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## GROUNDWATER QUALITY IN AKWA IBOM STATE USING REFRACTIVE INDEX METHOD ANALYSIS

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### ABSTRACT

A study on the purity of groundwater in Akwa Ibom State has been carried out using the refractive index method. Four strategically selected locations were chosen from four local government areas of Uyo, Eket, Ikot Ekpene and Ikono. The real and apparent depth method was used to determine the refractive indices of the groundwater samples. The results show that groundwater samples from borehole in Eket Local Government Area has an average value of 1.3381 with a deviation of 0.0048 and standard error of  $\pm 0.0030$ , Ikot Ekpene Local Government Area has an average value of 1.3539 with a deviation of 0.0238 and standard error of  $\pm 0.0092$ , Uyo Local Government Area has an average value of 1.3572 with a deviation of 0.0239 and a standard error of  $\pm 0.0112$  and Ikono Local Government Area has an average value of 1.3656 with a deviation of 0.0323 and a standard error of  $\pm 0.0160$ . The highest single value of 1.4194 was obtained in groundwater obtained from Mbiafun in Ikono Local Government Area. The values of the refractive indices obtained in the current study have compared favourably with that of publicly acceptable and regularly consumed Eva-water with a refractive index of 1.3333.

### INTRODUCTION

Water purity is the condition or quality of water being pure or a quantitative assessment of homogeneity or uniformity. Water quality is the physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirement of one or more biotic species and to any human need or purpose. It is mostly frequently used as reference to a set of standard against which compliance can be assessed, (Kinsler *et. al*, 2000; Harvy *et al*, 1998).

The most common standard used to assess water quality relate to health of ecosystem, safety of human contact and drinking. The purity of bore-hole water could be known by calculating the refractive index of the water samples and comparing the values calculated with standard value for pure water. The principle involved is refraction. The refractive index of water at 20°C is 1.332986 and that of normal ice is 1.31. The absorption spectrum of pure water is used in numerous applications, including light scattering and absorption by ice crystal and cloud water droplets, theories of the rainbow, determination of the single scattering albedo and ocean colour (Pope, 1997; Kwan *et al*, 2002).

### THEORY

Refraction is the change in direction of a wave due to change in speed. This is most commonly observed when a wave passes from one medium to another at an angle. (Nelkon and Parker, 1987). Refraction can be seen when looking into a bowl of water. If an observer looks at a straight object, such as a pencil or straw, which is placed at a slant position in water, the object appears to bend at the water surface. This is due to the bending of light rays as they move from water to air. Once the rays reach the eye, eye traces them back as straight line (line of sight), (Meeten, 1997). The lines of sight intersect at a light position than where the actual rays originated. This cause the pencil to appear higher and the water appear shallower than it really

is. The depth that the water appear to be when viewed from above is known as the apparent depth and the physical depth from the bottom of the bowl to the water level is the real depth (Young and Freedman, 2008; Ward *et al*, 2005; Moss, 1963).

Mathematically,

$$\text{Refractive index} = \frac{\text{Real depth}}{\text{Apparent depth}}$$

### MATERIALS AND METHOD

The groundwater samples used for the current water purity investigation in Akwa Ibom State were obtained from four strategically selected local government areas of Uyo, (the State Capital), Ikono, (the northern and rocky area of the State), Eket, (the oil base of Akwa Ibom State) and Ikot Ekpene, (a lowland area of Akwa Ibom State). At each of the local government areas, water samples were obtained from different locations at different bore-holes as follows:

Table 1: The study areas where the water samples were obtained

Ikono L.G.A	Oduk Ikono, Mbiafun, Oduk II Ndiya Mfia, Nung Udoe Itak.
Ikot Ekpene L.G.A	Uyo Road, Abak Road, Aba Road, Umuahia Road and Ikono Road
Uyo L.G.A	Ikot Ekpene Road, Barracks Road, Aka Road, Oron Road and Uniuyo.
Eket L.G.A	Ata-Obong Road, Esit Eket Road, Marina Road, Eket-Ibena Road and Onna Road.

### METHOD

A tall beaker containing the water sample is placed at the base of the retort stand and the depth of the water.  $D$  is measured and recorded. An optical pin  $P_2$  is placed at the bottom of the beaker and another pin  $P_1$  held in a sliding cork above the liquid in the beaker, in a clamp, (Fig. 1). Place a strip of plane mirror across the mouth of the beaker so that it covers about half of it.

