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Heterogeneous Porosity Influenced on Dissolved Lead Transport in Homogeneous Sand Deposition in Metropolitan City of Port Harcourt

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ABSTRACT

The transport of lead was monitored applying deterministic modeling techniques, the study were to monitor the transport of dissolved lead in the metropolitan city of Port Harcourt, the study monitor the rates of dissolved lead contamination in affected area of the city, this is to predictive the rate concentration to the optimum depth of the formation, this deposited formation are Phreatic beds, it implies that the transport of the dissolved lead has polluted the Phreatic depositions, the migration of the contaminant was influenced by the heterogeneous deposition of the strata formation in the study environment, such condition experienced variations in concentration, the impact of heterogeneity of deposited porosity of the formation were monitored in the study environment, these was through simulation of porous medium parameters at different depth to the optimum Phreatic beds, the reflection of porosity were observed from the graphical representation at various locations, the study has observed the reflections of the formation characteristics in this dimension, it has proved the platform to understand the impact of deposited porosity of sand in the transport of lead, the rate of concentration of dissolved lead in the study environment has been determined, the application of deterministic model has expressed the behaviour of the substance in the transport at homogenous sand depositions, the predictive values were subjected to validation with experimental data, and both parameters developed best fits correlation, the study is imperative because the homogeneous deposition of sand on lead transport has expressed the heterogeneity of the formation porosities, this condition has expressed the variation of strata disintegration of sedimentary deposition and that of variation of compaction in lithostructure of the formation.

Keywords: *heterogeneous, dissolved lead transport, homogeneous and sand*

INTRODUCTION

Monitoring the behaviour of groundwater systems, it has been observed that it rate of degradation on contaminant plumes are normally determined through the interplay between physical and bio-geochemical processes. More so as it is observed precisely, that is due to insufficient mixing of electron donors including that of contaminant plumes from chemicals) and electron acceptors (e.g., dissolved oxygen of the ambient groundwater) often limits (bio) chemical reactions, this process has been noted to be the t controlling natural attenuation of the contaminant plumes including that of performance of engineered remediation strategies Furthermore, the application term is used reactive transport process, while dilution is applied in the conservative transport. Dilution another physical process that is leading to the reduction of the peak concentration, it is also noted to cause of increase in the plume entropy. There is no doubt that the dilution including that of mixing of the plumes are caused by dispersion, to this extent, both processes are influenced by the heterogeneity and anisotropy of the porous media [1–3,20-22]. Contaminant transport from the quasi steady-state has been found in field through detail investigations.

To this extend, it has been observed that the contaminants are released continuously from the source such as NAPL (Non-aqueous Phase Liquid) this through spills or leaking landfills [4, 5, 22-24]. It steady-state setting, including its transverse dispersive mixing is the main process that determine the distance of the plume including the fate of the contaminant transport [6–11,25]. It is observed that it is only at the front of the plume does longitudinal dispersion play a significant role in steady-state plume transport. Such condition expresses the rate reflection by the steep concentration gradients observed at the fringes of groundwater plumes in the field investigations of contaminant aquifers [12–15, 26]. Meanwhile, porous media and it deposited heterogeneity and anisotropy including that of biogeochemical complexity of natural aquifer systems are definitely influenced by dilution and mixing. The interpretation separating different physical and chemical processes and the influencing factors is difficult in natural groundwater systems [20-24]. Several experts on modeling have conducted an investigation on transverse dispersion of conservative and reactive solutes research both on homogeneous and heterogeneous porous media [16–19,26-28]. Meanwhile, there are mainly significant challenge of various numerical methods is their numerical dispersion including that of the results uncertainties. Experimental approaches are always essential to give an intuitive vision of the phenomenon examination to verify the numerical models techniques [30-31].

THEORETICAL BACKGROUND

Governing Equation

$$Kc\frac{d^2c}{dx^2} + P_bV_s\frac{dc}{dx} - D_sC = 0 \qquad (1)$$

Nomenclature

D_s	=	Oxygen deficit (g/L)
V_s	=	River velocity (m/s)
P_b	=	Bulk Density (g/L)
C	=	Concentration (g/L)
Kc	=	Bacterial transport coefficient (g/L]
Z	=	Distance of migration (X)

$$\frac{d^2c}{dx^2} + P_bV_s\frac{dc}{dx} - \frac{D_sC}{Kc} = 0 \qquad (2)$$

Let $\frac{P_bV_s}{Kc} = U_o \quad \frac{D_s}{Kc} = U_1$

$$\frac{d^2c}{dx^2} + U_o\frac{dc}{dx} - U.c = 0 \qquad (3)$$

Let $\frac{dc}{dx} - Z,$

Such that $\frac{dc}{dx} = \frac{dZ}{dx}$

$$\frac{dc}{dx} = Z \qquad (4)$$

$$\frac{dc}{dZ} + U_oZ - Uc = 0 \qquad (5)$$

Jacobian (J) = $\begin{vmatrix} 0 & 1 \\ U_1 & -U_0 \end{vmatrix}$

Let $[J - \lambda I] = 0$

$\Rightarrow \quad \begin{vmatrix} 0 - & \lambda & 1 \\ U_1 & -U_0 & -\lambda \end{vmatrix} = 0$

