



Physicochemical and Metal Characterisation: Impact Assessment of Badagry Creek on Groundwater Quality in Ojo Community, Ojo, Lagos State

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Introduction

Groundwater is water present beneath the Earth’s surface, and it represents about 30% of the world’s fresh water [1]. Various factors for the preference of groundwater over surface water include convenient availability of source close to where water is required; its excellent natural quality which is adequate for potable need with little or no treatment; and relatively low capital cost of its development. Groundwater is also less vulnerable to pollution than surface water. Hence, it is preferable for domestic, agricultural, and industrial purposes [2].

Groundwater can gather in cracks in subsurface rocks, and in between soil surfaces, which serve as a filter. Therefore, water from aquifers can be abstracted using a water well [2]. However, there is a potential for contamination by toxic compounds, including spilled petroleum products, applications of chemicals and fertilizers, leachates and some microbial contamination [3].

Groundwater is also susceptible to saltwater intrusion in coastal areas, which leads to degradation in groundwater quality. Saltwater intrusion is the movement of saline water (from the sea) into freshwater aquifers. It is majorly caused by excess withdrawal of groundwater from wells, construction of navigation channels or oil field canals, and sea level changes [4]. Some impacts of saltwater intrusion on groundwater are loss of freshwater vegetation, spread of mudflats on formerly vegetative areas, poor quality of water for drinking and domestic uses, which could lead to chronic diseases, and possibly, death of humans and animals [5].

Aim

The purpose of this study is to evaluate the impact of Badagry creek on groundwater quality in Ojo Community, Ojo, Lagos State.

Objectives

- Analysis of physicochemical parameters in water samples.
- Analysis of trace metals in water samples.
- Data analysis using statistical tools, including descriptive analysis, pearson correlation coefficient, principal component analysis (PCA), and cluster analysis (Dendogram).



Fig 1: A glass of water (Source: eprojectlibrary.com)

Methodology

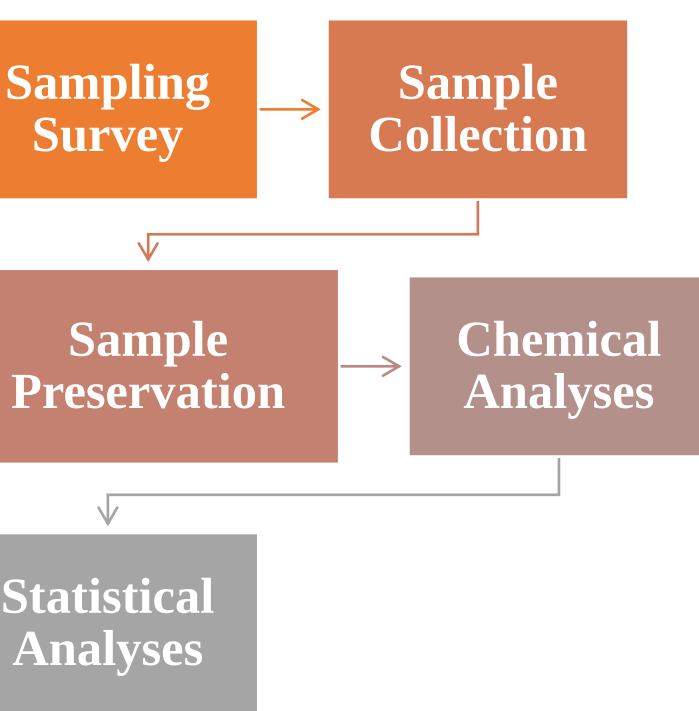


Fig 3: Flow chart showing methodology for the study.

