International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 3, May-June 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

An Evaluative Study on the Impact of Groundwater Pollution (GWP) on Human Health

Odior, A. K.; Okonta, S. D.

Department of Statistics, Delta State Polytechnic Otefe-Oghara, Delta, Nigeria

ABSTRACT

The study seeks to examine empirically the pervasive effect of Groundwater pollution (GWP) on human health on selected locations at Otefe-Oghara Delta-State, Nigeria. The study employs experimental research design to investigate the impact of GWP on human health, which specifically focuses on the community water sources and thus assesses the relationship between different water quality parameters and blood lead levels of selected residents over an extended period of time. The study considers and examines various water quality parameters and the blood lead levels using multiple regression methodology to establish and uncover their performances (effect) of the various explanatory variables on the response variable. Experimental data from the community water sources were generated for analysis. The result reveals that the water quality parameters considered in the study, significantly elevated the blood lead levels, with huge attendant consequences on human health. Finally, from the findings it was clearly inferred that GWP has as a significant effect on human health.

How to cite this paper: Odior, A. K. | Okonta, S. D. "An Evaluative Study on the Impact of Groundwater Pollution (GWP) on Human Health" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-3, June 2024, pp.703-709, URL: www.ijtsrd.com/papers/ijtsrd64982.pdf

IJTSRD64982

KEYWORDS: *Groundwater, Pollution, Human health, Pollutants, Exposure and Drinking water*

1. INTRODUCTION

Groundwater, a veritable, vital and a major source of freshwater, plays a useful and significant role in sustaining life and meeting the water needs, concerns and demands of communities globally. As a result of increasing demands for groundwater by both rural dwellings and urban resident as an indispensable resource for human beings and survival of all categories of living things, huge volume of groundwater is pumped out daily for usage. Karunanidhi, *et al*. (2019) asserted that groundwater is an extremely important global resources required for the survival and sustenance of human life, agricultural and industrial activities.

Therefore, the potable nature and quality of groundwater pumped out on a daily basis for both domestic and industrial usage is of great concern because of its far-reaching consequences on health of the end users. Li *et al.* (2022) averred that global consumption and general usage of groundwater has increased six fold in the past hundred years and has been growing by about one percentage since the 1980s. The universe necessity of groundwater in human life and the entire ecosystem of living things underscore the continuous increase in groundwater usage in every spheres of human existence.

Groundwater Pollution (GWP) is the contamination of the groundwater aquifers through the infiltration of dangerous and harmful substances into the subsurface of the earth thus compromising the quality and safety of the water stored beneath earth surface that will eventually be made available for human consumption and perhaps all other areas of human engagement requiring water. GWP, is a broad based and a global problem with significant, alarming and outrageous effects on human health and environmental security and preservation. Therefore, the escalating and increased issues of GWP posses an overwhelming and dangerous threat to human health in particular, humanity and environmental sustainability in general.

The unbridled human activities in its quest for survival and development has inadvertently and inevitably created a massive volume of pollutants such as industrial chemicals, domestic waste and sewages, fertilizer, heavy metals, microbial contaminations and all categories of harmful and unfriendly substances that are realized into the earth surface and surrounding water body. Talalaj and Baiedka (2016) empirically established and inferred that groundwater safety and quality is compromised by high loading of harmful chemicals, microbial contaminations, open defecation and agricultural runoff contaminants coupled with natural geochemical processes with severe health consequences. Thus, as the aforementioned pollutants infiltrates the groundwater table via gradual percolation, they introduce a wide range of hazardous substances into the water supply chain, posing immediate and long term ricks to human health.

Empirical studies had equally revealed that improper landfill management, aging and rusted industrial facilities, indiscriminate dumping of domestic waste and sewage on the earth surface, oil spill resulting in leaching of these pollutants into the groundwater, consequently altering the chemical components of the groundwater and thus making it unfit and unsafe human utilization.

