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Research article

MODELLING AND SIMULATION OF PRESSURE FLOW INFLUENCES ON SALMONELLA DEPOSITION PENETRATING UNCONFINED BED IN LATERITIC AND SILTY FORMATIONS IN COASTAL AREA OF BUGUMA; RIVERS STATE OF NIGERIA.

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Abstract

Pressures of flow influences on salmonella were found to be one the characteristic of microbial transport in penetration unconfined bed. The study were able to monitor the change in concentration with respect to time and distances at shallow depth to Phreatic zone, these condition implies that the transport of this microbes are found to migrate at every stratum within short period of time base on the pressure high flow in the coastal location, the rate of migration were influences by high degree of porous formation deposited in the study area, such condition has established fast migration with high concentration of salmonella in the study location, penetrating unconfined bed in the study location deposited fracture from disintegrating sediment developing linear migration through the fracture from sand stone transiting to unconfined bed. such condition that deposited high percentage of pore distribution from lateritic to silty formation were the unconsolidated sand stone with fracture, the porosity of the silty formation were through the pore distribution of the formation from the transition zone at the sand stone to unconfined deposition in the coastal location. These condition were experienced on physical process, while on ground water exploration it resulted to abortive well due to pollution from deposition of salmonella, monitoring and evaluation were the best option in other to determined the migration process and rate of concentration, mathematical method were found appropriate, it was applied by developing the model and simulating it, theoretical values were generated and it was compared with other data from column experiment, both values developed favuorable fits to validate the model, the study is imperative because the rate of migration including stratum that deposit highest level of salmonella concentration has been observed. Experts will definitely apply these conceptual tools to monitor the migration rate of salmonella in the study location.

Keywords: modeling and simulation, pressure flow, salmonella deposition, and silty formation.

1. Introduction

Over the last few decades deterioration of both the quality and quantity of groundwater has become a global phenomenon, which will further intensify the demand for drinking Water increases [22]. Numerous severe cases of groundwater contamination with reference to storm water infiltration have been documented worldwide [1,2and 3]. Few studies have also been documented nationally on groundwater with reference to major ions, trace elements and bacteriology [4, 5, and 6. However literature is silent on the impact of storm water infiltration into groundwater. In recent years attention on the increasing ionic concentration of traces metals in groundwater as result of storm water infiltration has been studied by various workers [7, 8, 9, 10, 11, 12, and 13]. These have been attributed to human interference, proliferation of industries and recent agriculture practices in urban areas where storm water flow recharges the aquifer system and thus degrading the water quality. It is often difficult to determine the exact source of major ions pollutants [12] because there are many potential sources of groundwater contamination including urban storm water runoff. Storm water infiltration in urban areas is cause of concern with regard to the risk of groundwater pollution [13, 6]. Storm water infiltration has been shown to affect groundwater quality and quantity [2, 9]. Contaminants present in urban storm water include volatile organic compound, pesticides, nutrients, and trace elements [2]. This can originate at the land surface or in the atmosphere [1]. Some constituents either volatize during storage or sorbs to the particulate matter [13,11]and are not transported to the water table; however, are more persistent, and may threaten groundwater quality. Malmquist & Hard (1981) studied the impacts from sub surface infiltration at three sites in Sweden and concluded that storm water infiltration affects the groundwater quality to a small extent. In a vast majority of developing countries, fast growing populations combined with poor living conditions in rural areas have forced many people to migrate to cities in search of better living conditions. This has led to a dramatic expansion of most of the major cities throughout developing countries, mainly via the uncontrolled growth of slums or squatter settlements on their fringes [14, 15, 16, 17,]. Nitrogen is one of the most abundant elements in the Earth's biosphere and one of the six elements (C, H, O, N, P, and S) that are the major constituents of living tissue. Nitrogen gas (N2) comprises approximately 78% of the Earth's atmosphere, but this is largely unavailable as a nitrogen source for most living organisms. Consequently, nitrogen availability in all ecosystems is largely dependent on inputs of biologically available nitrogen from external sources or internal cycling of nitrogenous compounds into biologically available forms. Nitrogen often limits biological production in estuaries, oceans, and many terrestrial systems (Schlesinger 1997[16,18] 12,13and 15], and can be limiting in lakes (White et al. 1985, Dodds et al. 1993), streams [22], and wetlands [20;21].

