



Groundwater Quality Assessment of Chilanchil Abay Watershed: The Case of Bahir-Dar City Waste Disposal Site

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Abstract. Groundwater has been under increasing threat of pollution in recent years due to improper management of the vast amount of wastes generated by various human activities. Improper dump sites have served many years as an ultimate disposal site for all types of waste; municipal solid waste, industrial sewage and hazardous waste in developing countries such as Ethiopia. Physical, chemical and biological processes interact simultaneously to bring about the overall decomposition of the wastes. One of the by-products of this mechanism is chemically laden leachate and it is a potentially hazardous waste from waste disposal sites. If not, deal properly, such kind of dumping site can cause pollution to groundwater (because of Leachates) and surface water (through contaminant transportation by flooding and groundwater movements). Therefore, this study investigates the spatial and temporal variation of groundwater quality within the Chilanchil Abay watershed during dry and wet season due to the waste disposal site of the Bahir Dar city. Water samples were collected from 6 sampling points of groundwater from 30th March to 20th August by a monthly period. Over 10 water quality parameters such as pH, TDS, Electrical conductivity, Turbidity, Temperature, DO, BOD, COD, TC, NO₃⁻ and PO₄³⁻, were analyzed. Moreover, the overall status of the groundwater quality of the study area was evaluated by the Canadian Water Quality Index. Based on the result of this model the status of the groundwater sample points throughout the study area were ranged from 42 to 46.2 (marginal status).

Keywords: Bahir-Dar city waste disposal site · CCMEWQI · Chillan Chile Abay watershed · Groundwater · Seasonal variation

1 Introduction

Water is the most bountiful asset on earth, yet just 3% are available for human exercises while the excess is available in the sea as a salt water (Love and Luchsinger 2014). It could be accessible in different structures and amount, yet its utilization for different objects is the subject of value. Of the apparent multitude of ecological worries that non-industrial nations face, the absence of satisfactory and clean water remains the most

difficult issue (Markandya 2006). When tainted, groundwater may everlastingly stay dirtied without cure or treatment. Sickesses may jump up through water contamination, particularly groundwater pollution, and quickly spread past human desire in view of its stream (Afolayan et al. 2012). Wastes of various sorts, generally strong wastes are the significant contribution of dumpsites/landfills. Concerning the hydrological investigation of groundwater, it streams from regions of higher geology towards zones of lower geography, accordingly achieving the assessment of the degradable material which structures leachate and sully the groundwater of the study area. Sadly, groundwater is very frequently thought to be no longer of any concern except for it requires extraordinary consideration. Groundwater isn't just preoccupied for flexibly or stream-controlled purposes, however it likewise normally takes care of surface - waters through springs and entries into waterways and it is regularly significant in supporting wetlands and their environments. Evacuation or redirection of groundwater can influence all out stream. A decrease in either nature of amount of the releasing groundwater can altogether impact surface water quality and the achievement of water quality norms. Surface water and groundwater are along these lines personally connected in the water cycle, with numerous normal issues. On the off chance that groundwater gets contaminated, it is troublesome, if certainly feasible, to restore. The moderate pace of groundwater stream and low microbiological movement, limit any self-refinement. Open and inappropriate unloading locales have been served numerous years as a definitive removal site for a wide range of waste; metropolitan strong waste, mechanical sewage and dangerous waste in non-industrial nations (Nathanson 2015). Physical, substance and organic cycles connect all the while to achieve the general decay of the squanders. One of the side-effects of this component is artificially loaded leachate and it is a conceivably unsafe waste from garbage removal destinations. If not manage legitimate waste administration, such sort of unloading site can make contamination groundwater (as a result of Leachates) and surface water (through foreign substance transportation by flooding, wind and ground water development from the open dump destinations). The Bahir-Dar city open site is among the inappropriate open dump site and situated in a spot where various individuals are living near. The people group who are living close to the removal site (in a place of downstream and upstream) are utilizing dirtied ground and surface water for their everyday exercises. Because of this it turns into a lot or danger to those networks with respect to the water quality perspective. Subsequently, the focal point of this study was to survey and assess the water quality in that watershed, particularly close to this garbage removal site to inspect its impact on ground and surface water quality.

2 Methodology

2.1 Descriptions of the Study Area

Eriamecharia municipal waste disposal site is 5 km far away from Bahir Dar city, Ethiopia on the highway to Addis Ababa and TIS Abay waterfall. It is part of the territory of the rural community of "sebatamit". As per the Central Statistics Agency of Ethiopia (CSA 2007 G.C), 3,053 females and 3,348 males a total of 6,401 populations are found around the dumpsite. Its geographical coordinates are: latitude 11.54, longitude 37.38 and altitude of 1803 m at 3° and its elevation above sea level is 1801 m. The height

and width of this irregular shape disposal site are 384 m (by the side of the agricultural land of Eriamecharia) and 174 m (by the side of the road of sebatamit towards Addis Ababa) respectively. It has neither been equipped with liners nor leachate collection system before ten years up to now. This site has not been designed systematically before being used for disposal/dumping of the waste. Furthermore, no environmental impact assessment has been carried out before the selection of this place to be a waste disposal site. Trucks and separate vehicles from different parts of the city collect and bring the waste to this site and dump in an anarchic way. The waste is dumped as such without segregation. On the other hand, the minimum amount of solid waste which is generated from the city and dumped in the site is, residential waste 12,610 kg/day, commercial 4,202 kg/day, service provider 988 kg/day, municipal waste 1,044 kg/day, total 22,774 kg/day (Source: solid waste characterization and quantification of the Bahir Dar city report, 2007). But currently, the minimum amount of waste dumped to the site is 31,321 kg/day (source: Authors observation).

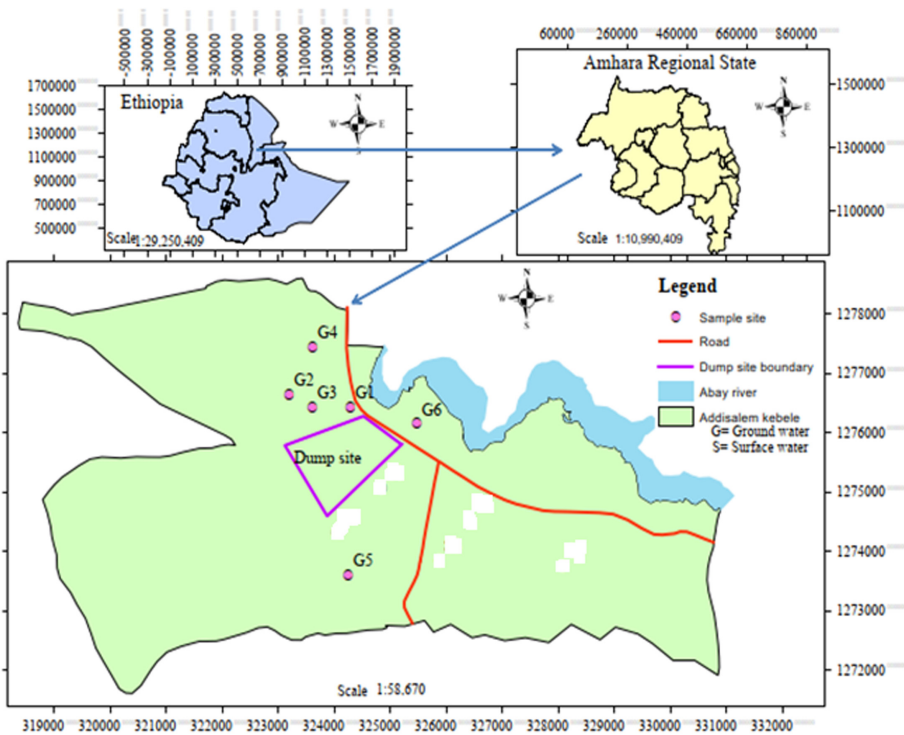


Fig. 1. Topographic map of the study Area.

