Investigating pH ,Conductivity Variations and Unknown Compounds in Water Samples across Tamil Nadu and Andhra Pradesh

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***Abstract*—This study assesses water quality across eight locations by analyzing 17 water samples from Tamil Nadu(TN) and Andhra Pradesh(AP) region for pH levels, conductivity, and the presence of unknown compounds using UV-visible spectroscopy. pH measurements and conductivity were recorded with standard instruments, while UV-visible spectroscopy was employed to determine the chemical composition of the water samples. By integrating these methods, this research explores spatial differences in key water quality parameters, particularly focusing on how pH and conductivity influence the presence and behavior of unidentified compounds. The results are valuable for water resource management, environmental monitoring, and agricultural applications. Additionally, the paper highlights the importance of pH, conductivity, Total Dissolved Solids (TDS), and UV-visible spectroscopy in water quality assessment and discusses potential factors affecting variations across sampling sites, with an emphasis on the impact of pH and conductivity on the detection and properties of unknown compounds.It is found that the correlation coefficient between Conductivity and TDS is approximately 0.986, indicating a very strong positive linear relationship and the TDS increases as the conductivity increases.**

I. INTRODUCTION

Water quality plays a vital role across environmental, industrial, and agricultural applications. A key measure of this quality is pH and electrical conductivity (EC), which indicates the concentration of hydrogen ions (H+) and the water's capacity to conduct electricity and thus reveals the water quality. On the pH scale, which ranges from 0 to 14, a low pH signifies acidity, while a high pH indicates alkalinity. Measured in micro-Siemens per centimeter (µS/cm), EC reveals the concentration of dissolved mineral content indicates the total amount of dissolved ions present in the water. Distilled water typically has a conductivity range of 0.5 to 3 µmhos/cm. Research on inland freshwater sources shows that streams supporting healthy, diverse fisheries generally have conductivity levels between 150 and 500 µmhos/cm. Conductivity levels outside this range may suggest that the water could be unsuitable for certain fish species or macro invertebrates. In industrial settings, water conductivity can reach as high as 10,000 µmhos/cm [1, 2]. Total dissolved solids (TDS) is the total amount of salts or mobile charged ions dissolved in the water [3].

pH is a fundamental parameter across numerous scientific fields, significantly impacting chemical reactions, biological processes, and the behavior of substances in aqueous environments [4-20]. Accurate pH measurement is essential in disciplines such as environmental science, chemistry, and biology, where it supports understanding and control of processes, from water quality assessment to industrial production [7, 9, 10, 20].In industrial environments, keeping pH levels within optimal ranges is essential for managing chemical reactions, ensuring product quality, and complying with regulatory standards [10, 20]. For example, in pharmaceutical production, accurate pH control is crucial to maintain the stability and efficacy of medications [10]. Ongoing technological advancements have resulted in highly accurate pH meters, electrodes, and sensors, significantly improving pH monitoring precision across a wide range of applications [10, 20]. Conductivity in an aqueous solution serves as a key indicator of water quality and can also reflect the concentration of ionizable substances present in the water [21].Measuring conductivity is crucial for monitoring and controlling various processes, especially in sectors like water treatment, chemical manufacturing, food and beverage production, and pharmaceuticals. Conductivity measurement helps determine the ionic content in a solution, which is important for assessing water purity, controlling chemical concentrations, and ensuring product quality and safety.TDS majorly includes species such as sodium, potassium, magnesium, calcium, strontium, barium, iron, aluminum, bicarbonate, chloride and sulfates [1,22,23, and 24] .Trace elements can also be present such as dissolved metals, metalloids and boron [25, 26]. UV-visible spectroscopy is a highly effective method for examining the chemical composition of water, using the interaction of ultraviolet and visible light with the sample to detect organic compounds or specific contaminants. When paired with pH and conductivity analysis, it provides detailed insights into the composition of solutions through their light absorption properties. By assessing samples at varying pH and conductivity levels with both techniques, researchers can gather valuable data on the presence, concentration, and behavior of various compounds [27-29].

For example, combining UV-visible spectroscopy with multivariate calibration allows for the detection of aromatic hydrocarbons in water samples [27]. Additionally, solid-phase extraction with UV-visible spectroscopy aids in identifying trace metals in seawater [28], while pre concentration methods paired with UV-visible spectroscopy enable accurate nitrate level measurement in water samples [29-31]. It detects how ultraviolet and visible light interact with the water sample, which can reveal the presence of organic compounds or specific contaminants. This research aims to evaluate pH and conductivity levels and identify unknown compounds through UV-visible spectroscopy in water samples gathered from eight different regions. In total, 17samples were collected to capture possible variations in these essential water quality parameters.The figure 1 shows the schematic diagram of our research used in this study.

