_1}{\partial t}\right| t = 0 \end{array}\right\} \qquad \text{..................................} \qquad (3)$$

$$V\frac{\partial c_2}{\partial t} = D\frac{\partial^2 c_2}{\partial X^2} \qquad \text{..................................} \qquad (4)$$

$$\left.\begin{array}{l} t = 0, \quad x = 0 \\ C_{(o)} = 0 \\ \left.\frac{\partial c_2}{\partial t}\right|_{t = 0} = 0 \end{array}\right\} \qquad \text{..................................} \qquad (5)$$

$$V\frac{\partial^2 c_3}{\partial t} = -\frac{V\partial c_3}{\partial X} \qquad \text{..................................} \qquad (6)$$

$$\left.\begin{array}{l} t = 0 \\ C_{(o)} = 0 \end{array}\right| t = 0 \Bigg\} \qquad \text{..................................} \qquad (7)$$

$$V\frac{\partial^2 c_4}{\partial X^2} = -V\frac{\partial c_4}{\partial X} \qquad \text{..................................} \qquad (8)$$

$$\left.\begin{array}{l} x = 0 \\ t = 0 \\ C_{(o)} = 0 \end{array}\right\} \qquad \text{..................................} \qquad (9)$$

$$\left.\frac{\partial c_4}{\partial X}\right| x = 0 \qquad \text{..................................} \qquad (10)$$

Applying direct integration on (2)

$$V\frac{\partial c}{\partial t} = \frac{P_b}{\theta}C + K_1 \quad \text{………………………………..} \quad (11)$$

Again, integrate equation (11) directly, yield

$$VC = \frac{P_b}{\theta}Ct + K_1 t \quad K_2 \quad \text{………………………………..} \quad (12)$$

Subject to equation (3), we have

$$VC_o = \quad K_2 \quad \text{………………………………..} \quad (13)$$

And subjecting equation (11) to (3)

$$at \left.\frac{\partial c_1}{\partial t}\right|_{t = 0} = 0 \quad C_{(o)} = C_o$$

Yield

$$0 = \frac{P_b}{\theta}C_o + K_2$$

$$\Rightarrow K_2 = -\frac{P_b}{\theta}C_o \quad \text{………………………………..} \quad (14)$$

So that, put (13) and (14) into (13), we have

$$VC_1 = \frac{P_b}{\theta}C_1 t - \frac{P_b}{\theta}C_o t + VC_o \quad \text{………………………………..} \quad (15)$$

$$VC_1 - \frac{P_b}{\theta}C_1 t = VC_o - \frac{P_b}{\theta}C_o t \quad \text{………………………………..} \quad (16)$$

$$\Rightarrow C_1\left(V - \frac{P_b}{\theta}t\right) = C_o\left(V - \frac{P_b}{\theta}t\right) \quad \text{………………………………..} \quad (16)$$

$$\Rightarrow C_1 = C_o \quad \text{………………………………..} \quad (17)$$

Hence equation (16) entails that at any given distance, *x*, we have constant concentration of the contaminant in the system. Now we consider equation (4) which is the progressive phase of the system.

$$V\frac{\partial c_2}{\partial t} = D\frac{\partial^2 c_2}{\partial X^2} \quad \text{…………………} \quad (4)$$

Approach this system using the Bernoulli's method of separation of variables

i.e. $$C_2 = XT \qquad \text{.....................................} \qquad (18)$$

i.e. $$V\frac{\partial c_2}{\partial t} = XT^1 \qquad \text{.....................................} \qquad (19)$$

$$\frac{\partial^2 c_2}{\partial X^2} = X^{11}T \qquad \text{.....................................} \qquad (20)$$

Put (19) and (20) into (18), so that we have

$$VXT^1 = DX^{11}T \qquad \text{.....................................} \qquad (21)$$

i.e. $$\frac{VT^1}{T} = \frac{DX^{11}}{X} = -\lambda^2 \qquad \text{.....................................} \qquad (22)$$

Hence $$\frac{VT^1}{T} + \lambda^2 = 0 \qquad \text{.....................................} \qquad (23)$$

$$X^{11} + \frac{\lambda^2}{V} = 0 \qquad \text{.....................................} \qquad (24)$$

And

$$DX^{11} + \lambda^2 T = 0 \qquad \text{.....................................} \qquad (25)$$

From (24) $$T = ACos\frac{\lambda}{V}t + BSin\frac{\lambda}{V}x \qquad \text{.....................................} \qquad (26)$$

