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Insights into a comparative analysis of groundwater samples collected from two locations of Madalvarigudem, Krishna District, and Andhra Pradesh, India

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ABSTRACT: Among all the water sources, the ground water is a key and most consistent source of water supply throughout the world. The current generation is witnessing a tremendous increase in the demand for fresh water owing to the exponential growth in the population. Monitoring and assessment of water quality parameters provides the basis for judging the suitability of water quality for its selected uses, necessary for water quality management and improving existing conditions. The present study was aimed at monitoring and evaluating the groundwater samples collected from two locations that include, Lingayas Institute of Management and Technology (LIMAT), Vijayawada campus, Andhra Pradesh, India, Madalvarigudem, Krishna district, Andhra Pradesh, India. The collected samples were analyzed for pH, total dissolved solids (TDS), total hardness (TH), alkalinity and acidity according to standard methods. As apparent from the groundwater quality parameter analysis, groundwater of LIMAT campus showed higher values of pH, TDS and TH, whereas groundwater of Madalavarigudem showed higher values of alkalinity and acidity. The water quality index (WQI) values further affirmed that groundwater samples collected from Madalavarigudem is of poor quality for drinking purpose. It is further suggested that relevant treatment techniques can be employed to make the groundwater safe for drinking purpose. Furthermore, this study also suggests adopting simple rainwater harvesting systems to improve groundwater recharge to make it a sustainable source of life.

KEYWORDS: Groundwater, total dissolved solids, hardness, analysis, water supply

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I. INTRODUCTION

The 21st century is witnessing water resources crisis, wherein many countries are facing issues in ensuring their mounting population get adequate and clean water. Among all the water sources available on the face of the earth, ground water is a key and most consistent source of water supply throughout the world. Some areas of the world are facing serious water shortage because to the utilization of groundwater at faster rate than it is naturally recharged (Prajapati and Bilas, 2018). The present-day cohort is witnessing groundwater as an imperative source of water supply since there has been a remarkable increase in the demand for fresh water owing to the exponential growth in the population. Groundwater entails a constraint with high values of salinity for its utility for irrigation and water supply. Hence, it is undeniably necessary to maintain the potability of water prior to human consumption (Uddin et al., 2017, 2018; Li et al., 2021).

The groundwater is imaginably thought as clean and free from pollution compared with the surface water. Groundwater serves as a source of potable water for nearly two billion people and nearly 40% of it is used for irrigation needs (Gleeson et al., 2020). Nevertheless, groundwater quality in the this generation is encountered with pollution due to the discharge of sewage and industrial wastewater, dumping of solid waste, negligent extraction of groundwater, population growth, developmental activities, rapid land use changes, climate change, etc (Uddin et al., 2016; Akhtar et al., 2021; Che Nordin et al., 2021; Sajib and Moniruzzaman, 2021; Diganta et al., 2021, 2023; Han and Currell, 2022; Shaibur et al., 2023; Uddin et al., 2023a; Uddin et al., 2024). The present-day generation is seeing raising groundwater depletion because of mounting population, industrialization, agricultural sources and the technologies involving waste disposals (Prajapati and Bilas, 2018; Ibrahim et al., 2023).

According to the United Nations sustainable development goals (SDGs), SDG 6 is treated as a significant pillar to ensure the availability and sustainable water management and sanitation for all by 2030. Therefore, it is crucial to treat all the water resources as responsible resources both in quality and quantity (Uddin et al., 2017; Uddin et al., 2018; Asha et al., 2020; Kodam et al., 2021; Osta et al., 2022). A recent study has described that the developing countries are facing groundwater quality limitations because of exaggerated use of agrochemicals, rapid urbanization, informal disposal of industrial waste; uncontrolled leaching of leachate from landfill sites and saltwater intrusion because of climate change (UN World Water Development Report, 2022). Henceforth, groundwater resources entail periodic monitoring to keep a check on the quality of water and guarantee the safe and viable utilization for human consumption.