2.2 Sample Collection, Preservation and Laboratory Analyses

Groundwater samples were collected from the chose test territories close to the dump-site called locally Zebir, to the research facility for the study. Those six inspecting

focuses were picked dependent on their availability, closeness to contamination sources, for example, common locales, cabin. Worldwide Positioning System pilot (GPS etrex VISTA HCX) was utilized to decide the genuine places of the inspecting focuses and referred to guarantee consistency in the testing focuses during resulting examining periods. The testing focuses were painstakingly chosen to incorporate the upstream, and the downstream networks. Taking the samples was begun during the dry season from the period of March and proceeded with a wet season up in the long stretch of August from all the six sample points. Groundwater tests were collected from the profundity of 5–12 m drill openings by utilizing an untamed water snatch sampler 3 L limit arranged with a straightforward draw - ring that took into account inspecting at different water profundities of a borehole for groundwater tests [9]. To evaluate the water quality, water samples were kept in 1 L polyethylene plastic bottles cleaned with cleaned with metal-free soap, washed with deionized water lastly drenched by 10% nitric corrosive for 24 h, at long last flushed with super unadulterated water. All water samples were put away in a refrigerator and conveyed around the same time to the research center and kept at a consistent temperature of 4 °C [10]. Water quality boundaries, for example, temperature, pH, electrical conductivity, total dissolved solids, turbidity, salinity were measured with convenient YSI Pro 30 Multiparameter (model HI 98130 HANNA). Other water quality parameters analyzed include, dissolved oxygen (DO) using HI 98193 dissolved oxygen meter BOD5 using BOD5 incubated in the presence of NaOH, COD using COD analysis method within in the presence of standard potassium dichromate, sulfuric acid reagent, ferroin indicator and standard ferrous ammonium sulfate titrant and total coil form was done using a membrane filter method. Phosphates (PO₄²⁻) and nitrate (NO₃⁻) were determined using the method of palintest Spectrophotometer (WAGTECH 8000). All the strategies for lab investigation were directed by the Standard Methods for the Study of Water and Wastewater (Apha Awwa 1998) [11].

2.3 CCME Water Quality Index Procedure

The CCME WQI model comprises of three proportions of fluctuation of chose water quality goals (Scope; Frequency; Amplitude) [12]. The “Scope (F1)” the quantity of factors not meeting water quality objectives. The “Frequency (F2)” the occasions these goals are not met (“bombed tests”). The “Sufficiency (F3)” speaks to the sum by which bombed tests don’t meet their destinations. These three elements consolidate to deliver a unitless incentive somewhere in the range of 0 and 100 that speaks to the general water quality. The detailing of the WQI as portrayed in the Canadian Water Quality Index 2001 specialized Report is as per the following. The measure for scope F1 is calculated as follows

$$F1 = \left(\frac{\text{Number of failed variables}}{\text{Total numbers of variables}} \right) * 100 \quad (1)$$

The measure for frequency F2 is calculated as follows:

$$F2 = \left(\frac{\text{Number of failed tests}}{\text{Total numbers of tests}} \right) * 100 \quad (2)$$

The measure for amplitude, F3 is calculated as follows.

The excursion is the number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective. When the test value does not exceed the objective:

$$\text{Excursion} = 100 - \left[\frac{\text{objective}}{\text{failed to values}} \right] - 1 \quad (3)$$

For cases in which the test value exceeds the objective.

$$\text{Excursion} = 100 - \left[\frac{\text{failed test value}}{\text{objective}} \right] - 1 \quad (4)$$

The collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives). This variable, referred to as the normalized sum of excursions (nse) is calculated as:

$$nse = \sum_{i=1}^{\infty} \frac{[\text{Excursions}]}{\text{number of tests}} \quad (5)$$

F3 is then calculated by an asymptotic function that scales the normalized sum of the excursions from objectives (nse) to yield a range between 0 and 100.

$$F3 = \left(\frac{nse}{0.01_{nse} + 0.01} \right) \quad (6)$$

The water quality index (CCME WQI) is then calculated as:

$$\text{CCMEWQI} = 100 - \left[\frac{\sqrt{F_1^2 + F_1^2 + F_3^2}}{1.732} \right] \quad (7)$$

The divisor 1.732 normalizes the resultant values to a range between 0 and 100, where 0 represents the “worst” water quality and 100 represents the “best” water quality.

3 Results and Discussion

3.1 Spatial and Temporal Variation of Groundwater Quality

3.1.1 Spatial and Temporal Variation in Physical Characteristics of Groundwater

The result of spatial and temporal variation of groundwater physical parameters measured in all six sampling points throughout the study time are presented in below table.

Total dissolved solid (TDS):- The total dissolved solids are a sign of the level of disintegrated substances, for example, metal particles in the water test. In this investigation, the measure of disintegrated strong in the ground water tests were gone from 1294.33 ± 6.35 to 1488 ± 12.12 mg/L With a mean value of 1408.86 ± 25.52 mg/L during the

Table 1. Seasonal and temporal variation in physical parameters of groundwater.

Sampling sites	E.C ($\mu\text{S}/\text{m}$)		TDS (mg/L)		Turbidity (NTU)		Temperature ($^{\circ}\text{C}$)	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
SS1	2037 \pm 34.1	842.33 \pm 32.5	1343.67 \pm 32.72	585.83 \pm 30.09	6.78 \pm 0.705	24.71 \pm 4.39	26.4 \pm 0.36	21.87 \pm 1.76
SS2	2183.33 \pm 176.29	804.67 \pm 16.80	1294.33 \pm 6.35	560.5 \pm 44.21	6.98 \pm 0.60	27.12 \pm 1.40	24.37 \pm 3.88	21.63 \pm 2.03
SS3	1939.33 \pm 36.295	869.667 \pm 71.93	1443.33 \pm 36.94	717.67 \pm 31.501	7.32 \pm 0.43	18.94 \pm 0.55	26.7 \pm 0.56	20.97 \pm 2.59
SS4	2211 \pm 62.65	805.667 \pm 56.37	1427.83 \pm 26.71	617.33 \pm 69.17	7.83 \pm 0.38	22.12 \pm 5.63	25.3 \pm 2.022	23.23 \pm 0.61
SS5	2271 \pm 24.02	866.67 \pm 37.541	1488 \pm 12.12	843.67 \pm 89.07	13.85 \pm 3.35	32.33 \pm 3.512	28.73 \pm 1.36	22.3 \pm 2.04
SS6	2220 \pm 20.66	901.67 \pm 114.18	1456 \pm 38.31	755.67 \pm 110.74	12.4 \pm 4.82	31.09 \pm 2.87	27.4 \pm 1.42	23.503 \pm 0.54

dry season while in a wet season from 560.5 ± 44.21 to 843.67 ± 89.07 mg/L with a mean value of $680.11 \pm$ mg/L (Fig. 1). The findings of the investigation showed that the deliberate mean values of total dissolved solid during the dry season (1408.86 ± 25.52 mg/L) and wet season (680.11 ± 62.47 mg/L) were within the WHO’s reasonable limit (500–1500 mg/L). Be that as it may, on the base of occasional variety all values of total dissolved solid during the dry season were higher than the values of the wet season (Fig. 1). This might have been because of the higher temperatures saw during the dry season which encouraged disintegration, particle trade limit, desorption and enduring cycles. Additionally, during the dry season borehole water vanished and ionic fixations expanded. The criticalness of this transient variety was upheld by the measurable consequence of single direction ANOVA. On The base of spatial variety in both dry and wet season the most extreme values of all total dissolved solid were seen at SS5 and SS6 though the base an incentive for dry and wet season recorded at SS2 (Fig. 1). This was because of the area of those sample points (SS5 and SS6) were beneath the garbage removal site which is helpless to more farming overflow and released city squander stream openly from the landfill site while for SS2 over the landfill site.