And (19) gives:

$$T = C\ell^{\frac{-\lambda^2}{V}t} \qquad \text{.....................................} \qquad (27)$$

By substituting (25) and (26) into (18) we get:

$$C_2 = \left[ACos\frac{\lambda}{\sqrt{V}}t + BSin\frac{\lambda}{\sqrt{V}}x\right]C\ell^{\frac{-\lambda^2}{V}t} \qquad \text{.....................................} \qquad (28)$$

Subject equation (28) to condition in (5), so that we have

$$C_o = AC \qquad \text{.....................................} \qquad (29)$$

Equation (29) becomes:

$$C_2 = C_o \ell^{\frac{-\lambda^2}{D}t} \, Cos \frac{\lambda}{\sqrt{V}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (30)$$

Again at $\left.\frac{\partial c_2}{\partial t}\right| = 0, \quad x = 0$

$t = 0, B$

Equation (30), becomes:

$$\frac{\partial c_2}{\partial t} = \frac{\lambda}{\sqrt{V}} C_o \ell^{\frac{-\lambda^2}{D}t} \, Sin \frac{\lambda}{V} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (31)$$

i.e. $0 = -C_o \frac{\lambda}{\sqrt{V}} \, Sin \frac{\lambda}{\sqrt{V}} 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (31)$

$C_o \frac{\lambda}{\sqrt{V}} \neq 0$ Considering NKP

Which is the substrate utilization for microbial growth (population), so that

$$0 = -C_o \frac{\lambda}{\sqrt{V}} \, Sin \frac{\lambda}{\sqrt{V}} B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (32)$$

$$\Rightarrow \frac{\lambda}{\sqrt{V}} = \frac{n\pi}{2}, n,1,2,3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (33)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

So that equation (30) becomes

$$C_2 = C_o \ell^{\frac{-n^2\pi^2 V}{2D}t} \, Cos \frac{n\pi\sqrt{V}}{2\sqrt{V}} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (35)$$

$$C_2 = C_o \ell^{\frac{-n^2\pi^2 V}{2D}t} \, Cos \frac{n\pi}{2} x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (36)$$

We consider equation (6)

$$V \frac{\partial c_3}{\partial t} = -V \frac{\partial c_3}{\partial X} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

We approach the system by using the Bernoulli's method of separation of variables

$$C_3 = X^1 T \quad \ldots\ldots\ldots\ldots \quad (37)$$

$$\frac{\partial c_3}{\partial t} = XT^1 \quad \ldots\ldots\ldots\ldots \quad (38)$$

$$\frac{\partial c_3}{\partial X} = X^1 T \quad \ldots\ldots\ldots\ldots \quad (39)$$

Again, we put (38) and (39) into (37), so that we have

$$VXT^1 = VX^1 T \quad \ldots\ldots\ldots\ldots \quad (40)$$

i.e. $\frac{VT^1}{T} = \frac{VX^1}{X} = -\lambda^2$ ……………………………….. (41)

Hence $\frac{VT^1}{T} + \lambda^2 = 0$ ……………………………….. 42)

i.e. $X^1 + \frac{\lambda^2}{V} X = 0$ ……………………………….. (43)

And $VT^1 + \lambda^2 T = 0$ ……………………………….. (44)

From (44) $X = ACos\frac{\lambda}{\sqrt{V}}X + BSin\frac{\lambda}{\sqrt{V}}X$ ……………………………….. (45)

And (38) give

$$T = C\ell^{\frac{-\lambda^2}{V}t} \quad \ldots\ldots\ldots\ldots \quad (46)$$

By substituting (45) and (46) into (37), we get

$$C_3 = \left(ACos\frac{\lambda}{\sqrt{V}}x + BSin\frac{\lambda}{\sqrt{V}}x \right) C\ell^{\frac{-\lambda}{V}t} \quad \ldots\ldots\ldots\ldots \quad (47)$$

Subject (47) to conditions in (9), so that we have

$$C_o = AC \quad \ldots\ldots\ldots\ldots \quad (48)$$

∴ Equation (48) becomes:

$$C_3 = C_o \ell^{\frac{-\lambda^2}{V}t} Cos \frac{\lambda}{\sqrt{V}} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (49)$$

Again, at $\left.\frac{\partial c_3}{\partial t}\right|_{t = 0, B} = 0, \quad t = 0$

