Physico-Chemical and Microbiological Analysis of Potable Ground Water in MIT and Abala, Afar Regional State, Ethiopia

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Abstract— this paper deals with the physic-chemical and microbiological analysis of the groundwater of MIT and Abala Afar regionals state, Ethiopia. Physicochemical parameters such pH, electrical conductivity, total dissolved solids, total solid, odder, taste, true color, turbidity, total alkalinity total hardness, Calcium Magnesium, Sodium, Potassium, Nickel, Zinc, Iron, Copper, Manganese, Ammonium, Aluminum, Chromium, Barium, Arsenic, Cadmium, Mercury, Chloride, Nitrate, Sulphate, Phosphate, Fluoride, microbiological parameters were analyzed. In microbiological analysis, total coliforms, and E. coli were determined. A sample was systematically taken from the two sample sites (Abala and MIT) near the middle of the vessel below the surface. In both sample locations the electrical conductivity, total dissolved solids, total solid, true color, turbidity, total hardness, Magnesium, Nickel, Iron, Arsenic, Cadmium, and Sulphate were found that higher than the permissible limits of the world health organization(WHO) standard. In both cases, samples were not found to contain significant quantities of bacteria. The results indicate that the groundwater sample is polluted and cannot be used for drinking purpose. Those water sources that do not conform to National Standard could result in public health problems in long time exposure. Therefore, adequate water remedy needs to be ensured earlier than usage. The neighborhood water authority shall strengthen local water nice monitoring and control structures additionally as hazard assessment and management mechanisms.

Index Terms— Electrical conductivity, Physico –chemical, Potable Groundwater, Total alkalinity, Total hardness

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1 INTRODUCTION

THE water is a crucial for mankind given that its miles at once related to people. To advantage a real understanding of the character of a specific water source; it's far thus generally necessary to measure numerous one of a kind homes with the resource of assignment analyses underneath the sizeable headings of bodily, chemical and organic trends [1], [2].

Herbal water our bodies frequently have impurities from various assets. The impurities may be suspended particles, colloidal materials and may also be dissolved cationic and anionic substances, different bio-assimilation and bio-accumulation of metals in aquatic organisms. Various natural and human activities, like industrial, domestic, agricultural activities and others are creating water pollution, particularly in surface and groundwater systems [3].

The groundwater is thought to be comparatively much clean and unfastened from pollution than surface water. It is the major source of drinking water in many urban and rural areas of Ethiopia[4], [5].

The supply of water determines the location and activities of people in an area, and our growing populace is placing wonderful demand upon herbal freshwater resources. However it's amazing varies from place to vicinity, every so often relying on seasonal changes the styles of soils, rocks, and surfaces[6].

In nature, the hydrochemistry of the water sources was affected by rich metal ions and other physical factors that lead the water more polluted Groundwater flows through the sediments, unfortunately, it can be contaminated through various ways such as iron and manganese are dissolved and may later be found in high concentrations in the water [7], [8].

Further, human activities can modify the herbal composition of groundwater through the disposal or dissemination of chemical substances and microbial recall on the land ground and into soils, or through the injection of wastes directly into groundwater[9], [10].

Urban activities, agriculture, and groundwater plumage can affect groundwater quality. Pesticides and fertilizers implemented to lawns and crops can gather and migrate to the water, hence affecting each the bodily, chemical and microbial exceptional of groundwater[3], [11], [12].

The prolonged discharge of industrial effluents, domestic sewage, and solid waste dump cause the groundwater to become contaminated and created health problems [8], [13] .

In Ethiopia, there's a rapid increase in population; but, the not unusual consuming water sources are restricted to wells, springs, and taps. Now a day, these water sources are becoming contaminated and the contamination level is increasing[4], [5], [14].

The only source of water for drinking and agricultural purpose at MIT and Abala district afar regional state are the groundwater. The problems of groundwater fantastic are lots greater acute inside the regions which can be densely populated.

