REPORT Vol. 6, 2018

ISSN 2320–6675 EISSN 2320–6853

DISCOVERY
Engineering

# The influential concepts of recharge and flow rate approach in evaluation of water quality

**Ukpaka C[1☼], Ngekpe EB[2]**

1.Jospaka Ventures Nigeria Limited, Port Harcourt, Rivers State, Nigeria
2.Department of Civil Engineering, Rivers State University, Nigeria

☼**Corresponding Author:**
Jospaka Ventures Nigeria Limited, Port Harcourt, Rivers State, Nigeria
Email: ukpachin@yahoo.com

**Article History**
Received: 27 April 2018
Accepted: 05 June 2018
Published: June 2018

**Citation**
Ukpaka C, Ngekpe EB. The influential concepts of recharge and flow rate approach in evaluation of water quality. *Discovery Engineering*, 2018, 6, 12-17



## ABSTRACT
The study is to evaluate selected heavy metals migration of chosen wells in the groundwater zone serving as water bearing aquifer of Abalama Community in Asari-Toru L.G.A, Rivers State taking Well A as control well and point of migration of water quality parameters to be simulated. The experimental and simulated heavy metals assessed are within WHO standards of acceptability limited. Used simulating matrix model to simulate the migration of heavy metals in this investigation is considered useful in monitoring and simulate groundwater quality of the research area.

**Keywords**: Abalama Community, Heavy metal, flow rate, Recharge, Matrix method

## 1. INTRODUCTION

The danger caused by the contamination of the environment with heavy metals is very destructive due to industrial and sewage sludge applications to our environment there by becoming a major factor to the speedy increase of heavy metal to our area, in addition, it is also noted that the occurrence of heavy metals in industrial and urban waste water brings about the pollution of water and soil. Existence of heavy metals leads to solemn threat to human health and ecological environment. Metals occurring as effluent are cadmium, arsenic, chromium, lead, zinc, mercury and copper caused by heavy metals or metals. Rocks, through weathering process causes natural levels of heavy metals.

Furthermore, organic contamination of water bodies has a added load of heavy metals to groundwater source which can be accredited to sewage and industrial waste. Metals such as copper and zinc in sewage mostly become bound to the sediments of the estuary. The said metals at this point are not biodegradable and persist in the environment. Groundwater may be contaminated due to either point of source or diffuse sources. In a farmyards area where there are wells, there is always possibility of wastewater runoff and other agricultural contaminants entering the groundwater directed or percolation process.

Investigation in this research is carried out to ascertain the circulation of heavy metals parameter in the selected wells in Asari-Toru local government area groundwater been influenced flow rate.

## 2. MATERIALS AND METHODS

### 2.1. Simulation Model Concept.

Research revealed that at this point of the assessment, the unconfined groundwater model can be used in this research taking Abalama community as a reference point. Therefore, if the flow is considered to be in x- dimensional and steady state with a hydraulic conductivity (k) in distributing or studying groundwater interaction of heavy metals. Then the Laplace equation is

$$\frac{d^2 H}{dx^2} = 0 \qquad (1)$$

Recharge is the ratio of rainfall amount that sooner or later finds its way into the bearing aquifer due infiltration processes and then influence water level.

If recharge is R, then

$$\frac{dq}{dx} = R \qquad (2)$$

Solving Equation(1) and substituting Equation(2) into the solution. Finally gives:

$$q = \frac{K}{2L}(H_R^2 - H_0^2) + \frac{R}{2}(l - 2x) \qquad (3)$$

Equation (3) is equation for flow with the effect of recharge.

### 2.2. Formulation Pattern of Discretization of Flow Groundwater

Considering compartment i and compartment j as show below representing flow groundwater movement from i to j having a flow rate $q_{ij}$. In simulation of compartment model of a substantial system, we theoretically isolate the system into different numeral of little components between which material is to distribute.