The Water Quality Index (WQI), which was developed in the early 1970s, gives an indication of the health of the water quality at various points and can be used to keep track of and analyze changes over time (Brown et al., 1972). The WQI is feasibly considered as one of the most applicable method, which converts huge data into a numeric score and reveals the water quality for its suitability for both various purposes (Eid et al., 2023; Uddin et al., 2023c; Uddin et al., 2023d; Uddin et al., 2022a; Uddin et al., 2022b; Uddin et al., 2022c).

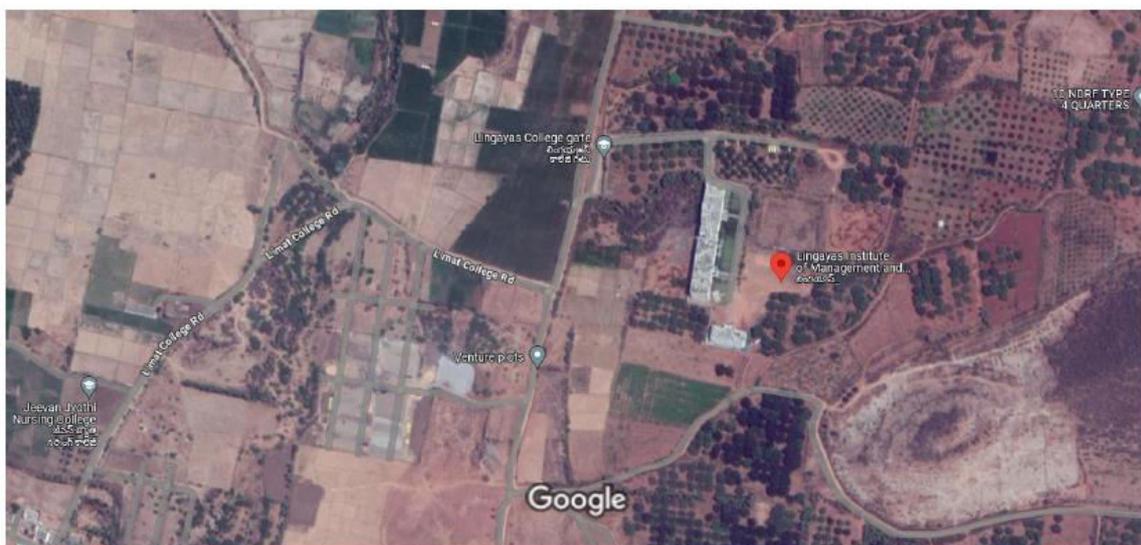
Therefore, as a matter of fact of the significance of groundwater and its analysis, the present study was aimed at monitoring and evaluating the variation in the physicochemical parameters of groundwater quality from two different sources that include, Lingayas Institute of Management and Technology (LIMAT), Vijayawada campus, Andhra Pradesh, India and Madalvarigudem, Krishna district, Andhra Pradesh, India, as there is a remarkable data gap for the selected region. The collected samples were analyzed for pH, total dissolved solids (TDS), total hardness (TH), alkalinity and acidity according to standard methods as these are few common parameters for water analysis. This study supported in generating basic information on the quality of groundwater and its present status.

II. MATERIALS AND METHODOLOGY

Study area

Groundwater samples were collected from two locations that include Lingayas Institute of Management and Technology (LIMAT), Vijayawada campus, and Madalvarigudem, Krishna district, Andhra Pradesh, India. Lingayas Institute of Management and Technology, Madalvarigudem is located at Madalvarigudem, which is a Village in Gannavaram Mandal in Krishna District of Andhra Pradesh State, India. It is located 65 Km towards North from District headquarters Machilipatnam, 305 Km from State capital Hyderabad. Maadalvarigudem is surrounded by Unguturu Mandal towards East, Penamaluru Mandal towards South, Kankipadu Mandal towards South, Agiripalli Mandal towards North. Figure 1 shows the satellite images of the study area.

