



Research Article

EVALUATION OF GROUND WATER QUALITY AT FOUR OIL EXPLORATION SITES IN IZOMBE, IMO STATE**¹Anyanwu, C.N, ¹Nwaka, D, ¹Ogueri, C, ¹Chinnah, U.K, ²Madu, H.C, ³Nwaka, S.U, ²Agorua, U.N, ⁴Aririguzo, B.N, ^{5*}Ndukwu, R.I, ⁴Ihem, E.E, ⁴Agim, L.C, ⁶Ihezue, C.I, ⁷Nwokeke, B.C, ⁴Chukwu, E.D, ⁴Osis, A and ⁸Chikaire, J.U**¹Department of Fisheries and Aquaculture, Federal University of Technology, Owerri, Imo State.²Department of Fisheries Technology, Imo State, Polytechnic, Omuma, Imo State.³Department of Fisheries Technology, Federal Polytechnic, Nekede, Owerri; Imo State.⁴Department of Soil Science Technology, Federal University of Technology, Owerri, Imo State.^{5*}Department of Geoinformatics and Surveying University of Nigeria, Enugu Campus, Enugu State.⁶National Root Crops Research Institute, Umudike, Abia State.⁷Department of Food Science and Technology, University of Agriculture and Environmental Sciences, Umuagwo, Owerri, Imo State.⁸Department of Agricultural Extension, Federal University of Technology, Owerri, Imo State, Nigeria.**Article History:** Received 21st December 2025; Accepted 17th February 2026; Published 1st March 2026**ABSTRACT**

The accumulation and toxic effects of nutrient build-ups have caused many ecological damages to the aquatic ecosystem. In this study, concentration of many inorganic nutrients and their effects on the physicochemical parameters of water were determined in the underground water at four oil locations in Izombe axis, Imo state, with non-oil spill area as the control. Samples of the underground water were collected with Nansen and hydrobios water samplers and transported to the laboratory for analysis, except some parameters that were analyzed in-situ. The results showed the presence of most of the inorganic nutrients analyzed in quantities above the admissible levels (control), while the results of most physicochemical parameters were within the admissible levels (control), with certain exceptions recorded above the admissible levels in some of the locations. This therefore, calls for restraint in some of the human activities within the underground water locations, especially in the areas connected with oil exploration in locations 1 and 3. This result showed that location 2 (new camp site) was of better quality in terms of the physical and chemical parameters evaluated as well as the level of nutrients in the affected sites, based on the control data supplied.

Keywords: Nutrients, Admissible, Exploration, Physicochemical, Underground water.**INTRODUCTION**

Water as an essential component of life deserve some level of caution in its usage. This is because fluctuations of water quality parameters may affect the physiological and health state of living organisms including man (Njiru *et al.*, 2004). Again, water plays a vital role in the productivity of aquatic species, as the understanding of the physical and chemical properties of water serves as the basis for considering whether water is rich or poor in their biological production as well as playing significant impact in the biotic community and life generally (Olajuyigbe and Fasakin,

2010). Bhagat *et al.*, 2013 in their study, investigated an assessment of the physicochemical parameters of cage system in River Dogwe area of Kaduna for a period of one year. They looked at the various physico-chemical parameters such as temperature, turbidity, free ammonia, water P^H, total alkalinity, total hardness, phosphate, sulphates etc. The results revealed that there was significant seasonal variation in some physicochemical parameters of the water which was attributed to the different seasons. Gupta, *et al.*, (2009) while studying the physicochemical parameters of ground water in selected areas of Kaithal

*Corresponding Author: NDUKWU, R.I, Department of Geoinformatics and Surveying University of Nigeria, Enugu Campus, Enugu State Email: raphael.ndukwu@unn.edu.ng.

City, India discovered the presence of inorganic salts (cations) such as Calcium, Magnesium, Potassium and sodium and the anions like Carbonates, nitrates, bicarbonates, sulphates and the chlorides. There are several factors that affects the quality of water, such as the basement formations like the ground water weathering, run-offs and several water discharges. These can be from natural processes or from human influence such as oil exploration areas farming activities, etc. (Onuoha, 2009).

MATERIALS AND METHOD

Study Area

The research was conducted at four different oil location namely location1 (the process area), location 2 (the new camp area), location 3 (at gate 2) while the location 4 (was at control point at Izombe community). Their various coordinates were as presented in Table I.