$(0 - \lambda)(U_0 - \lambda) + U_1 = 0$

$U_0\lambda + \lambda^2 + U_1 = 0$

$\lambda^2 + U_0 + U_1 = 0$

$$\lambda - \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Where $U = 1,\ b = U_0\ and\ C = U_1$

$$\lambda = \frac{-U_o \pm \sqrt{(U_o)^2 - 4\times1\times U_1}}{2\times1}$$

$$\lambda = \frac{-U_o \pm \sqrt{U_o^{\ 2} - 2U_1}}{2} \qquad (6)$$

$U_o = \frac{P_bV_s}{Kc} \quad and \quad U_1 \frac{D_s}{Kc}$

$$\lambda = \frac{-\frac{P_bV_s}{Kc} \pm \sqrt{\left(\frac{P_bV_s}{Kc}\right) - 4\frac{D_s}{Kc}}}{2}$$

$$\lambda = \frac{-\frac{P_bV_s}{Kc} \pm \sqrt{\frac{1}{Kc}(P_bV_s)^2 - 4D_s}}{2}$$

From (6)

$$\lambda_1 = \frac{-U_o + \sqrt{U_o^{\ 2} - 4U_1}}{2}$$

$$\lambda_2 = \left[\frac{-U_o - \sqrt{U_o^{\ 2} - 4U_1}}{2}\right]$$

$$\therefore \ C[x] = A\ell^{\lambda_1 x} + B\ell^{-\lambda_2 x} \qquad (7)$$

Given the initial condition

$C[o] = Co\ and\ C \to o,\ x \to \infty$

$$\left.\begin{aligned} Co &= A + B \\ 0 &= A \\ B &= Co \end{aligned}\right\} \qquad (8)$$

Hence

$$C\ell o^{-\lambda_2 v.t} \quad \text{.................} \quad (9)$$

$$C[x] = C\ell o^{-\lambda_2 X} \quad \Rightarrow C\ell o^{-\lambda_2 \frac{x}{t}} \quad \text{.................} \quad (10)$$

$$C\ell o^{-\lambda \frac{d}{v}} \quad \text{.................} \quad (11)$$

MATERIAL AND METHOD

Standard laboratory experiment where performed to monitor lead using the standard method for the experiment at different sample at different station, the water sample were collected in sequences base on specification stipulated at different locations, this samples collected at different location generated variations at different distance producing different lead concentration at lower end of the column through physiochemical analysis, the experimental result were compared with the theoretical values for model validation.

Results and Discussion

Table1. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L on Variation of porosity [0.2]	Experimental Values of Dissolved Lead [Mg/L] on Variation of porosity [0.2]
2	0.181558532	0.167908
4	0.164817503	0.156732
6	0.149620119	0.145972
8	0.135824046	0.135628
10	0.123300072	0.1257
12	0.111930901	0.116188
14	0.10161005	0.107092
16	0.092240858	0.098412
18	0.083735574	0.090148
20	0.076014539	0.0823
22	0.069005441	0.074868
24	0.062642633	0.067852
26	0.056866522	0.061252
28	0.051623011	0.055068
30	0.046862991	0.0493
32	0.042541879	0.043948
34	0.038619206	0.039012
38	0.031825605	0.030388
40	0.028891051	0.0267
42	0.026227084	0.023428
44	0.023808754	0.020572
46	0.021613412	0.018132
48	0.019620497	0.016108
50	0.017811343	0.0145
54	0.014678106	0.012532
56	0.013324677	0.012172
58	0.012096044	0.012228
60	0.0109807	0.0127
62	0.009968198	0.013588
64	0.009049057	0.014892
66	0.008214668	0.016612
68	0.007457215	0.018748
70	0.006769605	0.0213

Table2. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L on variation of Porosity [0.24]	Experimental Values of Dissolved Lead [Mg/L on variation of Porosity [0.24]
2	0.199714385	0.184732
4	0.181299253	0.172428
6	0.164582131	0.160588
8	0.149406451	0.149212
10	0.13563008	0.1383
12	0.123123991	0.127852