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In Abala kidney infection, gastric diseases, water-borne diseases, and bad taste are common reports on the Abala Hospital and comments of the community. The expected cause for these diseases is the potable groundwater. It is known that no water quality management studies and treatments are made in the Abala district afar region and MIT Ethiopia. Therefore it is important to know the incidences of diseases occurring due to polluted water.This could provide an opportunity to know the incidence of water-borne and other diseases in the district.

Hence In this work, the physicochemical analysis and microbiological characteristics of drinking water quality were studied at Abala district afar regional state and MIT, Ethiopia. The main aim of this study was to carry out different physicochemical parameters and microbiological characteristics of water samples collected from different sites of the Abala district afar region and MIT, Ethiopia using WHO standards water quality and to recommend whether it is potable or not.

2 MATERIAL AND METHODS

2.1 Description of Sampling and Experimental Site
The present piece of investigation is concerned with the qualitative and quantitative studies of Abala city. Abala city is found in the Afar region, Zone two, Abala. Abala is found east of Mekelle and 50 km far from Mekelle. The water source is used for drinking and cleaning purposes approximately by 30,000 peoples of Abala.

The laboratory activities were done at Mekelle University (college of veterinary medicine, College of Health Science, Department of Chemistry and Geology laboratories) and Ezana Mining Analytical Laboratory.

2.2 Experimental Materials
All the chemicals are analytical grade, Some of the chemicals and reagents that are used in the study are distilled water, Buffer pH = 4, 7 and 9, solvents (n-hexane, petroleum ether, ethyl acetate, methanol, Sulphuric acid H2SO4, and chloroform), Phenolphthalein indicator, Potassium chloride, Methyl orange indicator, culture media, Silver nitrate solution AgNO3, Potassium chromate indicator K2CrO4, CaCO3, HClO4, HNO3, ammonium metavanadate, KH2PO4, Standard HCl, NaCl, MgCl2, Standard EDTA solution, BaCl2, EDTA- disodium salt, Ammonium hydroxide-ammonium chloride buffer, Sodium hydroxide NaOH, Murexide indicator (ammonium purpurate with of NaCl), Eriochrome black T indicator EBT, vanillin, anhydrous sodium sulphate, and other chemicals and reagents are used. The apparatus which are used in the study are Separatory funnel, Hot air oven, Hood, pH meter, Conductivity meter, Beakers (different sizes), Flame Emission Photometer, Titration apparatus, Turbidimeter, UV-Visible Spectrophotometer, Quartz cuvette, Flasks (different sizes), Measuring Cylinder, Pipettes (different sizes), Electronic Balance, Heating Mantle, Incubator, Magnetic Stirrer, Rotary evaporator and other instruments are used.

2.3 Methods of Data Collection
A sample that was collected for analysis has been collected in such how to provide the foremost stratified sample possible (composite sample). They were taken near the middle of the vessel below the surface. The sample was collected in clean plastic canes by rinsing the container several times with water and next with the water that was sampled.

The samples were collected within the plastic cane and have the four-liter capacity with none air bubbles as per the quality procedure. The sample was taken as closely as possible to the source of the availability to attenuate the consequences of the distribution system. Water samples from wells were collected after the pump has run long enough to be delivering water that's representative of the groundwater feeding the well.

The sample site, time of sampling, date of sampling and sample number was recorded. Water samples from two sampling points situated at different places were collected. The samples were put to examination within the laboratory to figure out some physical, chemical and biological parameters.

2.4 Methods of Data Analysis
The physico-chemical analysis is being determined according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater published jointly by the American Public Health Association (APHA, 1998), the American Water Works Association (AWWA) and the Water Pollution Control Federation (WPCF).

The samples collected from Abala and MIT were analyzed for different physicochemical parameters such as pH, Electrical conductivity (EC), Total dissolved solids (TDS), Total solid(TS), True color(TCU), Turbidity(NTU), Total alkalinity (TA), Total hardness (TH), Calcium(Ca^{2+}), Magnesium(Mg^{2+}), Sodium (Na^+), Potassium(K^+), Nickel(Ni), Zinc(Zn), Iron(Fe), Copper(CU), Manganese(Mn), Ammonium(NH4), Barium(Ba Aluminum(Al), Chromium(Cr),), Arsenic (As), Cadmium (Cd), Mercury (Hg), Chloride (Cl-), Nitrate (NO3-), Sulphate (SO42-), Phosphate (PO43-), Fluoride (F-), Odder, and Taste, parameters using the standard methods given in APHA (American Public Health Association). A presumptive test using lactose broth would be performed for water samples to detect the presence of bacteria.