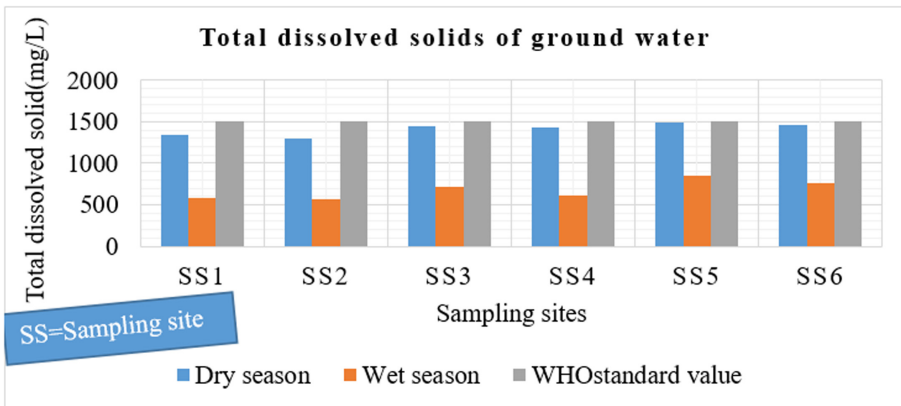


Fig. 2. Seasonal variation in total dissolved solid of ground water quality in the study area

Temperature:- The temperature of ground water samples investigated have a mean temperature values of $26.54 \pm 1.58^{\circ}\text{C}$ during the dry season with the most noteworthy temperature value of $28.73 \pm 1.36^{\circ}\text{C}$ at SS5. The mean temperature during the wet season was $22.25 \pm 1.59^{\circ}\text{C}$, with the most elevated value of $23.5033 \pm 0.54^{\circ}\text{C}$ at SS5 and SS6 (Table 1). From Table 1, one can see that the mean temperature during the dry season was higher than wet season because of the predominant air conditions. A higher number of daylight hours would normally suggest lower relative stickiness, a temperature increments of water bodies because of conduction and convection measures by the earth covering. This shows that the temperature of ground water is lower in the wet season than in the dry season. WHO report (2006), specifies that water for drinking and homegrown purposes ought to have a temperature not surpassing $30\text{--}40^{\circ}\text{C}$. Accordingly, temperature esteems recorded for ground water in the study region were inside the WHO passable breaking point. By and large temperature changes influence pH,

electrical conductivity, sorption measures, complexation, speciation, precipitation, redox responses, stream rate, particle trade limit, solvency of gases and additionally different accumulates, just to specify however a couple. Additionally, increment in temperature diminishes the measure of disintegrated oxygen, quickens nitrification and oxidation of smelling salts to nitrates and prompting oxygen lacking water climate. This builds harmfulness of pesticides and weighty metals in drinking water. Temperature increment in drinking water prompts a less attractive water taste. By and large, the ANOVA result shows that all the actual properties of ground water quality talked about above were seen to be altogether influenced by the season. This implies the distinction with respect to prepare was genuine however the distinction with respect to the event of test site was because of chance from the part of SPSS.

Electrical conductivity:- Conductivity in groundwater is influenced by the topography of the zone through which the water streams. In this study, the values of electrical conductivity at the six examples of groundwater during dry season went from 1939.33 ± 36.295 to 2271 ± 24.02 $\mu\text{S}/\text{cm}$ (Fig. 2) with a mean value of 2143.61 ± 58.999 $\mu\text{S}/\text{cm}$ while in a wet season it fluctuates from 804.67 ± 16.80 to 901.667 ± 114.18 $\mu\text{S}/\text{cm}$ with a mean value of 848.44 ± 54.88 $\mu\text{S}/\text{cm}$. The outcomes show that the mean values of electrical conductivity for the dry season were higher than the electrical conductivity of the wet season (Fig. 2). Apparently the qualities for the dry season surpasses WHO'S standard constraint of 1000 $\mu\text{S}/\text{cm}$ for drinkable water. This could be because of water vanishes during the dry season and grouping of particles increments thus electrical conductivity expands (the expansion in electrical conductivity was because of dissipation of water in under groundwater channels which expanded the centralizations of disintegrated salts or directing substances in the borehole water frameworks) and in the wet season, there is the weakening of the particles because of water expanding under groundwater volumes bringing about an abatement in electrical conductivity [13]. The discoveries of high-esteem E.C in a dry season during the study period was comparative with the investigation of [14] who have done the appraisal of weighty metals in the groundwater wells in the region of Nyanza metropolitan Solid waste in Kigali City-Rwanda and discovered the higher value of E.C during the dry season. From the information of dry season, the greatest qualities were acquired at SS5, SS6 and SS4 separately with a base an incentive at SS3 while in a wet season most extreme qualities were recorded efficient at SS6, SS3 and SS5 with a base an incentive at SS2 (Fig. 2). These distinctions in all values of the dry and wet season were because of the area of the sample points from the garbage removal site and different wellsprings of contamination. By and large, Electrical conductivity esteems give a helpful marker to spatial or potentially worldly changes in deliberation, salt water interruption; energize instrument, and so forth prompting diverse groundwater characteristics in wet and dry seasons.

Turbidity:- The value of turbidity reflects the transparency in water. It is brought about by the substances present in water in suspension. In characteristic waters it is brought about by earth, residue, natural issue, phytoplankton and other tiny life forms. Mean turbidity esteems recorded gave an outline of the varieties in groundwater quality during wet and dry seasons. In the dry season, the value of turbidity at all six samples of groundwater were ranged between 6.78 ± 0.705 to 13.85 ± 3.35 NTU with a mean value of 7.25 ± 0.56 NTU while in the wet season from 18.94 ± 0.55 to 32.33 ± 3.51 NTU

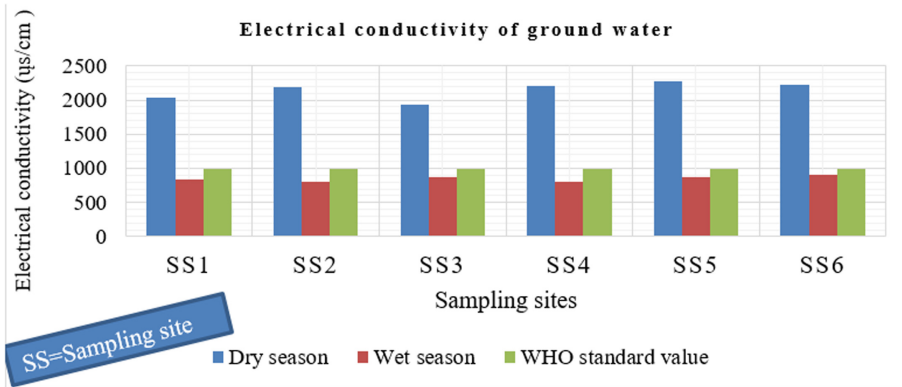


Fig. 3. Seasonal variation in Electrical conductivity of groundwater quality in the study area.