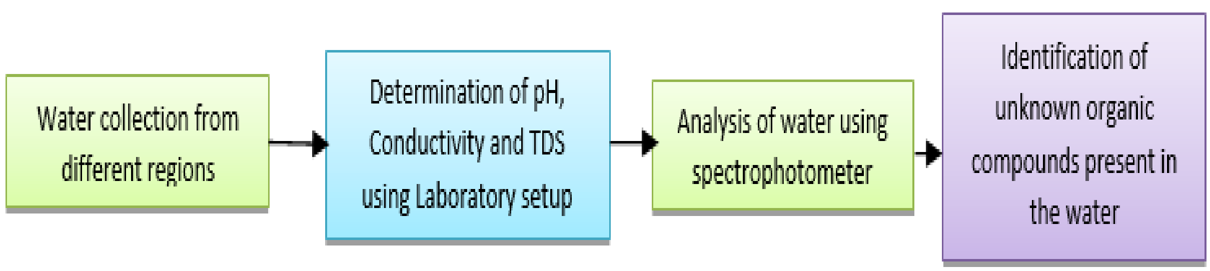


Figure 1. Taxonomy diagram of water quality monitoring system

This section will delineate the methodology used for sample collection, pH, conductivity and TDS measurements, and UV-visible spectroscopy analysis. The spatial distribution of all the three parameters and unidentified compounds across sampling locations is examined and analyzed for how these parameters may affect the detection of compounds by UV-visible spectroscopy. These findings will be useful for researchers and professionals in water resource management, environmental monitoring, and other fields where water quality is essential.

II. METHODOLOGY

Data Collection

Water samples were gathered from eight geographically diverse locations, encompassing a range of potential water sources, including tap water, bottled drinking water, RO water, and groundwater wells. Samples were taken at each location, resulting in a total of 17 collected samples. Figure 2 displays the water samples collected from these different locations.

Figure 1: Samples Collected from various regions

B. Methodology

The water samples were stored in pre-cleaned high-density polyethylene (HDPE) bottles, each rinsed three times with the sample water prior to filling to ensure purity. A standard volume of 500 mL was collected from each location. To prevent biological activity and maintain the chemical integrity of the samples, they were promptly transported to a laboratory for analysis within a specified timeframe. The the pH meter, conductivity meter and UV-visible spectrometer used in the laboratory were calibrated with standard solutions (distilled water) of known pH and conductivity values prior to starting measurements. Figure 2 shows the calibrated laboratory pH and conductivity meter used to record each sample's pH and conductivity after stabilization, with the probe fully immersed in the sample. All measurements were taken at a controlled temperature of 30°C.

The specifications of the pH meter: pH Range: 0 to 14 pH, mV Range: 0 to ±1999 mV, Resolution: 0.01, ±1 Digit, Repeatability: ±0.01pH, ±1 Digit, Accuracy: ±1mV, ±1 Digit and Input Impedance: > 10 Ohms. The specifications of the conductivity meter: 0-200µMhos/cm in 5 ranges, Accuracy: ±0.3% F.S in 200µMhos/cm to 200µMhos/cm, ±1% F.S in last range 1000mMhos/cm, Resolution: 0.1µMhos/cm, cell constant: 0.4 to 1.5 adjustable.

Figure 2: pH Meter and Conductivity meter Laboratory set up

(a) UV Visible spectroscopy

(b) Experimental setup

Figure 3: UV Visible spectroscopy

Figure 3 illustrates the experimental setup for UV-visible spectroscopy, including the following specifications: Serial No: A11665202165, P/N: 206-27600-45, Model: UV-2600 230V. To ensure accurate analysis, it is crucial to adhere to the manufacturer's instructions when setting up the UV-visible spectrometer. This process typically involves selecting the appropriate wavelength range and preparing blank samples. The water sample is placed in a cuvette and analyzed using the UV-visible spectrometer. The specific procedure may vary based on the instrument, but it generally involves measuring the absorbance or transmittance of light across the selected wavelength range. After analyzing the sample, the resulting spectrum is examined to identify any peaks or features that suggest the presence of unknown organic compounds. The collected data on pH, UV-visible spectroscopy, and sampling locations are compiled and analyzed.

III. RESULTS AND DISCUSSIONS

The study on measuring the pH of water samples from various locations in the metropolitan city of Chennai, Vaniyambadi, and Andhra revealed notable variations among the sites. The pH and conductivity of the collected water samples was tested and is summarized in Table 1. The pH levels ranged from acidic to slightly alkaline, with values between 4.5 and 7.7.and the conductivity levels varied from 0.067 to 2.09.

Table 1: Water samples from various locations and its measured pH, conductivity

AREA	TYPE OF WATER	pH	Conductivity mʊ	TDS mg/L
Andhra Pradesh	Sump water	7.52	0.890	817
	Bore water	7.46	1.764	2564
	RO water	6.53	0.092	50
Urapakkam	Drinking water(RO)	6.67	0.067	50
	Bore water	6.72	1.440	1694
Madipakkam	Sump water	7.11	1.543	1830
	Drinking Water(RO)	4.46	0.157	76
Pudupet	Sump water	6.61	0.457	490
	Drinking water(RO)	6.12	0.138	84
Royapuram	Bore water	6.48	0.467	459
	Sump water	5.78	0.480	520
Madhavaram	Bore water	6.48	1.31	1757
	Drinking water(RO)	6.37	0.12	45
Vandalur	Tap water	7.03	2.09	3000
	RO water	6.56	0.41	305
VANITEC (Vaniyambadi)	Tap water	7.66	1.83	2106
	Waste water	5.63	1.67	2470

The water sample was then analyzed using the UV-visible spectrometer. The specific procedure depends on the instrument but typically involves placing the sample in a cuvette and measuring the light absorbance across the desired wavelength range. Analyzing the resulting spectrum identify potential peaks or features that might indicate the presence of unknown organic compounds, indicating the differences in the mineral content and dissolved solids in the water samples.

