

## Effects of Pumping Time on Quality of Groundwater at Akoda –Ede, Osun State, Nigeria

O. O. Fadipe<sup>a\*</sup>, B. B. Oguntola<sup>b</sup> and J. O. Adeosun<sup>a</sup>

<sup>a</sup>Department of Civil Engineering, Osun State University, Osogbo, Nigeria

<sup>b</sup>Directorate of Works and Physical Planning, Redeemer's University, Ede, Nigeria

*Corresponding Author:* olayemifadipe@yahoo.com

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### ABSTRACT

*This study analyzed the effects of pumping time on groundwater quality of a borehole located at Akoda Area, Ede, Osun State with the aim of assessing the effects of pumping time on its quality. Akoda Ede is currently subjected to continuous pumping because of its recent sudden physical development which includes establishment of a private university. The selected borehole was subjected to continuous pumping for a period 12hrs and water samples were taken at intervals of 2hrs for physico-chemical analysis. The sampling process was repeated three times over a period of three months. Descriptive statistics was adopted to categorize the water analysis results for comparison with WHO standards while correlation coefficient ( $r$ ) was used to measure the degrees of linear association between the water quality parameters and time of pumping. The physico-chemical analysis of the water samples revealed that all the parameters were within WHO standards except lead (Pb) and chromium (Cr). The mean values obtained for Pb (0.05mg/l) and Cr (0.41mg/l) were higher than the permissible limits. Statistically significant correlations were found between the pumping time and selected groundwater quality parameters. As the pumping time increases; iron, lead, sodium, sulphate and nitrate contents decreases while chromium, calcium, total dissolved solid, phosphate, carbonate and pH contents increases. Treatment of groundwater in the area is recommended as excessive lead and chromium intake may cause joint disease and cancer respectively. Parameters that showed tendency to increase as pumping time increases should be subjected to further analysis beyond 12hr of pumping.*

### 1. INTRODUCTION

Groundwater is an essential and valuable water resource in many developing countries, especially in cities where there is pressure on public water supply because of insufficient infrastructure. It is a fundamental and crucial segment of human life supportive network. It is being used for drinking and mechanical purposes. There is developing worry on reduction of groundwater quality due to geogenic and anthropogenic activities (Chakrapani, 2005). The quality of water is not only essential for the survival of mankind but also directly or indirectly linked with human welfare, culture and economy (Matta, 2014).

Groundwater contains wide assortments of broke down inorganic compound constituents in different focuses because of synthetic and biochemical connections between water, the geographical materials through which it streams and to a lesser degree in view of commitment from the environment and surface water bodies (Matta, 2014). According to Ranjana (2010), the quality of public health depends to a greater extent on the quality of groundwater. Though groundwater quality is believed to be good compared to surface water, its quality is the sum of natural (geology of the environment) and anthropogenic influences (withdrawal, land use change, and solid waste dumping) (Chapman and Kimstach, 1996). Water quality parameters reflect the level of contamination in water resources and show whether water is suitable for human consumption.