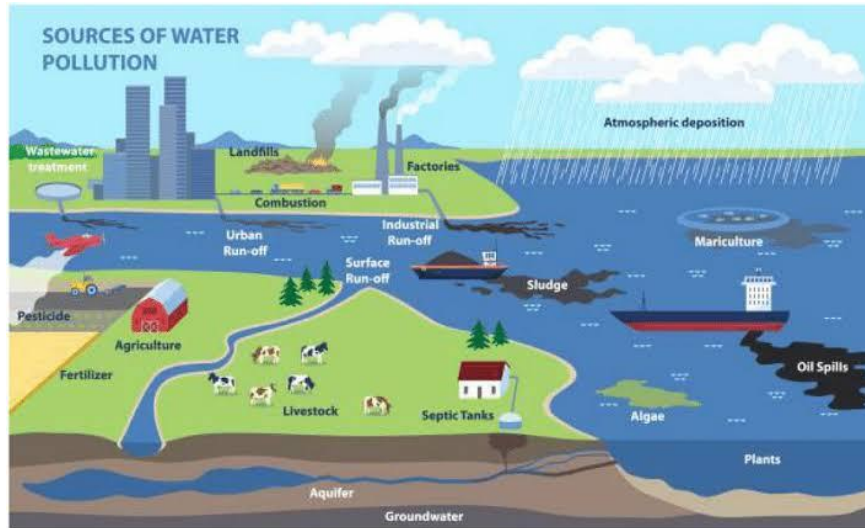


Fig 2: Sources of groundwater pollution (Source: istockphoto.com)

Study Area

Ojo is a Local government area, and town in the Badagry division of Lagos State, Nigeria, and is primarily residential. Ojo bounds the South of the Badagry Creek, through Victoria Island, it empties into the Atlantic Ocean. It houses some major markets, such as the Alaba International market, West Africa’s largest electronic market. The local government area consists of mangroves, swamps and sandy beaches. The major sources of water supply are hand-dug wells and bore-holes, with major preoccupations as fishing, trading, and sediment dredging.