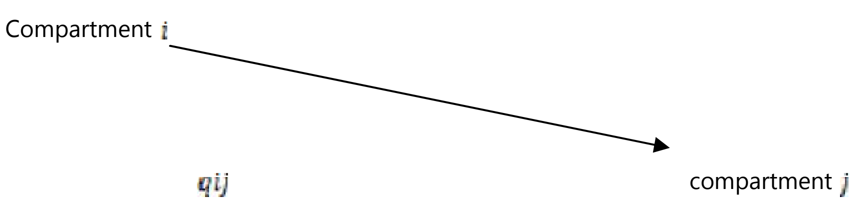


**Figure 1** Formulated connection between two Compartments Well Groundwater

Let the entries $s_i$ in the n x 1 matrix S defined the laboratory concentration of heavy metals at initial state and EC present the responding distributed heavy metals in groundwater.

Therefore, $$S = \begin{vmatrix} S_A \\ S_B \\ S_C \end{vmatrix} , C = \begin{vmatrix} EC_A \\ EC_B \\ EC_C \end{vmatrix} \quad (4)$$

Characterize groundwater parameter ($i$), let say that $s$ is the state of parameter of the groundwater tested. The n x1 matrix c is the estimated distributed groundwater parameter over time. This show that s and c are related by

$$EC = G S_{ij} \quad (5)$$

In general,

$$EC_A = Q_{AA}S_A + Q_{AB}S_A + --- Q_{in}S_{in}$$
$$EC_2 = Q_{BA}s_A + Q_{BB}s_B + --- Q_{2n}s_n \quad (6)$$
$$EC_n = Q_{n1}s_A + Q_{n2}s_B + --- + Q_{nn}s_n$$

$(Qij)$ is known as flow rate coefficient matrix. Considering that the sum of the entries in any column the transfer coefficient is equal to 1.

Developed Equation (5) is the used to simulation the interaction of heavy metals concentration of groundwater upon the influence of recharge.

### 2.3. Method of Data Collection

Water samples from Abalama Community wells in Asari-Toru, L.G.A., Rivers State, Nigeria were collected from the groundwater source serving selected area and were labeled as AW0, AWE1, AEW2, AEW3 and AEW4, respectively for Abalama for better identification of water specimens collected. Water samples collected in each well were put in cleaned plastic bottles bagged in polyethylene bags with ice block and moved immediately to be examined in the laboratory so as to determine the heavy metals concentration.

### 2.4. Data Analysis

**Table 1**: Analytical method for heavy metal parameters

| S/ No | Parameters | Analytical approach | WHO Standard |
|---|---|---|---|
| 1 | Ammonium (mg/l) | APHA 4500 $NH_3$ | 1.50 |
| 2 | Arsenic (mg/l) | APHA 3111B | 0.06 |
| 3 | Manganese (mg/l) | APHA 3111B | 0.50 |
| 4 | Nitrate (mg/l) | EPA 3521 | 10.0 |
| 5 | Reactive Silica (mg/l) | APHA 4500 $S1O_2$ | 0-0.30 |
| 6 | Total Mercury(mg/l) | APHA 3111B | 0.04 |
| 7 | Copper (mg/l) | APHA 3111B | 1.0 |
| 8 | Cadmium (mg/l) | APHA 3111B | 0.10 |
| 9 | Lead (mg/l) | APHA 3111B | 0.10 |
| 10 | Cyanide (mg/l) | APHA 4500 CN | 0.07 |
| 11 | Selenium | ASTMD 3859 | 0.01 |
| 12 | Zinc (mg/l) | APHA 3111B | 3.0 |

**2.5. Well Assessment Evaluation**

Well evaluation was carried out to generate required parameter needed for the research such as water table elevations of the wells. Elevations of water table of interest were completely generated after several weeks of research.

## 3. RESULTS AND DISCUSSION

Circulation of heavy metal parameters for Abalama wells due to recharge and flow rate were estimated using created predictive Equation (6). Taking R (Recharge) = 0.2mm/day = 2.0 x $10^{-4}$m/d ($R/2$ = 1x$10^{-4}$m/d).