Figure 4 shows the spectrum of the waste water and tap water obtained from the final process from VANITEC, Vaniyambadi. In these certain organic acids, like acetic acid or formic acid, have weak absorptions around this wavelength range. Their presence could be more likely considering the slightly acidic pH (5.63) and conductivity (1.67mʊ) of the wastewater, it's plausible that certain organic acids, such as acetic acid or formic acid, may exhibit weak absorptions within this wavelength range. With a pH of 7.66 and conductivity of 1.83 mʊ, the tap water is more likely to contain nitrate ions (NO3-), a prevalent inorganic constituent known to absorb light around 210-220 nm.

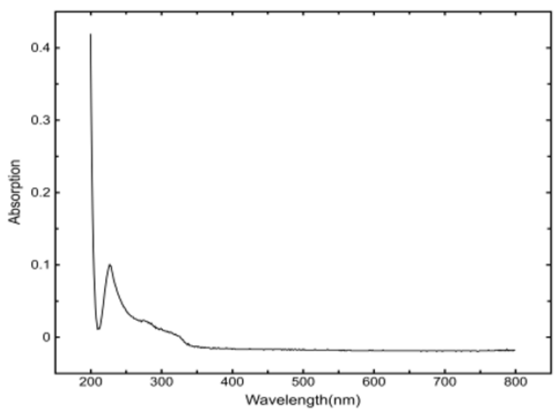


Figure 4 (a)Wastewater final process from Vanitec

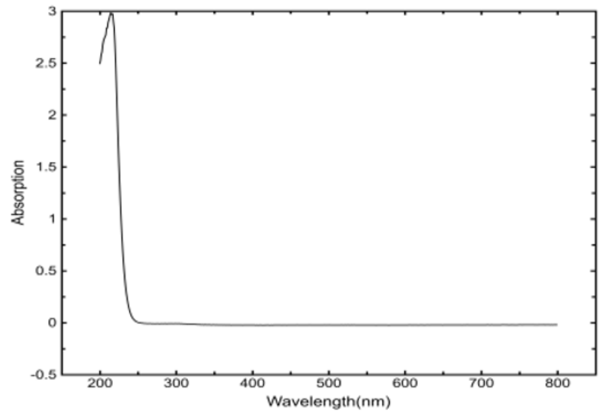


Figure 4 (b) Tap water from Vanitec

It is observed from the absorbance spectrum of figure 5, that the pH of 6.56 and conductivity reading of 0.41mʊ suggests slightly acidic RO water, which can sometimes occur after RO treatment due to the presence of carbon dioxide (CO2) in the water. A pH of 7.03 and conductivity of 2.09mʊ suggests the presence of high concentrations of chloride ions (Cl-) in the water source.This abundance of chloride ions could potentially contribute to an absorption peak around 200 nm.