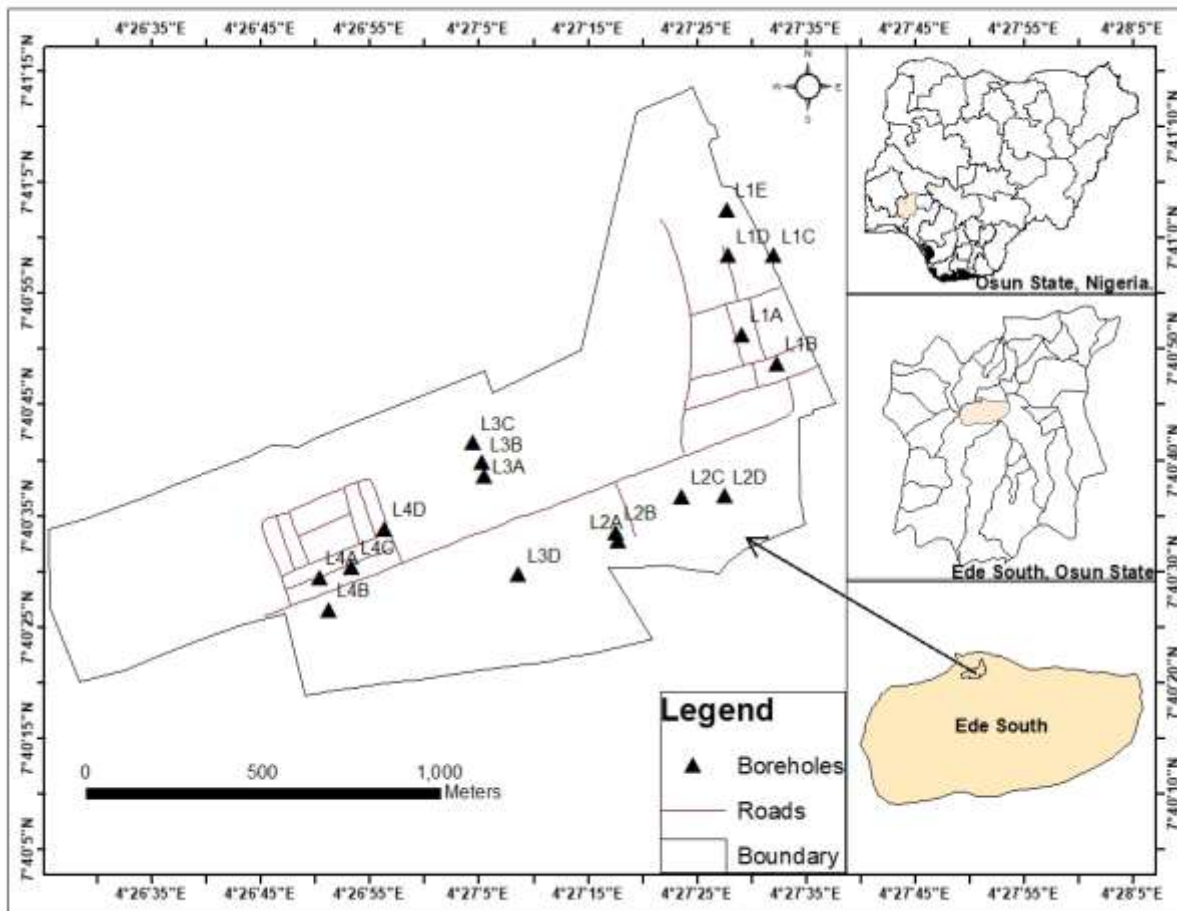
Ambiga and AnnaDurai (2015) studied the development of water quality index and regression model for assessment of groundwater quality. The investigation revealed that the ground water of the study area requires some extent of treatment before utilization, and needs to be confined from the perils of pollution. Patel and Dhiman (2011) studied the temporal variation and linear regression analysis of hydrochemical facies of groundwater present at different locations in Anand taluka. Their study showed that certain parameters like Electrical Conductivity (EC), Total Dissolve Solid (TDS), pH and Chloride (Cl-) varies moderately to high in some places. A positive correlation was observed between EC and Cl. Their study evaluated the quality of the groundwater in the study area and was limited to correlation between the water quality parameters but not with pumping time.

Joarder *et al.* (2007) studied regression analysis of ground water quality data of Sunamganj District, Bangladesh with the aim of developing linear regression equations to predict the concentration of water quality constituents having significant correlation coefficients with EC. They concluded that the linear regression equations developed for predicting the concentration of different parameters based on EC can successfully be used within reasonable precision. Their study did not explore the effect of pumping on water quality but rather focused on correlation of EC with identified water quality parameters. Sherif and Singh (2002) studied effect of groundwater pumping on seawater intrusion in coastal aquifers. The effect of pumping activities on the seawater intrusion in the Nile Delta aquifer of Egypt was investigated. It was concluded pumping should be located in the middle Delta and avoided in the eastern and western sides of the Delta as pumping increased salt water intrusion in the areas. Their study revealed that pumping is responsible for change in the water quality.