For water bearing aquifer of Abalama, water zone, sand/coarse is given as k = 62.5m/day = 7.23 x $10^{-4}$m/sec, flow rate based on groundwater gradient from control well to others. The summary of results of heavy metals distribution using Eqn.(6) gives;

**Table 2** Well A, Experimental and simulated results of heavy metal water quality

| Parameters | EC,0 | EC,1 | EC,2 | EC,3 | EC,4 | SR,0 | SR,1 | SR,2 | SR,3 | SR,4 |
|---|---|---|---|---|---|---|---|---|---|---|
| Lead(mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Nitrate(mg/l) | 4.57 | 2.66 | 4.0 | 2.54 | 3.40 | 1.78 | 1.39 | 1.11 | 0.69 | 1.19 |
| Zinc(mg/l) | 0.06 | 0.10 | 0.22 | 0.11 | 0.05 | 0.03 | 0.07 | 0.06 | 0.05 | 0.08 |
| Ammonium (mg/l) | 0.06 | 0.03 | 0.04 | 0.07 | 0.06 | 0.03 | 0.04 | 0.06 | 0.06 | 0.07 |
| Reactive Silica (mg/l) | 15.51 | 14.35 | 15.02 | 15.00 | 14.70 | 9.13 | 9.23 | 9.32 | 8.48 | 9.15 |
| Manganese (mg/l) | 0.11 | 0.01 | 0.02 | 0.06 | 0.90 | 0.12 | 0.01 | 0.19 | 0.33 | 0.15 |
| Total Mercury (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Selenium (mg/l) | - | - | 0.01 | 0.01 | 0.01 | - | - | 0.01 | 0.01 | 0.01 |
| Cadmium(mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Arsenic (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Cyanide (mg/l) | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Copper (mg/) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

**Table 3** Well B, Experimental and simulated results of heavy metal water quality

| Parameters | EC,0 | EC,1 | EC,2 | EC,3 | EC,4 | SR,0 | SR,1 | SR,2 | SR,3 | SR,4 |
|---|---|---|---|---|---|---|---|---|---|---|
| Lead(mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Nitrate(mg/l) | 4.21 | 2.28 | 3.94 | 2.41 | 3.00 | 1.45 | 1.00 | 1.03 | 0.33 | 1.07 |
| Zinc(mg/l) | 0.04 | 0.08 | 0.20 | 0.09 | 0.03 | 0.02 | 0.05 | 0.04 | 0.03 | 0.06 |
| Ammonium (mg/l) | 0.04 | 0.01 | 0.02 | 0.05 | 0.04 | 0.01 | 0.02 | 0.04 | 0.04 | 0.05 |
| Reactive Silica (mg/l) | 13.23 | 12.12 | 13.00 | 11.97 | 12.50 | 7.08 | 7.22 | 7.21 | 6.12 | 7.15 |
| Manganese (mg/l) | 0.09 | 0.04 | 0.05 | 0.06 | 0.70 | 0.08 | 0.03 | 0.07 | 0.66 | 0.14 |
| Total Mercury (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Selenium (mg/l) | - | - | 0.01 | 0.01 | 0.01 | - | - | 0.01 | 0.01 | 0.01 |
| Cadmium(mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Arsenic (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Cyanide (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Copper (mg/) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