Total Coliform Microbiological evaluation becomes also done. To analyze general in water samples, the special Merck Kits were used. After taking samples, the Merck kit became placed at 37°C in an incubator for 24 hours. After the specified time, the samples have been analyzed.

Escherichia Coli: After the gathering of samples and making use of well-known strategies, the samples have been located at 44°C for 24 hours for quantitative analysis. On a subsequent day, the colonies had been counted and the full quantity turned into recorded.

3 RESULTS AND DISCUSSION

The aim of the present study is to determine the groundwater contamination around Abala (L_1) and MIT (L_2) area. For this study, a physicochemical analysis was done with the groundwater samples collected from two different places in Abala and MIT area.

The average results of the physicochemical parameters for different water samples are presented in Table 1. These results were compared with the values of prescribed standard quality

parameters presented in Tables 1.

The quality of water resources depends on the location and management of water sources. It includes anthropogenic discharge as well as the natural physicochemical properties of the area. The results of physicochemical analysis of water samples are discussed as below.

3.1. PH

PH can be a degree of whether or not a liquid is acid or alkaline. The pH ranges from zero (very acid) to 14 (very alkaline)[15], [16].

The pH was recorded as 7.25, and 7.27at sampling location L_1 and L_2, respectively and are found to be in the permissible limit as prescribed under standard values of WHO.

3.2. Electrical Conductivity (EC)

Electrical Conductivity values were 1973 µS/cm at L_1 and 1501 µS/cm at L_2.

Electrical Conductivity values for both the investigated samples were found to be greater than the limit prescribed by the WHO standard, which indicates the presence of a high amount of dissolved inorganic substances in ionized form.

3.3. Total Dissolved Solids (TDS).

It usually related to conductivity. Water containing more than 500 mg/l of TDS is not considered desirable for drinking water supplies, the maximum value of TDS during the study period was found as 1406.97 mg/l at sampling location L_1 and the minimum was 1070.38 mg/l at L_2. The TDS values of the water samples of the selected places are greater than the limit by WHO standard.

3.4. Total Alkalinity (TA)

The alkalinity charge in water provides a precious idea of herbal salts determined inside the water. The cause of alkalinity is the presence of minerals that dissolve in water from the soils. The maximum value of alkalinity was found as 240 mg/l at sampling location L_2 and found greater than the limit prescribed by the WHO standard (200 mg/l CaCO3). The alkalinity value of L_1 is recorded 185 mg/l which is less than the limit prescribed by WHO standard.

3.5. Total Hardness (TH)

The total hardness measured at L_1 and L_2 was 655 mg/l and 683.33 mg/l respectively, which are higher than the permissible limit prescribed by WHO standards (200 mg/l).

3.6. The Oder, and Taste

The water sample analyzed in both sit is shown not unpleasant taste and odorless character.

3.7. True Color (TCU)

The total true color measured at L_1 and L_2 was 16.89 and 13.41 TCU respectively, which are higher than the permissible limit prescribed by WHO standards (5 TCU).

3.8. Turbidity (NTU)

The prescribed limit of turbidity of groundwater is 1.5 nephelometer turbidity units (NTU) in WHO Standards. In both the water samples collected, the turbidity value was 4.96 NTU and 3.75 NTU, and their average value was 4.355 NTU. The results showed that the turbidity of the two samples was higher than the WHO standards.

3.9. Total solid (TS)

The total solid value was recorded 2526 mg/l at sample location $L1$ and 416 mg/l at sample location L_2. Total solid values for both the investigated samples were found to be greater than the limit prescribed by the WHO standard.

3.10. Cadmium

Cadmium is used in the metallic and plastics industry and is a commonplace factor of batteries. It could additionally enter the water from trace impurities inside the zinc of galvanized pipes and solders and a few metallic fittings. Cadmium can collect inside the kidneys [15].