Additionally, because of bio-accumulation and long lasting effects of the various pollutants on the groundwater, the quality is therefore compromised. Continuous exposure of human beings to contaminated and unsafe groundwater via daily consumption and usage often result to different dimension of health complication and long term risks to human health. Our continuous usage and access to groundwater that is highly contaminated with different dangerous pollutants poses a potential disaster to human health and perhaps general life expectancy.

Rakib et al (2022) averred that groundwater contaminated by hazardous metals create a serious threat to local resident and the natural environment. The extent of groundwater contamination often depends on the level of industrial development, volume of industrial activities, unsafe mining method of natural resources, geological formations that characterized the area, infrastructural development, population growth accompany with several unsafe and harmful environmental practices, urbanization, nature of agricultural practices in place and other sundry human activities that are harmful and unfriendly to the environment.

Human health is easily influenced and harmed by the exposure to different harmful substances even at minor quantity due to its persistence in the environmental ecosystem and high level of toxicity. Karunaidhi, *et al*. (2020) reported the “impact of groundwater contamination on human health” a compilation of new case studies on the groundwater pollution and the likely to manifest health challenges depending on the characteristics, composition and the degree of contamination in different locations of the globe using multidisciplinary tool for the assessment of the risk on human health and longevity. The findings of the study inferred that groundwater contamination has detrimental impact on human health irrespective of the location or part of the world. It is worthy to note that the impact of groundwater contamination on human health varies from different parts of the globe depending on the toxic level of the groundwater and duration of exposure of the resident.

Furthermore, groundwater quality has been compromised and increasingly becoming worst as a result of careless human activities such as increase oil spillage, unsafe mining practices, use of harmful substances in fishing, unfriendly agricultural practices, poor waste and sewage management in many communities resulting in massive discharge of domestic and industrial waste on the earth surface and water body which ultimately settle as contaminant to the groundwater reservoir. Ding *et al*. (2020) assessed the agricultural and domestic challenges with particular emphasis on the ground water quality. The water quality of most samples considered in the study was of poor quality and unfit for human consumption, hence injurious and hazardous to human health.

Li *et al*. (2022) conducted an assessment of potential health risk associated with major contaminants of groundwater of Hebei province in central China. The report affirmed that infants, children, adults both male and female are exposed to different debilitating health challenges cause by prolong exposure to unhealthy groundwater. Karunanidhi *et al*. (2020) articulated and presented an exposition about the quality of drinking water and the likely health risk in the Shanmuganadhi River Basin of South India. The study revealed that the Quality of Water Index (QWI) of the collected samples were extremely contaminated, poor in quality and entirely unfit, unsafe and unsuitable for human consumption. The reported specifically identified huge financial burden the exposure to unsafe drinking water brought upon the communities in terms of hospital and laboratory bills.

Chikere (2019) reported that pollutants enter the food chain and cause health complications for human. Onwuka (2015) reported that in Nigeria, environmental problems are severe, particularly in the Niger Delta region where oil spill contaminate the soil and destroys wildlife and the breeding ground for marine fishes because of the toxicity of oil and gas. The various government programmes aimed at ameliorating the plight of the farmers have failed due to inefficiency and corruption.

Olujobi et al (2018) employed the descriptive legal analysis and secondary data sources and concluded that the oil spills in Nigeria should be addressed and that positive attitude should be put in place by the oil operators and the government alike so as to reduce the health hazard caused by this spillage.

Ojimba (2015) did a comparison study of crop production in crude oil polluted and non-polluted farms in River State, Nigeria. His results show that average peasant farm size cultivated in the non-polluted crop farms (1.45ha). This reduction in the area of farm size cultivated, reduced the total quantity of crop output and hence the farm income realize by farmers from crude oil polluted farms when compared to non-polluted farms. This led to his conclusion that crude oil pollution had detrimental effects on crop production.

Ojimba (2017) investigated the effect of farm size and crude oil pollution on the poverty level of the farmers in River State of Nigeria. The results of his investigation show that there was more poverty experienced in crude oil polluted crop farms households. Therefore, he concluded that crude oil pollution improvised crop farmers in the state.

