A REPORT
OF THE
SHORT TERM DEPARTMENTAL PROJECT CARRIED OUT BY TEACHER INVESTIGATORS AND STUDENT TRAINEES

"ANALYSIS OF PHYSICO-CHEMICAL PROPERTIES OF UNTREATED DRINKING WATER IN SHILLONG CITY"

Abstract: The aim of this study was to determine the physico- chemical properties of untreated drinking water available in Shillong city, Meghalaya, India. Twenty-three water samples were collected and tested from different sources of ground water and spring water. In this study, we observed that most of the parameter's test were below the prescribed or acceptable limit as per BIS recommendation.

Department of Chemistry

8/1/2023

NAME OF INVESTIGATORS AND STUDENTS' TRAINEES

DR. D.G.MARBANIANG, PRINCIPAL INVESTIGATOR

MR. E.R.DKHAR, CO-INVESTIGATOR

MR. D.F.DIENGDOH, CO-INVESTIGATOR

DR.T.MUKHIM, CO-INVESTIGATOR

DR. (MRS.) C.L.NONGPIUR, CO-INVESTIGATOR

DR. (MRS.) S.L.NONGBRI, CO-INVESTIGATOR

AMICA BONANAZA PAPANG, STUDENT TRAINEE

LAIAMONLANG SOHTUN, STUDENT TRAINEE

DAIAHUN MANNER, STUDENT TRAINEE

LARISHISHA MAWLONG, STUDENT TRAINEE

BAPYNHUNLIN LYNGDOH, STUDENT TRAINEE

IBADAHUN KHARMALKI,STUDENT TRAINEE

ANALYSIS OF PHYSICO-CHEMICAL PROPERTIES OF UNTREATED DRINKING WATER IN SHILLONG CITY

Introduction

With the ever-growing population and the uncontrolled developmental activities, there is increase demand for clean drinking water. It is witness that many streams, lakes, pond, and even wells are severely affected by the non-eco-friendly activities occuring around them.

Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. Therefore, it is necessary that the quality of drinking water should be checked at regular time interval.

The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Natural water contains different types of impurities which are introduced into aquatic system by different ways such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities, including mining, processing and the use of metal-based materials. (Awokunmi, 2010)

It is very essential and important to test the water before it is used for drinking, domestic, agricultural and industrial purpose. Water must be tested for different physico-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to used that water and what extend we need its quality and purity. Water contains different types of floating, dissolved, suspended and microbiological organisms (Patil P.N, 2012).

Shillong the capital of Meghalaya, located in the north eastern region of India is a picturesque hill station which is endowed with rolling hills, deep gorges, beautiful waterfalls and heavy rainfall. The city is ever expanding due to the growing population. With the increase in population, there is also an increase in the requirement of different natural resources like living space and water. To accommodate the population, forest areas are being cleared thereby destroying the water recharge system and exposing the water resource to contamination. To meet the water needs, the residents of the city are dependent on the supply of treated water by the Public Health and Engineering Department of the

government. However, with the passage of time, the supply and demands ratio is decreasing. Therefore, the residents are now turning their attention either to ground water or few natural streams to meet their water needs. Those who are dependent on ground water and stream water would use it for domestic purposes, and their only treatment option is boiling the water. This, we know, is only sufficient to kill only some micro-organisms but cannot remove physical and chemical parameters.

Aims and Objectives

1. The aim of the study is to estimate the concentration of selected drinking water parameters in untreated drinking water bodies collected from different sources in and around Shillong City.
2. To compare the data with standard limits as per the Bureau of Indian standards (BIS) or World Health Organisation (WHO) recommendations.
3. To explore practical remedial measures for any parameter that exceeds the permissible limit and to suggest the same to those who are using the water body for domestic usage including drinking.

Methodology

Twelve (12) drinking water parameters were selected for the study based on the availability of the method and instrumentation for analysis. Analysis was performed by the teacher investigators and the student trainees in the Department of Chemistry, Lady Keane College, Shillong. Before the analysis, all methods were calibrated using blanks and standard solutions. All reagents used were of analytical / exelar grade only. The efficiency of the analysis ranges from 95-99%. The following methods were employed for the analysis of the different drinking water parameters:

Methods used for analysing the different drinking water parameters in samples water

Sl. No	Parameters	Method used
1.	pH	Potentiometric
2.	Conductivity	Conductance measurement
3.	Alkalinity	Methyl Orange & Phenolphthalein Titrimetric
4.	Chloride	Mohr Argentometric titration