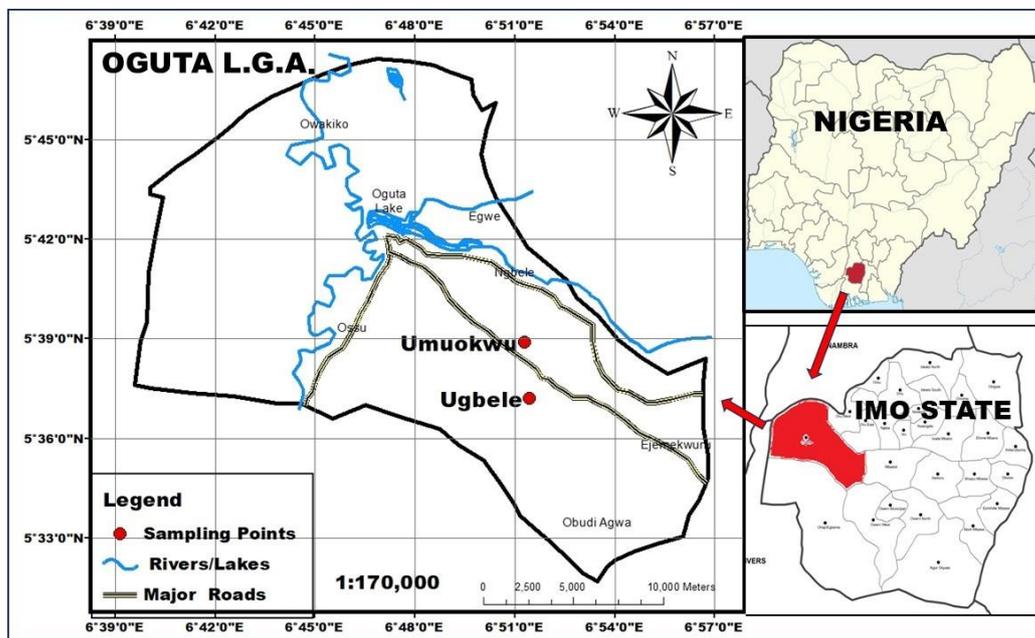


Figure 1. Study location.

Table 1. Izombe Oil Exploration Sites, Imo State.

SAMPLE CODE	DESCRIPTION	LATITUDE	LONGITUDE
Location 1	At the Process Area	05° 38' 133''N	006°46'22.7''E
Location 2	At New Camp Site	05° 37' 06.1''N	006°48'50.8''E
Location 3	At Gate 2	05° 38' 32.7''N	006°50'57.4''E
Location 4	Control Point at Izombe Community	05° 38' 03.7''N	006°51'36.2''E

Water quality Assessment

A number of field-test kits or water quality test kits were available for use on the spot analysis, in-situ. Water quality parameters such as water P^H, temperature, Dissolved Oxygen (DO) are always measured in the field because they change with time due to bacterial activities and delayed measurements that may result to erroneous results.

Collection of Water Samples

Water samples were collected within and across the locations at Izombe, Imo State using the different equipment that depended on the depth of the water. But for water from the ground, with greater depths, water samples such as the Nansen water sampler and the hydrobios water

sampler were used. Water samples collected are transferred in plastics or glass bottles for nutrients assessment and transported in ice chests to the laboratory for analysis. The water temperature was measured in-situ using the mercury in glass thermometer, (model JPB-607 FOR TABLE) calibrated in degrees Celsius. This was achieved by inserting the probe of the meter in the water at 10-15cm below the surface water and readings taken in °C. The water P^H was determined with a P^Hmeter suntex P^H meter model (HI-98107) that was switched 30 minutes before the test. The probe of the meter was inserted at test tube containing the water samples and readings recorded accordingly. The dissolved oxygen (DO) were measured with DO meter, which was allowed to stabilize for 15 minutes and the

calibration done following the manufacture's procedure by inserting the probe in 5% Na₂SO₄ solution.