Google Maps Lingayas Institute of Management and Technology



Imagery ©2024 CNES / Airbus, Maxar Technologies, Map data ©2024 100 m

(a)

Google Maps Madalavarigudem



(b)

Figure 1. Satellite images of the study area, a.) Lingayas Institute of Management and Technology (LIMAT), Vijayawada campus and b.) Madalavarigudem, Krishna district.

Methodology

Based on the time frame and limited resources available, groundwater monitoring was carried out by collecting the samples for a period of 35 days (March to April, 2024) from the study area and the collected samples were analyzed for pH, TDS, TH, alkalinity and acidity using standard methods described in American Public Health Association (APHA) (APHA, 2005) as these are common for water analysis. The pH in the samples was verified with pH paper (S. D. Fine-chem Ltd, Mumbai, India). The TDS in the samples was quantified using a Generic Digital LCD TDS Meter (Generic, TDS-3, India). Alkalinity, total hardness and acidity in the samples were determined by titration method as per the methods available in APHA standards. Water quality was evaluated based on the water quality standards recommended by Bureau of Indian Standards (BIS) (BIS, 2012) and World health organization (WHO). Water quality index (WQI) of the selected samples is calculated based on Brown et al. (1972) to test the suitability of the groundwater quality for drinking purpose.

III. RESULTS AND DISCUSSION

Groundwater is supposed as a very vital resource in India for urban water use; however, it is not properly explored owing to the inadequate monitoring and evaluation. To address this issue, it is necessary to obtain accurate information via monitoring and to understand what is the problem and its origin, its seriousness, and causes for it. Such type of information would lead the determination of economical and durable solutions to the problems associated with water. Figure 2 shows the trend of pH of the samples collected from two different locations of the selected study area. The pH of any aquatic body influences the chemical reaction, hence considered as a key factor in aquatic ecosystems (Wang et al., 2002; Fakayode, 2005).

During the period of investigation for 35 days, for the Madalavarigudem samples, the pH value was in the range of 6.5-9.0, whereas for the LIMAT campus samples, the pH value was in the range of 6.5-8.0, which is within the permissible limit as per the BIS standards. The results infer that the pH value in the two locations indicate the alkaline nature of the groundwater, which can be attributed to the different types of buffers generally present in the groundwater (Weber and Stun, 1963).

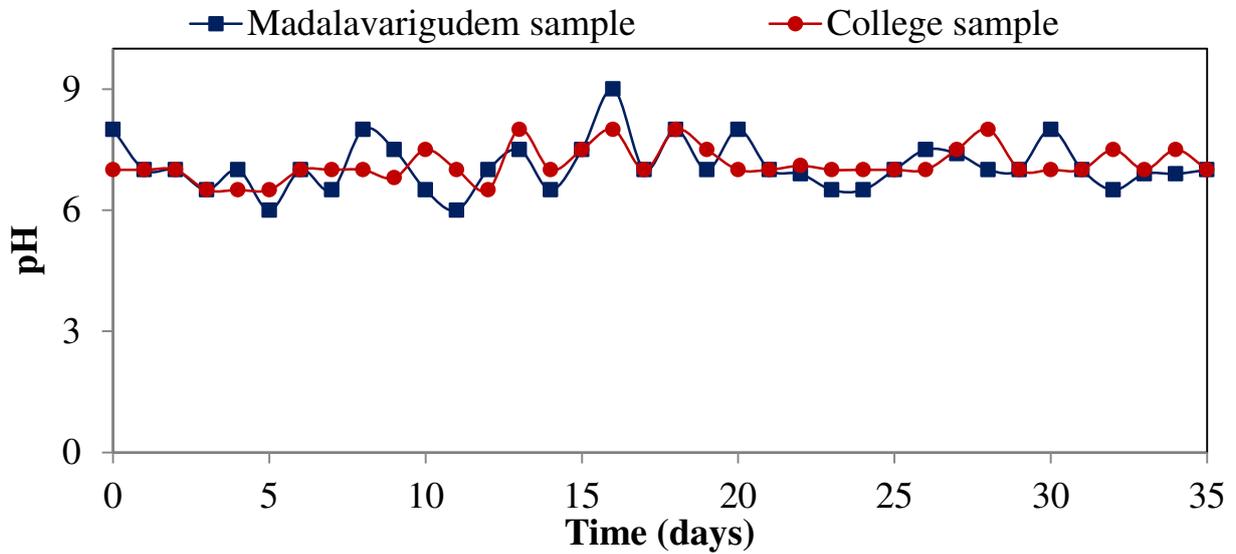


Figure 2. Trend of pH values of the samples collected from three different locations.