The values of cadmium measured at L_1 and L_2 water samples are 0.11 mg/l and 0.02 mg/l and are over the acceptable limit of WHO standards.

3.11. Barium

A concentration of barium was found 0.09 mg/l at sample location L_1 and 0.07 mg/l at sample location L_2. Both samples were found less than the permissible limit of WHO standards

3.12. Zinc

The Zinc content in the groundwater of the study area has a concesntration of zero (below detection limit) at sample location L_1 and 3 mg/l at sample location L_2. Groundwater at sample location L_1 was below detection limit of zinc. Groundwater at sample location L_2 was found less than the permissible limit of WHO standards.

3.13. Nickel

Nickel could also be a metal utilized within the assembly of stainless steels and alloys and for this reason, can be present in water that comes into touch with nickel or chromium plated taps particularly wherein the water has been stagnant before consumption. Nickel compounds are carcinogenic and steel nickel as likely carcinogenic [15].

The values of Nickel measured at L_1 and L_2 water samples are 0.63 mg/l and 0.15 mg/l, which are over the acceptable limit of WHO standards.

3.14. Manganese

Manganese is an element plentiful within the Earth's crust and is commonly found in groundwater. In common with iron, the troubles related to stages of manganese above the parametric value are basically aesthetic, as manganese can reason staining problems. High stages of manganese additionally motive objectionable tastes inside the water but there are not any particular toxicological connotations[17].

The concentrations of manganese estimated are below detection limit of the instrument, at both sample locations.

3.15. Chloride

The maximum value of chloride was recorded 560.62 mg/l at sampling location L_1 and found greater than the WHO standards. 33.67 mg/l was recorded at L_2, which is less than the permissible limit prescribed by WHO standards (250mg/l).

3.16. Sodium

A concentration of sodium was found 24 mg/l at sample location L_1 and 12 mg/l at sample location L_2. Both samples were found under the permissible limit of WHO standards.

3.17. Potassium

The concentration of potassium was estimated 1.65 mg/l at a sample location L_1 and 1.02 mg/ml at sample location L_2. All the samples were found to have a lower concentration of K+ than the permissible limit of WHO.

3.18. Arsenic

Arsenic is a cumulative poison and its presence indicates pollution. It is used as weedicide in agriculture and may contaminate the water supplies (Agency & Estate, 2014); Lina et al.(2019).

A concentration of Arsenic was found 1 mg/l at sample location L_1 and 0.012 mg/l at sample location L_2. Both samples were found over the permissible limit of WHO standards (0.01 mg/l).

3.19. Nitrate

The nitrate content in the groundwater of the study area has a concentration of 7.26 1 mg/l at sample location L_1 and 7.51 mg/l at sample location L_2. Both samples were found under the permissible limit of WHO standards. In excessive amounts, nitrate may cause disease characterized by blood changes.

3.20. Chromium

Chromium is normally discovered in the Earth's crust, although can be present in water from contamination from wooden treatment chemical compounds. The toxicity of chromium depends on the form in which its miles observed [18].

The values of chromium measured in L_1 and L_2 water samples are 0.007 mg/l and 0.009 mg/l and are below the acceptable limit of WHO standards.

3.21. Copper

Copper was recorded as 0.003 mg/l, and 0.006 mg/l at sampling location L_1 and L_2, respectively and are found to be less than in the permissible limit as prescribed under standard values of WHO standards.

3.22. Mercury

Mercury can be a totally toxic metal that on the whole affects the kidney. It's been utilized in electrical appliances, batteries, plastics and in dental amalgams, although lots of the ones uses are not to any extent further relevant[15].

The values of mercury measured at both water samples are below detection limit, which indicates that the water samples are below detection limit of the instrument.

3.23. Fluoride

A small concentration of fluoride in drinking water has a beneficial impact on human health for preventing dental caries. The higher concentration of fluoride than that of 1.5 mg/l consists of an extended chance of dental fluorosis and lots of better awareness results in skeletal fluorosis[17].