with a mean 26.0517 ± 3.056 NTU (Fig. 3). As one can see from Fig. 3 underneath the mean values of turbidity recorded in the wet season (26.0517 ± 3.056 NTU) were higher than WHO's (2006) passable constraints of 5-25 NTU just as from the mean values of dry season (7.25 ± 0.56 NTU). This may have been because of the coagulation of broke down substances in the boreholes, particles from enduring activities in the underground streams and surface overflow from farming fields around the groundwater sources, broken up dirt and mud materials into the groundwater through invasion. This implies during a precipitation, particles from the waste removal site and encompassing area are washed into the water sample points and filtering into groundwater making the water a sloppy earthy colored tone, demonstrating water that has higher turbidity esteems. Additionally, during the wet season, water speeds are quicker and water volumes are higher, which can all the more effectively work up and suspend material from the stream bed, causing higher turbidities. The purpose behind the dry season to be lower was a direct result of the decrease in overflow material, encourages, suspended solids and shaded disintegrated substances which added to the turbidity of the sample points from the waste removal site. This higher value of turbidity in a wet season looks like crafted by [15] who surveys the occasional variety in Physico-substance properties of groundwater around Karu abattoir. Figure 3 shows that, on the base of spatial variety in both dry and wet season the greatest values of turbidity were seen at SS5 and SS6 whereas the base an incentive at SS1 for the dry season and at SS3 for the wet season. This was because of the area of those sample points (SS5 and SS6) were underneath the waste removal site which is helpless for more agrarian spillover and released metropolitan waste stream uninhibitedly and various individuals are utilizing those sample points in like manner for their homegrown reason, accordingly, particles won't get enough habitation time for settling while SS1 and SS3 are situated over the landfill site which is normal the impact of waste removal site is non-critical. By and large, the high turbidities establish a wellbeing hazard for the youngsters burning-through this water. High turbidity likewise demonstrates a higher measure of all out suspended solids which may incorporate microorganisms, such as microbes or parasites just as an expansion in the convergence

of minerals [16]. Watershed highlights, such as geography, compound manure and pesticide overflow from rural activity metropolitan advancement activity, geology, vegetation and precipitation functions can all significantly impact crude water turbidity in the study area.

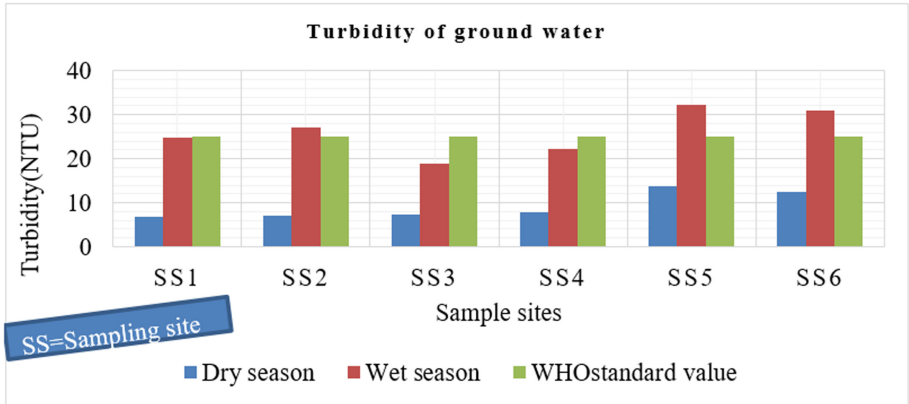


Fig. 4. Seasonal variation in turbidity of groundwater quality in the study area.

3.1.2 Spatial and Temporal Variation in Chemical Characteristics of Groundwater

The result of spatial and temporal variation of groundwater chemical parameters measured in all six sampling points throughout the study time are presented in below table (Table 2).

Groundwater pH:- The value of pH is one of the most habitually utilized tests in water science. The pH results for the groundwater tests from the study area went from 6.67 ± 0.42 to 9.2 ± 0.16 with a mean value of 8.49 ± 0.33 for the dry season and went from 6.48 ± 0.67 to 7.59 ± 0.095 (Fig. 4) with a mean value of 6.88 ± 0.49 for wet seasons. The outcome study of water tests shows the pH of groundwater was over the WHO suitable constraint of 5.5–7.5 for drinking water for both wet and dry season (Fig. 4 below). This could be because of run off from the network (Humans add to raised pH fundamentally as supplement overflow most usually compost). As from the Fig. 4 beneath demonstrated at SS1 and SS5 registered the most reduced and the most elevated pH esteems all through the time of study separately. In the base of occasional variety, the mean value of pH in groundwater was lower in the wet season than in the dry season (Fig. 4). This may have been expected to during wet season precipitation consolidates with carbon dioxide can impact the water toward acidity, lower temperature consequently lower TDS esteems, adsorption cycles and lower particle trade limit occurring [17]. The discoveries of lower esteem pH in a wet season during the study period was comparable with crafted by [18] who explores occasional variety in Physico-synthetic attributes of country groundwater of Benue state, Nigeria and discovered lower value of pH during wet season. Hence, carbon dioxide is the most widely recognized reason

Table 2. Seasonal and temporal variation in chemical properties of ground water

Sampling sites	Ph		DO (mg/L)		BOD (mg/L)		COD (mg/L)	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
SS1	6.67 ± 0.42	6.48 ± 0.67	2.16 ± 0.087	9.18 ± 0.17	2.23 ± 0.10	2.81 ± 0.37	61 ± 2.65	72.33 ± 5.51
SS2	8.67 ± 0.21	6.66 ± 0.61	2.51 ± 0.11	8.97 ± 0.09	2.80 ± 0.04	3.1 ± 0.12	61.67 ± 2.08	77.43 ± 4.18
SS3	8.96 ± 0.03	6.63 ± 0.77	2.34 ± 0.148	7.54 ± 1.14	2.79 ± 0.076	2.98 ± 0.15	60 ± 2	77.3 ± 9.02
SS4	8.65 ± 0.92	6.59 ± 0.61	2.05 ± 0.09	7.83 ± 0.87	2.26 ± 0.06	2.72 ± 0.25	68.13 ± 1.70	73.27 ± 3.26
SS5	9.2 ± 0.16	7.59 ± 0.095	1.58 ± 0.12	2.7 ± 0.58	3.12 ± 0.07	3.91 ± 0.04	71.5 ± 1.10	80.63 ± 6.97
SS6	8.8 ± 0.27	7.32 ± 0.18	2.76 ± 0.08	7.92 ± 0.48	2.85 ± 0.01	3.02 ± 0.23	71.67 ± 1.53	83.1 ± 8.15

for causticity in water. Photosynthesis, breath and disintegration all add to pH changes because of their effects on CO₂ levels. The pH esteems inside the scope of 5.5–7.5 were reasonable for the ordinary scope of water system [19]. The pH of the Groundwater falls above FAO and WHO water quality standards for water system and use as crude public water flexibly in dry season (Fig. 4). As per [19] pH surpasses from 7.5 isn't prudent for water system reason. For the most part, the acidity may have been because of high carbon dioxide focuses from eutrophication cycles of natural issue, adsorption of metal anions and presence of some non-metallic mixes, for example, fluorides in the groundwater sources. The low pH esteems which were regular in the wet season are credited to the anaerobic conditions that could prompt the creation of acidic substances, such as natural acids.