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2. Governing equation

$$\bar{V}\frac{\partial c^2}{\partial t^2} = \bar{K}h_{(x)}\frac{\partial c}{\partial Z} - \frac{Q}{n_e}\frac{\partial c}{\partial Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Nomenclature

C	=	Salmonella concentration	$[ML^{-3}]$
$H_{(x)}$	=	Aquifer thickness	[L]
$\bar{K}$	=	Homogenous permeability	$[LT^{-1}]$
Q	=	Rate of flow	$[LT^{-1}]$
Ne	=	Porosity	[-]
T	=	Time	[T]
Z	=	Variation Depth	[L]

Substituting $C = TZ$

$$\bar{V}\,ZT^{11} = \bar{K}h_{(x)}Z^1T - \frac{Q}{n_e}Z^1T$$

Dividing by T,Z, we have

$$\bar{V}\frac{T^{11}}{T} = \bar{K}h_{(x)}\frac{Z^1}{Z} - \frac{Q}{n_e}\frac{Z^1}{Z} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

$$\bar{V}T^{11} = \bar{K}h_{(x)}Z^1 - \frac{Q}{n_e}Z^1 = \beta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

$$\bar{V}\frac{T^1}{T} = \beta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (4)$$

$$\bar{K}h_{(x)}\frac{Z^1}{Z} = \beta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (5)$$

$$-\frac{Q}{n_e}\frac{Z^1}{Z} = \beta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (6)$$

This implies that equation (5) and (6) can be expressed as:

$$\left[\bar{K}h_{(x)} - \frac{Q}{n_e}\right]\frac{Z^1}{Z} = \beta^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (7)$$

$$\bar{V}\frac{T^{11}}{T}\frac{dc}{dt} = \beta^2 \qquad \ldots\ldots\ldots\ldots \qquad (8)$$

$$\bar{V}\frac{d^2}{dt^2} = \beta^2 \qquad \ldots\ldots\ldots\ldots \qquad (9)$$

$$\bar{K}h_{(x)}\frac{dc}{dz} = \beta^2 \qquad \ldots\ldots\ldots\ldots \qquad (10)$$

$$\frac{Q}{n_e}\frac{dc}{dz} = \beta^2 \qquad \ldots\ldots\ldots\ldots \qquad (11)$$

$$d^2z = \left[\frac{\beta^2}{\bar{\bar{V}}}\right] = dz \qquad \ldots\ldots\ldots\ldots \qquad (12)$$

$$\int d^2 - \int\frac{\beta^2}{\bar{\bar{V}}}dz \qquad \ldots\ldots\ldots\ldots \qquad (13)$$

$$dz = \frac{\beta^2}{\bar{\bar{V}}}z + C_1 \qquad \ldots\ldots\ldots\ldots \qquad (14)$$

$$\int dz = \int\frac{\beta^2}{\bar{\bar{V}}}z\ dz + C_1\int dz \qquad \ldots\ldots\ldots\ldots \qquad (15)$$

$$z = \frac{\beta^2}{\bar{\bar{V}}}\frac{z^2}{2} + C_1 + C_2 \qquad \ldots\ldots\ldots\ldots \qquad (16)$$

$$z = \frac{\beta^2}{\bar{\bar{V}}}\frac{z^2}{2}\ C_1z + C_2 \qquad \ldots\ldots\ldots\ldots \qquad (17)$$

$$z = 0$$

$$z = 0$$

$$\boxed{z = \frac{\beta^2}{2\bar{\bar{V}}}z^2 + C_1z + C_2} \qquad \ldots\ldots\ldots\ldots \qquad (18)$$

Auxiliary Equation becomes:

$$\Rightarrow \frac{\beta^2}{2\overline{V}} z^2 + C_z + C_2 = 0 \qquad \ldots\ldots\ldots\ldots \qquad (19)$$