The probe was inserted at each test tube and the readings recorded in mg/L. The conductivity of the water which is the ability of the water sample to conduct electrical current due to the presence of total dissolved solids. The calibration was done in micro-Siemens per centimeter (us/cm), and is usually a temperature compensated battery powered electronic switch gear meter, which was read directly in us/cm at 20°C. It can equally be determined by being calculated as 2/3 of the total dissolved solids (TDS). The salinity/chloride in water was also referred as the total concentration of all ionic constituents that was present in the water sample. It was measured by argentometric titration (AgNO₃ method) to get the chloride concentration that was later converted to salinity after Swingle (1979) using the factor $S\%_{00} = 1.85 \times Cl\% + 0.03$ samples of water that were collected in clean glass bottles to avoid interference of sulphate and sulphides. Free chlorides were estimated by titrating samples of water against the standard solutions of sodium hydroxide or sodium carbonate using 10 drops of phenolphthalein solution as the indicator.

Other parameters such as the COD was determined according to the method of Gupta *et al.*, 2009, TDS and TSS by the method of Onuoha, 2009. Carbonates by Devendra *et al.*, 2014, using strong acid (HCL) with phenolphthalein as indicator. Calcium was measured by complex metric titration with a standard solution of EDTA, using pattons and reader indicator under the PH condition

of more than 12.6. Sulphates were measured by the nephelometric method in which the concentration of the turbidity was measured against a known concentration of synthetically prepared sulphate solution.

RESULTS AND DISCUSSION

The results of water quality parameters at Izombe point stations and its spatial distribution are presented in Table 2, 3, and figures 2 and 3. It was observed that the location 2 contained the higher concentrations of DO, conductivity, salinity and total dissolved solids (TDS) and total suspended solids (TSS) while the location 3 were more in temperature, P^H, chemical oxygen demand (COD), and Nitrates. The location 1 contained more of the color, sulphates, phosphates, potassium, sodium, magnesium and calcium. There were no significant (P<0.05) differences among the nutrients in the three location for turbidity, sulphides and bicarbonates as all of them fall within their recommended acceptable levels. Most of the water quality parameters fall above the control values in almost all the parameters considered, but not above those specified by the Federal Ministry of Environment (FME_{ev}, 1991) that were available. The values in the control were in tandem with the parameters for temperature, water, P^H, turbidity, sulphides, bicarbonates, and nitrates except in location 2, where they were lower for chlorides, COD, Phosphates, potassium, sodium and magnesium as against the control values. Lower values for calcium were only recorded in location 3 as against the control value.

Table 2. Physicochemical parameters of four ground water locations at izombe oil exploration sites, imo state.

Parameter	Location 1	Location 2	Location 3	Control	FME _{ev} (1991)	EGASPIN (2018)
Temp. (°C)	29.9√	30.0√	30.2√	31.2	20-30	2.5
Water PH	6.76√	6.82√	6.84√	6.91	6.0-9.0	6.5-9.2
DO (mg/L)	6.24√	6.42√	6.20√	6.19	6.8	NA
Conductivity (x/cm)	10.0 ^{xx}	12.50 ^{xxx}	9.50 ^x	7.0	NA	NA
Salinity (%)	1.27 ^x	1.74 ^{xxx}	1.41 ^{xx}	0.2	NA	600
Turbidity (NTU)	0.10√	0.10√	0.10√	0.10	25.0	25.0
Colour (CTU)	13.5 ^{xxx}	1.0√	1.0√	1.0	15.0	NA
Chloride (mg/L)	2.50 ^x	1.75√	2.50	2.0	NA	NA
TDS (mg/L)	5.0 ^{xx}	6.25 ^{xxx}	4.75 ^x	4.0	200	200-500
TSS (mg/L)	2.0 ^x	3.0 ^{xxx}	2.50 ^{xx}	1.0	30	30
COD (mg/L)	28.0 ^{xx}	23.0√	32.0 ^{xx}	24.0	40	40

Note: FME_{ev}..... Federal Ministry of Environment, (1991)

EGASPIN- Environmental guidelines and standard for petroleum industries in Nigeria (2018)

Xxx= highly concentrated; xx= High concentration; x= slightly concentrated; √ = within acceptance level