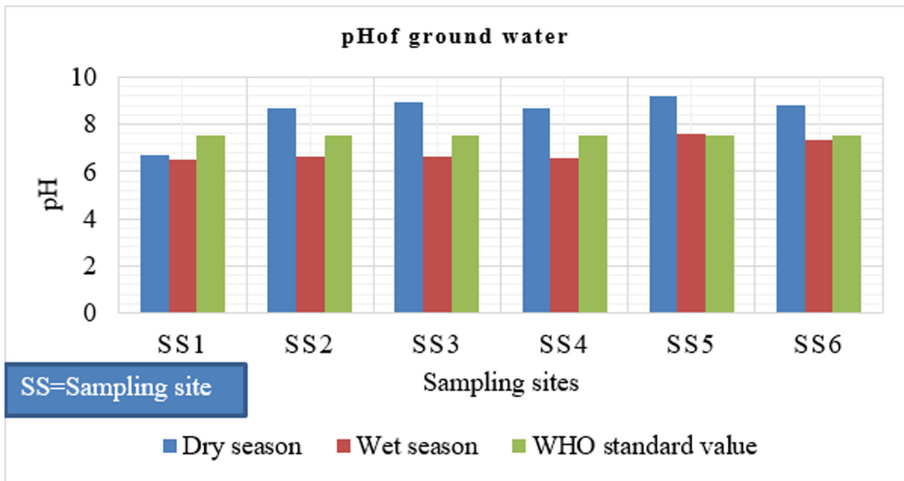


Fig. 5. Seasonal variation in pH of groundwater quality in the study area

Dissolved oxygen:- The findings of the study show that the values of broke down oxygen were ranged between 2.05 ± 0.09 to 2.76 ± 0.08 mg/L during dry season (Fig. 5) with the mean value of 2.24 ± 0.102 mg/L where as in the wet season from 2.7 ± 0.58 to 9.18 ± 0.17 mg/L with the mean value of 7.36 ± 0.56 mg/L (Fig. 5). The recorded outcomes (Fig. 5) show that the measure of disintegrated oxygen during wet season were higher than the value of dry season. This may have been because of temperature and downpour fall. This was in accordance with the investigation of [15] who explores the occasional varieties in physicochemical properties of groundwater around Karuabattoir. As recorded over the measure of temperature estimated in a wet season was lower than dry season and afterward it tends to hold high broke up oxygen which leads disintegrated oxygen to be higher in wet season. Other than to those in wet season oxygen is blended in through downpour, wave and wind subsequently its incentive to be recorded at the example point was increment when contrasted with dry season. Likewise, spatial variety among the six sample points in both dry and wet season was watched. Figure 5 shows that in dry season the base worth was estimated at testing point 5. This was because of

testing point 5 was the most noteworthy top to bottom from all. At that point at the most elevated profundity, air was not cooperating all the more moderately and the water that is close to the residue will be drained of oxygen. Then again, the greatest value of broke down oxygen in dry season was estimated at inspecting point 6 (Fig. 5) which is regularly spring water. In spite of the fact that spring waters are considered as ground water, they are basically engrossing oxygen from environmental air therefore testing guide 6 has higher incentive as analyzed toward the other. Where as in the wet season the greatest worth happens at examining point 1 (Fig. 5) because of this testing point is found far separated from the landfill site the upstream way (over the landfill site) and the base an incentive at inspecting point 5 like dry season. The oxidation of natural substances and diminished inorganic substances prompts lower oxygen content in groundwater. For the most part, a high substance of oxygen penetration water advances the groundwater with oxygen. On account of most groundwater revive happens in the wet season and lower solvency of oxygen in warm water than in chilly water, higher substance of disintegrated oxygen are estimated in the wet season. Notwithstanding, in wet season the deliberate mean value of DO was above WHO water quality reasonable constraint of 5 mg/L. On the record of this the factual investigation of fluctuation (ANOVA) result demonstrates that there was critical contrast in mean DO fixation between and inside seasons during the study period ($p < 0.05$). As broken-down oxygen levels in water dip under 5.0 mg/L, oceanic life is put under pressure. The lower the fixation, the more noteworthy the pressure. Low broke down oxygen (DO) fundamentally results from extreme green growth development brought about by phosphate. As the green growth bite the dust and deteriorate, the cycle devours broke up oxygen. This can bring about lacking measures of broke up oxygen accessible for oceanic life.

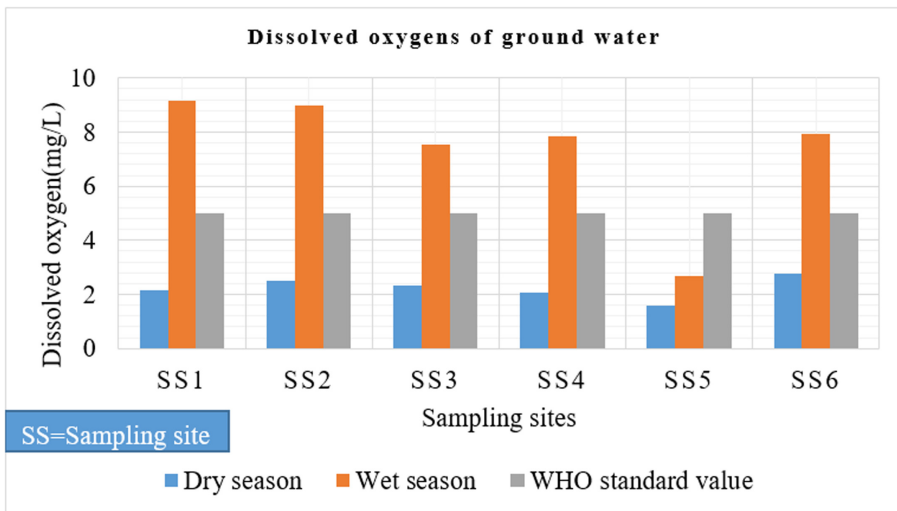


Fig. 6. Seasonal variation in the dissolved oxygen of groundwater quality in the study area.

Biological oxygen demand:- From the stud, the measure of BOD for all samples during the dry season were ranged from 2.23 ± 0.10 to 3.12 ± 0.07 mg/L with a mean value of 2.68 ± 0.07 mg/L while during the wet season the value of BOD fluctuates from 2.72 ± 0.25 to 3.91 ± 0.04 mg/L with a mean value of 3.09 ± 0.202 m/L (Fig. 6). The discoveries of this investigation show that the mean value of the wet season was higher than the mean value of the dry season (Fig. 6). This may have been because of permeation and invasions of biodegradable natural issue and draining of natural iron or potentially manganese into the springs in light of the waste removal site. The higher BOD saw in the wet season inferred that popularity for oxygen was made to help the activity cycle [20] noted comparative circumstances of high BOD and presume that it was because of higher natural waste burden experienced during the blustery season. [21] likewise saw that BOD vacillation between season might be credited to extra natural issue brought into groundwater as the consequence of overflow and soil disintegration brought about by ceaseless precipitation in the downpour season. In the part of spatial variety, the most extreme BOD esteem was recorded at inspecting point 5 and testing point 6 separately for both dry and wet season (Fig. 6). This was because of the profundity of boreholes and the areas of test focuses from the garbage removal site (the toxin source) since in the most elevated top to bottom and downstream from the poison source generally described by an insufficiency of oxygen. Though the base qualities were gotten at testing point 1 and inspecting point 4 (Fig. 6) individually for both dry and wet season because of both are situated over the unloading site which isn't rich with a lot of natural waste that originates from the source (removal site). By and large, the BOD values of groundwater tests all through the study period were beneath the EPA'S/WHO/rule values of 5 mg/l (Fig. 6). This shows that the water was reasonably acceptable between times of BOD for various family exercises, since low BOD is a marker of good quality water, while a high BOD demonstrates dirtied water. From the ANOVA result, there was no conceivable huge variety between the examining focuses just as between the seasons that may lead the BOD past the constraint of WHO. In water with a BOD level of above 5 mg/L, the water is considered fairly contaminated in light of the fact that there is typically natural issue present and microbes are disintegrating this waste. The higher the BOD esteem, the more noteworthy the measure of natural issue or food accessible for oxygen-devouring microbes. Body esteems increment when supplement burdens and amassing of plant rotting matters in examining focuses increment.