Applying quadratic expression we have

$$M = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad \ldots\ldots\ldots\ldots \qquad (20)$$

$$M_{1,2} \quad \frac{-C_1 \sqrt{C^2 - 4\frac{(\beta^2)}{4\overline{V}} C_2}}{\frac{\beta^2}{\overline{V}}} \qquad \ldots\ldots\ldots\ldots \qquad (21)$$

$$M_1 = \frac{-C_1 + \sqrt{C^2 - 2C_2 \frac{\beta^2}{2\overline{V}}}}{\frac{\beta^2}{\overline{V}}} \qquad \ldots\ldots\ldots\ldots \qquad (22)$$

$$M_2 = \frac{-C_1 - \sqrt{C_1^{\ 2} - 2C_2 \frac{\beta^2}{\overline{V}}}}{\frac{\beta^2}{\overline{V}}} \qquad \ldots\ldots\ldots\ldots \qquad (23)$$

Assuming this discriminate is a complex root; therefore, equation (22) and (23) can be expressed as:

$$\boxed{C = [T, Z] = D_1 \, Cos \, M_1 t + D_2 \, Sin \, M_2 z} \qquad \ldots\ldots\ldots\ldots \qquad (24)$$

But if $t = \frac{d}{v}$

$$\boxed{C = [T, Z] = D_1 \, Cos \, M_1 \frac{d}{V} + D_2 \, Sin \, M_2 \frac{d}{V}} \qquad \ldots\ldots\ldots\ldots \qquad (25)$$

And Z = $V.T$

$$\boxed{C = [T, Z] = D_1 \, Cos \, M_1 V.t + D_2 \, Sin \, M_2 V.t} \qquad \ldots\ldots\ldots\ldots \qquad (26)$$

3. Materials and method

Standard laboratory experiment where performed to monitor the rate of salmonella concentration using column experiment at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different locations, this samples collected at different location generate variation at different depth producing different migration of salmonella concentration through pressure flow at different strata, the experimental result are applied to compare with the theoretical values to determined the validation of the model.

4. Result and Discussion

Results and discussion are presented in tables including graphical representation of salmonella concentration

Table 1: Theoretical values of Salmonella concentration at different depths

Depth [m]	Concentration Mg/L
3	7.11E-03
6	0.0142
9	0.021
12	0.028
15	0.035
18	0.042
21	0.049
24	0.056
27	0.064
30	0.071

Table 2: Theoretical values of Salmonella concentration at different depth

Time per day	Concentration Mg/L
10	0.41
20	0.83
30	1.25
40	1.67
50	2.09
60	2.51
70	2.92
80	3.34
90	3.76
100	4.18

Table 5: Comparison of Theoretical and Measured Values of Salmonella Concentration Different Depth

Depth [m]	Theoretical Values	Measured Values
3	7.11E-03	6.00E-03
6	0.0142	0.012
9	0.021	0.018
12	0.028	0.024
15	0.035	0.03
18	0.042	0.036
21	0.049	0.042
24	0.056	0.048
27	0.064	0.054
30	0.071	0.06

Table 6: Comparison of Theoretical and Measured Values of Salmonella Concentration Different Time

Time per day	Theoretical Values	Measured Values
10	0.41	0.4
20	0.83	0.81
30	1.25	1.22
40	1.67	1.63
50	2.09	2.04
60	2.51	2.45
70	2.92	2.88
80	3.34	3.27
90	3.76	3.68
100	4.18	4.09