14	0.111771055	0.117868
16	0.101464943	0.108348
18	0.092109131	0.099292
20	0.083615993	0.0907
22	0.075905985	0.082572
24	0.068906896	0.074908
26	0.062553174	0.067708
28	0.056785313	0.060972
30	0.05154929	0.0547
32	0.046796067	0.048892
34	0.042481126	0.043548
38	0.035008166	0.034252
40	0.031780156	0.0303
42	0.028849792	0.026812
44	0.02618963	0.023788
46	0.023774754	0.021228
48	0.021582547	0.019132
50	0.019592478	0.0175
54	0.016145916	0.015628
56	0.014657144	0.015388
58	0.013305648	0.015612
60	0.01207877	0.0163
62	0.010965018	0.017452
64	0.009953963	0.019068
66	0.009036135	0.021148
68	0.008202937	0.023692
70	0.007446566	0.0267

Table3. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L on variation of Porosity [0.24]	Experimental Values of Dissolved Lead [Mg/L on variation of Porosity [0.24]
2	0.217870239	0.20066
4	0.197781003	0.18644
6	0.179544143	0.17274
8	0.162988856	0.15956
10	0.147960087	0.1469
12	0.134317081	0.13476
14	0.12193206	0.12314
16	0.110689029	0.11204
18	0.100482688	0.10146
20	0.091217447	0.0914
22	0.082806529	0.08186
24	0.075171159	0.07284
26	0.068239827	0.06434
28	0.061947614	0.05636
30	0.056235589	0.0489
32	0.051050255	0.04196
34	0.046343047	0.03554
38	0.038190726	0.02426
40	0.034669261	0.0194
42	0.031472501	0.01506
44	0.028570505	0.01124
46	0.025936095	0.00794
48	0.023544597	0.00516
50	0.021373612	0.0029
54	0.017613727	-6E-05
56	0.015989612	-0.00076
58	0.014515252	-0.00094
60	0.013176839	-0.0006

62	0.011961838	0.00026
64	0.010858869	0.00164
66	0.009857601	0.00354
68	0.008948658	0.00596
70	0.008123526	0.0089

Table4. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L variation on of Porosity [0.26]	Experimental Values of Dissolved Lead [Mg/L on variation of Porosity [0.26]
2	0.236026092	0.21846
4	0.214262754	0.20404
6	0.194506155	0.19014
8	0.17657126	0.17676
10	0.160290094	0.1639
12	0.145510171	0.15156
14	0.132093065	0.13974
16	0.119913115	0.12844
18	0.108856246	0.11766
20	0.098818901	0.1074
22	0.089707073	0.09766
24	0.081435422	0.08844
26	0.073926479	0.07974
28	0.067109915	0.07156
30	0.060921888	0.0639
32	0.055304443	0.05676
34	0.050204967	0.05014
38	0.041373287	0.03846
40	0.037558366	0.0334
42	0.034095209	0.02886
44	0.030951381	0.02484
46	0.028097436	0.02134
48	0.025506646	0.01836
50	0.023154746	0.0159
54	0.019081537	0.01254
56	0.017322079	0.01164
58	0.015724857	0.01126
60	0.014274909	0.0114
62	0.012958658	0.01206
64	0.011763775	0.01324
66	0.010679068	0.01494
68	0.00969438	0.01716
70	0.008800487	0.0199

Table5. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L on variation of Porosity [0.28]	Experimental Values of Dissolved Lead [Mg/L on variation of Porosity [0.28]
2	0.254181945	0.235188
4	0.230744504	0.219652
6	0.209468167	0.204692
8	0.190153665	0.190308
10	0.172620101	0.1765
12	0.156703261	0.163268
14	0.14225407	0.150612
16	0.129137201	0.138532
18	0.117229803	0.127028
20	0.106420355	0.1161
22	0.096607617	0.105748
24	0.087699686	0.095972

26	0.079613131	0.086772
28	0.072272216	0.078148
30	0.065608187	0.0701
32	0.059558631	0.062628
34	0.054066888	0.055732
38	0.044555847	0.043668
40	0.040447471	0.0385
42	0.036717917	0.033908
44	0.033332256	0.029892
46	0.030258777	0.026452
48	0.027468696	0.023588
50	0.024935881	0.0213
54	0.020549348	0.018452
56	0.018654547	0.017892
58	0.016934461	0.017908
60	0.015372979	0.0185
62	0.013955478	0.019668
64	0.01266868	0.021412
66	0.011500535	0.023732
68	0.010440101	0.026628
70	0.009477447	0.0301