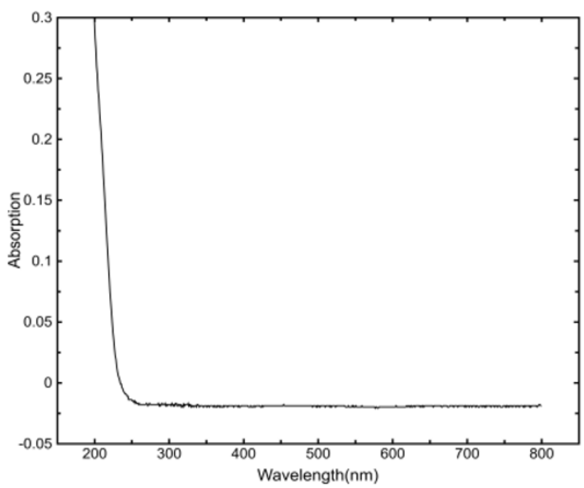


Figure 5(a) RO Water in Vandalur region

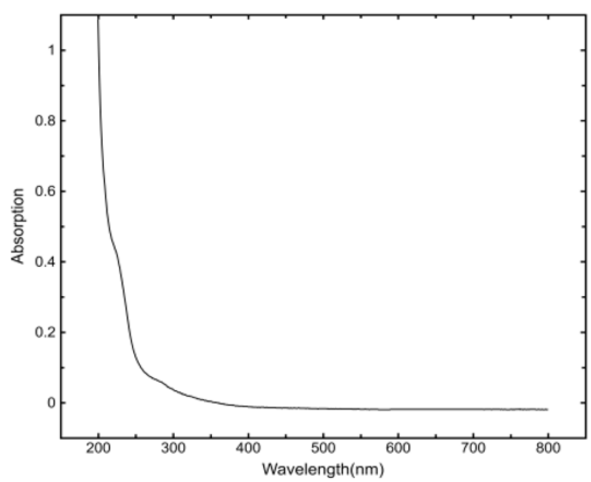


Figure 5 (b) Tap water in Vandalur region

From the spectrum shown in Figure 6, the absorbance value seems unreliable, and we can't interpret the UV-visible spectrum (300-800 nm) for the drinking water sample (pH 4.46)with a conductivity of 0.157 mʊ. However, the low pH (4.46) is a cause for concern in drinking water. This acidic water could be due to natural geological formations or contamination. Long-term consumption of highly acidic water can be corrosive to pipes and potentially leach metals into the water. It's important to ensure that drinking water meets safety standards for pH. Certain organic pollutants like pesticides or disinfection byproducts might also be absorbed in the madipakkam region tap water as shown in figure 6.The presence of an organic compound with an absorbance of 1.1 at 245 nm could suggest the incomplete removal of certain organic compounds during treatment. Potential contribution from natural organic matter present in the water source before treatment as it has a pH of 7.11 and the conductivity of 1.543 mʊ.

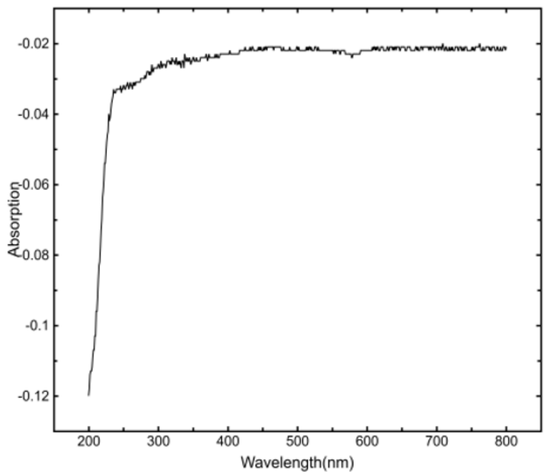
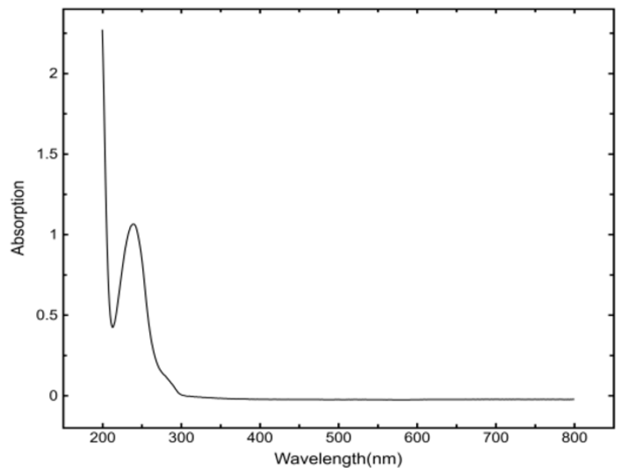


Figure 6(a) : Drinking water (RO



(b) Tap water in Madipakkam region

It is found that the sump water obtained from Royapuram region, the decomposing organic matter (leaves, fish waste) could contribute to aromatic compounds or proteins. Disinfection byproducts like chlorinationmight lead to trace amounts of nitrates or chlorinated organic compounds which has a pH of 5.78 conductivity of 0.480 ʊ and is shown in figure 7.

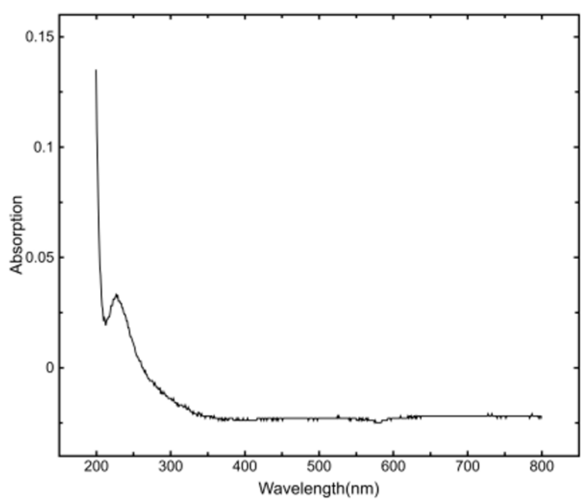
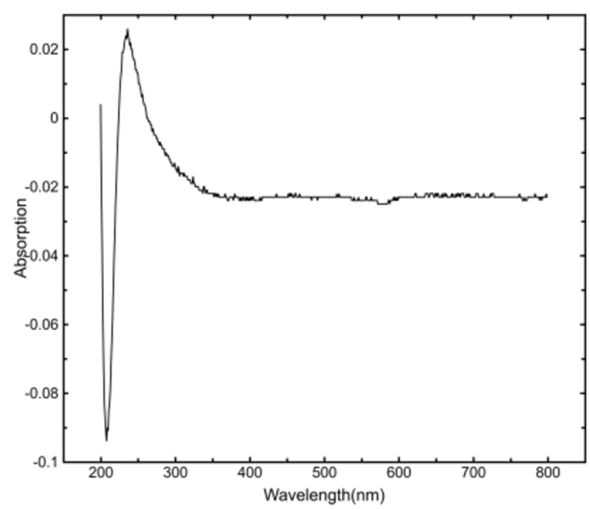


Figure 7(a): Sump water in Royapuram region



(b): Bore water in Royapuram region

Identifying compounds based solely on a wavelength of 240 nm and an absorbance of 0.02 in bore water with pH of 6.48 and conductivity of 0.467 mʊ is challenging. The low absorbance (0.02) indicates a low concentration, making identification even more challenging. The bore water composition can vary depending on location and geology, influencing the absorbing compounds is seen from figure 7.