The groundwater quality in any area varies with its physical and chemical parameters, which consequently is highly influenced by geological formations, anthropogenic activities and climatic conditions (Matthess, 1982; Subramani et al., 2005). Moreover, groundwater chemistry varies with respect to the duration of contact of groundwater with a particular rock. The longer is the duration of contact, the greater is the vulnerability for the effect of rock chemistry on the formulation and pH of the groundwater. The groundwater pH varies depending on the composition of the rocks and sediments that surround the travel pathway of the recharge water infiltrating to the groundwater (American Ground Water Trust 2003).

Total dissolved solids

The TDS refers to the amount of dissolved material present in the water body and serves as a parameter for pollution indicator. The range of TDS of the samples collected from two locations is shown in Figure 3. A range of 117-280 mg/L TDS was obtained in the Madalavarigudem samples, whereas in the LIMAT campus samples, it was in the range of 199-273 mg/L (Fig. 3). High concentration of TDS in the groundwater sample can be attributed to the leaching of salts from soil and, also domestic sewage may percolate into the groundwater, which may lead to increase in TDS values (Prasanth et al., 2012). Slightly high TDS values in the samples could be attributed to the presence of elevated solid materials (both dissolved and suspended) contributed by various anthropogenic activities taking place in the study area in line with the study reported by Lamare and Singh (2016). The TDS values in two locations are slightly above the permissible limits as per the BIS standards, which need to be treated if it is meant for drinking purpose. However, it could be directly used for domestic purpose. Excess TDS in water can be removed using reverse osmosis (RO) or deionization (DI), and distillation.

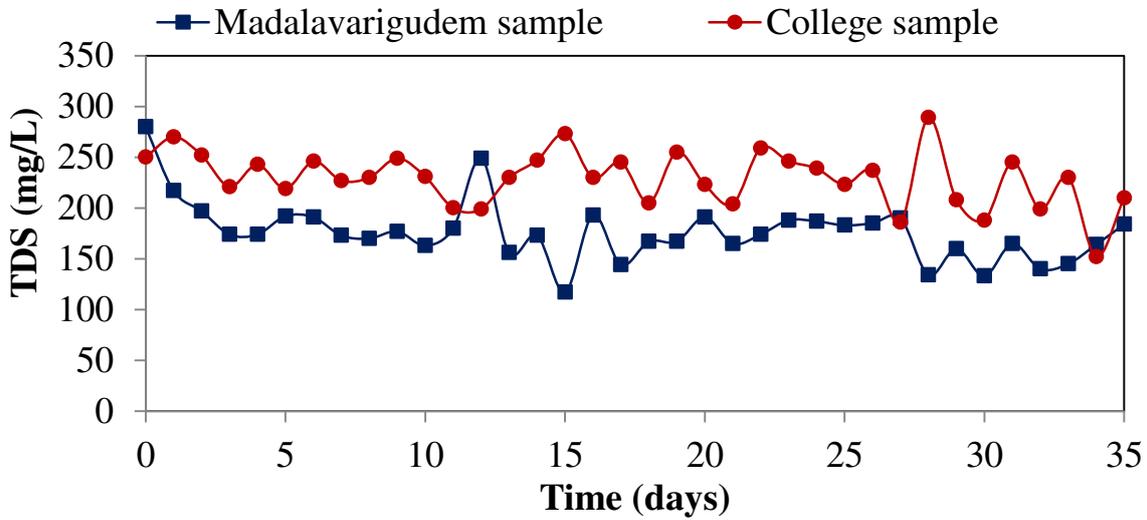


Figure 3. Trend of TDS values of the samples collected from three different locations.