5.	Total Hardness	EDTA Titration
6.	Nitrite	Sulphanilimide Spectrophotometric
7	Sulphate	Spectrophotometric (using $BaCl_2$ as a precipitant)
8	Iron	Phenanthroline spectrophotometric
9	Fluoride	Ion electrode method
10	Nitrate	Phenoldisulphonic acid Spectrophotometric
11	Boron	Curcumin spectrophotometric
12	TDS	Conductance

Sampling

Water samples were collected from 21 stations located in and around Shillong city during the month of July, 2023 (Rainy Season). Water samples comprises of ground water (bore well and dug well) and surface water which are consumed by the people without any scientific treatment.

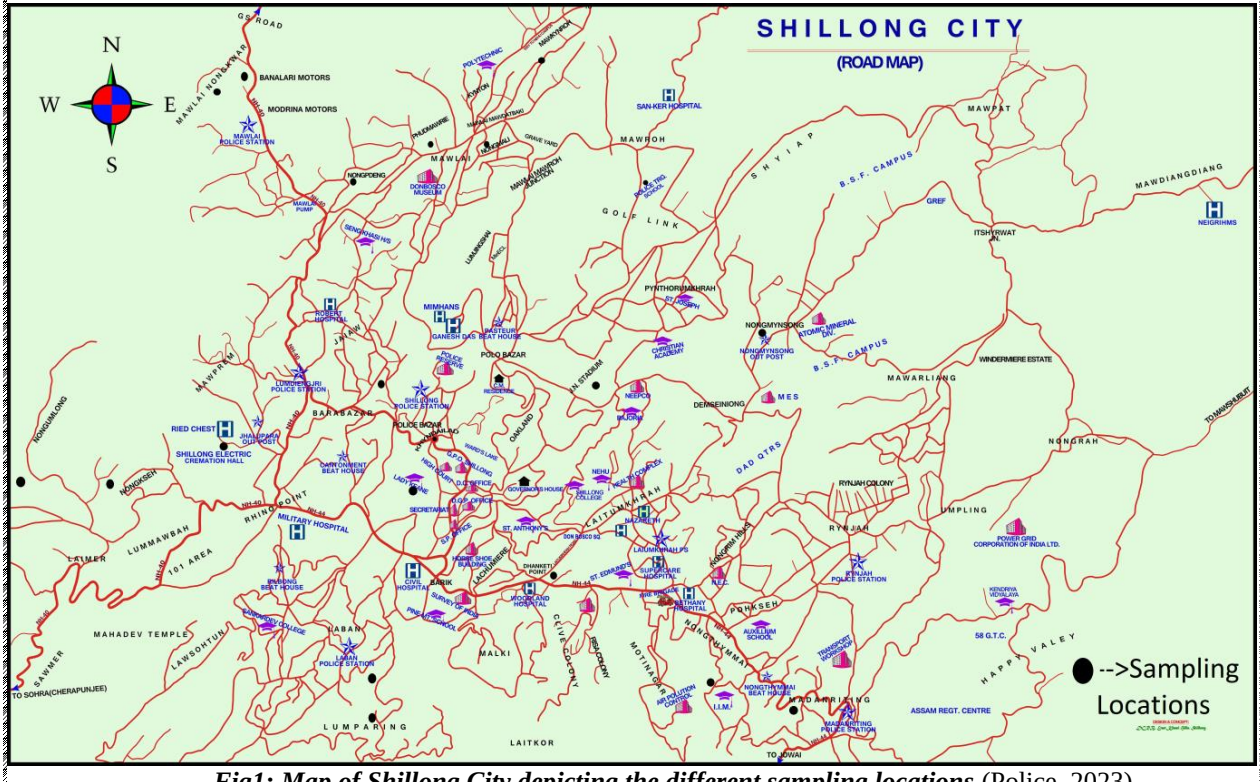

Fig1: Map of Shillong City depicting the different sampling locations (Police, 2023)

Grab water sample were collected from these different locations in pre-treated polythene bottle while making sure that contamination from all sources is minimised.

The samples after collection were immediately brought to the laboratory for analysis.