Gulgundi and Shetty (2018) studied groundwater quality assessment of urban Bengaluru using multivariate statistical techniques. Results obtained from principal component analysis showed that groundwater quality variation is mainly explained by dissolution of minerals from rock water interactions in the aquifer, effect of anthropogenic activities and ion exchange processes in water but was not related to pumping effect. This study aimed at determining the effect of pumping on water quality of Akoda Ede aquifer, the objective was to analyze the physico-chemical characteristics of the groundwater as affected by pumping as there has not been study on effect of pumping on water quality in the study area.

## Description of the Study Area

The study area, Akoda-Ede, is in Ede South Local Government Area of Osun State, Nigeria. It has an area of 219 km<sup>2</sup> and population of 76,035 at the 2006 national census (NPC, 2006). Ede lies on approximately latitude 07° 40'North and longitude 04°30'East. The study area soils belong to the highly ferruginous tropical red soils associated with basement complex rocks. They are generally deep as a result of the dense humid forest cover in the area and of two types; namely, deep clayey soils formed on low smooth hill crests and upper slopes; and the more sandy hill wash soils on the lower slopes. The well drained clay soils of the hill crest and slopes are very important as soil degradation and soil erosion are generally not serious in the area, but considerable hill wash is recorded along the slopes of the hills (Adewale, 2002). Figure 1 presents the map of the study area showing location of boreholes.



**Figure 1:** Map of the study area

## 2. METHODOLOGY

A borehole L1A (Figure 1) at longitude of 4.45808 and latitude of 7.68093, was selected for this study, the submersible pump in the borehole was powered by generator continuously for a period of 12hrs. The pumped water from the borehole was conveyed by discharge pipe to an overhead for immediate use where it could not recharge the well under investigations. The 12hrs pumping was repeated three times over a period of 3 months. Water samples were taken at interval of 2hrs directly from the pumped borehole during pumping to determine its quality and also to correlate its quality with pumping time. The samples were collected in prewashed 1litre white kegs and were labeled accordingly. The first sample was taken at 0 hr to serve as control while the remaining samples were taken at intervals of 2 hrs. They were transported to the laboratory and were analysed within 24 hrs. Heavy metal characteristics (Iron, lead, chromium, sodium, zinc, calcium) were analyzed using Shimadzu AA-6800 Atomic Absorption Spectrophotometer (AAS) machine. The anions (Nitrate, Carbonate, Phosphate, Sulphate.) were analyzed using Jenway 7305 UV – visible spectrophotometer machine. Physical parameters (pH and TDS) were analyzed using hand held Thermo Scientific pH meters in the laboratory.

The results of the analysis were subjected to descriptive and inferential statistics of 2018 excel statistical software. Descriptive statistics such as measure of central tendency (mean, median, mode and sum) was used to categorize water analysis results for comparison with WHO standards. Correlation coefficient (r)

which measures the strength and direction of a linear relationship between two variables was used to measure the degrees of linear relationship between the water quality parameters and time of pumping. The  $r$  values falls between +1 and -1. The closer it is to either +1 or -1 shows a perfect linear relationship between the two variables.