Table6. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L on variation of Porosity [0.30]	Experimental Values of Dissolved Lead [Mg/L on variation of Porosity [0.30]
2	0.272337798	0.2525
4	0.247226254	0.2353
6	0.224430179	0.2192
8	0.203736069	0.2037
10	0.184950108	0.1888
12	0.167896351	0.1745
14	0.152415075	0.1608
16	0.138361287	0.1477
18	0.12560336	0.1352
20	0.114021809	0.1233
22	0.103508161	0.112
24	0.093963949	0.1013
26	0.085299783	0.0912
28	0.077434517	0.0817
30	0.070294486	0.0728
32	0.063812819	0.0645
34	0.057928808	0.0568
38	0.047738408	0.0432
40	0.043336576	0.0373
42	0.039340626	0.032
44	0.035713131	0.0273
46	0.032420119	0.0232
48	0.029430746	0.0197
50	0.026717015	0.0168
54	0.022017158	0.0128
56	0.019987015	0.0117
58	0.018144065	0.0112
60	0.016471049	0.0113
62	0.014952298	0.012
64	0.013573586	0.0133
66	0.012322002	0.0152
68	0.011185823	0.0177
70	0.010154408	0.0208

Table7. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L on variation of Porosity [0.002]	Experimental Values of Dissolved Lead [Mg/L on variation of Porosity [0.002]
2	0.001815585	0.001692
4	0.001648175	0.001588
6	0.001496201	0.001488
8	0.00135824	0.001392
10	0.001233001	0.0013
12	0.001119309	0.001212
14	0.001016101	0.001128
16	0.000922409	0.001048
18	0.000837356	0.000972
20	0.000760145	0.0009
22	0.000690054	0.000832
24	0.000626426	0.000768
26	0.000568665	0.000708
28	0.00051623	0.000652
30	0.00046863	0.0006
32	0.000425419	0.000552
34	0.000386192	0.000508
38	0.000318256	0.000432
40	0.000288911	0.0004
42	0.000262271	0.000372
44	0.000238088	0.000348
46	0.000216134	0.000328
48	0.000196205	0.000312
50	0.000178113	0.0003
54	0.000146781	0.000288
56	0.000133247	0.000288
58	0.00012096	0.000292
60	0.000109807	0.0003
62	9.9682E-05	0.000312
64	9.04906E-05	0.000328
66	8.21467E-05	0.000348
68	7.45722E-05	0.000372
70	6.76961E-05	0.0004

Table8. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Distance [x]	Predictive Dissolved Lead [Mg/L on variation of Porosity [0.0024]	Experimental Values of Dissolved Lead [Mg/L on variation of Porosity [0.0024]
2	0.002178702	0.0020624
4	0.00197781	0.0019296
6	0.001795441	0.0018016
8	0.001629889	0.0016784
10	0.001479601	0.00156
12	0.001343171	0.0014464
14	0.001219321	0.0013376
16	0.00110689	0.0012336
18	0.001004827	0.0011344
20	0.000912174	0.00104
22	0.000828065	0.0009504
24	0.000751712	0.0008656
26	0.000682398	0.0007856
28	0.000619476	0.0007104
30	0.000562356	0.00064
32	0.000510503	0.0005744
34	0.00046343	0.0005136
38	0.000381907	0.0004064

40	0.000346693	0.00036
42	0.000314725	0.0003184
44	0.000285705	0.0002816
46	0.000259361	0.0002496
48	0.000235446	0.0002224
50	0.000213736	0.0002
54	0.000176137	0.0001696
56	0.000159896	0.0001616
58	0.000145153	0.0001584
60	0.000131768	0.00016
62	0.000119618	0.0001664
64	0.000108589	0.0001776
66	9.8576E-05	0.0001936
68	8.94866E-05	0.0002144
70	8.12353E-05	0.00024