Absorption range (-0.05), wavelength range (250-800 nm), and source drinking water with pH 6.67 and conductivity of 0.067 mʊ occurs in the drinking water as observed from figure 8. Many organic and inorganic compounds absorb light across this broad wavelength range (250-800 nm). Typically, absorbance values are non-negative

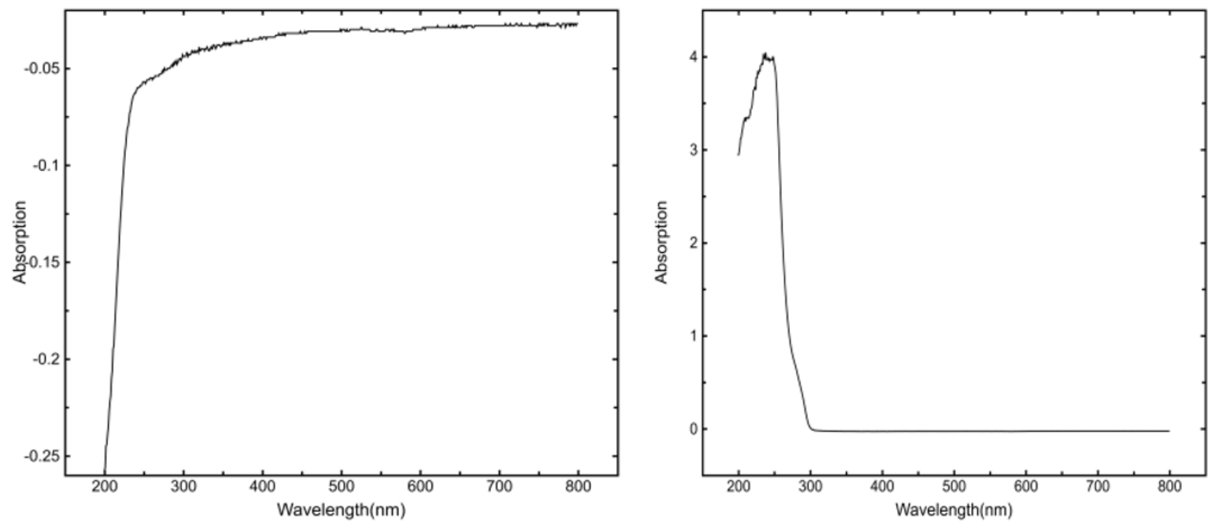


Figure 8(a) Drinking water(RO) (b) Tap water in Urapakkam region

The tap water from Urapakkam region shows the wavelength 240-250 nm, absorbance 4, (figure 8) and pH 6.72 and conductivity of 1.440 mʊ. This range indicates the absorbing compound likely contains aromatic groups (ring-shaped carbon structures with alternating single and double bonds) or conjugated double bonds (alternating single and double bonds between carbon atoms). This suggests a relatively high concentration of the absorbing compound in the tap water. In the sample collected from Andhra region, the humicsubstances are formed from the decomposition of organic matter and are commonly found in bore water as shown in figure 9. They can absorb UV light around 210 nm and a specific aromatic hydrocarbon, benzene, a contaminant is found in some bore water sources due to industrial pollution.