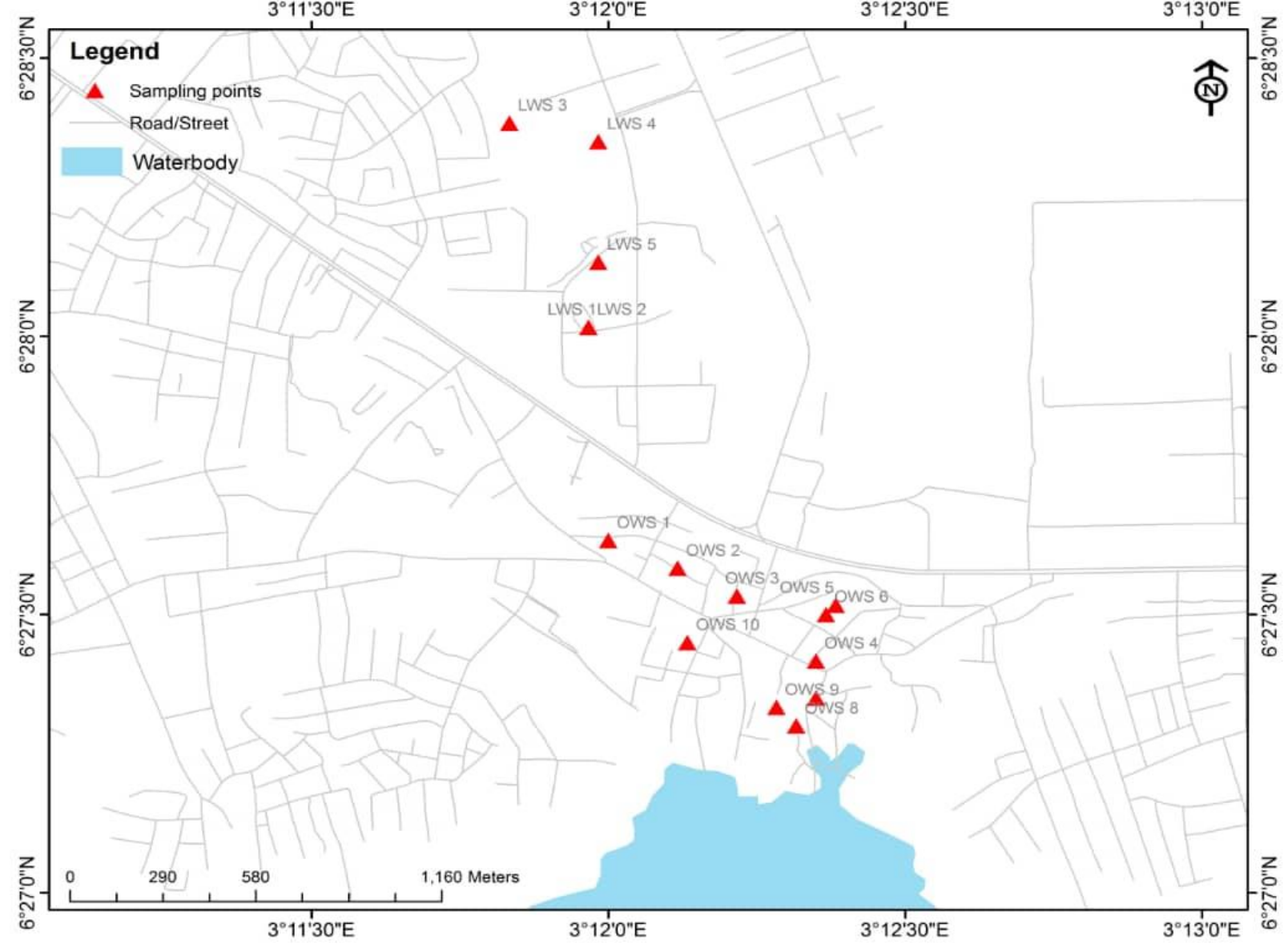


Fig. 4: Map showing sample locations

Sample Collection

- Groundwater samples were collected from 15 locations (hand-dug wells), in the Ojo community, and the sample locations were recorded using a Global Positioning System (GPS), as shown in Table 1.0 above.
- The plastic bottles used (1.5 L and 0.75 L) were acid-washed, for physicochemical and metal analyses respectively [6].
- The water samples taken for metal analyses (0.75 L) were preserved with about 1.5ml of concentrated HNO₃, while water samples collected for physicochemical analysis were filled to the brim of the 1.5 L plastic bottles, to avoid microbial degradation of water samples.
- The collected samples were taken to the laboratory, and stored in the refrigerator at 4°C.

Chemical Analyses

- pH and temperature of the groundwater samples were determined in-situ electronically, with a pH meter, while electrical conductivity (EC), and total dissolved solids (TDS) by conductivity meter.
- Acidity, alkalinity, total hardness (TH), and chloride were determined titrimetrically.
- Phosphate (PO₄³⁻) was determined using the colorimetric method, while nitrate (NO₃⁻) was done using the ultraviolet spectrophotometric screening method, and sulphate (SO₄²⁻) was determined by turbidimetry. The concentrations were analysed with a UV-Vis Spectrophotometer.
- Samples were analysed for trace metals by acid digestion method, and quantification by Flame Atomic Absorption Spectrophotometer (FAAS) [7].

Results and Discussion

Table 1: Descriptive Analysis for Physicochemical Parameters

Parameters	Min	Max	Mean	SD	CV%	SEM	Exceedance	WHO	NSDWQ
pH	5	8	6.33	0.72	11.0	0.19	0.84	6.5 – 8.5	6.5 – 8.5
Temp (oC)	27.1	32.6	29.97	1.72	5.67	0.44			
EC (µS/cm)	323	2940	1311.8	782.72	61.1	202.1	0.94	1.4	1
Acidity (mg/L)	24.6	96.6	59.93	16.96	28.3	4.38			
Alkalinity (mg/L)	12.6	98.6	48.67	23.93	49.2	6.18			
Total Hardness (mg/L)	22	133.4	83.08	33.66	40.5	8.69	0.17	500	150
Total Dissolved Solids (mg/L)	173.9	1786	808.66	530.19	65.5	136.89	0.81	1000	500
Chloride (mg/L)	1	181.24	62.19	55.84	90	14.42	0.25	250	250
Nitrate (mg/L)	6.68	44.01	29.24	16.26	54.8	4.2	2.92	10	10
Phosphate (mg/L)	0.03	0.11	0.04	0.02	50	0.01	0.01	5	5
Sulphate (mg/L)	26.49	274.86	119.66	79.87	66.7	20.62	0.48	250	250
Salinity	0	0.33	0.11	0.1	91.9	0.03			
Zinc	0	0.27	0.12	0.09	70	0.02	0.04	3	3
Iron	0	4.34	0.74	1.42	190.5	0.37	2.48	0.3	0.3
Copper	0	0.06	0.01	0.02	125.6	0	0	1.5	1
Lead	0	0.18	0.03	0.05	191.5	0.01	27.67	0.001	0.01
Magnesium	0.28	13.02	3.68	3.97	107.6	1.03	7.36	0.5	20
Calcium	4.68	180.31	42.57	52.32	122.9	13.51			150
Sodium	3.16	69.53	29.85	24.03	80.5	6.2	0.15	200	200
Potassium	1.44	48.48	17.96	14.2	78.7	3.67			