**Table 4** Well C, Experimental and simulated results of heavy metal water quality

| Parameters | EC,0 | EC,1 | EC,2 | EC,3 | EC,4 | SR,0 | SR,1 | SR,2 | SR,3 | SR,4 |
|---|---|---|---|---|---|---|---|---|---|---|
| Lead(mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Nitrate(mg/l) | 4.37 | 2.46 | 2.98 | 2.34 | 3.20 | 1.58 | 1.19 | 0.91 | 0.49 | 0.99 |
| Zinc(mg/l) | 0.04 | 0.08 | 0.02 | 0.09 | 0.03 | 0.01 | 0.05 | 0.04 | 0.03 | 0.06 |
| Ammonium (mg/l) | 0.06 | 0.03 | 0.04 | 0.07 | 0.06 | 0.03 | 0.04 | 0.06 | 0.06 | 0.07 |
| Reactive Silica (mg/l) | 15.31 | 14.15 | 14.92 | 14.98 | 14.68 | 8.93 | 9.03 | 9.03 | 8.28 | 8.98 |
| Manganese (mg/l) | 0.11 | 0.01 | 0.02 | 0.06 | 0.90 | 0.12 | 0.01 | 0.19 | 0.33 | 0.15 |
| Total Mercury (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Selenium (mg/l) | - | - | 0.01 | 0.01 | 0.01 | - | - | 0.01 | 0.01 | 0.01 |
| Cadmium(mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Arsenic (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Cyanide (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Copper (mg/) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

Table 2 -4 presents the experimental and simulated heavy metals assessed for five different weeks for Abalama, Community. Heavy metal parameters of Abalama well A were used to simulate the migration of the considered water quality parameter to other well.

## 4. CONCLUSION

The following conclusions can be drawn from the research.

1.The formulation model of flow rate generated using the one dimensional Laplace Equation and applying Darcy's law were useful in simulating heavy metals in the researched area as per the developed simulating matrix model of Equation (6) is considered.

2.Research essential parameters considered in the investigation are hydraulic gradient, hydraulic conductivity; assumed flow movement and recharge were used in simulating heavy metals circulation in the aquifer zone of interest.

3.The simulated and experimental results of the evaluated heavy metals are within agreeable limit of WHO standard pointing to the reliability of the concept used in the research which agreed with Ukpaka et al 2017.

**Nomenclature**,

$q$ = Flow rate, ($m^3$/day)

K = Aquifer permeability, (m/day)

$y_R$ = Water table height for reference points, (m)

$y_0$ = Water table height for consideration points, (m)

R = Recharge, (m/day)

$x$= Any distance along the length, (m)

$l$ = Length apart between the communities, (m)

$EC_A$ = Heavy metal value for Abalama well A,(mg/l)

$EC_B$ = Heavy metal value for Abalama well B(mg/l)

$EC_C$ = Heavy metal value for Abalam well C, (mg/l)

$EC_D$ = Heavy metal value for Abalama well D, (mg/l)

$EC_E$ = Heavy Metal value for Abalama well E, (mg/l)

$C_F$ = Heavy Metal value for Abalama well F, (mg/l)

## REFERENCE

1. APHA (1981), standard methods for examination of water & waste water (15ed) America Public Health Association, AWWA, WPCF, WASHINGTON DC.
2. Arcadio, P. S. and Gregoria, A. S. (1991). Environmental Engineering: A design Approach, Prentice – Hall of India private Limited New Delhi 110001, p. 2 -52