Results and discussion

The results of the finding of this present study are depicted in Table 1 below:

Table1: Table showing Minimum, Maximum, Mean, Median. Mode and standard Deviation of the values of different parameters tested

	pH	Conductivity	Alkalinity	Chloride	Hardness	TDS	Iron
Maximum	7.9	528	68	65	107.8	0.296	0.16
Minimum	3.84	14	4	3		0.008	0.03
Mean	5.245	167.227	18.818	21.091	47.914	0.102	0.062
Median	5.1	167.227	8	18	48.157	0.102	0.06
Mode	5.230	203	8	7	13.2	-	0.06
Standard Deviation	0.857	119.032	19.930	15.584	31.809	0.068	0.027

(Contd.) Table1: Table showing Minimum, Maximum, Mean, Median. Mode and standard Deviation of the values of different parameters tested

	Boron	Fluoride	Nitrate	Nitrite	Sulphate
Maximum	1.14	0.082	28.716	0.134	0.080
Minimum	0.130	0.002	0.796	0	0
Mean	0.454	0.015	8.765	0.041	0.031
Median	0.43	0.008	6.476	0.007	0.03
Mode	0.4	0.006	-	0.002	0
Standard Deviation	0.211	0.019	7.670	0.052	0.027

- **pH**

From the present study, it is observed that the pH values of water ranged from a minimum value of 3.84 to a maximum value of 7.90 with a mean value of 5.245. The median of the values is 5.1 indicating that most of the water samples are acidic. The pH of most natural water source ranges from 6.5-8.5 while deviation from the neutral point (7.0) maybe as a result of fluctuations in the CO_2/bicarbonate/carbonate equilibrium (Awokunmi, 2010). The pH of most of the samples are lower than the Bureau of Indian standards (BIS) recommended limit of 6.5-8.5 (BIS, 2012). The low pH values obtained in the water samples might be due to the high level of free CO_2.P. Kerketta et al, 2013 studied the overall pH in drinking water in Ranchi, Jharkhand, India and reported a range from 6.3-7.4. they

reported that six water samples were below the prescribed level of 6.5. However, their findings are still higher than the pH observed in the present study. (Kerketta P, 2013). Similar studies of pH in untreated drinking water (from well and surface water) were carried out by Fadaei and Sadeghi, 2014 in Shahrekord, Iran. They reported a pH range from 7.3 to 8.4 with a mean value of 7.6±0.21 which is much higher than that observed in the present study.The pH of drinking water has no immediate direct effects on human health but has some indirect health effects by bringing changes in other water quality parameter such as solubility of metal and survival of pathogen. (Abdolmajid, 2014)

- **Conductivity**

From the present study, it is observed that the conductivity values of the water samples range from a minimum value of 14 μS/cm to a maximum value of 528 μS/cm with the mean value of 167.23 μS/cm. The median of the value is 167.23 μS/cm indicating that most of the water samples have low salinity. Water sample in six locations were seen to be moderately saline water bodies. The conductivity values were also observed to fluctuate from one location to the other. Electrical conductivity is useful to indicate the total ionized constituent of water. It is directly related to sum of the cations and anions. Christiansen (1942) suggested the 6 conductivity classes (Christiansen, 1942). These are as follows:

C1 - 0.00 to 250 μS/cm – Low salinity water
C2 - 250 to 750 μS/cm – Moderate salinity water
C3 - 750 to 2250 μS/cm – Medium High salinity water
C4 - 2250 to 4000 μS/cm – High salinity water
C5 - 4000 to 6000 μS/cm – Very high salinity water
C6 - Above 6000 μS/cm – Water should not be used

Kerketta et al, 2013 studied the overall conductivity in drinking water in Ranchi, Jharkhand, India and reported a range from 83±1.15 to 1508±0μS/cm. They reported that the two sample were above prescribed level. The conductivity of their water sample shows Medium high salinity water (Kerketta P, 2013) whereas in Shillong city it can be class as Moderate salinity water as per the present study. The prescribed limit as per WHO/BIS is 300 μS/cm (BIS, 2012). Most of the water samples in the present study show conductivity less than the prescribed limit and in only one location the limit was exceeded. High

quantities of cations and anions, on the other hand, may alter the chemical composition of the aquatic system.

- **Total dissolved solid (TDS)**

From the present study, it is observed that the TDS in water samples ranged from a minimum value of 0.008mg/L to a maximum of 0.296mg/L with a median value of 0.1mg/L. According to BIS, the acceptable limit for TDS is 500mg/L (BIS, 2012). Low TDS indicate low pollution influx. In many of the sampling locations, the water source is well insulated from the immediate surrounding thereby protecting them. Kerketta et al, 2013 estimate the TDS of drinking water and reported to range from 67-1846mg/L. The mean values ranged from 73±1 (Kerketta P, 2013). These findings are much higher than that observed in the present study.