The fluoride content of groundwater at L_2 is 0.86 mg/l which is under acceptable limit. The fluoride content of groundwater at L_1 was measured 1.56 mg/l, which are over acceptable limits of WHO standards.

3.24. Iron

Iron is taken into consideration as an essential micronutrient. Long time intake of consuming water with high attention of iron may result in liver sicknesses[15], [17].

The iron concentration was recorded, 0.71 mg/l and 0.68 mg/l at sample location L_1 and sample location L_2 respectively, which are overprescribed limit of WHO standard.

3.25. Sulphate

The values of sulphate measured at sample location L_1 and sample location L_2 are 403.61 mg/l and 398.43mg/l and are over the applicable limit of WHO standards.

3.26. Ammonium

Ammonium in water substances originates from agricultural and commercial methods. Increased ranges of ammonium may get up from extensive agriculture in the catchment of the water source[18].

A concentration of ammonium was found 0.061 mg/l at sample location L_1 and 0.013 mg/l at sample location L_2. Both samples were found under the permissible limit of WHO standards.

3.27. Calcium

Over 95% of total frame calcium is discovered in bones and enamel, in which it features as a key structural element. Where it functions as a key structural element. Insufficient intakes of calcium were related to increased risks of osteoporosis, kidney stones, colorectal cancer, hypertension and stroke, coronary artery ailment, insulin resistance, and weight problems[3], [9].

The calcium concentration was recorded, 87 mg/l and mg/l at L_1 and 95 mg/l L_2 respectively, which are less than the prescribed limit of WHO standard.

3.28. Magnesium

In this study, magnesium measured 105 mg/l at sample location L_1 and 107 mg/l at sample location L_2. According to this study, the magnesium content of the water samples did exceed the WHO standards.

3.29. Phosphate.

Phosphate is a made of phosphorus. Water bodies can be infected from the courses of washing with phosphorus-containing detergents in it. This can get to the water table through leaching, infiltration, and seepage from water bodies. Phosphorus is a constituent of DNA or RNA. Via the infiltration of detergents down the water desk, other organic and inorganic chemical components can get to infect the water[16], [18].

In this study, phosphate found 0.79 mg/l at sample location L_1, which is over the prescribed limit of WHO standard. 0.05 mg/l at sample location L_2, which was below WHO recommended standards.

3.30. Aluminum

Aluminum is found in water because of its use as aluminum sulphate within the water remedy technique, though maybe obviously found in some waters [15].

A concentration of aluminum was found 0.15 mg/l at sample location L_1 and 0.63 mg/l at sample location L_2. Sample location two was found over the permissible limit of WHO standards.

3.31. Total coliform and E.coli

Coliform count and E.coli are the counts of viable microbial colony units in both water samples. The total coliform count in both the water sample location is zero (free). Sample location L_1 and L_2 were fit for drinking.

TABLE 1.

ANALYTICAL AVERAGE RESULTS OF THE PHYSICO-CHEMICAL PARAMETERS VALUES FOR COLLECTED GROUNDWATER OF MIT AND ABALA, AFAR REGIONAL STATE, ETHIOPIA.