Total hardness

Total hardness is used to describe the effects of dissolved minerals (mostly calcium and magnesium) determining suitability of water for various purposes due to the presence of several metallic salts (Deepa et al., 2016). The variation of TH in the samples collected from two different locations is shown in Figure 4. The TH was in the range of 0-210 mg/L in the Madalavarigudem samples, whereas for the LIMAT campus samples, the TH was in the range of 0-230 mg/L. Sawyer and McCarty (1967) classified groundwater, based on TH, with TH <75 designated as soft, with TH 75–150 as moderately hard, with TH 150–300 as hard and TH >300 as very hard.

The results obtained in this study indicate that the water in the study area is hard to very hard. The hardness of the water is due to the presence of alkaline earths such as calcium and magnesium. Also, the increase in the maximum level of total hardness is due to presence of carbonate and non-carbonate compounds (Ramesh et al., 2013). Total hardness values in the two locations are slightly beyond the permissible limit as per the BIS standards, deducing that the groundwater is hard water which is to be treated if it is meant for drinking purpose. However, it could be directly used for domestic purpose. Softening process could be employed to remove excess total hardness in water.

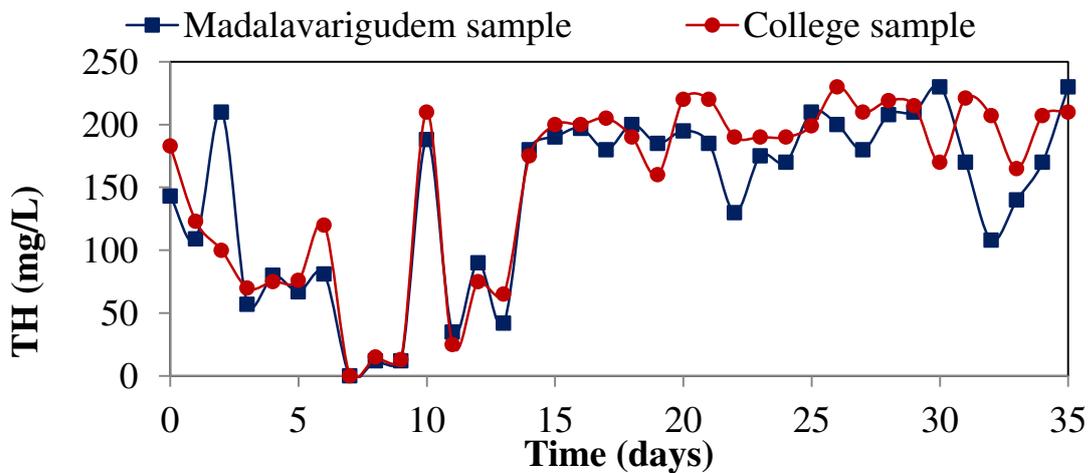


Figure 4. Total hardness values in the samples from three different sites.

Alkalinity

The acid neutralizing capacity of water is determined by the alkalinity of any aquatic system (Murangan and Prabakaran, 2012). The variation of alkalinity in the samples collected from two locations is shown in Figure 5. Alkalinity was in the range of 525-910 mg/L in the Madalavarigudem samples, whereas for the LIMAT campus samples, the alkalinity was in the range of 550-750 mg/L. It is well reported in the literature that generally, natural water is represented as a solution comprising of Ca^{2+} , Mg^{2+} , alkaline metals and SO_4^{2-} , Cl^- and, those contributing to alkalinity, i.e., CO_3^{2-} and HCO_3^- (Prasanth et al., 2012). The alkalinity values in the selected locations are beyond the permissible limit as per the BIS standards, which need to be treated if it is meant for drinking purpose. Excess alkalinity in water can be removed using water softening process.