- **Alkalinity**

From the present study, it is observed that the alkalinity values of water ranges from a minimum value of 4mg/L to a maximum value of 68mg/L with a mean value of 18.8mg/L. The median of the values is 8.0mg/L. Alkalinity is composed primarily of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{2-}). Alkalinity acts as a stabilizer for pH. Alkalinity, pH and hardness affects the toxicity of many substances in the water. Alkalinity makes water useful and helps in coagulation. It is less preferable at less than 100mg/L for domestic use (Gupta, 2017). Kerketta et al, 2013 reported that the overall range of alkalinity in drinking water examined by them ranged from 22 to 256 mg/L and the mean values ranged from 35±1 to 144.75±40.359 mg/L (Kerketta P, 2013). According to BIS the permissible limit, the alkalinity in drinking water is 600 mg/L (BIS, 2012). The values observed from the present study were lower than the permissible limit of 600mg/L.

- **Total Hardness**

From the present study, we observed that the total hardness values of water samples ranged from a minimum value of 3mg/L to a maximum value of 65mg/L with a mean value of 21.1mg/L. The median of the values is 18mg/L indicating that most of the water samples are soft water. According to BIS the permissible limit for total hardness in drinking water is

200 mg/L (BIS, 2012). All values of total hardness are within the limits prescribed by BIS for the drinking water purposes. Principally, the calcium and magnesium presence are responsible for the hardness of the water. High amount of magnesium imparts a repulsive taste to the portable water.Water can be classified as soft (<75mg/L), moderately hard (75-150mg/L), hard(150-300mg/L) and very hard(>300mg/L) according to the concentration of calcium and magnesium. It is an important criterion for determining the usability of water domestic, drinking and many industrial applications. Water having hardness below 300mg/L is considered portable, but beyond this limit cause gastro-intestinal irritation (Patil P.N, 2012).

- **Chloride**

From the present study, it is observed that the Chloride content water samples ranged from a minimum value of 3.0mg/L to a maximum of 65.0mg/L with a median value of 18mg/L indicating large variation in the chloride levels. The BIS prescribed limit for chloride in drinking water is 250mg/L (BIS, 2012). All our water samples are having chloride concentration less than the prescribed limit. Fadaei and Sadeghi, 2014 in their evaluative and assessment study of Drinking water quality in Shahrekord, Iran, reported a chloride ranged from 31-110.9mg/L with an average value of 51.34±14.6mg/L (Abdolmajid, 2014).Their finding was similar to what is observed in our present study. Chloride is mainly obtained from the dissolution of salts of hydrochloride as table salt (NaCl) and also from anthropogenic sources through industrial wastes, sewage, sea water, etc. Low chloride concentration indicates low pollution influx.

- **Fluoride**

From the present study, it is observed that the Fluoride content in water samples ranged from a minimum value of 0.0019mg/L to a maximum of 0.082mg/L with a mean value of 0.015±0.02mg/L. The observed values are well below the recommended limit. The recommended limit for fluoride in drinking water as per BIS recommendations is 1.5mg/L. This low concentration of fluoride is also observed in other places. For example, Fadaei and Sadeghi, 2014 in their evaluative and assessment study of Drinking water quality in Shahrekord, Iran, reported a fluoride ranged from 0.19 to 0.28mg/L with an average value of

0.2±0.1mg/L (Abdolmajid, 2014). The optimal drinking water concentration of fluoride for dental health is generally between 0.5 and 1.5mg/L and depends on the volume of drinking water consumed as well as intake and exposure from other sources.