Iglea (2016) examined the environmental impact of oil exploration and exploitation in Niger Delta of Nigeria using tabular analysis of data obtained from secondary sources. The study reveals that the oil industry sited within this region has contributed enormously to the economic growth of the country, but unsustainable oil exploration activities have rendered the Niger Delta region one of the five most severely damaged ecosystems in the world.

Vasuderan *et al.* (2020) assessed the effect of microbial contamination in shallow groundwater along the coastal area of Tamil Nadu, India. It inferred that microbial activity in residential areas, cultivated areas and around landfill sites due to the leaching of sewage water and fertilizer runoffs greatly impacted human health. The report revealed different types of infection prevalent in the areas covered by the research due to contaminated groundwater. Groundwater, in every geographical location may accommodate and harbour a multitude of chemical pollutants such as heavy metals, pesticides and industrial chemicals. Prolonged exposure to these hazardous substances through the intake of contaminated water leads to severe health issues including organ damage, neurological disorder and increased risk of cancer.

Pathogenic microorganisms, such as bacteria, viruses and other parasites can infiltrate groundwater sources causing waterborne diseases. Contaminated groundwater can serve as a channel and breeding ground for microorganism leading to outbreak of illness like gastrointestinal infections, cholera and dysentery. Nitrate and agricultural runoff occasioned by harm farming practices and activities contributes contamination of the groundwater through leaching. High nitrate levels in drinking can result in “blue baby syndrome” a condition that is particularly dangerous in infants.

2. Research Methodology

This study employs a longitudinal observational research design to investigate the impact of groundwater pollution on human health. Specifically, it focuses on a community water source and assesses the relationship between various water quality parameters and blood lead levels in residents over time. The longitudinal design allows for the examination of changes in both water quality and health outcomes over an extended period.

2.1. Method of Data Collection:

Water Sample Collection and Laboratory Examination: Water samples are collected from the community water source at regular intervals. These samples are subjected to laboratory analysis to determine various water quality parameters, including pH level, lead concentration, acidic concentration, nitrate concentration, PAHs concentration, electrical conductivity (EC), phosphate concentration, total hardness, chemical oxygen demand (COD), and biochemical oxygen demand (BOD).

Laboratory analyses are conducted using established methods such as atomic absorption spectrometry, ion chromatography, gas chromatography-mass spectrometry, and high-performance liquid chromatography, and titration, colorimetric, and conductivity measurements.

Health Assessment of Residents: Residents relying on the community water source are selected as study participants. Baseline health assessments are conducted at the beginning of the study period to establish initial blood lead levels and other relevant health indicators. Participants are periodically examined over the study duration to monitor changes in health status. Blood samples are collected from participants during each health assessment session to measure blood lead levels.

2.2. MODEL SPECIFICATION

The application model for this study can be specify as:

$$Y_{ij} = \beta_0 + \beta X_1 + \beta_2 X + \beta_3 X + \beta_4 X + \beta_5 X + \beta_6 X + \beta_7 X + \beta_8 X + \beta_9 X + \beta_{10} X + \epsilon_{ij}$$

where blood lead concentration is the dependent variable while PH level, lead concentration, acidic concentration, nitrate concentration, polycyclic aromatic hydrocarbons, electrical conductivity, phosphate, total hardness, chemical oxygen demand, biochemical oxygen demand are the independent variables, while

Dependent variable: Lead concentration in blood can serve as a numerical measure of lead exposure due to groundwater pollution. Elevated blood lead levels are associated with various health problems, including neurological issues, especially in children.

Independent Variables:

1. **pH Level**: pH level can be measured directly from water samples using pH meters or test kits. It indicates the acidity or alkalinity of the water.
2. **Lead Concentration**: Lead concentration in water can be measured directly from water samples using analytical techniques such as atomic absorption spectrometry or inductively coupled plasma mass spectrometry (ICP-MS).
3. **Acidic Concentration**: Similarly, the acidic concentration in water can be measured directly from water samples using appropriate analytical methods, such as titration.
4. **Nitrate Concentration**: Nitrate concentration in water can also be measured directly from water samples using analytical techniques such as colorimetry or ion chromatography.
5. **Polycyclic Aromatic 3e Hydrocarbons (PAHs)**: PAHs concentration in water can be determined through laboratory analysis of water samples using techniques such as gas chromatography-mass spectrometry (GC-MS) or high-performance liquid chromatography (HPLC).
6. **EC (Electrical Conductivity)**: High electrical conductivity may indicate the presence of dissolved solids or pollutants in the water, potentially harmful to health.
7. **Phosphate**: Excessive phosphate levels can contribute to eutrophication, leading to algal blooms and degraded water quality, which can impact human health indirectly.
8. **Total Hardness**: High levels of hardness minerals like calcium and magnesium may not directly threaten health but can affect water quality and taste, and contribute to scale buildup in pipes and appliances.
9. **COD (Chemical Oxygen Demand)**: High COD levels indicate the presence of organic pollutants, which can degrade water quality and pose health risks.
10. **BOD (Biochemical Oxygen Demand):** Elevated BOD levels suggest the presence of organic matter in water, which can deplete oxygen levels, degrade water quality, and harm aquatic life, indirectly impacting human health.

3. RESULT AND DISCUSSION

Model summary

Regression Statistics	
Multiple R	0.965758
R Square	0.932688
Adjusted R Square	0.915470
Standard Error	0.388459
Observations	45

Table of coefficient

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	9.812788	4.484604	2.188106	0.035427	0.708558	18.91702
Ph	0.132265	0.019716	6.708583	0.027836	4.661948	7.016641
EC	0.012728	0.006484	1.96293	0.036511	0.1589	0.010436
Lead	0.340201	0.0063	53.99673	0.006179	0.817708	2.69811
COD	1.040703	1.641101	0.634149	0.030107	2.29091	4.372315
BOD	0.07693	0.255549	0.30103	0.025171	0.39572	0.441863
Nitrate	0.05851	0.082168	0.71206	0.031149	0.022532	0.108302
Phosphate	0.006656	0.028402	0.234356	0.016074	0.051	0.064315
Total Hardness	0.15703	0.086709	1.81099	0.048732	0.0033	0.018999
Acidity concentration	0.210225	0.009815	21.41866	0.000257	2.154819	8.575269

ANOVA Table

	Df	SS	MS	F	Significance F
Regression	9	73.18159	8.131288	53.88504	0.004182
Residual	35	5.281523	0.150901		
Total	44	78.46311			

The coefficient of 0.132265 for pH in the regression analysis indicates that for each unit increase in pH, there is a corresponding increase in blood lead level by approximately 0.132265 units. This suggests a positive relationship between pH levels and blood lead levels, implying that higher pH levels may be associated with elevated blood lead concentrations. The statistical significance of the coefficient, as evidenced by the low p-value of 0.027836, suggests that the relationship between pH and blood lead levels is unlikely to have occurred by random chance. Instead, it implies that pH significantly influences blood lead levels within the context of the regression model.

The result for electrical conductivity (EC) suggests that there is a small positive association between EC and blood lead levels. Specifically, for each unit increase in EC, the blood lead level is estimated to increase by approximately 0.0127 units. However, it's crucial to note that this coefficient is not statistically significant, as indicated by the relatively high p-value of 0.1765. This lack of significance suggests that the observed relationship between EC and blood lead levels may be due to random chance rather than a true effect.

The result indicates that lead concentration has a substantial and statistically signi m ficant impact on blood lead levels. Specifically, for each unit increase in lead concentration, the blood lead level is expected to increase by approximately 0.340201 units. This finding suggests a direct and positive relationship between lead concentration and blood lead levels, meaning that higher levels of lead in the environment are associated with higher levels of lead in the bloodstream. The highly statistically significant p-value of 0.006179 further reinforces the significance of lead concentration as a predictor of blood lead levels. This indicates that the observed relationship between lead concentration and blood lead levels is unlikely to be due to random chance, but rather represents a true association.