Most of the parameters were within WHO allowable limits in drinking water [8], however NO₃⁻ Iron, Lead and Magnesium showed high exceedance values at 2.92, 2.48, 27.67, and 7.36 respectively. Excess nitrate in water causes death of infants, shortness of breath in adults, and methaemoglobinemia, also known as "blue baby syndrome“, while an excess of Lead causes Plumbism in infants.

Table 3: Principal Component Analysis for Physicochemical parameters

	Component Matrix			
	PC 1	PC 2	PC 3	PC 4
pH	-0.486	-0.245		0.185
Temp (oC)	-0.44	-0.523	-0.052	0.419
EC (µS/cm)	0.969	0.038	0.045	0.117
Acidity (mg/L)	0.571	0.224	0.368	-0.326
Alkalinity (mg/L)	0.008	-0.088	0.928	0.246
Total Hardness (mg/L)	0.74	0.122	0.53	0.283
Total Dissolved Solids (mg/L)	0.949	-0.002	0.009	0.228
Chloride (mg/L)	0.97	0.046	0.022	0.091
Nitrate (mg/L)	0.814	0.165	-0.284	0.129
Phosphate (mg/L)	0.259	-0.452	-0.416	0.329
Sulphate (mg/L)	0.949	0.072	0.042	-0.063
Salinity	0.97	0.046	0.022	0.091
Zinc	-0.38	0.688	0.308	0.16
Iron	-0.308	0.839	-0.17	-0.007
Copper	0.159	0.143	0.359	-0.71
Lead	-0.317	0.863	-0.15	0.165
Magnesium	-0.051	0.926	0.028	0.188
Calcium	-0.097	0.974	-0.08	0.136
Sodium	0.752	-0.006	-0.209	-0.119
Potassium	0.966	0.146	0.058	-0.054
Total variance	8.53	4.417	2.459	1.295
% of variance	42.65	22.083	12.295	6.477
CV%	42.65	64.733	77.027	83.505

The factor analysis extracted four major components (PCs), with a total variance of 83.51%. PC 1 accounts for 42.65%, PC 2 for 22.08%, and PC 3 for 12.30%, while PC 3 accounted for 6.48%. EC, TH, TDS, Chloride, NO₃⁻, SO₄²⁻, Salinity, Na, and K contributed significantly to PC1, PC 2 had positive contributions from Fe, Pb, Mg and Ca, while pH and Alkalinity contributed significantly to PC 3.