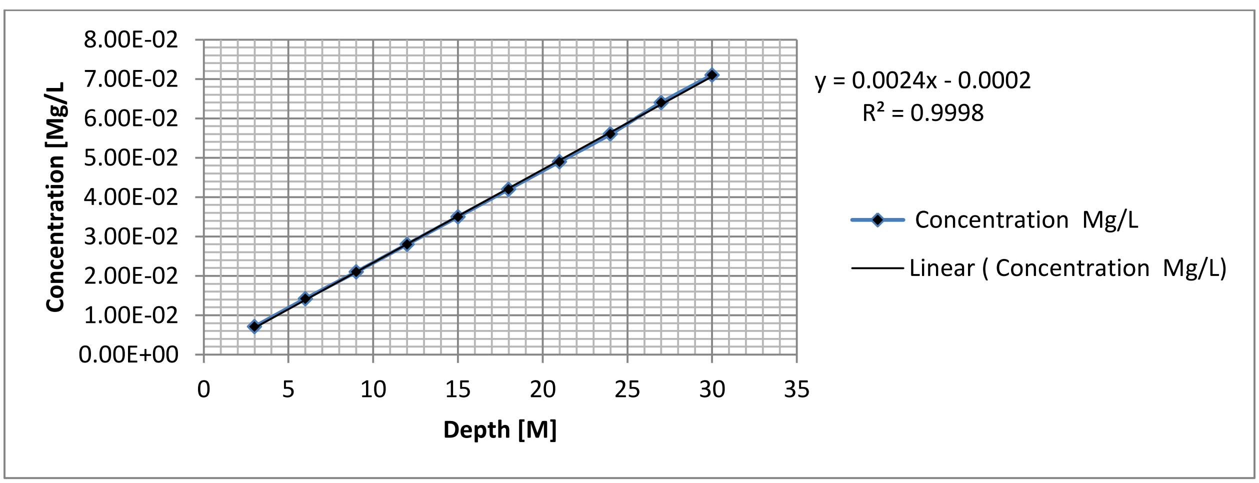

Figure 1: Theoretical values of Salmonella concentration at different depth

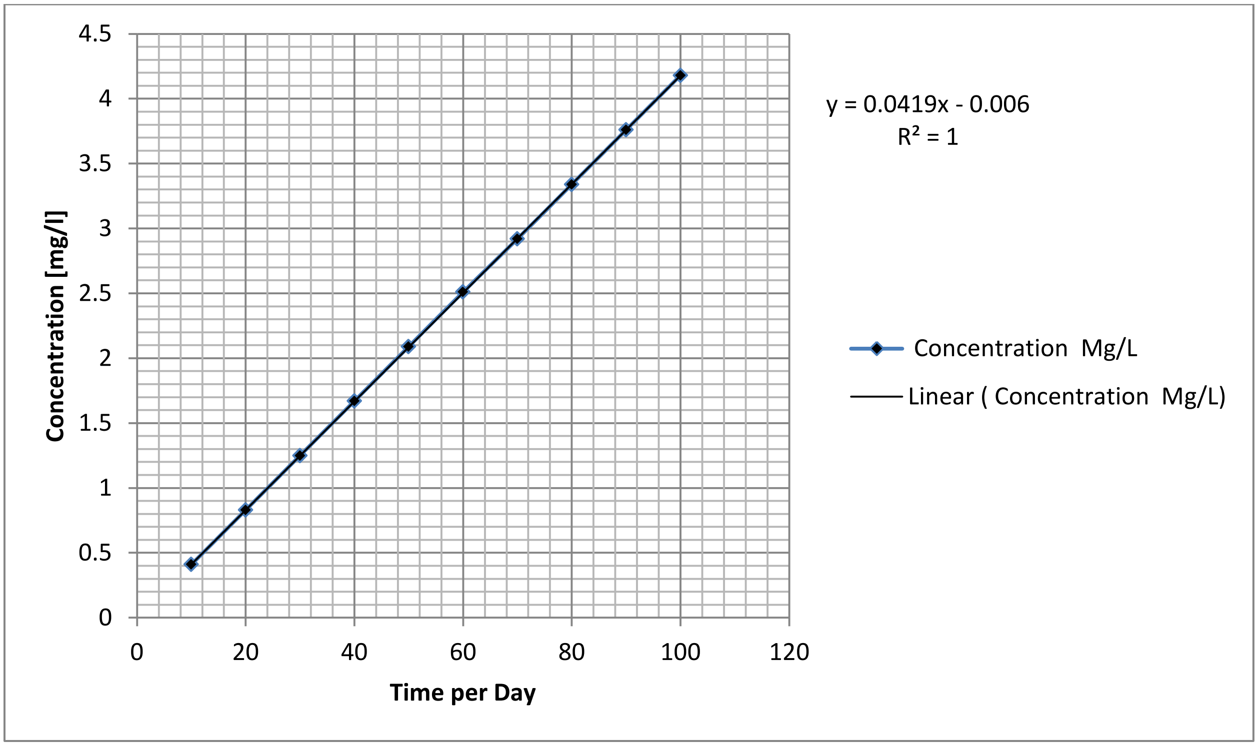

Figure 2: Theoretical values