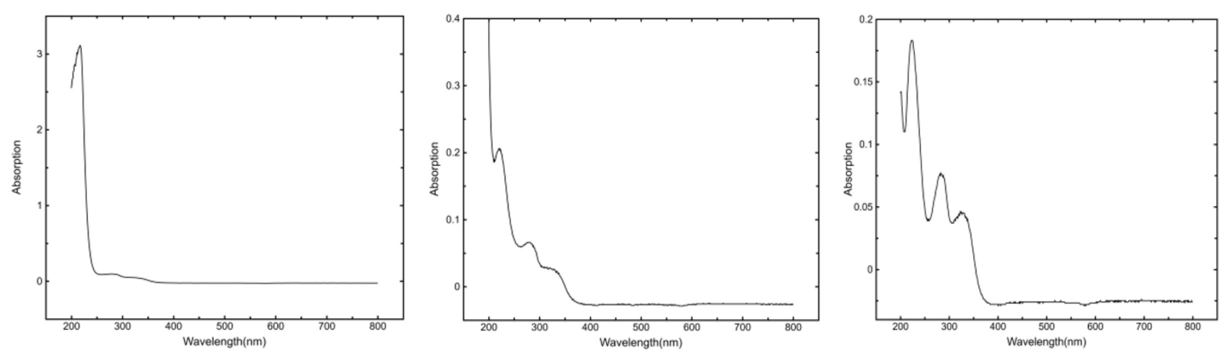


Figure 9 (a) Bore water (b) Sump water (c) RO water in Andhra Pradesh region

The presence of three distinct peaks in the absorption spectrum (230 nm, 290 nm, and 330 nm) from figure 9, suggests a mixture of compounds rather than a single one. pH of 7.52 and conductivity 0.890 mʊ suggests slightly alkaline sump water. The Peak at 230 nm denotes Conjugated double bonds and Compounds with alternating single and double bonds between carbon atoms can also absorb in this region and Peak at 290 nmshows Nitrate ions (NO3-): While less common, nitrate ions can also absorb around 290 nm. The UV-visible spectrum shown in figure 9(c), of RO water in the AP region shows a pH of 6.53 and conductivity of 0.092 mʊand peaks at three wavelengths: 220 nm (highest at 0.18 absorption coefficient), 300 nm (0.075), and 320 nm (0.04). The sample measured is a type of purified water. Dissolved gases like oxygen or ozone can also absorb UV light in this range. At lower pH levels, nitrates (NO3-) can convert to nitrites (NO2-), which exhibit absorption around 220 nm.

The spectrum in figure (10) of the drinking water at pudupet area shows the absorption is at -0.05 at 250nm which has a pH of 6.12 and conductivity of 0.138 mʊ. It contains Chlorine dioxide, a disinfectant sometimes used in water treatment, absorbs UV light around 250 nm. However, its presence depends on the specific treatment process used for drinking water. The absorption observed at 240 nm in tap water, with a pH of 6.67 and a conductivity of 0.457 ʊ, indicates a very dilute concentration, as evidenced by the low absorption coefficient of 0.01. This absorption is likely attributed to the presence of Humic Acid, a type of natural organic matter commonly found in tap water. Humic Acid possesses a complex structure containing aromatic rings and conjugated double bonds, which are known to absorb UV light around 240 nm.

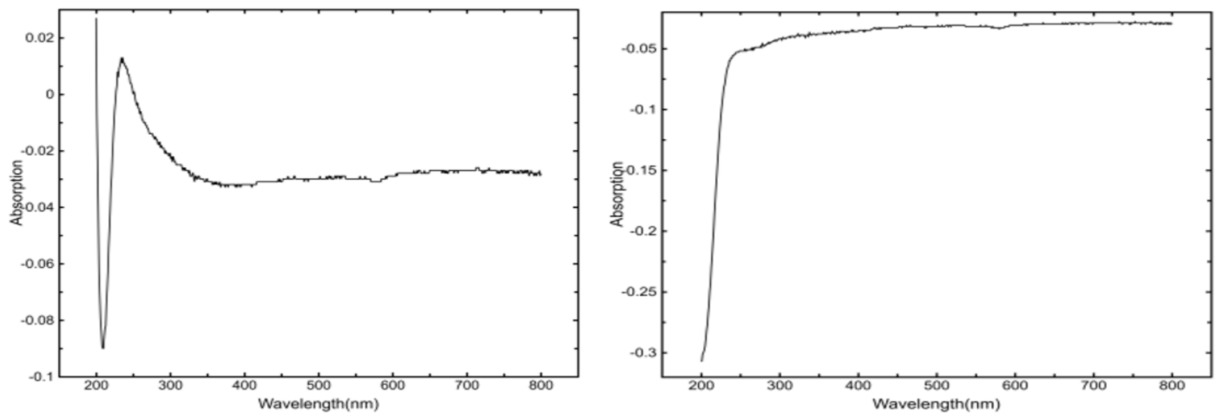


Figure 10 (a): Tap water (b)Drinking water (RO) in Pudupet region

The UV-visible absorption data (2.75 at 210 nm) ,pH (6.48) and conductivity of 1.31 mʊ from figure 10, shows Carbonyl groups (C=O), commonly found in organic molecules like aldehydes, ketones, and carboxylic acids found in the bore water of Madhavaram region.The high absorption coefficient (2.75) indicates a significant presence of UV-absorbing compounds in the bore water. The absorption around 210 nm suggests the presence of carbonyl groups or nitrate ions. The figure 10 shows the absorption of 1 at 200 nm and a pH of 6.37 and conductivity of 0.12 mʊ for drinking water in the Madhavaram region. Many compounds strongly absorb around 200 nm, including aromatic rings, conjugated double bonds, or carbonyl groups (C=O) aromatic hydrocarbons could be present as contaminants.