### 3. RESULTS AND DISCUSSION

The result of physico-chemical analysis of the water samples are presented in Table 1. It was revealed that all the parameters which include iron (Fe), sodium (Na), calcium (Ca), phosphate (P), sulphate (S), nitrate (N), carbonate (C), total dissolved solid (TDS) and pH having mean value of 0.02 mg/l, 2.24 mg/l, 0.02 mg/l, 1.15 mg/l, 61.21 mg/l, 2.69 mg/l, 2.29 mg/l, 4.65 mg/l and 6.20 mg/l were within WHO standards except lead (Pb) and chromium (Cr). The mean value (0.05 mg/l) of Pb is higher than the 0.01 mg/l permissible limit and mean value (0.41 mg/l) of Cr is higher than the 0.05 mg/l permissible limit. This is detrimental to the groundwater quality since Pb and Cr are commutative poisons and possible carcinogens. Uwamariya (2013) stated that excessive lead intake may cause the development of auto-immunity in which a person's immune systems attack its own cells which can lead to joint disease. The consumption of excessive quantity of chromium may result in plain respiratory, cardiovascular, gastrointestinal, hematological, hepatic, renal, and neurological. Though the indication of carcinogenicity of chromium in people and global living thing appears tough (Chen *et al.*, 2009). This research work confirmed the work done by Olorunfemi *et al.*, (2011) which reported that groundwater in Ejigbo and environs, southwest, Nigeria are free of acid, Na, Ca and Fe. However, concentration of lead and cadmium exceeded WHO standard. In a study conducted by Akinola *et al.* (2018), water quality parameters (pH, temperature, PO<sub>4</sub>, SO<sub>4</sub> and NO<sub>3</sub>) determined for borehole water in Iwo, Osun State were found to fall within the WHO standard as also reported by this work.

**Table 1:** Result of Physico-Chemical Analysis

| Parameters (mg/l)           | Number (N) | Range Min | Max   | Mean Mean | Std. Error | Std. Deviation | Variance | WHO     |
|-----------------------------|------------|-----------|-------|-----------|------------|----------------|----------|---------|
| Iron (Fe)                   | 6          | 0.02      | 0.03  | 0.02      | 0.00       | 0.00           | 0.00     | 0.3     |
| Lead (Pb)                   | 6          | 0.05      | 0.06  | 0.05      | 0.00       | 0.00           | 0.00     | 0.01    |
| Chromium (Cr)               | 6          | 0.40      | 0.43  | 0.41      | 0.01       | 0.01           | 0.00     | 0.05    |
| Sodium (Na)                 | 6          | 2.07      | 2.35  | 2.24      | 0.04       | 0.10           | 0.01     | 200     |
| Zinc (Zn)                   | 6          | 0.13      | 0.17  | 0.15      | 0.01       | 0.01           | 0.00     | 5       |
| Calcium (Ca)                | 6          | 0.05      | 0.05  | 0.05      | 0.00       | 0.00           | 0.00     | 75      |
| Phosphate (P)               | 6          | 1.00      | 1.23  | 1.15      | 0.04       | 0.09           | 0.01     | 5       |
| Sulphate (S)                | 6          | 58.10     | 66.47 | 61.21     | 1.22       | 2.98           | 8.89     | 200     |
| Nitrate (N)                 | 6          | 2.39      | 2.85  | 2.69      | 0.07       | 0.17           | 0.03     | 11      |
| Carbonate (C)               | 6          | 224       | 235   | 229       | 1.68       | 4.11           | 16.97    | 0.1     |
| Total Dissolved Solid (TDS) | 6          | 442       | 472   | 456       | 4.82       | 11.79          | 139.10   | 500     |
| (pH)                        | 6          | 6.11      | 6.25  | 6.20      | 0.02       | 0.06           | 0.00     | 6.5-8.5 |
| Valid N (listwise)          | 6          |           |       |           |            |                |          |         |

The result of the correlation of pumping time with heavy metal, chemical and physical characteristics is presented in Table 2. The results revealed that as the pumping time increases, there is a strong decrease in Iron, weak increase in lead, weak decrease in chromium, weak increase in sodium, moderate decrease in zinc, weak increase in calcium, strong increase in phosphate, strong decrease in sulphate and nitrate, strong increase in carbonate and pH and weak increase in Total dissolve solid. The correlation revealed that phosphate, carbonate and pH have tendency to increase as pumping time increases. Iron and Zinc also have strong correlation with sulphate. According to Chris (2012) at higher pH, basic water,  $\text{HCO}_3^-$  dissociates to yield  $\text{H}^+$  and a carbonate ion ( $\text{CO}_3^{2-}$ ).  $\text{CO}_3^{2-}$  is dominant at  $\text{pH} > 10.3$  and  $\text{HCO}_3^-$  dominates between  $\text{pH}$  6.3 and 10.3. This explains the strong correlation of pH and  $\text{CO}_3$  with pumping time.