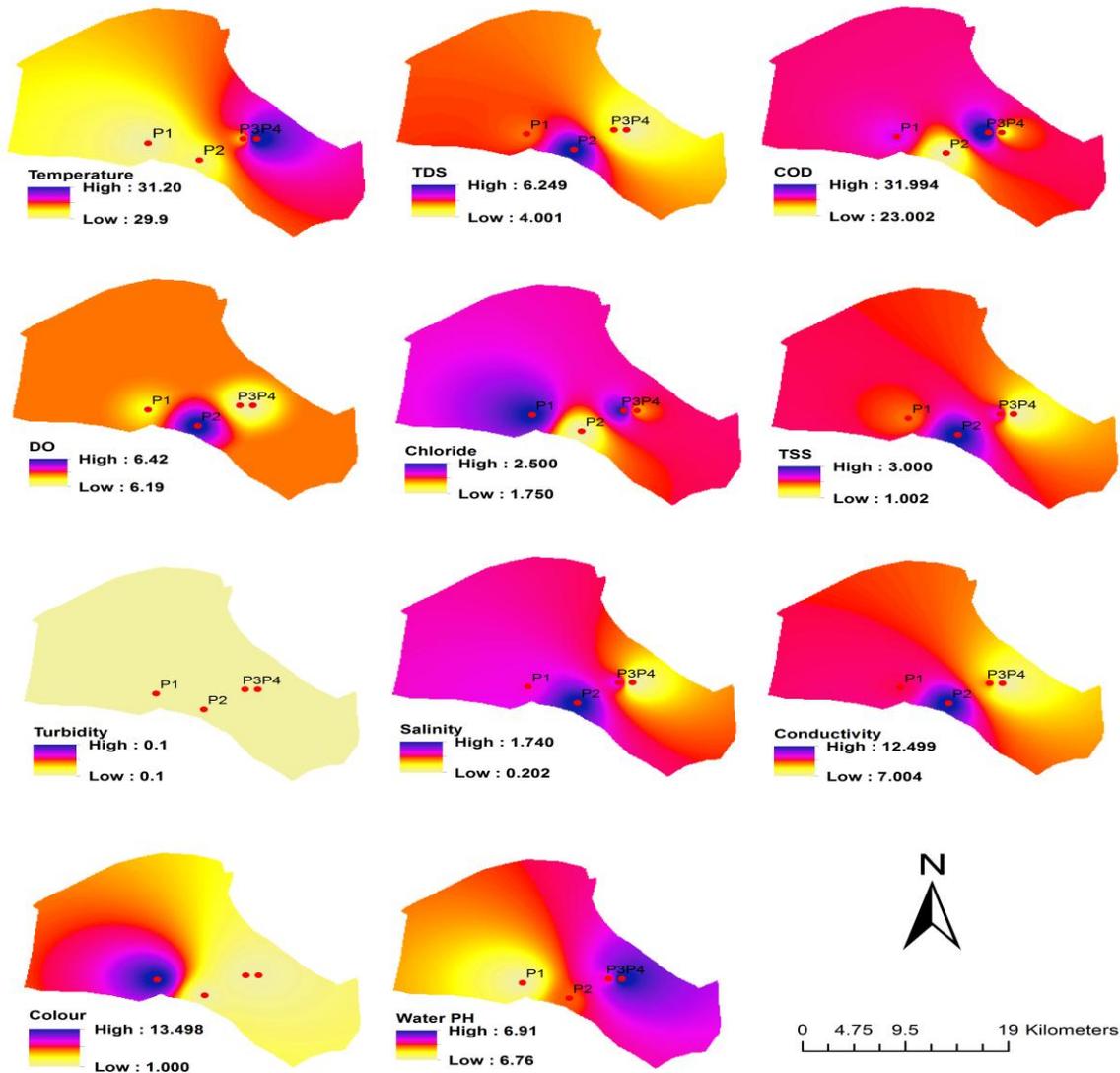


Figure 2. Spatial Variability of Physiochemical Parameters of ground water in the study location.

Table 3. Concentration of some inorganic nutrients at four under ground water locations at izombe oil exploration sites, imo state.