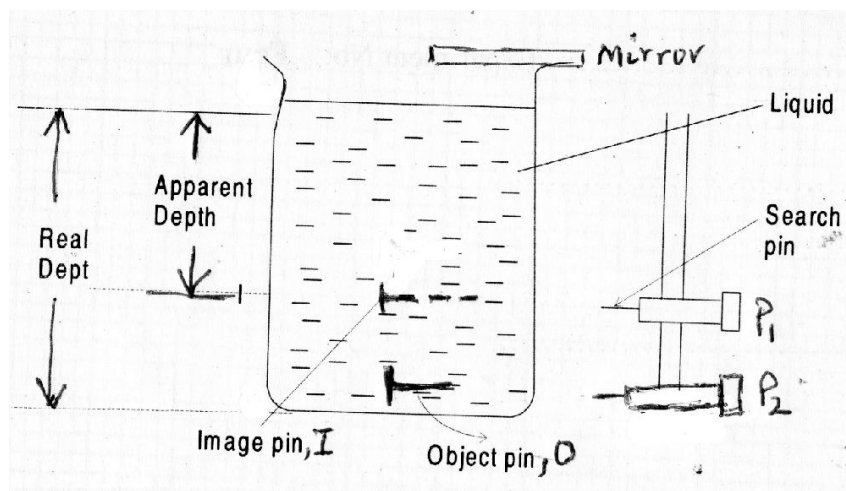


Figure 1: Refractive Index Analysis

View the pin  $P_1$  with the eye above it and adjust its position by raising it up and down until it image as seen reflected from the mirror, coincided with the image of the pin  $P_2$  as refracted by the water. The apparent depth and real depths are therefore measured and the refractive index calculated.

**RESULTS**

Table 2: Refractive Indices of the groundwater samples analyzed

	Source	Real Depth (Cm)	Apparent Depth (Cm)	Refractive Index, N	Average Refractive Index, N
Ikono	Oduk Ikono	11.70	8.70	1.3488	1.3515
	Mbiafun	11.90	8.90	1.3371	1.3783
	Oduk Ii	11.50	8.60	1.3372	1.3653
	Ndiya Mfia	11.40	8.40	1.3571	1.3671
	Uyo Road	10.40	7.70	1.3506	1.3522
Ikot Ekpene	Abak Road	11.80	6.50	1.3538	1.3551
	Aba Road	12.30	6.90	1.3529	1.3529
	Ikono Road	9.30	6.80	1.3676	1.3524
	Ikot Ekpene Road	10.00	7.30	1.3699	1.3629
	Barrack Road, Uyo	10.00	7.40	1.3514	1.3543
Uyo	Aka Road	9.00	6.70	1.3433	1.3476
	Oron Road	9.70	7.20	1.3472	1.3516
	Uniuyo	10.00	7.20	1.3889	1.3695
	Ataobong Uyo Road	9.40	7.00	1.3429	1.3445
	Esit Eket Road, Eket	10.00	7.50	1.3333	1.3333
	Marina Road, Eket	9.50	7.10	1.3380	1.3387
	Eket Ibeno Road, Eket	10.10	7.60	1.3289	1.3424
	Onna Road	10.20	7.70	1.3247	1.3318

Table 3: Comparative values of the Refractive Indices of the groundwater and pure water samples in Uyo L.G.A

Locations	Refractive Index, n	Refractive Index of Pure Water, $n'$	Deviation D= n - $n'$	$(n - n')^2$
Ikot Ekpene Rd.	1.3629	1.3333	0.0296	0.0008762
Barracks Road	1.3543	1.3333	0.0210	0.0004410
Aka Road	1.3476	1.3333	0.0143	0.0002045
Oron Road	1.3516	1.3333	0.0183	0.0003349
UNIUYO	1.3695	1.3333	0.0352	0.001310

$$\sum(n - n')^2 = 0.003167$$

$$\text{Standard Deviation, } \sigma = \left[ \frac{\sum(n - n')^2}{N} \right]^{1/2} = \left[ \frac{0.003167}{5} \right]^{1/2} = 0.02517$$

$$\text{Standard Error, } \alpha = \frac{\sigma}{\sqrt{N}} = \frac{0.02517}{\sqrt{5}} = 0.01126$$

Table 4: Comparative values of the Refractive Indices of the groundwater and pure water samples in Eket L.G.A

Locations	Refractive Index, n	Refractive Index of Pure Water, $n^{\bar{}}$	Deviation D=n - $n^{\bar{}}$	$(n - n^{\bar{}})^2$
Atabong Rd.	1.3445	1.3333	0.0112	0.0001254
Esit Eket	1.3333	1.2222	0.0000	0.0000
Marina Rd.	1.3387	1.3333	0.0054	0.00002916
Ibeno Rd.	1.3424	1.3333	0.0091	0.00008281
Onna Rd.	1.3318	1.3333	-0.0015	0.000002250

$$\sum(n - n^{\bar{}})^2 = 0.0002396$$

$$\text{Standard Deviation, } \sigma = \left[ \frac{\sum(n - n^{\bar{}})^2}{N} \right]^{1/2} = 0.006923$$

$$\text{Standard Error, } \alpha = \frac{\sigma}{\sqrt{N}} = 0.003096$$

Table 5: Comparative values of the Refractive Indices of the groundwater and pure water samples in Ikono L.G.A