N0.	Parameter's	Sample Point Parametric Value		WHO .(mg/l)
		L_1	L_2	
1	True Color (TCU)	16.89	13.41	5
2	Odor	Odorless	Odorless	-
3	Taste	test less	test less	-
4	Turbidity (NTU)	4.96	3.75	1.5
5	Total solids 105^0c(mg/l)	2526.00	416.00	500
6	T. dissolved solid 105^0c (mg/l)	1406.97	1070.38	500
7	EC (μS/cm)	1973.00	1501.00	1000
8	PH	7.25	7.27	6.5-8.5
9	Ammonium (mg/l NH_4)	0.061	0.013	1.5
10	Sodium (mg/l Na)	24.00	12.00	50.00
11	Potassium (mg/l K)	1.65	1.02	12
12	Total hardness (mg/l Ca-CO_3)	655	683.33	200.00
13	Calcium (mg/l Ca)	87	95	200.00
14	Magnesium (mg/l Mg)	105	107	100.00
15	Iron (mg/l Fe)	0.71	0.68	0.3
16	Manganese (mg/l Mn)	0.00	0.00	0.3
17	Fluoride (mg/l F)	1.56	0.86	1.5
18	Chloride (mg/l Cl)	560.62	33.67	250.00
19	Nitrate (mg/l NO_3)	7.26	7.51	50.00
20	Alkalinity (mg/l Ca-CO_3)	185.00	240.00	200
21	Sulphate (mg/l SO_4^{-2})	403.61	398.43	200.00
22	Phosphate (mg/l PO_4^{-3})	0.79	0.05	0.1
23	Copper (mg/l Cu)	0.003	0.006	2
24	Aluminum (mg/l Al)	0.15	0.63	0.2
25	Chromium (mg/l Cr)	0.007	0.009	0.05
26	Zinc (mg/l Zn)	0.00	3	15.00
27	Barium (mg/l Ba)	0.09	0.07	0.7
28	Nickel (mg/l Ni)	0.63	0.15	0.07
29	Arsenic (As)	1	0.012	0.01
30	Cadmium (mg/l Cd)	0.11	0.02	0.003
31	Mercury (Hg)	0.00	0.00	0.006
32	Total Coliform per 100ml	0.00	0.00	Absent
33	E.coli per 100ml	0.00	0.00	Absent

4 CONCLUSION AND RECOMMENDATIONS

The study assessed and analyzed the varied physicochemical and microbiological quality of the chosen groundwater, and compare the effect, sources, and degree of pollution within the water sources of the two sites.

An in-depth study of all the sample sites of groundwater was administered by taking certain important parameters like Total coliform, E.coli,, pH, Electrical conductivity (EC), Total dissolved solids (TDS), Total solid(TS), True color(TCU), Turbidity(NTU), Total alkalinity (TA), Total hardness (TH), Calcium(Ca^{2+}), Magnesium(Mg^{2+}), Sodium (Na^+), Potassium(K^+), Nickel(Ni), Zinc(Zn), Iron(Fe), Copper(CU), Manganese(Mn), Ammonium(NH_4), Barium(Ba)s Aluminum(Al), Chromium (Cr),), Arsenic (As), Cadmium (Cd), Mercury (Hg), Chloride (Cl-), Nitrate (NO_3-), Sulphate (SO_4^{2-}), Phosphate (PO_4^{3-}), Fluoride (F-), Odder, and Taste, parameters that are essential for the determination of water quality. Instruments like Hot air oven, Hood, pH meter, Conductivity meter, Flame Emission Photometer, Atomic Absorption Spectrophotometer (AAS), Titration apparatus, Turbidimeter, UV-Visible Spectrophotometer, and other instruments are used.

The results indicate that the groundwater sample is polluted and cannot be used for drinking purpose. This pollution status of MIT and Abala is extremely regarding the deterioration of their physicochemical qualities. Though the sources of these deteriorations are often both natural and anthropogenic, the measured water quality parameters during this new study indicate that their elevated levels are mostly because of the human activities present within the areas.

Those water sources that do not conform to National Standard could end publicly health problems in while exposure. Therefore, the local water authority shall make stronger nearby water exceptional tracking and management systems also as chance evaluation and management mechanisms. The responsible non-governmental and governmental organizations should give decision on the treatment and management of these sources of potable water.
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REFERENCES

[1] H. M. Özler and A. Aydın, "Hydrochemical and microbiological quality of groundwater in West Thrace Region of Turkey," *Environ. Geol.*, vol. 54, no. 2, pp. 355–363, 2008, doi: 10.1007/s00254-007-0822-7.

[2] S. Perween and U. Fatima, "Physico-Chemical Analysis of Groundwater Quality in Aligarh City , Uttar Pradesh," *Int. J. Sci. Nat.*, vol. 6, no. 3, pp. 397–405, 2015.

[3] D. Kumar, "Physico-Chemical Analysis of Drinking Water in Hanumangarh District, Rajasthan India," *Int. J. Emerg. Trends Sci. Technol.*, vol. 03, no. 10, pp. 4685–4694, 2016, doi: 10.18535/ijetst/v3i10.04.