- **Nitrate**

From the present study, it is observed that the nitrate content in drinking water samples ranged from a minimum value of 0.796mg/L to a maximum of 28.716mg/L with a mean value of 8.77±7.67mg/L. The median of the nitrate concentrations in the different sampling locations was observed to be 6.476mg/L. From the median value we can understand that there is a wide variation of nitrate concentration in the different locations. All the sampled water reported nitrate concentration well below the BIS permissible limit of 45mg/L (BIS, 2012). The maximum contaminant level (MCL) for nitrate in public drinking water supplies in the United States (U.S.) (USEPA, 2023) is 10 mg/L as nitrate-nitrogen (NO_3-N). This concentration is approximately equivalent to the World Health Organization (WHO) guideline of 50 mg/L as NO_3 or 11.3 mg/L NO_3-N (multiply NO_3 mg/L by 0.2258) (WHO, 1998). The permissible limit for nitrate in water as per BIS is 45mg/L. High levels of nitrate in water can be a result of runoff or leakage from fertilized soil, wastewater, landfills, animal feedlots, septic systems, or urban drainage. It can be difficult to pinpoint where the nitrate in drinking water comes from because there are many possibilities (USEPA, 2023). The value of nitrate obtained in the present study may indicate the pollution of the drinking water sources.Adimasu, 2015 performed a physicochemical and biological water quality assessment of Lake in Hawassa for multiple designated water uses and reported the highest mean value of 8.87mg/L and 8.46mg/L nitrate for the lake with an average value of 5.27mg/L to the lake system. But in all the observed sites, the amounts of nitrate concentration were below the permissible limit of BIS for drinking uses which is 45mg/L (Adimasu, 2015).

- **Nitrite**

From the present study, it is observed that the nitrite contentin drinking water samples ranged from a minimum value of below detection limit (BDL) to a maximum of 0.134mg/L with a mean value of 0.04±0.05mg/L. The median of the nitrite concentrations in the different sampling locations was observed to be 0.007mg/L. The Maximum Contaminant

Level, or MCL, for nitrate is 10 milligrams per liter (mg/L) and nitrite is 1.0 milligrams per liter (mg/L) (USEPA, 2023). For nitrite, human data reviewed by JECFA support the current provisional guideline value of 3 mg/L (acute), and 0.2 mg/L (chronic) (as nitrite, WHO) based on induction of methemoglobinemia in infants (WHO, 1998). Thus, the World Health Organization (WHO) recommended the upper limit of concentration of daily nitrate and nitrite uptake to be 3.7 mg/kg and 0.06-0.07 mg/kg, respectively. It is seen that the nitrite concentration is lower than the WHO permissible in drinking water.

- **Sulphate**

Sulphate is a compound found in nature. It occurs naturally in water in various amounts. If a high level of sulphate is in water, the water may have a bitter taste. Sulphates are also found in minerals, soil, rocks, plants and food. The presence of high concentration of SO_4^{2-} in the drinking water may lead to dehydration, stomach complaints and possibly diarrhoea. From the present study, it is observed that the sulphate content in drinking water samples ranged from a minimum value of below detection limit (BDL) to a maximum of 0.08mg/L with a mean value of 0.03±0.027mg/L. The WHO and BIS prescribes limits for sulphate in drinking water is 500mg/L and 200mg/L respectively (BIS, 2012) (WHO, 1998).Sulphate concentration in natural water ranges from a few to a several hundred mg/L but no major negative impact of sulphate on human health is reported. Fadaei and Sadeghi, 2014 in their evaluative and assessment study of drinking water quality in Shahrekord, Iran, reported a sulphate ranged from 20-75mg/L with an average value of 25±11.7mg/L (Abdolmajid, 2014) which is lower than the prescribed limits but higher than what is observed in the present study.

- **Iron**

From the present study, it is observed that the iron content in drinking water samples ranged from a minimum value of 0.03mg/L to a maximum of 0.16mg/L with a mean value of 0.06±0.027mg/L. According to BIS, the acceptable limit for iron in drinking water is 0.3mg/L (BIS, 2012). All the samples in the present study show iron level well below the acceptable limit.

Iron is the second most abundant metal in the earth's crust. Dissolved iron in water, causes the water to taste metallic". The water may also be discoloured due to suspended

solids containing minerals of iron that appear brownish in colour. Iron will leave red or orange rust stains in the sink, toilet and bathtub. It can build up in your dishwasher and discolour ceramic dishes. It can also enter into the laundry equipment and cause stains on clothing. Even though the EPA says that the iron in the drinking water is safe to drink, the iron sediments, other trace impurities may support bacteria that are harmful, and these bacteria are mostly found in wells where the water has not been chlorinated. Elemental iron is rarely found in nature, as the iron ions Fe^{2+} and Fe^{3+} readily combine with oxygen and sulphur containing compounds to form oxides, hydroxides, carbonates, and sulphides, so, dissolved iron more commonly exists in the form of its oxides". To provide safe drinking water to the public, both government and private organizations measure iron content in drinking water and other tap waters in every sector including schools, hospitals, industries, etc. (USEPA, 2023). Manjesh and Ramesh, 2012 in their Assessment of Physico-chemical Properties of Ground Water in Granite Mining Areas in Jhansi, U.P reported the ranges of iron to be in between 0.11- 1.0 ppm in mining and residential area of Bijjoli (Manjesh, 2012). These observed values are higher than the present findings which can be attributed to many reasons geology being one of them.