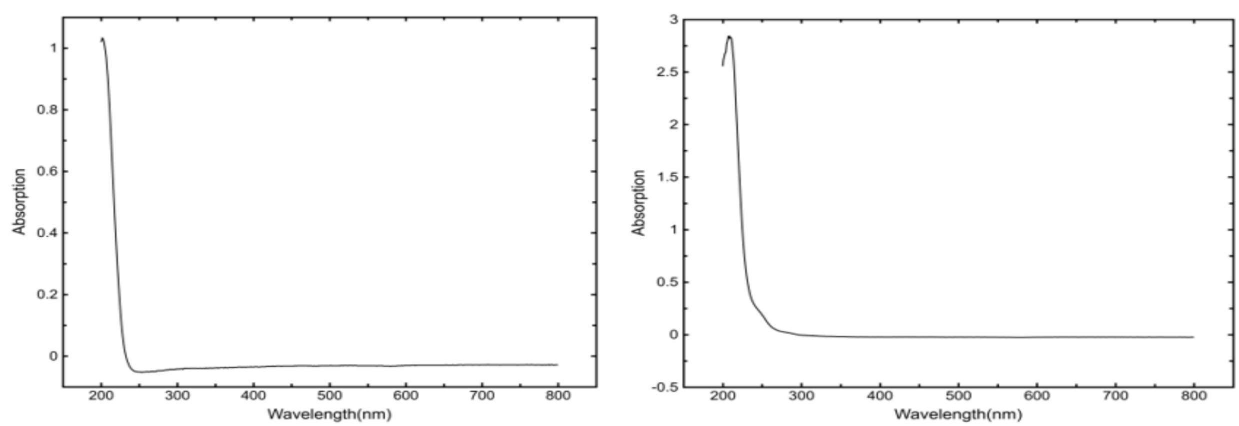


Figure 11 (a) Drinking water (RO) (b) Bore water in Madhavaram region

Thus various mineral components in drinking water can have both beneficial and harmful impacts on living things, depending on their concentration and the individual's health situation. Here are some minerals that are frequently found in drinking water and their possible negative effects:

High Nitrate levels in drinking water can lead to health risks such as methemoglobinemia (blue baby syndrome) in infants [32, 33] such as methemoglobinemia (blue baby syndrome) in infants, increased risk of certain cancers, potential adverse effects on thyroid function and respiratory disorders. Contamination primarily arises from agricultural runoff and improper waste disposal. Regular monitoring and treatment are crucial to ensure safe drinking water for all.

Elevated Carbon dioxide levels in drinking water can cause acidic conditions, leading to corrosion of metal pipes, which can release toxic metals like lead into the water [34]. Excessive CO_2 can also affect the taste and odour of water, impacting its palatability. Additionally, it may contribute to the formation of carbonate scales in water distribution systems, reducing flow rates and increasing maintenance costs.

Benzene in drinking water poses serious health risks, including increased cancer risks (particularly leukemia), adverse effects on the immune system, and potential harm to foetal development during pregnancy [35]. Chronic exposure to benzene can lead to long-term health issues, making it crucial to limit benzene content in drinking water to safe levels through effective water treatment and regulatory measures.

Chlorine is commonly used to disinfect drinking water, killing harmful bacteria and viruses. However, excessive chlorine levels can lead to a strong taste and odour [36], as well as potential health risks such as skin and eye irritation. Long-term exposure to high chlorine levels has been linked to respiratory issues and may contribute to certain types of cancer. Regular monitoring and maintenance of chlorine levels are crucial for ensuring safe drinking water.

High levels of Sodium in drinking water can lead to health issues [37] such as hypertension and cardiovascular problems, particularly for individuals with pre-existing conditions. It can also affect the taste of water, making it less palatable. Monitoring and controlling sodium content in drinking water are important for maintaining public health and ensuring water quality.

The Environmental Protection Agency (EPA) sets secondary drinking water regulations that recommend a maximum total dissolved solids (TDS) level of 500 ppm in drinking water. Levels above 1000 ppm are considered unsafe, and if TDS exceeds 2000 ppm, a filtration system may struggle to effectively reduce those levels. The acceptable TDS classifications are as follows: Excellent: less than 300 mg/L; Good: 300–600 mg/L; Fair: 600–900 mg/L; Poor: 900–1200 mg/L; and Unacceptable: above 1200 mg/L. [38].From Table 2, we can find that the RO treated water in the areas like Andhra Pradesh, pudupet, Royapuram, Vandalur is almost good for consumption as drinking water.Whereas in some regions the TDS level in the bore water is unacceptable. Hence they have to be treated before consumption.These minerals, when present in high concentrations in drinking water, can have a long-term deleterious impact on human health. Regular water quality monitoring and proper treatment procedures are critical to providing safe drinking water to everybody

Table 2. TDS and its acceptable level

AREA	TYPE OF WATER	TDS mg/L	Acceptable level of TDS
Andhra Pradesh	Sump water	817	Fair
	Bore water	2564	Unacceptable
	RO water	50	Excellent
Urapakkam	Drinking water(RO)	50	Excellent
	Bore water	1694	Unacceptable
Madipakkam	Sump water	1830	Unacceptable
	Drinking Water(RO)	76	Excellent
Pudupet	Sump water	490	Good
	Drinking water(RO)	84	Excellent
Royapuram	Bore water	459	Good
	Sump water	520	Good

Madhavaram	Bore water Drinking water(RO)	1757 45	Unacceptable Good
Vandalur	Tap water RO water	680 305	Good Good
VANITEC (Vaniyambadi)	Tap water Waste water	2106 2470	Unacceptable Unacceptable