Chemical oxygen demand:- COD is a pointer of natural contamination, which is brought about by the inflow of homegrown waste, live stocks and modern waste that contains a raised degree of natural toxins [22]. The study of the investigation show that synthetic oxygen interest in all the six groundwater tests went from 60 ± 2 to 71.67 ± 1.53 mg/L during the dry season with a mean value of 65.67 ± 1.84 while in the wet season it went from 72.233 ± 5.51 to 83.1 ± 8.15 mg/L with a mean value of 77.34 ± 6.18 mg/L (Fig. 7). From this (Fig. 7) one can see that the values of both dry and wet season were beneath the EPA/WHO/rule allowable cutoff. This could presumably be on the grounds that the vast majority of the wastes that are being created from the different networks (accessible at the dumpsite) are biodegradable or the watched contaminations of borehole water tests contemplated may not be because of substance oxidation of toxins present however because of high-impact corruptions of natural issue present by

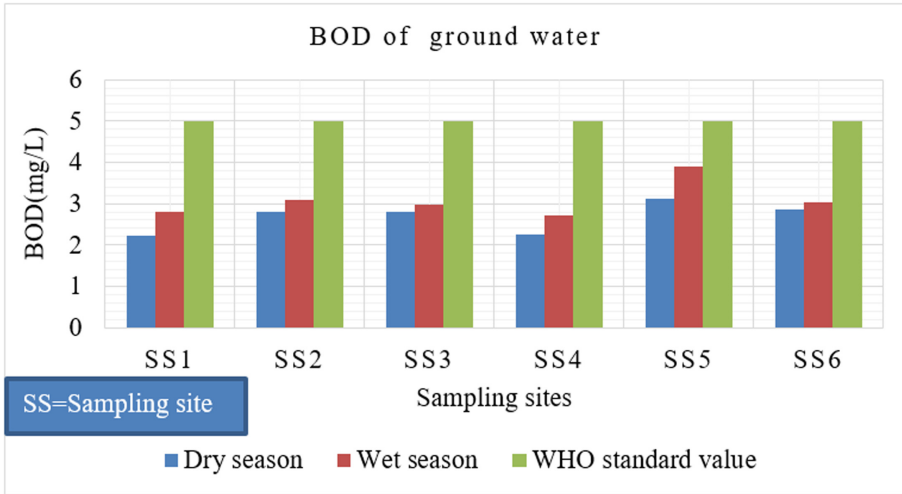


Fig. 7. Seasonal variation in the BOD of ground water quality in the study area.

microorganism in the water tests. Despite the fact that all values of this study adjust to as far as possible the mean value of COD during the wet season was higher than the value of the dry season (Fig. 10). This may have been because of the impact of family substance items, for example, cleansers, cleansers, shampoos, additives, colors, and cleaners accessible in the dumpsite by the activities of precipitation. Therefore, the delay aggregation of leaked natural leachates in the spring can increment. The disclosures of the high value of COD in a wet season during the assessment time period of this exploration was similar with the study of [23] who have done the assessments of occasional varieties in Physico-compound attributes of Tapi estuary in Hazira modern region and found higher assessment of COD during the wet season than the dry season. In the base of spatial variety most extreme and least qualities were recorded at examining point 6 and inspecting point 1 individually for both dry and wet season (Fig. 7). When contrasted this finding and different studies a higher scope of COD qualities than those in this investigation was acquired in the study that surveyed the nature of boreholes found near the dumpsite in Benin and south-south Nigeria. The COD reach in this study show comparable with COD scope of 55–89 mg/L got in the appraisal of water nature of borehole around chose landfills in Kanometropolis, north Nigeria, just as some chose boreholes in Umiahia in Abia state, southeast Nigeria, in that they are underneath the suggested esteem set by WHO [24].

3.1.3 Spatial and Temporal Variation of Nutrients and Micro Biological Parameters of Groundwater Quality

The result of spatial and temporal variation of groundwater nutrients and microbiological parameters measured in all six sampling points throughout the study time are presented in below table (Table 3).

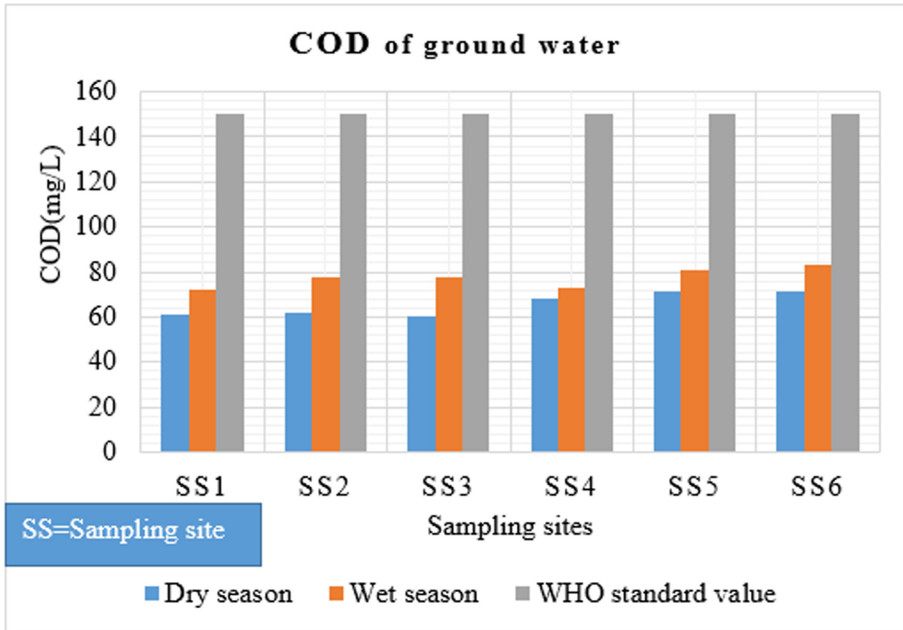


Fig. 8. Seasonal variation in the COD of groundwater quality in the study area.

Dynamics of nitrate in ground water:- From the study, the centralizations of nitrate during dry season changed between 0.071 ± 0.0011 to 0.08 ± 0.0021 mg/L with a mean value of 0.34 ± 0.006 mg/L while in a wet season it went from 0.51 ± 0.02 to 0.94 ± 0.056 mg/L with a mean value of 0.62 ± 0.07 mg/L (Fig. 8). The result of Fig. 8 shows that all values of the dry and wet season were amazingly beneath the WHO standard value of 50 mg/L for groundwater. This could presumably be because of the nonappearance of DO essentially in the wastewater; a more modest measure of nitrate is delivered from alkali just as decay of food wastes and different wellsprings of protein. Generally, factors influencing the event of nitrate in groundwater boreholes are subsurface mud focal points and land use practice. The divulgements/discoveries/of low values of nitrate (beneath WHO standard) during the assessment time span was comparable with crafted by [25] who have evaluated nitrate in wells and springs in the north-focal Ethiopian high terrains and discovered worth which is not as much as WHO standard breaking point all through the investigation period. Despite the fact that all qualities were beneath as far as possible the mean groupings of nitrate acquired during wet season were higher than the value of dry season (Fig. 8). The exposures of the high value of nitrate in a wet season during the study period were like the exploration of [26] who researches groundwater quality in an upland horticultural watershed in the sub-muggy Ethiopian good countries and discovered the higher value of nitrate during the wet season than the dry season. This may have been because of high nitrate fixation in the wet season proposed that expanded flush of nitrate causing segments (blended source, for example, rotting plant or creature material, rural composts, excrement, fertilizer,

Table 3. Spatial and temporal variation in measured values of nutrients and micro biological parameters