Parameter	Location 1	Location 2	Location 3	Control	FME _{ev} (1991)	EGASPIN (2018)
Phosphate (mg/L)	0.332 ^{xx}	0.144 [√]	0.256 ^x	0.218	1.0	NA
Nitrate (mg/L)	0.367 [√]	0.382 ^x	0.508 ^{xx}	0.362	50.0	NA
Potassium (mg/L)	1.02 ^{xx}	0.704 [√]	0.838 ^x	0.752	10	NA
Sodium (mg/L)	2.26 ^{xx}	1.54 [√]	1.84 ^x	1.66	200.0	NA
Magnesium (mg/L)	3.83 ^{xxx}	2.62 [√]	3.13 ^{xx}	2.82	30	NA
Calcium (mg/L)	5.25 ^{xx}	4.90 ^x	4.14 [√]	4.78	75	NA
Sulphate (mg/L)	2.14 ^{xxx}	1.32 ^{xx}	0.877 ^x	0.657	200	NA
Sulphide (mg/L)	<0.002 [√]	<0.002 [√]	<0.002 [√]	<0.002	0.05	NA
Bicarbonate (mg/L)	<0.50 [√]	<0.50 [√]	<0.50 [√]	<0.50	120.0	NA

Note: FME_{ev}..... Federal Ministry of Environment, (1991)

EGASPIN- Environmental guidelines and standard for petroleum industries in Nigeria (2018)

^x= slightly concentrated; ^{xx}= High concentration; ^{xxx}= highly concentrated; [√] = within admissible level (Control)

The results in the values of the conductivity and total dissolved solids, show that the three (3) locations had higher levels of the concentrations than the control. It is of note that the specific conductance values of natural waters increase with increasing concentrations of total dissolved solids (TDS) (Onuoha, 2009). This is in agreement with what was observed here where values of the conductivity and total dissolved solids (TDS) tally in increasing and decreasing order. The amount of nutrients here is indicative

of the quality of water, and could serve as a source of solubilization into water that depends on the physicochemical parameters and uptake by benthic organisms (Ogoyi *et al*, 2011; Ajimaet *al*, 2015). The values of temperature and water P^H followed a particular pattern among the three locations, showing that the temperature of water increases with increasing value of the P^H, which is an indication of the organic load of the water (Tambekar *et al.*, 2016).

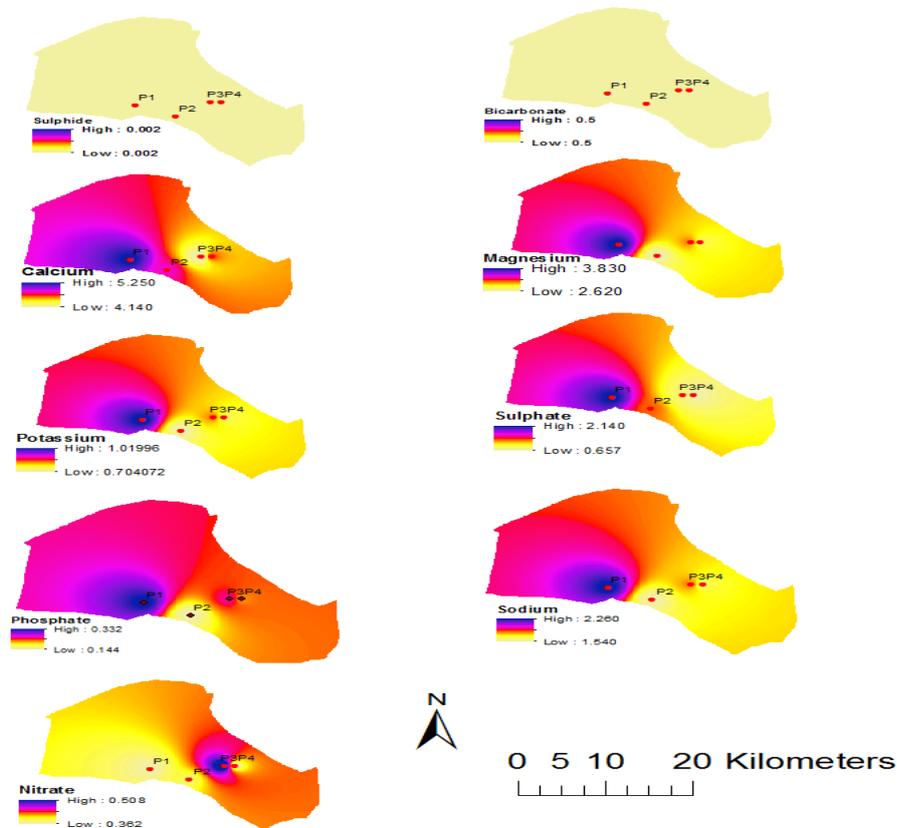


Figure 3. Spatial Variability of some inorganic nutrient's concentration in ground water of the study location.