**Table 2:** Correlation of Pumping Time with the Water Quality Parameters

|                 | Time  | Fe    | Pb    | Cr   | Na    | Zn    | Ca    | Po <sub>4</sub> | So <sub>4</sub> | No <sub>3</sub> | Co <sub>3</sub> | TDS  | pH |
|-----------------|-------|-------|-------|------|-------|-------|-------|-----------------|-----------------|-----------------|-----------------|------|----|
| Time            | 1     |       |       |      |       |       |       |                 |                 |                 |                 |      |    |
| Fe              | -0.55 | 1.00  |       |      |       |       |       |                 |                 |                 |                 |      |    |
| Pb              | 0.12  | -0.42 | 1.00  |      |       |       |       |                 |                 |                 |                 |      |    |
| Cr              | -0.32 | -0.08 | 0.17  | 1.00 |       |       |       |                 |                 |                 |                 |      |    |
| Na              | 0.02  | -0.31 | 0.19  | 0.88 | 1.00  |       |       |                 |                 |                 |                 |      |    |
| Zn              | -0.43 | 0.34  | -0.80 | 0.27 | -0.46 | 1.00  |       |                 |                 |                 |                 |      |    |
| Ca              | 0.08  | -0.14 | -0.10 | 0.04 | -0.24 | 0.20  | 1.00  |                 |                 |                 |                 |      |    |
| Po <sub>4</sub> | 0.64  | -0.94 | 0.34  | 0.18 | 0.10  | -0.32 | 0.17  | 1.00            |                 |                 |                 |      |    |
| So <sub>4</sub> | -0.57 | 0.75  | -0.53 | 0.38 | -0.59 | 0.75  | -0.17 | -0.72           | 1.00            |                 |                 |      |    |
| No <sub>3</sub> | -0.50 | 0.04  | 0.40  | 0.33 | -0.53 | 0.19  | -0.06 | -0.04           | 0.41            | 1.00            |                 |      |    |
| Co <sub>3</sub> | 0.66  | 0.12  | -0.08 | 0.49 | -0.44 | -0.12 | 0.28  | -0.02           | 0.04            | 0.29            | 1.00            |      |    |
| TDS             | 0.11  | -0.12 | -0.56 | 0.41 | 0.35  | 0.27  | 0.60  | 0.10            | -0.28           | 0.69            | 0.01            | 1.00 |    |
| pH              | 0.64  | -0.52 | -0.18 | 0.48 | -0.36 | 0.13  | 0.61  | 0.70            | -0.34           | 0.19            | 0.41            | 0.42 | 1  |

#### 4. CONCLUSION

The physico-chemical analysis of the water samples revealed that all the parameters were within WHO standards except Pb and Cr. The mean value (0.05 mg/L) of Pb is higher than the 0.01 mg/L permissible limit and mean value (0.41mg/L) of Cr is higher than the 0.05mg/L permissible limit. The result of correlation analysis of all parameters with pumping time showed that that pumping time has strong correlation with  $\text{CO}_3$ ,  $\text{PO}_4$  and pH.

Treatment of groundwater in the area is recommended as excessive lead intake may cause the development of auto-immunity in which a person's immune systems attack its own cells which can lead to joint disease and excess intake of chromium causes cancer. Parameters that showed tendency to increase as pumping time increases should be subjected to further analysis beyond 12hrs of pumping to confirm if their values will increase beyond WHO allowable values during pumping. These parameters are pH, carbonate and phosphate.



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