Sampling sites	NO ₃ ⁻ (mg/L)		PO ₄ ³⁻ (mg/L)		TC (CFU/100 ml)	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
SS1	0.071 ± 0.0011	0.53 ± 0.056	0.0058 ± 0.003	0.0018 ± 0.001	8.33 ± 0.1.53	13 ± 3
SS2	0.72 ± 0.023	0.66 ± 0.053	0.0088 ± 0.0029	0.031 ± 0.023	6.33 ± 1.53	13.67 ± 5.132
SS3	0.09 ± 0.003	0.94 ± 0.056	0.048 ± 0.0023	0.0072 ± 0.005	7.33 ± 3.51	18.33 ± 4.51
SS4	0.73 ± 0.01	0.51 ± 0.02	0.039 ± 0.003	0.05 ± 0.0075	5 ± 1	16 ± 1
SS5	0.073 ± 0.0021	0.52 ± 0.16	0.064 ± 0.0042	0.264 ± 0.0.34	11.67 ± 2.52	23 ± 6
SS6	0.08 ± 0.0021	0.55 ± 0.06	0.098 ± 0.001	0.262 ± 0.87	9 ± 2	20 ± 4.583

human or creature waste, and homegrown sewage) got from garbage removal site and the regions around during storm function brought about nitrate focus or the expanded nitrate level was because of freshwater inflow and earthly run-off during the wet season [27]. Another conceivable method of nitrates passage is through oxidation of smelling salts type of nitrogen to nitrite arrangement [28]. For the most part, during the wet season groundwater is revived through precipitation by means of permeation prompting an overall ascent in the degree of the water. This makes them exceptionally powerless to contamination and overflow exercises as components in soils and shakes are effectively delivered into the water. The principle wellspring of nitrate in these groundwater tests could be credited utilization of synthetic composts on ranches, emanating releases and spillover from animal feedlots have been recognized as one of the fundamental drivers of nitrate in groundwater. Also, inappropriate removal of human and creature waste on open land brings about filtering of remaining nitrate subsequently causing high nitrate fixation in groundwater in the wet season. In most case employments of substance manures; ill-advised removal of human and creature wastes and impact of seasons are basic components for wellsprings of nitrogen-containing exacerbates that are changed over to nitrate in the dirt. Then again, the low mean worth was recorded during the dry season because of less freshwater inflow and high saltiness [29] and [30]. In the part of spatial variety, the greatest worth was gotten at inspecting point 4 with a base an incentive at testing point 1 during the dry season while in the wet season the most extreme worth happens at examining point 3 with a base an incentive at testing point 1 (Fig. 11). The purpose behind the qualities to be most extreme may have been because of plant rotting, fertilizer, manure, and overflow since testing point 3 and inspecting point 4 borehole tests are found especially at brushing area and nurseries while for the base the converse is valid. From the ANOVA result, there was no conceivable huge variety between the examining focuses just as between the seasons that may lead the centralization of nitrate over the restriction of WHO.

Dynamics of phosphate in ground water:- The grouping of phosphate in the ground-water tests went from 0.0088 ± 0.0029 to 0.098 ± 0.001 mg/L in the dry season and 0.002 ± 0.001 to $0.264 \pm 0.0.34$ mg/L in the wet season (Fig. 9). The discoveries of the investigation show that more significant levels of phosphate focuses were anyway enrolled during the wet seasons contrasted with dry seasons in all the groundwater tests (Fig. 9). This distinction can be clarified as far as expanded dampness in the ground of garbage removal site which contains human squanders, sedated shampoos, food waste and beauty care products that can filter the phosphate into groundwater. By and large, the value of phosphate during the blustery season can increment because of the conceivable contribution of phosphates from the outside climate, inappropriate removal of strong wastes and overflow because of unreasonable utilization of compound composts into the water and normal decay of rocks and minerals that contain phosphates. Phosphates are typically profoundly adsorbed into the dirt and can be shipped into the catchments and the beneficiary water bodies by the activities of downpour and afterward represented the high phosphate focus in nearby water bodies. The base value of phosphate was enlisted during the dry season, this may have been because of the low solvency of local phosphate minerals and the capacity of soils to hold phosphate. This is in accordance with

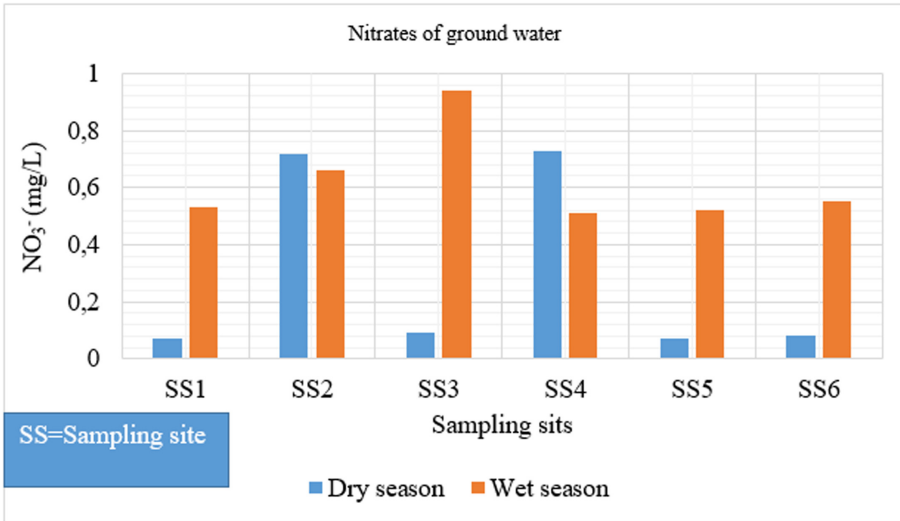


Fig. 9. Seasonal variation in the nitrate of groundwater quality in the study area.

the discoveries of [23] who examines occasional varieties in Physico-substance qualities of Tapi estuary in the Hazira mechanical territory and discovered a higher value of phosphate during the wet season than dry. From the purpose of spatial variety, the most elevated centralizations of phosphate were recorded at examining point 5 followed by inspecting point 6 during the blustery season with a base an incentive at testing point 1 while in the dry season the most elevated level was at testing point 6 with a base an incentive at inspecting point 2 (Fig. 9). This was because of the areas of boreholes from the chose garbage removal site. From underneath acquired outcome (Fig. 9) with the exception of examining point 5 and inspecting point 6 the grouping of PO4³⁻ in both dry and wet seasons were beneath WHO norms limit (PO4³⁻ = 0.1 mg/L). On record of this, the measurable study of change (ANOVA) results demonstrates that there was no huge contrast in mean phosphate fixation between and inside testing focuses just as seasons during the investigation period ($p < 0.05$).

Total coliform:- The results of the bacteriological investigation of borehole water tests demonstrate that the measure of complete coliform during the dry season was gone from 5 ± 1 to 11.67 ± 2.52 CFU/100 ml with a mean value of 7.9 ± 2.01 CFU/100 ml though in a wet season the all-out coliform varied from 13 ± 3 to 23 ± 6 CFU/100 ml with a mean value of 17.3 ± 4.04 CFU/100 ml (Fig. 10). From the outcome, one can see that the bacterial settlement checks were all over the WHO rule cutoff of 0 CFU/100 ml for drinking purposes. Accordingly, groundwater tests were polluted with complete coliform. This must be because of wastes especially human wastes which are shipped from Bahir Dar city and released legitimately to the open land (at the open garbage removal site). It can, thusly, be derived that the boreholes were essentially dirtied by the channels radiating from the waste site that vacant their substance straightforwardly out of the dark land. The deliberate mean value of absolute coliform during the wet season was higher than that of the dry season. This could be because of the released human