Equation (49), becomes:

$$\frac{\partial c_3}{\partial t} = \frac{\lambda}{\sqrt{V}} C_o \ell^{\frac{-\lambda^2}{D}t} \; Sin \frac{\lambda}{V} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (50)$$

i.e. $$0 = \frac{-C_o \lambda}{\sqrt{V}} \; Sin \frac{\lambda}{V} 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (51)$$

$$C_o \frac{\lambda}{\sqrt{V}} \neq 0 \quad \text{Considering NKP}$$

Which is the substrate utilization for microbial growth (population), so that

$$0 = -C_o \frac{\lambda}{\sqrt{V}} \; Sin \frac{\lambda}{\sqrt{V}} B \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (51)$$

$$\Rightarrow \frac{\lambda}{\sqrt{V}} = \frac{n\pi}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (52)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (53)$$

So that equation (30) becomes

$$C_3 = C_o \ell^{\frac{-n^2\pi^2 V}{4D}t} \; Cos \frac{n\pi\sqrt{V}}{2\sqrt{V}} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (54)$$

$$\Rightarrow C_3 = C_o \ell^{\frac{-n^2\pi^2 V}{4V}t} \; Cos \frac{n\pi}{2} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (55)$$

Now, we consider equation (8), which is the steady flow rate of the system

$$\frac{D\partial^2 c_4}{\partial X^2} = -V \frac{\partial c_4}{\partial X} \qquad \ldots\ldots\ldots\ldots\ldots \qquad (8)$$

Using Bernoulli's method, we have

$$C_4 = XT \qquad \text{.....................................} \quad (56)$$

$$\frac{\partial c_4}{\partial X^2} = X^{11}T \qquad \text{.....................................} \quad (57)$$

$$\frac{\partial c_4}{\partial X} = X^1T \qquad \text{.....................................} \quad (58)$$

Put (57) and (58) into (8), so that we have

$$DX^{11}T = -VX^1T \qquad \text{.....................................} \quad (59)$$

i.e. $\frac{DX^{11}}{X} = \frac{VX^1}{X} = \varphi$ .... (60)

$$\frac{DX^{11}}{X} = \varphi \qquad \text{.....................................} \quad (61)$$

$$\frac{-VX^1}{X} = \varphi \qquad \text{.....................................} \quad (62)$$

$$X = A\frac{\varphi}{D}X \qquad \text{.....................................} \quad (63)$$

And $X = B\ell\frac{-\varphi}{V}X$ .... (64)

Put (63) and (64) into (56), gives

$$C_4 = A\ell^{\frac{\varphi}{V}x} \; B\ell^{\frac{-\varphi}{V}x} \qquad \text{.....................................} \quad (65)$$

$$C_4 = AB\ell^{(x-x)}\frac{\varphi}{V} \qquad \text{.....................................} \quad (66)$$

Subject equation (66) and (67) yield

$$C_{(4)} = (o) = C_o \qquad \text{.....................................} \quad (67)$$

So that, equation (68) becomes

$$C_4 = C_o\ell^{(x-x)}\frac{\varphi}{V} \qquad \text{.....................................} \quad (68)$$

Now assuming that, at the steady flow, there is no NKP for substrate utilization, our concentration here is zero, so that equation (68) becomes

$$C_4 = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (69)$$

Therefore solution of the system is of the form

$$C = C_1 + C_2 + C_3 + C_4 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (70)$$

We now substitute (17), (36), (55) and (69) into (70), so that we have the model of the form

$$C = C_o + C_o \ell^{\frac{-n^2\pi^2 V}{2D}t} \bullet {}^{\frac{n^2\pi^2 V}{4D}x} \, Cos \frac{n^2\pi^2}{4} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (71)$$

$$\Rightarrow \; C = C_o \left[1 + \ell^{\frac{-n^2\pi^2 V}{2D}t} \bullet {}^{\frac{n^2\pi^2 V}{4D}x} \, Cos \frac{n^2\pi^2}{4} x \right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (72)$$

4. Conclusion

Physiochemical influence on Thermotolerant transport in homogeneous coarse and gravel formation pressured by dispersion using colloid filtration method were through column experiment. This is through the attachment of the microbes at the particle grain in the formation, phreatic formation may be polluted, when wastewater penetrates into the soil by recharges groundwater via leaking sewerage systems, leakage from manure, wastewater or sewage sludge spread by farmers on fields, waste from animal feedlots, waste from healthcare facilities, leakage from waste disposal sites and landfills, or artificial recharge of treated waste water. These sources of pollution transport of Thermotolerant to ground water aquifers were developed mathematically to monitor gravel and coarse formation in the deltaic area, the distance from source of the pollution to point of abstraction is small, and there is a real chance of abstracting microbes. To predict the presence of Thermotolerant in water, usually a separate group of microorganisms is used. To monitor this process, mathematical model were developed through a governing equation modified from variables that influence the transport of Thermotolerant pressured by dispersion in the study area.