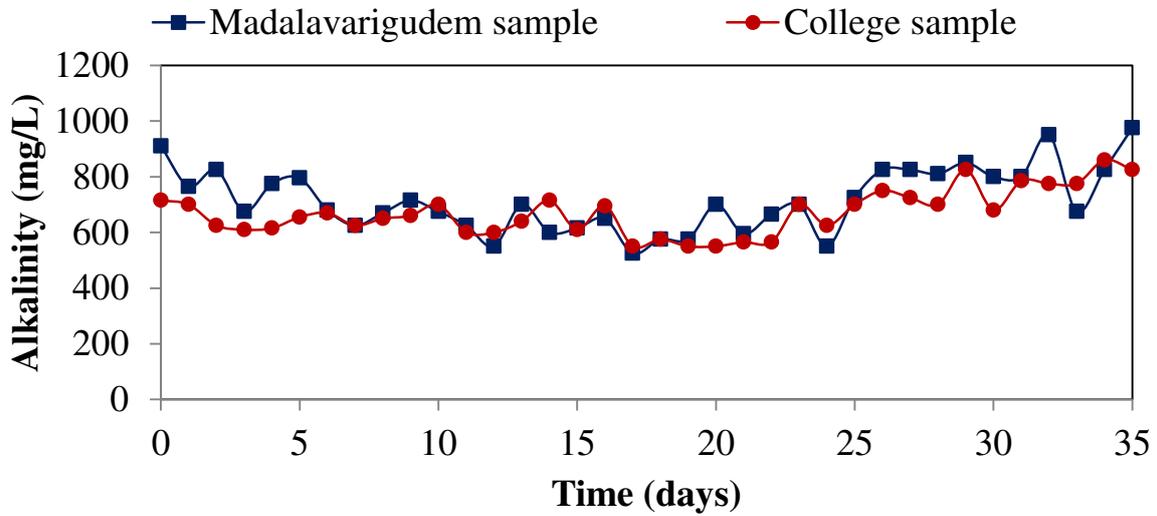


Figure 5. Alkalinity values of the groundwater samples from three different locations.

Acidity

Acidity in the samples collected from two locations is shown in Figure 6. The acidity was in the range of 105-460 mg/L in the Madalavarigudem samples, whereas for the LIMAT campus samples, the alkalinity was in the range of 45-525 mg/L. If the geology of the aquifer containing the groundwater has few carbonate rocks, the groundwater will tend to remain acidic. Acidity in water is not in itself harmful to health. Many popular beverages have considerable acidity or alkalinity.

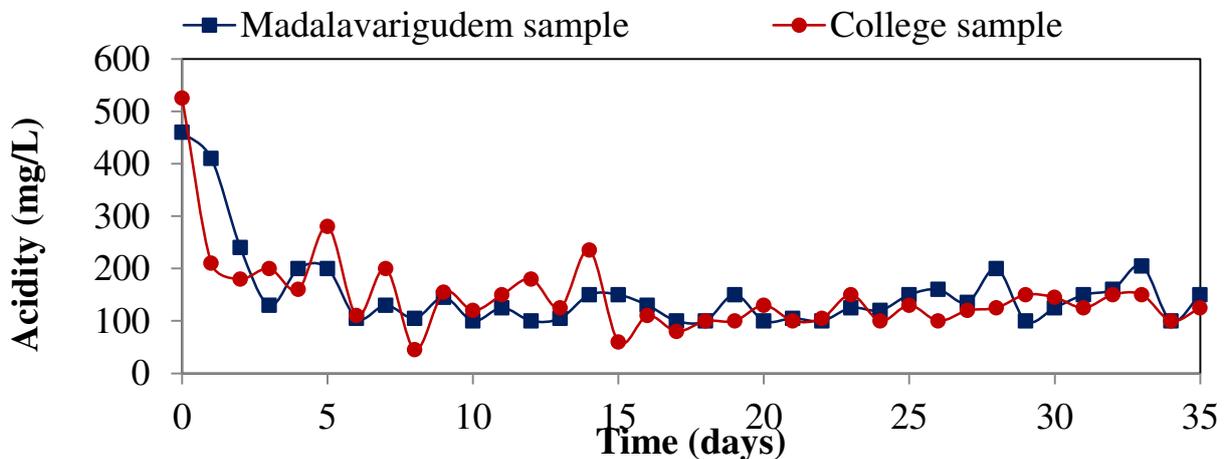


Figure 6. Acidity values in the samples from three different sites.