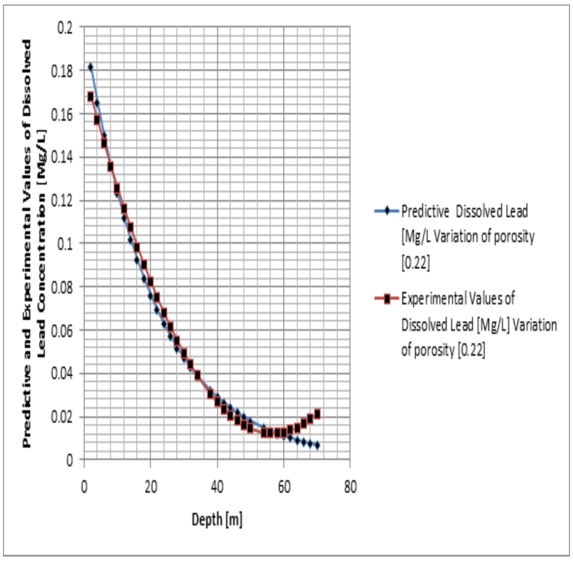

Figure1. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

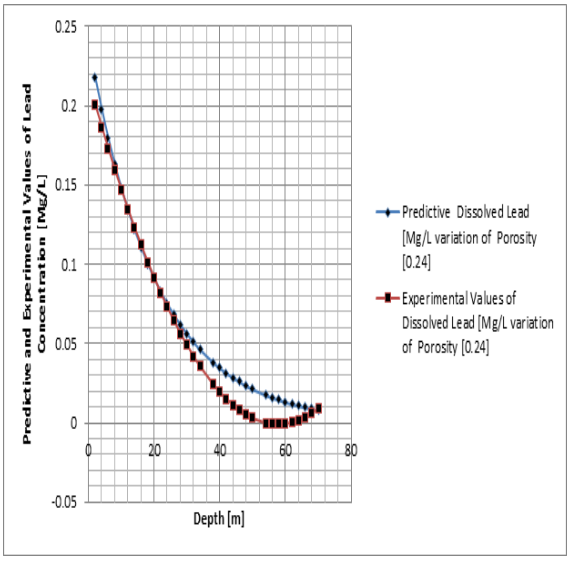

Figure3. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

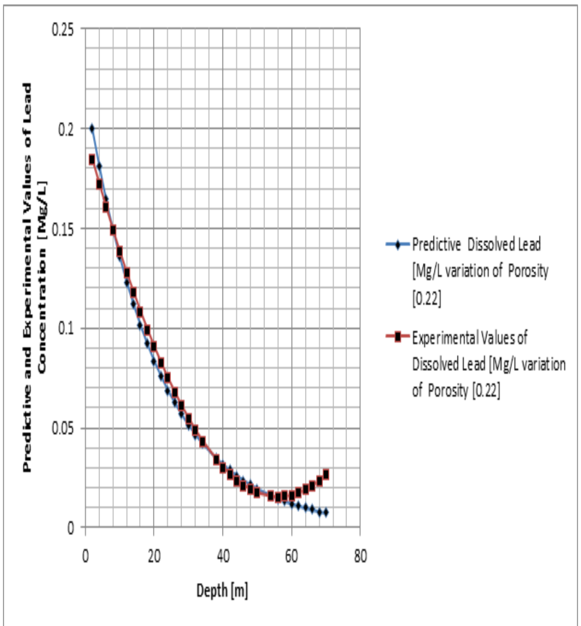

Figure2. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

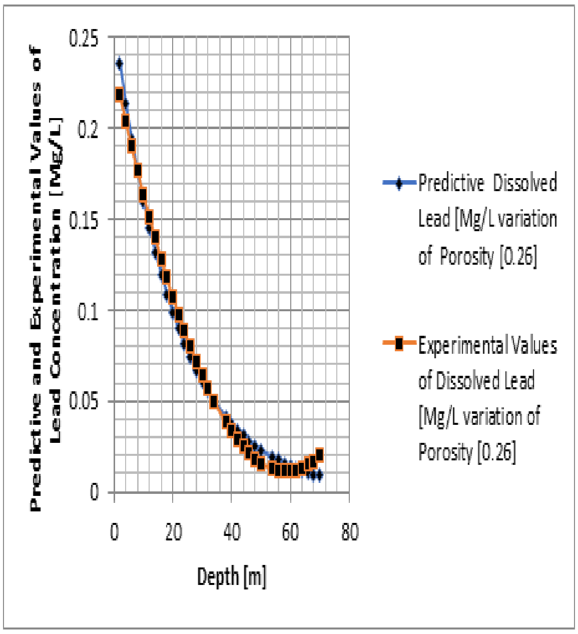

Figure4. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

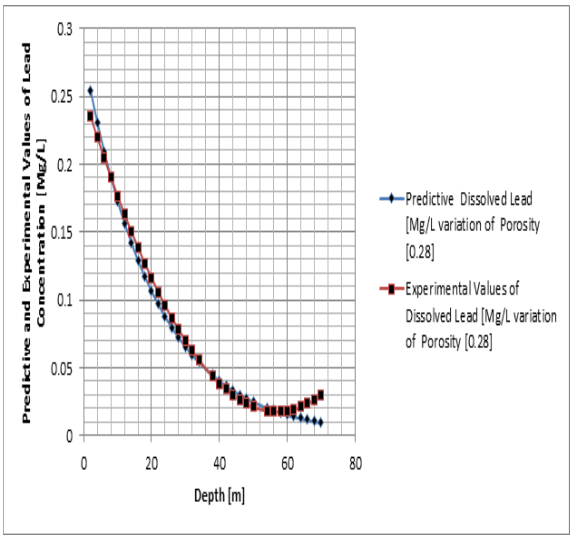

Figure5. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

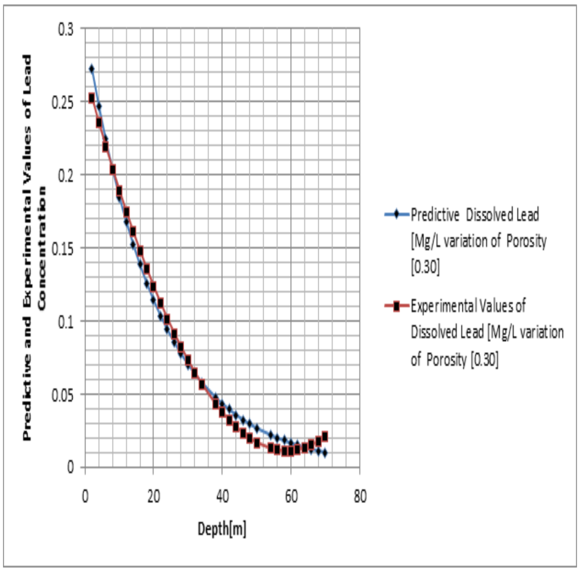

Figure6. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

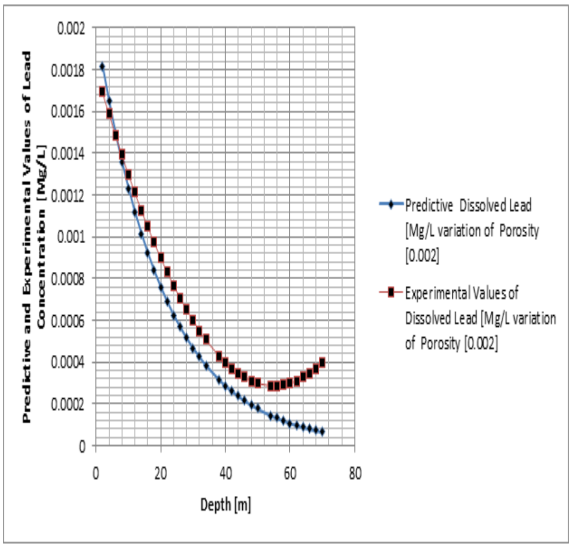

Figure7. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

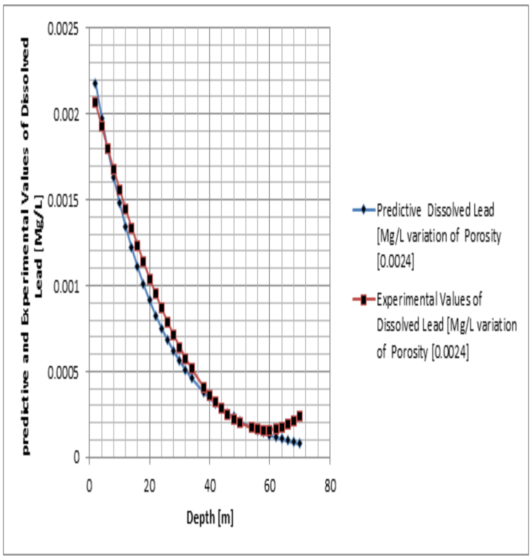

Figure8. *Predictive and Experimental Values of Dissolved Lead Concentration at Different Depth*

Figure 1-8 explained the behaviour of dissolved lead in the metropolitan city of Port Harcourt, decrease in concentration observed variations based on heterogeneous structure of the formation, these are basically on porosity deposition of the formation, the behaviour of the transport substance were simulated to reflect the influences from the variation deposition of porosity in the study environment, the trend from all the figures maintained decrease with increase in distance that recorded the minimum concentration at seventy metre, but the concentration were observed to experienced variation in the dissolved lead, the study monitoring the influence from this formation characteristics that expressed the effect from these parameters on the transport rate of the dissolved lead in the study area. The deltaic nature of metropolitan city of port expressed the heterogeneity deposition of soil porosity in the transport process influenced by lead , there were characterized through the simulation to explained the rate of heterogeneity porosity on dissolved lead, monitoring the soil porosity based on these factors expressed the rates of concentration from high porosity to the lowest porosity reflecting the transport process of lead, the trend on decrease state were monitored and observation carried out shows that even though there is decrease with respect to increase in depth, concentration experienced the highest rate of lead deposition as it is expressed in the trend. The experimental values in the entire trend expressed decrease with increase in depth; the predictive and experimental values maintained best fits correlation, this has expressed the authenticity of the model.