of Salmonella concentration at different Time

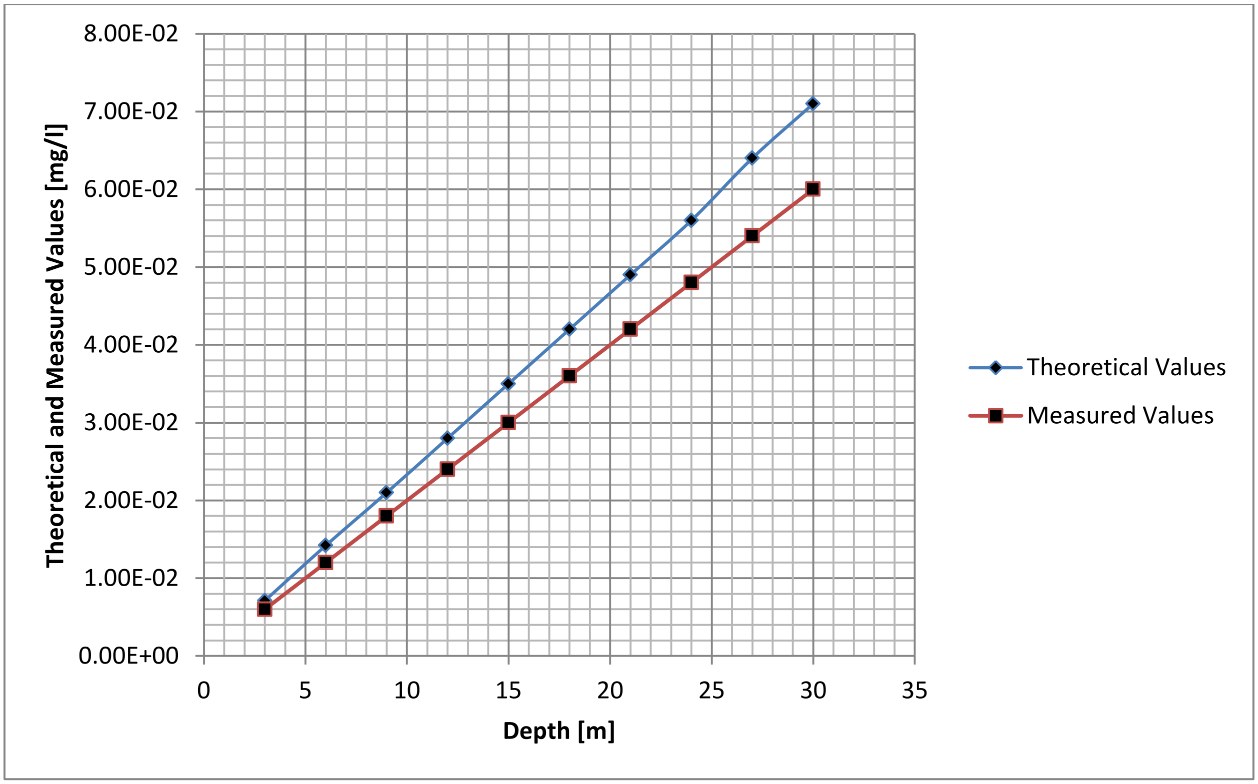

Figure 3: Comparison of Theoretical and Measured Values of salmonella Concentration at Different Depth