This may mean that the P^H in location 3 may contain more organic loads due to probably discharges from other sources that empty into the location 3. This confirms the statement that the higher the P^H, the more the increase in temperature of the water and less DO (Okereke and Udebuani, 2006). However, the mean temperature in the three locations fall below the value in the control, 31.2°C and 6.91 and the recommended range of 20-30°C and 6.0 – 9.0 by Federal Ministry of environment (FMEV, 1991). The PH of the water samples from the three locations showed records of being slightly acidic, and were in the levels recommended by FME_{ev} (1991) and ESASPIN (2008) and also in tallied with the control values. This shows that the three locations were within the safe level by FME_{ev} and the control for both aquatic organisms and human use (Nagler, 2019, W.H.O, 2003). The dissolved

oxygen (DO) as seen in table 2 shows the mean values of DO among the three locations and ranges from 6.20 in location 3 to 6.42mg/L in location 2 and were not significantly different (P<0.05) with the control value (6.19). Dissolved Oxygen is a critical factor in aquatic habitats for the survival of aquatic organisms and humans (Robert *et al*; 2014). Some of the available nutrients in water samples showed that most of them are above the admissible levels for both human and aquatic lives.

Results showed that nutrients like sulphates, phosphates, potassium, sodium, magnesium and calcium were higher than the control in most of the locations signifying nutrient infiltration that may not be good for use by man and other aquatic habitats. This is because nutrient enrichment may lead to plankton bloom that may eventually result to

plankton die-offs and decrease in the oxygen depletion of the water (Onuoha, 2009). However certain nutrients like the sulphides and bicarbonates and chlorides fall within the control levels while others such as the phosphates, potassium, sodium, magnesium were better at the location 2 (new camp) and so safer than the other 2 locations, including the levels of COD and the chlorides. The presence of sodium and chlorides in safe levels at the location 2 is a good indication of homeostatic functioning of the water. The higher levels of TDS, TSS and salinity above the control in almost all locations showed suspended solids in water as well as biological activity in the contaminated water. This may be attributed to waste water discharges across the 3 locations due to human influence or natural occurrences due to weathering. This calls for restraint around the water courses. There are more indications that location 1 (process site) carries more of the inorganic nutrients due probably to the location as a site for processing oil materials while location 2 (new camp site) fared better because major operations are just picking up there. Phosphate- phosphorus occur in form of orthophosphates and polyphosphates in water and are dominant in run-offs, effluents and polluted waters, including discharges from agricultural activities. Nitrogen-nitrates occur in both general waters and waste-waters in decreasing oxidation state of nitrates, nitrites, ammonia and organic nitrogen. They are in the ground-waters than in the surface waters due to the process of nitrogen cycle for photosynthetic autotrophs. Nitrates and phosphates support aquatic plant growth, influencing algal blooms and water quality, while calcium and magnesium help remove impurities in water and help in medication and shell production. Sulphates and sulphides are involved in bacteria- sulfate reduction that influences water chemistry. In all, dissolved nutrients are essential for various biological, chemical and ecological processes. They also play important roles in the maintenance of ecological balance, supporting plant and aquatic life and equally involved in the promotion of human health.

CONCLUSION

The results of the evaluation of ground-water parameters within the four locations of oil exploration in Izombe area of Imo state showed variations among the locations. However, it was observed that more build-up of nutrients above the admissible levels (control) occurred more in locations 1 and 3 where there are more activities of oil explorations in the area (process area and site of gate 2 exploration). The site 2 (new camp) observed to contain most of the nutrients within the acceptable levels could be attributed to new explorations within the area, thereby leading to less concentration of nutrients, including better water quality characteristics (such as levels of turbidity, chlorides, COD and colour). Furthermore, our observations showed that most of the parameters compared with the standard regulatory bodies fall below the recommended levels. This could not however, confuse us to state that cautions are needed in the areas of explorations to reduce

the level of oil spillage for both aquatic lives and human health conditions.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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