Conclusion

Porosity in the deposition of the formation were monitored to determined the reflection of it heterogeneity in metropolitan city of the study environment, the dissolved lead in the transport system were observed to be influenced by the variation of formation porosity in the study area, the predictive model applying deterministic modeling techniques from derived solution developed the model that expressed the reflections of porosity in heterogeneous depositions, these generated the migration of dissolved lead. Such study became imperative due the rates of negative impact it has generated in the study environment, due the deltaic nature of the study environment, most affect area on its Aquiferous zone are pose to be under serious treat developing high degree of Aquiferous pollution in the affected environment, the waste dump site based on its long negative impact causing this level of contamination in the study area, the dissolved lead on its transport process observed high to low concentration, but with variation of concentration at different locations considered in the study area, these were experienced from the simulation expressed in the transport process, the study has definitely generated the reflection variation impact on the porosity depositions from concentration observed in all the figures, the predictive values was compared with experimental data, and both parameters developed best fits correlations.

References

[1] Chiogna, G.; Cirpka, O.A.; Grathwohl, P.; Rolle, M. Transverse mixing of conservative and reactive tracers in Porous media: Quantification through the concepts of flux-related and critical dilution indices. Water Resour. Res. **2011**, 47, W02505. [CrossRef]

[2] Chiogna, G.; Hochstetler, D.L.; Bellin, A.; Kitanidis, P.K.; Rolle, M. Mixing, entropy and reactive solute transport. Geophy. Res. Lett. **2012**, 39, L20405. [CrossRef]

[3] Rolle, M.; Eberhardt, C.; Chiogna, G.; Cirpka, O.A.; Grathwohl, P. Enhancement of dilution and transverse reactive mixing in porous media: Experiments and model-based interpretation. J. Contam. Hydrol. **2009**, 110,130–142. [CrossRef]

[4] Mace, R.E.; Fisher, R.S.; Welch, D.M.; Parra, S.P. Extent, Mass, and Duration of Hydrocarbon Plumes from Leaking Petroleum Storage Tank Sites in Texas; Geologic Circular 97-1; Bureau of Economic Geology, University of Texas at Austin: Austin, TX, USA, 1997.

[5] Wiedemeier, T.H.; Rifai, H.S.; Newell, C.J.; Wilson, J.T. Natural Attenuation and Fuels and Chlorinated Solventsin the Subsurface; JohnWiley & Sons, Inc.: Hoboken, NJ, USA, 1999.

[6] Anneser, B.; Einsiedl, F.; Meckenstock, R.U.; Richters, L.; Wisotzky, F.; Griebler, C. High-resolution monitoring of biogeochemical gradients in a tar oil-contaminated aquifer. Appl. Geochem. **2008**, 23, 1715–1730. [CrossRef]

[7] Cirpka, O.A.; Frind, E.O.; Helmig, R. Numerical simulation of biodegradation controlled by transverse mixing. J. Contam. Hydrol. **1999**, 40, 159–182. [CrossRef]

[8] Ham, P.A.S.; Schotting, R.J.; Prommer, H.; Davis, G.B. Effects of hydrodynamic dispersion on plume lengthsfor instantaneous bimolecular reactions. Adv. Water Resour. **2004**, 27, 803–813. [CrossRef]

[9] Knutson, C.; Valocchi, A.; Werth, C. Comparison of continuum and pore-scale models of nutrient biodegradation under transverse mixing conditions. Adv. Water Resour. **2007**, 30, 1421–1431. [CrossRef]

[10] Mayer, K.U.; Benner, S.G.; Frind, E.O.; Thornton, S.F.; Lerner, D.N. Reactive transport modeling of processes controlling the distribution and natural attenuation of phenolic compounds in a deep sandstone aquifer.J. Contam. Hydrol. **2001**, 53, 341–368. [CrossRef]

[11] Prommer, H.; Anneser, B.; Rolle, M.; Einsiedl, F.; Griebler, C. Biogeochemical and isotopic gradients in aBTEX/PAH contaminant plume: Model-based interpretation of a high-resolution field data set. Environ. Sci. Technol. **2009**, 43, 8206–8212. [CrossRef]

[12] Amos, R.T.; Berkins, B.A.; Delin, G.N.; Cozzarelli, I.M.; Blowes, D.W.; Kirshtein, J.D. Methane oxidation ina crude oil contaminated aquifer: Delineation of aerobic reactions at the plume fringes. J. Contam. Hydrol.**2011**, 125, 13–25. [CrossRef]

[13] Davis, G.B.; Barber, C.; Power, T.R.; Thierrin, J.; Patterson, B.M.; Rayner, J.L.; Wu, Q. The variability and intrinsic remediation of a BETX plume in anaerobic sulphate-rich groundwater. J. Contam. Hydrol. **1999**, 36,265–290. [CrossRef]