- **Boron**

From the present study, it is observed that the boron content in drinking water samples ranged from a minimum value of 0.13mg/L to a maximum of 1.14mg/L with a mean value of 0.45±0.021mg/L. The median value is 0.43mg/L which indicates that this is variation in the concentration of boron in the different samples collected. According to BIS, the acceptable limit for boron in drinking water is 0.5mg/L. Seven samples in the present study show boron level higher than the acceptable limit (BIS, 2012). Boron enters the environment from both natural sources such as weathering of rocks and soils and seawater spray, as well as human activities such as fossil fuel combustion and municipal and industrial wastewater discharge. Boron is also found in pesticides, cosmetics, pharmaceuticals and natural health products and is found in many consumer products such as swimming pool and spa products and cleaning products. In water, boron exists primarily as boric acid and borate. Boron is not an essential element, but some studies indicate it may be beneficial to human health (Canada, 2020)

- **Conclusion**

From the present study, we can see that almost all the drinking water parameters under investigation in the water samples are within the prescribed or acceptable limit as per BIS or WHO recommendations, except for the boron, pH and nitrate level. From this study, we can recommend that the water samples be treated with lime for neutralising the low pH followed by precipitation or filtration process for removal of boron and nitrate. Due to the high consumption rate of water (say a minimum of ~2L per day), some parameters may still offer a risk to the consumer. Therefore, a for a health risk assessment study should be taken up. Even though, in many cases, the water sample is consumed after boiling, a bacteriological study is also important to understand the risk involved in consuming untreated drinking water.

- **Acknowledgement**

On behalf of the project team, I would like to express my sincerest thanks and gratitude to the Principal of the College for giving the necessary permission and support to carry out the work, the staffs of the department for extending their help in various ways during the course of the project and to the Student Trainees for their hard work and proactive contribution to the successful completion of the project.

- **References**

Abdolmajid, F. a. (2014). Evaluation and Assesment of Drinking Water Quality in Shahrekord, Iran. *Resources and Environment* , 168-172.

Adimasu, W. (2015). Physicochemical and biological water quality assessment of Lake Hawassa for multiple designated water uses. *Journal of Urban and Environmental Engineering* , 146-157.

Awokunmi, S. O. (2010). Determination of physico-chemical parameters and heavy metals in water samples from Itaogbolu area of Ondo-State, Nigeria. *African Journal of Environmental Science and Technology* , 145-148.

BIS, I. 1. (2012). *Indian Standard Drinking Water Specitication.* New Delhi: Publication Unit, BIS New Delhi India.

Canada, H. (2020). *Canada.ca.* Retrieved from https://www.canada.ca/content/dam/hc-sc/documents/programs/consultation-boron-drinking-water/document/boron-gtd-consultation-09-12-2019-eng.pdf

Christiansen, J. E. (1942). Irrigation by Sprinkling,. *California Agricultural Experiment Station Bulletin 670, University of California, Berkeley,* .

Gupta, G. B. (2017). Analysis of total alkalinity in drinking water in Kotputli Town, Rajasthan. *Indian Streams Research Journal* , 1-3.

Kerketta P, S. l. (2013). Analysis of Physico-chemical properties and heavy metals in drinking water from different sources in and around Ranchi, Jharkhand, India. *Veterinary World* , 370-373.

Manjesh, K. a. (2012). Assessment of Physico-chemical Properties of Ground Water in Granite Mining Areas in Jhansi, U.P. *International Journal of Engineering Research & Technology* .

Patil P.N, S. D. (2012). Physico-chemical parameters for testing of water - A Review. *International Journal of Environmental Sciences* , 1194-1205.

Police, S. (2023, August 1). *https://meghalaya.nic.in*. Retrieved from https://shillongpolice.gov.in: https://shillongpolice.gov.in/map_shg.html

USEPA. (2023, MARCH 15). *epa.gov*. Retrieved from www.epa.gov: https://www.epa.gov/region8-waterops/nitrate-rule-maximum-contaminant-level-mcl-public-notification-template

WHO. (1998). *Health criteria and other supporting information - Guidelines for drinking-water quality, 2nd ed.* . Geneva: WHO.