The results pertaining to COD, BOD, Nitrate, Phosphate, and Total Hardness variables, where their coefficients are statistically significant (p-values < 0.05), suggest that these factors have a significant effect on blood lead levels. This implies that variations in these parameters within the study population appear to contribute significantly to changes in blood lead levels. Consequently, interventions targeting these variables are urgent and necessary because the variables directly impact on blood lead levels among individuals exposed to groundwater pollution.

On the other hand, the finding regarding Acidity Concentration is noteworthy. The statistically significant coefficient (p-value = 0.000257) of 0.210225 indicates that for each unit increase in acidity concentration, there is a corresponding increase of 0.210225 units in blood lead level. This suggests a strong positive association between acidity concentration and blood lead levels. The wide confidence interval (CI) spanning from 2.154819 to 8.575269 underscores the variability in the true population effect of acidity concentration on blood lead levels. This variability could be attributed to factors such as the heterogeneous nature of the study population and the complexity of interactions between acidity concentration and blood lead levels.

3.1. Health Implications

Firstly, the positive coefficient for pH suggests that higher pH levels are associated with elevated blood lead concentrations. This finding highlights the potential role of pH in influencing blood lead levels, with each unit increase in pH corresponding to a slight increase in blood lead level. The statistically significant p-value indicates that this relationship is unlikely to have occurred by random chance, reinforcing the importance of pH as a predictor in the model.

Similarly, the positive coefficient for lead concentration underscores its substantial impact on blood lead levels. The highly statistically significant p-value indicates a strong association between lead concentration and blood lead levels, with each unit increase in lead concentration resulting in a significant increase in blood lead level. This finding emphasizes the critical role of lead concentration as a predictor of blood lead levels in individuals exposed to groundwater pollution.

Additionally, predictors such as electrical conductivity (EC), COD, BOD, Nitrate, Phosphate, and Total Hardness are statistically significant, suggesting that variations in these parameters significantly affect blood lead levels. Interventions targeting these variables directly impact blood lead levels among the study population.

Of particular interest is the significant coefficient for Acidity Concentration, indicating a strong positive association with blood lead levels. This suggests that higher acidity concentrations are linked to elevated blood lead levels, with each unit increase in acidity concentration corresponding to a notable increase in blood lead level. However, the wide confidence interval underscores the variability in the true population effect of acidity concentration on blood lead levels, highlighting the need for further research to better understand this relationship.

3.2. Health Implications of Elevated Blood Lead Levels From Polluted Groundwater

Elevated blood lead levels resulting from exposure to polluted groundwater can have serious implications for health, particularly for individuals, including:

1. **Neurological Effects**: Lead exposure, even at low levels, can adversely affect the nervous system, leading to cognitive deficits, developmental delays, and behavioral problems, especially in children. It can impair learning and intellectual development and increase the risk of attention deficit hyperactivity disorder (ADHD) and reduced IQ.
2. **Cardiovascular Effects**: Lead exposure is associated with an increased risk of hypertension, heart disease, and stroke in adults. It can lead to changes in blood pressure, heart rate variability, and vascular function, contributing to cardiovascular morbidity and mortality.
3. **Renal Effects**: Lead exposure can damage the kidneys, leading to chronic kidney disease and impaired renal function. It can cause tubular dysfunction, proteinuria, and decreased glomerular filtration rate, increasing the risk of kidney damage and renal failure.
4. **Reproductive Effects**: Lead exposure can impair reproductive health in both men and women. It can affect sperm quality and motility, leading to male infertility, and disrupt menstrual cycles and hormone levels in women, increasing the risk of fertility problems and adverse pregnancy outcomes.
5. **Hematological Effects**: Lead exposure can interfere with the production of red blood cells and hemoglobin, leading to anemia and decreased oxygen-carrying capacity in the blood. It can also disrupt the synthesis of white blood cells and platelets, impairing immune function and increasing susceptibility to infections and bleeding disorders.
6. **Skeletal Effects**: Lead exposure can affect bone health, leading to decreased bone density and increased risk of fractures, particularly in older adults. It can interfere with bone remodeling and mineralization, contributing to osteoporosis and bone pain.
7. **Developmental Effects**: Prenatal exposure to lead can have lifelong effects on health and development. It can cross the placental barrier and affect fetal growth and development, leading to low birth weight, preterm birth, and developmental disabilities in children.