[14] Thornton, S.F.; Quigley, S.; Spence, M.J.; Banwart, S.A.; Bottrell, S.; Lerner, D.N. Processes controlling the distribution and natural attenuation of dissolved phenolic compounds in a deep sandstone aquifer. J. Contam. Hydrol. **2001**, 53, 233–267. [CrossRef]

[15] Tuxen, N.; Albrechtsen, H.-J.; Bjerg, P.L. Identification of a reactive degradation zone at a landfill leachateplume fringe using high resolution sampling and incubation techniques. J. Contam. Hydrol. **2006**, 85, 179–194. [CrossRef]

[16] Dentz, M.; Le Borgne, T.; Englert, A.; Bijeljic, B. Mixing, spreading and reaction in heterogeneous

media:A brief review. J. Contam. Hydrol. **2011**, 120, 1–17. [CrossRef]

[17] Chiogna, G. Transverse Mixing of Conservative and Reactive Tracers in Porous Media. Ph.D. Thesis, University of Tübingen, Tübingen, Germany, 2010.

[18] Cirpka, O.A.; de Barros, F.P.J.; Chiogna, G.; Rolle, M.; Nowak,W. Stochastic flux-related analysis of transverse mixing in two-dimensional heterogeneous porous media. Water Resour. Res. **2011**, 47, WR010279. [CrossRef]

[19] Chiogna, G.; Cirpka, O.A.; Grathwohl, P.; Rolle, M. Relevance of local compound-specific transverse dispersion for conservative and reactive mixing in heterogeneous porous media. Water Resour. Res. **2011**, 47, W07540. [CrossRef]

[20] Tiantian Xu, Yu Ye *, Yu Zhang and YifanXie 2018 Recent Advances in Experimental Studies of Steady-State Dilution and Reactive Mixing in Saturated Porous Media water open access journal pp1-17

[21] Eluozo S.N, Oba A.L Modeling and simulation of cadmium transport influenced by high degree of saturation and porosity on homogeneous coarse depositions MOJ Civil Engineering Vol. 4 issue 4.2018

[22] Eluozo SN, Afiibor B.B. Dispersion and dynamics influences from phosphorus deposition on e-coli transport in coastal deltaic Lake, MOJ Applied Bionics and biomechanics 2018 Vol. 2 Issue 5

[23] Eluozo S.N, Oba A.L Predicting heterogeneous permeability coefficient pressured by heterogeneous seepage on coarse deposition MOJ Civil Engineering Vol. 4 issue 4.2018

[24] Eluozo S.N, Ezeilo F. E. Numerical Modeling of Nocardia Migration Influenced Transport Pressured by Dispersion and Velocity in Fine Sand Formation in Wetland Environment, *Journal of Water Resources Engineering and Management 2018 Vol. 5 Issue 1 Pp,25-32*

[25] Eluozo S. N, Ezeilo F. E. Modeling Heterogeneous Porosity in Alluvia Plain Deposition in Deltaic Formation; *Recent Trend in Civil Engineering & Technology 2018.Vol, 8 Issues (2): Pp1-10.*

[26] Ezeilo F.E, Eluozo S.N. Dispersion and Storage Coefficient Influences on Accumulation of Frankia Transport in Heterogeneous Silty and Fine Sand Formation, Warri Delta State of Nigeria*; International Journal of Mechanical and Civil Engineering Vol. 4 Issue 4 April 2018Pp. 1-16.*

[27] Eluozo S.N, Amadi C.P, Modeling and Simulation of Legionella Transport Influenced by Heterogeneous Velocity in Stream. *Journal of Water Resource Engineering and Management*. *2019; 6 (2):25– 31P*

[28] Eluozo S.N, Amadi C.P, velocity and Oxygen Deficit Influence on the Transport of Francisela in Eleme Creek. *Journal of Water Resource Engineering and Management*. 2019; 6(2):43–48p

[29] *Eluozo. S. N, Afiibor. B.B.* Mathematical Model to Monitor the Transport of Bordetella Influenced by Heterogeneous Porosity in Homogeneous Gravel Depositions Journal of Geotechnical Engineering *Vol. 6, No 1 (2019)*

[30] Ezeilo F.E, Eluozo S.N. Linear Phase Velocity Effect on Accumulation of Zinc in Homogeneous Fine Sand Applying Predictive Model, *International Journal of Mechanical and Civil Engineering Vol. 4 Issue 4 April 2018Pp. 17-32.*

[31] Eluozo S. N, Ezeilo F. E. Predicting the Behaviour of Borrelia in Homogeneous Fine Sand in Coastal Area of Bakana *Recent Trend in Civil Engineering & Technology 2018.Vol, 8 Issue (2): Pp1-19.*

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