The concern for acidity in drinking water is that even mildly acid water can dissolve lead or copper that may be present in plumbing pipes and fixtures. Because of this fact, almost all the standards formulated to regulate the quality of water has determined that drinking water should have a pH between 6.5 and 8.5 in order to limit the concentration of dissolved contaminants from acidic waters or the buildup of scale deposits from alkaline water. Water quality index (WQI) is considered as one of the most effective method of measuring water quality. According to Brown et al. (1972), the WQI can be used to monitor water quality changes in a particular water supply overtime, or it can be used to compare any water supply quality with other water supplies in a selected region or from around the world. The WQI helps in reducing the huge water quality data to a simple value that expresses the overall water quality at a certain location and time centered on several water quality parameters. Table 1 presents the water quality status based on WQI.

Table 1. Water quality status based on WQI (WHO, 2004)

S. No.	Water Quality Index	Status of Water Quality
1	0 – 25	Excellent Water Quality
2	26 – 50	Good Water Quality
3	51 – 75	Poor Water Quality
4	76 – 100	Very Poor Water Quality
5	> 100	Unfit for Drinking

The WQI values of Madalavarigudem and LIMAT campus samples obtained in this study are 59.29 and 20.32. The results indicate that groundwater collected from Madalavarigudem is of poor quality as per the information presented in the Table 1 (WHO, 2004). Similar results were reported by Prajapati and Bilas (2018), wherein WQI values ranged from 28 to 65, whereas in few samples, the WQI values were reported as 182.48 and 535.32, indicating that the water samples are unfit for drinking. The groundwater collected from Madalavarigudem falls under poor water quality in line with the Table 1. Whereas, the groundwater collected from LIMAT campus falls under fairly good water quality in line with Table 1, indicating that this water can be used for drinking purpose, provided after treatment.

In this study, as apparent from the groundwater quality parameter analysis, groundwater of LIMAT campus showed higher values of pH, TDS and TH, whereas groundwater of Madalavarigudem showed higher values of alkalinity and acidity. Calcium and Magnesium ions often lead to leach in the groundwater from the minerals surrounding groundwater and thus, contribute to the increased hardness and alkalinity values. This is in line with the results obtained in the present study. As per the literature, bedrock geology and climate plays a vital role in groundwater quality of southern India, but may also be affected in some parts by pollution, particularly from agricultural and industrial sources (Ramakrishna et al., 2009). It is further suggested that relevant water treatment techniques can be employed to make the groundwater safe for drinking purpose. As per the scarcity of water in the future, rainwater harvesting technologies, which are locale specific, can be explored and implemented for its practicality and employment in various communities and institutes, which could lead to groundwater recharge.

IV. CONCLUSION

The present study was aimed at monitoring and evaluating the variation in the water quality parameters, such as pH, total dissolved solids (TDS), alkalinity, total hardness and acidity of groundwater samples collected from two locations that include Lingayas Institute of Management and Technology (LIMAT), Vijayawada campus, Andhra Pradesh, India, and Madalvarigudem, Krishna district, Andhra Pradesh, India. This study was considered for a period of 35 days and the results indicate that the groundwater of LIMAT campus showed higher values of pH, TDS and TH, whereas groundwater of Madalavarigudem showed higher values of alkalinity and acidity. The WQI values of Madalavarigudem and LIMAT campus samples obtained in this study are 59.29 and 20.32 indicating that the groundwater collected from Madalavarigudem is of poor quality and unfit for drinking as per world health organization (WHO). Additionally, this study also recommends implementing simple rainwater harvesting systems to improve groundwater recharge and make it a sustainable source of life.

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