References

[1] Agbalagba, O.E., Agbalagba, O.H., Ononugbo, C.P., Alao, A.A. (2011). Investigation into the physico-chemical properties and hydrochemical Processes of groundwater from commercial boreholes in Yenagoa, Bayelsa State, Nigeria. African Journal of Environmental Science and Technology, 5(7), 473-481.

[2] Ehirim, C.N., Ofor, W. (2011). Assessing Aquifer vulnerability solid wastes landfill Sites in a Coastal Environment, Port Harcourt, Nigeria. Trends in Applied Sciences Research, 6(2), 165 –173.

[3] Horsfall, M., Spiff, A.I. (1998). Principles of environmental Chemistry. Metrol Prints Ltd, Nigeria, pp. 107–118. Martens, D.A., Frankenberger, Jr.T. (1995). Enhanced Degradation of Polycyclic Aromatic ydrocarbons in soil treated with an Advanced Oxidative Process—Fenton's Reagent. Journal of Soil Contamination, 4(2), 175-190.

[4] Odukoya, O.O., Arowolo, T.A., Bamgbose, O. (2002). Effect of Solid Waste. Landfill on underground and surface water quality at Ring Road, Ibadan. Global J. Environ. Sci., 2(2), 235–242.

[5] Ogbuagu, D.H., Okoli, C.G., Gilbert, C.L., Madu, S. (2011). Determination of the contamination of roundwater sources in Okrika Mainland with Polynuclear Aromatic Hydrocarbons (PAHs). British Journal of Environment & Climate Change, 1(3), 90-102.

[6] Decker, J.C. (1981). Potential health hazards of toxic residues in sludge. In sludge-health risk of land application. Ann. Arbon. Sci. Publ. Inc., pp, 85-102.

[7] Egila, J.N., Terhemen, A. (2004). A preliminary investigation into the quality of surface water in the environment of Benue Cement Company Plc. Gboko, Benue State. Nigeria. Int. J. Sci. Tech., 3(1), 12-17.

[8] Martens, D.A., Frankenberger, Jr.T. (1995). Enhanced Degradation of Polycyclic Aromatic Hydrocarbons in soil treated with an Advanced Oxidative Process—Fenton's Reagent. Journal of Soil Contamination, 4(2), 175-190.

[9] Gordon T. Amangabara1* and John D. Njoku Assessing Groundwater Vulnerability to the Activities of Artisanal Refining in Bolo and Environs, Ogu/Bolo Local Government Area of Rivers State; Nigeria *British Journal of Environment & Climate Change*

[10] Abam, T.K.S., 1999. Dynamics and quality of water resources in the niger delta. Impacts of urban growth on surface water and groundwater quality. Preceedings of IUGG Symposium, Birmigham, Publication no. 259.

[11] Ako, B.D., 1982. Geophysical prospecting for groundwater in an area without adequate geological data base. J. Min. Geolog., 18: 88-105.

[12] Ekine, A.S. and G.T. Osobonye, 1996. Surface geoelectric sounding for the determination of aquifer characteristics in parts of Bonny Local Government Area of Rivers State. Niger. J. Phys., 85: 93-97.

[13] Mbonu, P.D.C., J.O. Ebeniro, C.O. Ofoegbu and A.S. Ekine, 1991. Geoelectric sounding for the determination of aquifer characteristics in parts of the Umuahia area of Nigeria. Geophys., 56: 284-291.

[14] Figueras MJ, Guarro J, Soler L, Inza I, Polo F (1992) Estudio piloto sobre la contamination de las playas del litoral Catalan. [A pilot study on the contamination of Catalounian beaches.] Proceedings of the 1° Congreso Nacional del Medio Ambiente, adrid.

[15] Signorile G, Montagna MT, Sena G, Cavallo RA (1992) Bacteriological surveys in waters and sands of Taranto coastal areas. *L'Igiene Moderna*, 98(3): 475–483.

[16] Ghinsberg RC, Leibowitz P, Witkin H, Mates A, Seinberg Y, Bar DL, Nitzan Y, Rogol M (1994) *Monitoring of selected bacteria and fungi in sand and seawater along the Tel-Aviv coast.*