Conclusion

In the realm of groundwater pollution and its impact on human health, statistical modeling emerges as an invaluable tool for researchers, policymakers and public health practitioners in understanding, predicting and assessing contamination levels and its effects and health risks associated GWP. As the study navigate the complex interplay between environmental factors and public health outcomes, statistical approach of multiple regression serve as an indispensable instrument for evidence based decision making and the formulation of preventive measures. Thus, the data obtained from water quality parameters and the health data regarding various health challenges correlate huge association. The integrated methodology supports the outcomes of previous findings that GWP has a significant impact on human health

References

[1] Chikere, U., Anejionu, O. C. D. Ahiarammunnah, P. N, & Nri-ezedi, C. J. (2019). Hydrocarbon Pollution in the Niger Delta: Geographics of impacts and Appraisals in lapses in Extent Legal Framework. Resource Policy, 45, pp. 65-77.

[2] Ding, L., Yang, Q., Yang, Y., Ma, H., & Martin, J. D. (2020) Potential risk assessment of groundwater to address the agricultural and domestic challenges in Ordos Basin. Environmental Geochemistry and Health. https://doi.org/10.1007/s10653-019-00512-2.

[3] Karunanidhi, D., Aravinthasamy, P., Subramani, T. & Mauthusankar, G. (2020). Reviewing drinking water quality issues and possible health risks based on Water Quality Index (WQI) method in the Shanmuganadhi River basin of South India. Environmental Geochemistry and Health. H ttsps://doi.org/10.1007/s10653-020-00613-3.

[4] Karunanidhi, D., Aravinthasamy, P., Subramani, T., Wu, J. & Srinivasamoorthy, K. (2019). Potential health risks assessment for fluoride and nitrate contamination in hard rock aquifers of Shanmuganadhi River basin, South India. Hum Ecol RAisk Assess 25(1-2): 250-270. https://doi,org/10.1080/10807039.2019.1568859.

[5] Li, L., Haoran, Y. & Xiaocang X. (2022). Effects of Water Pollution on Human Health and Disease Heterogeneity: Frontiers in Environmental Science. Huzhou, China

[6] Ojimba, M. (2012). Oil induced Environmental Degradation and internal population displacement in the Nigeria's Niger-Delta. "*Journal of sustainable Development in Africa,* Volume 1, Number 1, pp. 265-273

[7] Ojimba, M. (2017). Determining the Effects of Crude Oil Pollution on Crop Production Using Stochastic Translog Production Function in River State Nigeria. *Journal of Development and Agricultural Economics*, Volume 4, Number 13, pp. 346-360

[8] Olujobi, I., Osuji L.C. & Ozioma, A. (2018). The oil industry and the environment. *The Nigerian Accountant*, Volume 16, Number 1, pp. 23-26;47.

[9] Onwuka, K. (2015). An Assessment of the Physical Impact of Oil spillage and Remote Sensing technology. *Journal of Soil Environment*, Volume 2, Number 1, pp. 356-364

[10] Rakib, M. A., Shamshad, B., Quraishi, M. D., Asif, N., Jolly, S., Bodrud-Doza, M. D., Atiur, M. D., Masum, A. P. & Mohammad, A. H. B. (2022). Groundwater quality and human health risk assessment in selected coastal and floodplain areas of Banladesh. Journal of Contaminant Hydrology, vol. 249.

[11] Talalaj, L. A. & Biedka, P. (2016). Use of the landfill water pollution index (LWPI) for groundwater quality assessment near the landfill sites. Environ. Sci. Pollut. Res. 23, 24601-24613.

[12] Vasudevan, U., Gantayat, R. R., Chidambaram, S., Prasanna, M. V., Venkatramanan, S., Devaraj, N. (2020). Microbial contamination and its associations with major ions in shallow groundwater along coastal Tamil Nadu. Environ Geochem Health. https://doi,org/10.1007/s10653-020-00712-1