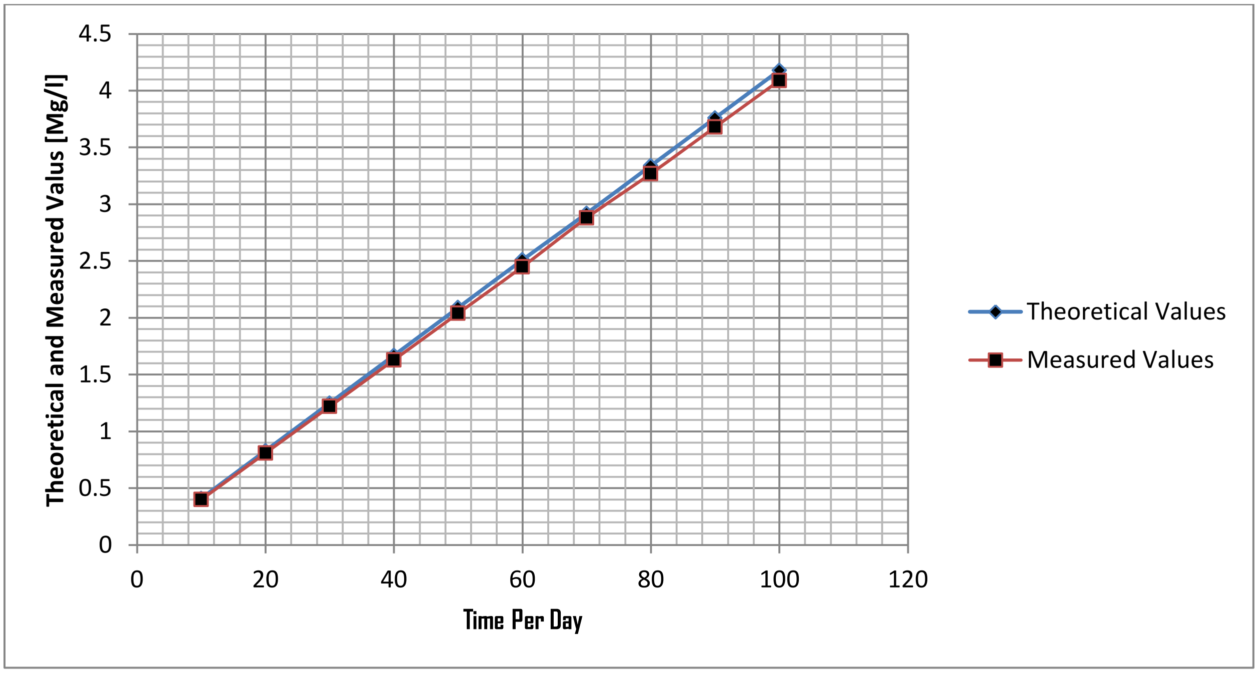

Figure 4: Comparison of Theoretical and Measured Values of salmonella Concentration at Different Time

The study on the migration of salmonella in coastal area has been thorough expressed in the system, developing the following graphical representation. Rapid migration were observed from the lowest at 3m to the optimum at 30m, the behaviour of microbes are base on the structural setting of the strata, the rate of porosity from the transition zone to silty formation were observed, such condition developed fracture at the porous sand stone, the migration of this microbes are influenced by these condition as rapid concentration are observed at thirty metres, the theoretical values were compared with experimental values, both values developed favuorable fit validating the model.

5. Conclusion

Ground water pollution has been a serious threat to most coastal area in deltaic environment. Since it's a valuable resources, most people around the globe relies on ground water exploration and exploitation, the quality of water is what border most settler of the deltaic environment, salmonella are constantly cause lots of hundred of death in the deltaic location, due to high deposition of the contaminants in the study area. The deposition of the microbes were found to become predominant through the structural setting of the formation, high degree of porosity from the lateritic soil transiting through a porous sand stone to silty formation pressured the rapid migration of salmonella to Phreatic zone, the rate of pollution sources were observed through a physical process in ground water exploration in the study location. To solve these problem, mathematical modeling techniques were found appropriate in other to monitor and evaluate the deposition and concentration level of the microbes, the developed governing equation produced a model to predict the deposition of the microbes in the study location, the developed model were simulated, theoretical values were generated thus experimental values were compared with the theoretical values, both parameters generated favuorable fits validating the model, experts will definitely find this model as a useful tools in monitoring and evaluating the deposition of salmonella in coastal area of Buguma.

References

[1] Lops, T.J., & Bender, D.A. (1998). Non point sources of volatile organic compounds in urban areas relative importance of land surfaces and air, Environmental Pollution, vol. 101, no. 2, p. 221-230.

[2] Fisher, D., Charles, E. G., & Baehr, A. L. (2003). Effects of storm water infiltration on quality of groundwater beneath retention and detention basins, Journal of Environmental Engineering, vol. 129, no. 5, p. 464 – 471

[3] Zubair, A. (1998). Groundwater pollution and its environmental impact on health in Karachi region Pakistan, Ph D thesis, University of Ulster, Northern Ireland, UK, p. 113- 123.