Locations	Refractive Index, n	Refractive Index of Pure Water, $n^{\bar{}}$	Deviation D=n - $n^{\bar{}}$	$(n - n^{\bar{}})^2$
Oduk Ikono	1.3515	1.3333	0.0182	0.0003312
Mbiafun	1.3783	1.3333	0.045	0.002025
Oduk II	1.3653	1.3333	0.032	0.001024
Ndinya Mfia	1.3671	1.3333	0.034	0.001142

$$\sum(n - n^{\bar{}})^2 = 0.0002396$$

$$\text{Standard Deviation, } \sigma = \left[ \frac{\sum(n - n^{\bar{}})^2}{N} \right]^{1/2} = 0.03362$$

$$\text{Standard Error, } \alpha = \frac{\sigma}{\sqrt{N}} = 0.0168$$

Table 6: Comparative values of the Refractive Indices of the groundwater and pure water samples in Ikot Ekpene L.G.A

Locations	Refractive Index, n	Refractive Index of Pure Water, $n^{\bar{}}$	Deviation D=n - $n^{\bar{}}$	$(n - n^{\bar{}})^2$
Uyo Rd.	1.3522	1.3333	0.0189	0.0003572
Abak Rd.	1.3551	1.3333	0.0218	0.0004752
Aba Rd.	1.3569	1.3333	0.0236	0.0005569
Umuahia Rd.	1.3529	1.3333	0.0196	0.0003842
Ikono Rd.	1.3524	1.3333	0.0191	0.003642

$$\sum(n - n^{\bar{}})^2 = 0.0021383$$

$$\text{Standard Deviation, } \sigma = \left[ \frac{\sum(n - n^{\bar{}})^2}{N} \right]^{1/2}$$

$$\text{Standard Error, } \alpha = \frac{\sigma}{\sqrt{N}} = 0.0009248$$

Table 7: Summary of results in the study areas.

L.G.A.	Study Areas	Refractive Index	Refractive Index Of Pure Water	Deviation	Error
Ikono	Oduk Ikono	1.3515	1.3333	0.01820	0.01680
	Mbiafun	1.3783	1.3333	0.04500	
	Oduk II	1.3653	1.3333	0.03200	
	Ndiya Mfia	1.3671	1.3333	0.03380	
Ikot Ekpene	Uyo Rd.	1.3522	1.3333	0.01890	0.01126
	Abak Rd.	1.3551	1.3333	0.02180	
	Aba Rd.	1.3569	1.3333	0.02360	
	Umuahia Rd.	1.3529	1.3333	0.01960	
Uyo	Ikot Ekpene Rd	1.3629	1.3333	0.02960	0.01126
	Barrack Rd.	1.3543	1.3333	0.02100	
	Aka Rd.	1.3476	1.3333	0.01430	
	Oron Rd.	1.3516	1.3333	0.01830	
	Uniuyo	1.3695	1.3333	0.03620	
Eket	Atabong Rd	1.3445	1.3333	0.01120	0.004800
	Esit Eket Rd.	1.3333	1.2222	0.0000	
	Marina Rd.	1.3387	1.3333	0.005400	
	Ibeno Rd.	1.3424	1.3333	0.009100	
	Onna Rd.	1.3318	1.3333	-0.001500	

Table 8: Overall mean of Refractive Index in each Local Government Area.

L.G.A	Mean Refractive Index	Refractive Index Of Pure Water	Deviation	Standard Error
Ikot Ekpene	1.3539	1.3333	0.02388	0.009248
Uyo	1.3572	1.3333	0.2390	0.01126
Eket	1.3381	1.3333	0.004800	0.003096
Ikono	1.3656	1.3333	0.03230	0.01680

Table 8 gives the overall mean of the refractive index in each of the local government considered in this research with their calculated standard error.

### DISCUSSION AND CONCLUSION

The refractive index method for the determination of bore-hole water purity in Akwa Ibom State has proved a potent tool for the above study. The twenty water samples obtained have show similar trends in refractive index values. The refractive indices have valued between 1.33 and 1.36 with a deviation of 0.0048 to 0.0323 and an error of 0.0030 to 0.0168 when compared with the publicity acceptance value of 1.333 for Eva-water though the highest single value of 1.4194 was obtained in Mbiafun in Ikono L.G.A and the lowest single value of 1.3333 was obtained in Esit Eket Road in Eket L.G.A, the borehole water in Akwa Ibom State are found to be considerably pure.

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