All the samples except for the drinking water from (Madipakkam,) have a pH in the range of 6.48 to 7.52, which is slightly acidic to slightly basic. This indicates that these samples are likely within the acceptable drinking water pH range. UV-visible spectrophotometry to investigate the presence of UV-absorbing compounds in various water sources, including RO water (pH 6.53), tap water (pH 6.61), drinking water (pH 6.12, 6.37), and bore water (pH 6.86). The observed absorption peaks provided valuable insights into the potential presence of different types of compounds, but limitations inherent to UV-visible data prevented definitive identification of single specific compounds. The slightly acidic pH of RO water (6.53) might influence the presence of dissolved organic acids or trace metal contaminants compared to the slightly alkaline bore water (pH 6.86).The pH range of drinking water samples (6.12-6.37) fell within a typical range and wouldn't significantly impact the interpretation of UV-visible data related to the presence of common organic contaminants or dissolved gases. All water samples exhibited absorption peaks in the UV range (200-320 nm), indicating the presence of UV-absorbing compounds. The absorption intensity varied across samples, with bore water showing the strongest absorption (2.75 at 210 nm). Based on the peak locations, potential functional groups include aromatic rings, conjugated double bonds, or carbonyl groups. However, definitive identification requires a broader spectral range and/or complementary techniques. Thus by analyzing the pH of the water samples, the samples whose pH is >7.00 can be treated by adding necessary compounds to remove the unwanted contaminants and reduce the pH to nearly 7.00.

The analysis of UV-visible absorption spectra alongside conductivity measurements offers valuable insights into water composition and quality across a spectrum of conductivity levels. At the lowest conductivity levels, such as in bore water with a conductivity of 0.12mʊ, observations reveal potential organic contaminants, including aromatic hydrocarbons, indicated by strong absorption at 200 nm. This suggests the necessity for vigilant monitoring and management to mitigate potential health risks associated with such contaminants. Conversely, at the highest conductivity levels, such as in drinking water with a conductivity of 1.440 mʊ, findings indicate the presence of compounds like chlorine, carbon dioxide, a disinfectant used in water treatment, contributing to absorption peaks at 250 nm. The implications of these findings underscore the importance of understanding the treatment processes involved and ensuring the effectiveness of disinfection methods. Overall, regardless of conductivity level, the identification of specific absorption patterns facilitates the detection of various compounds, ranging from natural organic matter to disinfection by-products, enabling informed decision-making in water resource management and ensuring the safety and sustainability of drinking water supplies.

To further explore the relationship between Conductivity and TDS, we can perform statistical analysis such as calculating correlation coefficients or fitting a regression model to understand the strength and nature of their relationship. The figure (12) shows the linear regression plot for the conductivity and TDS.

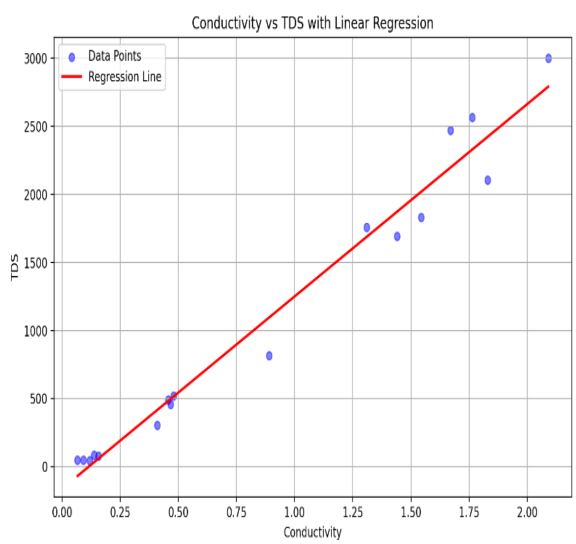


Figure 12. Conductivity Vs TDS plot

The correlation coefficient between Conductivity and TDS is approximately 0.986, indicating a very strong positive linear relationship between the two variables. This suggests that as Conductivity increases, TDS tends to increase as well. The data shows a strong linear relationship (R-squared ≈ 0.973),and shows random scatter around zero, indicating a good model fit. Also, it follows a normal distribution (p-value = 0.80 > 0.05)

IV. CONCLUSION

Thus, in this study the water samples were collected from various regions in Tamil Nadu and Andhra Pradesh. The pH, Conductivity and TDS were studied for the various samples using the laboratory setup available in the department of Electronics and Instrumentation Engineering. The pH level in almost all regions was from 6.5 to 8.5 which is the acceptable limit by the Government. It was found that RO water in Madipakkam area, normal water from Royapuram area and waste water from Vanitec, Vaniyambadi were acidic and is more likely to be contaminated with pollutants. This can make it unsafe to drink, and it can also corrode metal pipes. By analysing using the UV spectrophotometer the spectrum of the types of water in different regions were studied. It was observed that the water contained contaminants like Carbonyl groups, aromatic hydrocarbons, carbon dioxide and some minerals like Sodium, nitrate, benzene and Chlorine. Due to the high level of the minerals, it can be compensated by methods like using a neutralizing filter to raise the pH to acceptable level,which can reduce the long-term health issues.As a future recommendation, it is advised to utilize the latest sensors for detecting additional quality parameters, implement wireless communication standards for improved connectivity, and leverage IoT technology to enhance the water quality monitoring system. Using IoT, we can create a system that continuously monitors water quality and automatically sends alerts when certain parameters, such as pH, conductivity, or the presence of contaminants, exceed acceptable thresholds. This approach will ensure a quicker response to safeguard water resources.

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