Table 2: Pearson Correlation for Physicochemical Parameters

Parameters	pH	Temp (oC)	EC (µS/cm)	Acidity (mg/L)	Alkalinity (mg/L)	Total Hardness (mg/L)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Sulphate (mg/L)	Salinity	Zinc	Iron	Copper	Lead	Magnesium	Calcium	Sodium	Potassium
pH	1																			
Temp (oC)	0.41	1																		
EC (µS/cm)	0.43	-0.374	1																	
Acidity (mg/L)	0.11	-0.315	.515*	1																
Alkalinity (mg/L)	.794**	0.031	0.046	0.162	1															
Total Hardness (mg/L)	0.04	-0.288	.787**	.615*	0.509	1														
Total Dissolved Solids (mg/L)	-	-0.291	.957**	0.481	0.061	.767**	1													
Chloride (mg/L)	-	-0.42	.979**	.531*	0.034	.749**	.959**	1												
Nitrate (mg/L)	.603*	-0.427	.786**	0.235	-0.228	.517*	.775**	.734**	1											
Phosphate (mg/L)	-	0.392	0.222	-0.12	-0.205	-0.043	0.412	0.264	0.173	1										
Sulphate (mg/L)	-	-0.48	-.594*	.909**	0.491	0.081	.677**	.856**	.924**	.762**	0.171	1								
Salinity	0.46	-0.42	.979**	.531*	0.034	.749**	.959**	1.000**	.734**	0.265	.924**	1								
Zinc	0.20	-0.201	-0.322	-0.092	0.267	-0.007	-0.289	-0.319	-0.192	-0.414	-0.284	-0.319	1							
Iron	0.12	-0.257	-0.249	0.012	-0.238	-0.218	-0.255	-0.234	-0.134	-0.276	-0.266	-0.234	.522**	1						
Copper	0.06	-0.279	0.117	0.451	0.167	0.081	0.075	0.118	-0.062	-0.129	0.186	0.118	0.113	0.079	1					
Lead	0.12	-0.106	-0.258	-0.028	-0.196	-0.147	-0.251	-0.259	-0.094	-0.259	-0.294	-0.259	.679**	.861**	0.006	1				
Magnesium	0.10	-0.325	-0.027	0.163	0.027	0.108	-0.04	-0.02	0.119	-0.376	0.014	-0.02	.623*	.764**	-0.008	.853**	1			
Calcium	0.22	-0.393	-0.035	0.091	-0.127	0.032	-0.056	-0.025	0.1	-0.378	-0.033	-0.025	.685**	.881**	0.008	.887**	.935**	1		
Sodium	0.44	-0.289	.612*	0.451	-0.161	0.39	.654**	.612*	.742**	0.282	.669**	.612*	-0.435	-0.254	0.135	-0.186	0.081	-0.101	1	
Potassium	0.45	-0.459	.944**	.624*	0.034	.727**	.889**	.936**	.798**	0.116	.929**	.936**	-0.28	-0.202	0.253	-0.172	0.11	0.034	.756**	1

Alkalinity and pH, Chloride and TDS showed strong inter elemental associations. Electrical conductivity (EC) also showed strong correlations with TDS, as well as Chloride , Nitrate and Sulphate. Iron also had strong correlations with Pb and Mg. The level of Chloride observed could indicate impact of salt water intrusion in the study area.

Table 3: Principal Component Analysis for Physicochemical parameters

Sample Locations	Index value	Water Quality Status
OWS 1	53.07	Poor
OWS 2	123.21	Unfit for Consumption
OWS 3	125.90	Unfit for Consumption
OWS 4	250.55	Unfit for Consumption
OWS 5	138.29	Unfit for Consumption
OWS 6	46.52	Good
OWS 7	108.38	Unfit for Consumption
OWS 8	149.89	Unfit for Consumption
OWS 9	74.31	Poor
OWS 10	90.17	Very poor
LWS 1	70.19	Poor
LWS 2	120.07	Unfit for Consumption
LWS 3	41.33	Good
LWS 4	35.74	Good
LWS 5	16.56	Excellent



Fig. 5: Infant with methemoglobinemia -"blue baby syndrome" (Source: American Scientist).

The Water Quality Index (WQI) results show that 46.67% of the water samples in the Ojo community groundwater are unfit for consumption, 6.67% is very poor, 20% is poor, 20% is good for consumption, and only 6.67% is excellent.

Conclusion

There is a possible direct impact of the water body on the sampling locations close to the surface water boundary, given by the high concentrations of water quality parameters such as nitrate, electrical conductivity, and lead.

This study aligns with Goals 3 and 6 of the Sustainable Development Goals (SDGs), which aim at good health and wellbeing, as well as providing clean, safe water for all. There is therefore, need for sustainable monitoring, protection and management of the groundwater aquifers in Ojo Community, Ojo, Lagos State, especially for those closest to the Badagry Creek.

Recommendation

Dredging activities are carried out daily at the shore of the Ojo Ferry Station. Government officials should devise monitoring and enforcement policies on these activities, which could be responsible for rise in water level, and possible intrusion into the groundwater aquifers.

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