[4] A. Ayaliew Werkneh, "Physico-Chemical Analysis of Drinking Water Quality at Jigjiga City, Ethiopia," *Am. J. Environ. Prot.*, vol. 4, no. 1, p. 29, 2015, doi: 10.11648/j.ajep.20150401.14.

[5] B. Wakuma and T. Fita, "Physico-Chemical Analysis of Drinking Water (in case of," vol. 7, no. 4, pp. 364–370, 2017.

[6] L. Palamuleni and M. Akoth, "Physico-chemical and microbial analysis of selected borehole water in Mahikeng, South Africa," *Int. J. Environ. Res. Public Health*, vol. 12, no. 8, pp. 8619–8630, 2015, doi: 10.3390/ijerph120808619.

[7] A. Mishra and V. Bhatt, "Physico-chemical and microbiological analysis of under ground water in V.V Nagar and near by places of Anand District,Gujarat, India," *E-Journal Chem.*, vol. 5, no. 3, pp. 487–492, 2008, doi: 10.1155/2008/671978.

[8] E. R. Sunday and E. E. Chidi, "Physico-chemical and Microbiological Evidence of Drinking Water Quality in Ugbowo , Benin City , Nigeria," vol. 4, no. 1, pp. 12–18, 2019, doi: 10.11648/j.ijmb.20190401.13.

[9] S. Devi and R. Premkumar, "Physico-Chemical Analysis Of Water Samples Near Industrial Area, Kurinjipadi Block, Cuddalore District, Tamilnadu, India," *Int. J. ChemTech Res.*, vol. 4, no. 1, pp. 29–34, 2018, doi: 10.20902/ijctr.2018.110610.

[10] J. Kaur, S. Kaur, V. Dashora, Y. Chaudhary, P. Nijhawan, and S. Saini, "Microbiological and Physico-Chemical Quality of Groundwater at a Resettlement Colony , Madanpur Khadar in Delhi , India," vol. 1, no. 3, pp. 26–38, 2015.

[11] C. Ecjhao, "Studies on Some Physico-Chemical and Microbiological Characteristics of Potable Water Used in Some Rural Areas of Surat District (Gujarat)," vol. 2, no. 2, pp. 113–120, 2005.

[12] C. Nagamani and C. Saraswathidevi, "Physico-chemical analysis of water samples," *Int. J. Sci. Eng. Res.*, vol. 6, no. 1, pp. 2149–2155, 2015.

[13] J. J. Sunday, N. C. O. Spencer, O. Kingsley, A. O. Edet, and D. D. Amaka, "Original Research Article Physico-chemical and microbiological properties of water samples used for domestic purposes in Okada town , Edo state , Nigeria," vol. 3, no. 6, pp. 886–894, 2014.

[14] Z. A. Alemu, K. T. Teklu, T. A. Alemayehu, K. H. Balcha, and S. D. Mengesha, "Physicochemical quality of drinking water sources in Ethiopia and its health impact: a retrospective study," *Environ. Syst. Res.*, vol. 4, no. 1, 2015, doi: 10.1186/s40068-015-0049-7.

[15] E. P. Agency and J. C. Estate, "Drinking Water Parameters Microbiological , Chemical and Indicator Parameters in the 2014 Drinking Water," 2014.

[16] A. Kumar, G. M. Zaiad, I. M. Awheda, and F. M. Fartas, "Physico-Chemical Analysis of Ground Water in Different Sites of Al-khums City , Libya," vol. 3, no. 7, pp. 2395–2398, 2014.

[17] D. Lina, A. Kharate, B. Awati, and S. Ashwini, "A study on Physicochemical and Microbiological Evaluation of Tap Water of Bidar District," *Int. J. Curr. Microbiol. Appl. Sci.*, vol. 8, no. 04, pp. 290–295, 2019, doi: 10.20546/ijcmas.2019.804.033.

[18] P. N. Patil, D. V Sawant, and R. N. Deshmukh, "Physico-chemical parameters for testing of water – A review," vol. 3, no. 3, pp. 1194–1207, 2012.