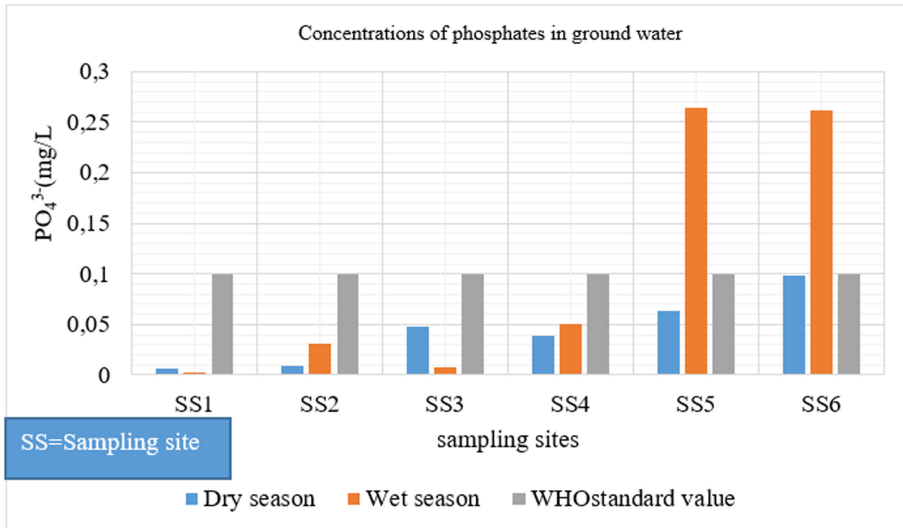


Fig. 10. Seasonal variation in the phosphate of groundwater quality in the study area.

wastes or fecal issues are flushed/washed/away by the activities of precipitation from its source to the diverse water bodies. At that point during its stream, it joins surface waters and open boreholes other than filtering into groundwater through permeation and invasion. The vehicle of exposed soil debased with dung by the breeze/downpour/into open bores just as surface overflow could likewise have represented the high bacterial burden during the wet season when contrasted with the dry season. Test focuses that are closest to the removal site in the downstream like examining point 5 and inspecting point 6 were more influenced by the absolute coliform. Un expectedly test focuses which are situated over the dumpsite were dirtied with absolute coliform. This may have been because of dung and different wastes from anthropogenic sources (open field crap along the boreholes by people and different creatures that eat alongside the groundwater tests) situated in hedges near boreholes. This was inevitably washed by water as spillover towards groundwater tests and afterward spilled into groundwater other than to blend in with the open boreholes and spring water by means of surface stream. The most extreme qualities among the six groundwater tests were found at examining point 5 inspecting point 6, examining point 1 and examining point 3 with a base at inspecting point 4 during the dry season while in a wet season the greatest qualities were gotten at inspecting point 5, testing point 6, testing point 3 and examining point 4 with a base at inspecting point 1. The transient mean value of absolute coliform in the water at the six examining purposes of the investigation zone during the dry and wet season were appeared in Fig. 10.

3.2 Assessing/Evaluating/Changes in Groundwater Quality of Chilanchil Abay Watershed through Water Quality Index (CCMEWQI)

In this investigation, the CCME Water Quality Index was applied and tried for the Chilanchil Abay Watershed quality. The record goes from 0 to 100 and relying upon

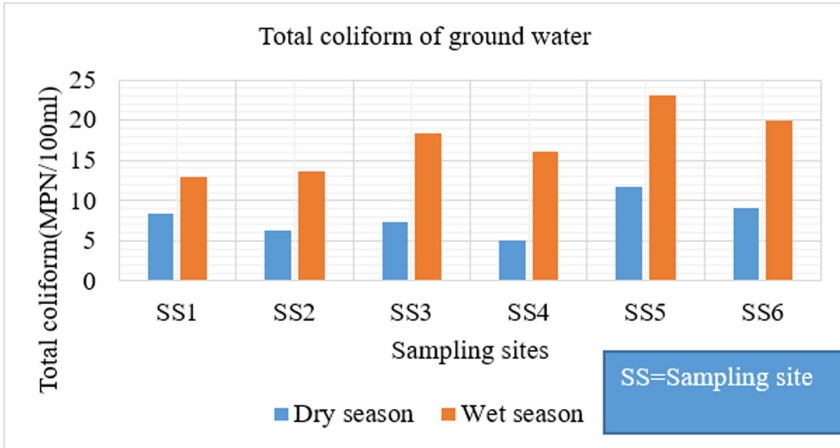


Fig. 11. Seasonal variation in total coliform of groundwater quality in the study area.

the worth; the water quality is portrayed as great, great, reasonable, negligible and poor. The CCME WQI was determined utilizing the technique portrayed by CCME 2001 rules (Eq. 1, 2, 3, 4, 5, 6 and 7). The outcomes got from the utilization of CCME WQI concerning supplements, hefty metals, and physico-synthetic attributes were introduced in Tables and diagrams underneath.

Table 4. Variation of WQI of Chilanchil Abay watershed with different sampling points

Sampling points	Level	Status
SS ₁	46.2	Marginal
SS ₂	45.53	Marginal
SS ₃	45.52	Marginal
SS ₄	45.53	Marginal
SS ₅	42	Poor
SS ₆	42.2	Poor

Study in Chilanchil Abay watershed Table 4 above and Fig. 11 beneath shows the variety of WQI with CCME standard level to assess the status of existing groundwater quality in the investigation territory. The determined outcomes got from all inspecting purposes of groundwater were indicating four sample points as minimal and two sample points as poor for 30th March 2011 to twentieth August 2011. All the negligible status test focuses are found in the upstream of the garbage removal site. This shows that water quality is much of the time jeopardized or disintegrated; conditions regularly stray from normal or attractive levels. This could be come about due to rotting of plants and creatures, farming composts and open abandonment exercises. While the excess two helpless status test focuses were found in the downstream of the garbage removal site.

This demonstrates that the water nature of these testing focuses is constantly imperiled or decayed; conditions normally veer off from regular or attractive levels. Considering all example locales, test site SS5 and test site six have demonstrated the most noticeably awful quality with regards to CCMEWQI. The reasons may incorporate the movements of leachate in downstream from the dumpsite towards those two sample points (Fig. 12).

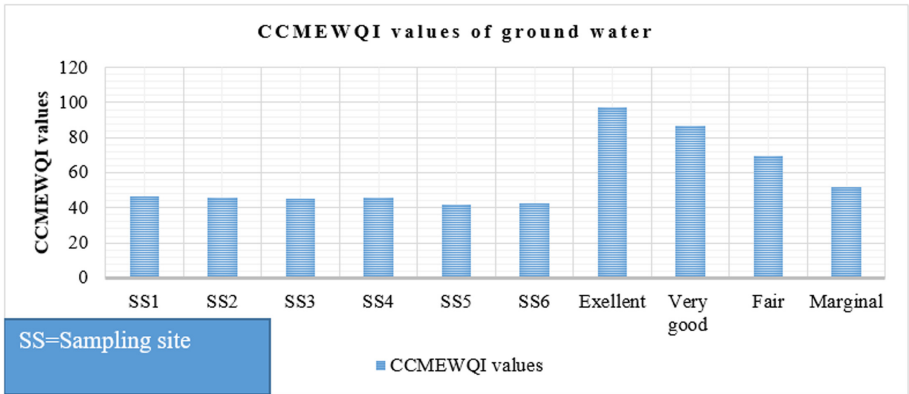


Fig. 12. Figure 11: variations of water quality index in the study area at different groundwater sample sites

4 Conclusion

The temporal and spatial variations of groundwater quality of Chilanchil Abay watershed was assessed following WHO quality parameters and Canadian water quality index. The analysis of physicochemical properties and concentrations of nutrients recorded values, show that BOD, COD, and NO₃-were within the acceptable limit for groundwater during the study time while the remains fluctuated with the seasons.

From the findings of the study, it assured that sample points below the dumpsite were more affected than the sample points of upstream.

The total coliform counts detected were above the permissible limits for drinking water in all sample points. Data suggested the importance of greater attention for household contamination, environmental sanitation control and awareness about water contamination since the open waste disposal site and practice of open defecation have actually impacted the watershed of the study area.

According to the Canadian water quality index (CCMEWQI), the water quality of Chilanchil Abay watershed was categorized under poor and marginal status.

Acknowledgments. The authors would like to thank Bahir Dar University, Bahir Dar institute of technology for financial supports of this project.

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