[4] Rahman, A., Lee, H.K. & Khan, M.A. (1997). Domestic water contamination in rapidly growing megacities of Asia : a case of Karachi, Pakistan, Environmental Monitoring & Assessment, vol. 44, p. 339-360.

[5] Ku. I.F.H., Hagelin N.W., & Buxton H.T. (1992). Effects of urban storm runoff control on groundwater recharge in Nassau County, New York, Groundwater, vol. 30, no. 4, p. 507-514

[6] Zubair A 2007 groundwater pollution resulting from storm water infiltration in Karachi department of environmental sciences federal urdu university of art, science & technology gulshan-e-iqbal campus, karachi-75300, Pakistan

[7] Wilde, F.D. (1994). Geochemistry and factors affecting groundwater quality at three storm water management sites in Maryland, Report of Investigations no. 59, Maryland Geological Survey, Baltimore, Md., p. 201.

[8] Pitt, R. (1996). Groundwater contamination from storm water infiltration, Ann Arbor Press, Chelsea, Michigan**,** p. 83-135.

[9] Eluozo S.N Nwaoburu A.O 2013 Mathematical model to predict adsorption rate of potassium influenced by permeability in lateritic and silty soil formation in coastal area of eagle island, Port Harcourt, Niger delta of Nigeria International Journal of Sustainable Energy and Environment Vol. 1, No. 5, June 2013, PP: 111 –119,

[10] Ford, M. (1990). Extent, type and sources of inorganic groundwater below the Birmingham conurbation, Ph D thesis, University of Birmingham

[11] Mikkelsen, P.S., Weyer, G., Berry, C. Walden, Y., Colandini, V., Poulsen, S. Grotehusmann, D. & Rohlfing, R. (1994). Pollution from urban storm water infiltration, Water Science and Technology**,** vol. 29, no. 1-2, p. 291-302.

[12] Mikkelsen, P.S., Jacobsen, P., & Fujita, S. (1996). Infiltration practice for control of urban storm water, Journal Hydraulic Research, vol. 34, no. 6, p. 827-840.

[13] Soupir M. l. Mostaghimi1 1, S, . Yagow1 E .R, Hagedorn C. and. Vaughan D. H 2006 transport of fecal bacteria from poultry litter and cattle manures applied to pastureland Water, Air, and Soil Pollution pp 169: 125–136

[14] Wang, H., Ou, L ., Che, W. & Li, J. (2003). Soil infiltration and purification of storm water runoff in Beijing urban area, IWP publishing, Water Intelligence Online, p. 135.

[15] Crowther, J., Kay, D. and Wyer, M. D.: 2002, 'Faecal-indicator concentrations in waters draining lowland pastoral catchments in the UK: Relationships with land use and farming practices', *Water Res*. **36**(7), 1725–1734

[16] Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological Applications. 8: 559-568.

[17] Marco, A., C. Quilchano, and A.R. Blaustein. 1999. Sensitivity to nitrate and nitrite in pond-breeding amphibians from the Pacific Northwest, USA. Environmental Toxicology and Chemistry. 18: 2836-2839.

[18] Vitousek, P.M., J. Aber, R.W. Howarth, G.E. Likens, P.A. Matson, D.W. Schindler, W.H. Schlesinger, and D.G. Tilman. 1997. Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications. 7: 737-750.

[19] Crowther, J., Kay, D. and Wyer, M. D.: 2002, 'Faecal-indicator concentrations in waters draining lowland pastoral catchments in the UK: Relationships with land use and farming practices', *Water Res*. **36**(7), 1725–1734

[20] Eluozo S.N 2013 Mathematical model to predict Pathogen Deposition influenced by degree of Saturation in Organic and Lateritic soil in Waste dumps site of Port Harcourt Metropolis Global Open Journal of Environmental Protection Vol. 1, No. 1, November 2013, PP: 20 - 29 Available online at http://scitecpub.com/Journals.php

[22] World Health Organization (2006). Guidelines for drinking water quality recommendations, Chemical Facts Sheets, 3rd ed., vol. 1, p. 296-459