3. Dash. J. R., Dash. P. C. and Patra. H. K., (2006), A correlation and regression study on the ground water quality in rural areas around Angul – Talcher industrial zone, international journal of environmental protection, 26(6), pp. 550 – 558.
4. Eluozo,S.N. and Nwofor, T.C.(2012), Evaluating the variation of transmissivity on groundwater development in Rivers State. International Journal of Applied Environmental Science, 7(2), 141-147
5. Garg, S.K.(2007), Hydrology and Water Resources Engineering, 14th Revised Edition, RomeshChanderKhanna for Khanna publishers 2-B, Nath Market, NaiSarak, Delhi-110006. pp.700-703
6. Gajendran C., Thamarai P., and Baskar., (2010), Water quality evaluation for Nambiyar river basin, Tamil, India by using geo – statistical analysis, Asian Journal of Microbiology, Biotechnology and environmental science, 12(3), pp. 555 – 560
7. Gerard, K. (1998), Environmental engineering, international edition Mcgraw – Hill New York, P. 200 – 350
8. Goel, P. K. (2006), Water pollution, causes effects and new age internatim (p) Ltd, publishers. P. 1- 300
9. Masters, G. M. (1991). Introduction to Environmental Engineering and science prentice Hall, englelvoodclifts, N. J
10. MCGHEE, T. J. (1991) Water supply and sewerage, MCHra Hill, New York.
11. Nigeria Industrial Standard, Nigerian Standard for drinking water quality NIS 554, 14, 2007.
12. Nwaogazie, I. L. (2008), Finite element modeling of engineering system with emphasis in water resources 2nd Edition, University of Port Harcourt Press, Nigeria, p. 41 – 180
13. Ogedengbe A. O., Abba M. U., (2006), An assessment of Dug – well water quality and uses in Mubi, Nigeria, Journal of Sustainable Development in Agriculture and Development, 2(1), p. 10.
14. Okeke C. O. Igboanua A. H. (2003), Characteristics and quality assessment of surface water and ground water resources of Akwa Town, Southeast, Nigeria. J. Niger. Assoc. Hydrol. Geol., 14, p. 71 – 77
15. Pathak H., Limaye S. N. (2011d), A mathematical modeling with respect to DO for environmentally contaminated drinking water sources of Makronia sub-urban area, India: A case study, Ovidius University Annals of Chemistry, Vol. 22(2), 2011. ISSN – 1223 – 7221.
16. Pathak H., Limaye S. N. (2012a), Assessment of Physico – chemical quality of municipal water samples of Makronia sub – urban RArea of BundelKhand Region, India, Anaele University din Oradea – SeriaGeografie, 2, 122 – 127
17. Pathak, H., Lirmaye, S. N. (2012b). A water quality index mathematical modeling of water samples of Rajghat, water supply reservoir sagar (M. P.) with respect to total dissolved solids: A regression analysis, the polytechnic institute of Iasi, 2012, vol. 1, ISSN: 0254 – 70104
18. Patowary, Kabita and Bhattacharya K. G., (2005), Evaluation of drinking water quality of coalmining area, Assam, Indian Journal environmental protection, 25(3), pp. 204 – 211
19. Prashuhn, A. L. (1987). Fundamental of Hydraulic Engineering Holt, Rinehart and Winston, New York.
20. Schimpf, M. E., Petteys, M. P., (1997) Characterization of humic materials by flow field – flow fractional colloid surf, 120 – 130.
21. Suleiman F. B. (2006), Analysis of some sachet water samples in Katsina, Nigeria, Chem. Class journal of Chemical Society of Nigeria, Zaria chapter, 3, p. 42 – 44
22. Sunder, K., Vidya, R., Amitata, M., and Chandrasekaran, N. (2010), High Chromium Tolerant Bacteria Strain from River Basin, impact of Tannery pollution, Resaerch Journal of Environment and Earth Sciences, 2 (2): pp.112-117.
23. Wang, X., Sato, T., Baoshan, X., and Tao, S. (2005), Health risk of heavy metals to the general public in Tiajin, China via consumption of vegetables and fish, Science of the Environmental safety 66: 224-239.
24. Ukpaka C. P. and Ukpaka C. (2016), Characteristics of Groundwater in Port – Harcourt.Journal of Advances in Environmental sciences. Volume 1 Number 2, pp 59 – 71.
25. Ukpaka, C., Ify, L.N., Peter, U.C., (2015).Prediction of nitrate interaction for Egi Clan groundwater investigation in Rivers State of Nigeria. CASRP Journal of Applied Sciences, 1(14), 118-132.
26. Ukpaka, C. (2016): Assessment of Groundwater Quality in Egi Clan, Rivers State, Thesis University of Port Harcourt
27. Velaiappan, A., Mechias, G. and Kasinathan, P. (2002), Effect of heavy metal toxicity on the nodulation pattern of legume cultivars, J. Ecotoxicol Enviromental monitor, 12: 17-20.
28. WHO (2001), Guidelines for Drinking Water Quality. Addendum: Microbiological agents in drinking water. World Health Organization, Geneva.