MONITORING WATER TEMPERATURE AT HOUSEHOLD LEVEL IN DIFFERENT TYPES OF STORAGE TANK USING SENSOR AND ASSESSING THE EFFECT OF AMBIENT AIR TEMPERATURE ON WATER TEMPERATURE

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ABSTRACT

The lack of continuous water supply in a city has led its consumers to store water in storage tank. Investigating the chemistry of stored water on various types of water storage containers is an important issue. So, it is essential to monitor the temperature of stored water and find the relation between air temperature and water temperature in both overhead water tank and underground water tank. Analysis of the data will also give us an idea about the possible effect of overhead tank material on water temperature. Sensors have been installed in two different locations of Dhaka city.The types of overhead tank are different (RCC and Plastic). In each location, two liquid temperature sensors and one air temperature sensor are installed. Using these sensor, we are collecting the temperature data at 15 min interval. All the three sensors relate to Enviro Sampler that communicates with sensors via RS485 Modbus (a wire connected protocol) and stores the data locally. According to sensors data, air temperature is quite similar in two stations as they are both in Dhaka city. Groundwater tank temperature remains almost constant throughout the day. However, the overhead temperature shows some different patterns in two different tanks (RCC and Plastic). The pattern of plastic overhead tank's water temperature follows ambient air temperature.But in RCC tank the overhead temperature takes much more time to reach its maximum temperature than Plastic tank. Similarly cooling down of water takes longer time in RCC than in Plastic. Which denotes that in RCC tank heat is retained longer time in water than in Plastic tank but water is heated quickly in Plastic tank.

Keywords: *Ambient Air Temperature, Liquid Temperature Sensor, Air Temperature Sensor, RCC and Plastic.*

1. INTRODUCTION

Water storing is a common phenomenon in Dhaka city and Bangladesh. It is seen that water is drawn from the distribution system, stored in underground reservoir, pumped to overhead reservoir. Then using gravity pressure, water reaches to the consumers. In extreme cases, water stays in reservoirs for 12hrs-24hrs. During this time water temperature in the stored water is affected by the ambient temperature and there are so many water quality parameters which are temperature sensitive. In a study it is found that, the effect of changing ambient air temperature on the water temperature and various water quality parameters i.e., chlorine residuals, TTHM concentrations, and bacterial activity in drinking water distribution systema (Lai & Dzombak, 2021).

(Ogbozige et al., 2018) investigated the chemistry of stored water for high solar heating during the dry season on various types of water storage containers. They experimented on two sources of potable water on six different storage materials for six-week retention time with sampling frequency of seven days interval. They found that the concentration of chlorine in the storage vessels at any time was not a function of the material of construction used, nor the color of materials but rather, a function of time. Among the plastic tanks, total bacteria recorded in water stored in colored tanks were less than those recorded in black tanks due penetration of ultra-violet rays through the colored plastic tanks that might have destroyed some of the bacteria especially at the surface of the water in these tanks.

(Schafer & Mihelcic, 2012) also assessed the effect of storage tank material on household water quality recording temperature measurements in every 30 min over a period of 12 h, covering the time of sunrise to sunset (7:00 a.m.–7:00 p.m.). It is seen that free chlorine concentration is decreased. If water temperatures were measured to be greater than 15°C for a significant period of daylight hours, there is potential for microbial growth, especially because this threshold level has been cited as leading to increased microbial growth (Fransolet et al., 1985). So, it is necessary to monitor water temperature at household level.

2. METHODOLOGY

Water temperature is affected by ambient temperature. For assessing the effect of ambient temperature on water temperature at household level, sensors are installed at ground water tank as well as in overhead water tank at two locations of Dhaka city. At one location, the overhead tank is made of concrete, while at the other, the overhead tank is made of plastic. The effect of air temperature is much more in overhead water tank than underground water tank as overhead water tank is the open in the ambient condition. Using the sensor, the temperature data are collected at every 15 min interval to assess the relation between air temperature and water temperature in both overhead water tank and underground water tank. Analysis of the data will also give an idea about the possible effect of overhead tank material on water temperature.

2.1 Locations of Measurement

Two sensors have been installed in two different locations of Dhaka city. One is installed in Dhanmondi (Road 15A) under Dhaka South City Corporation (DSCC) and another at Mirpur (Section 14) under Dhaka North City Corporation (DNCC). Figure 1 shows the locations of the sites in a Google map.

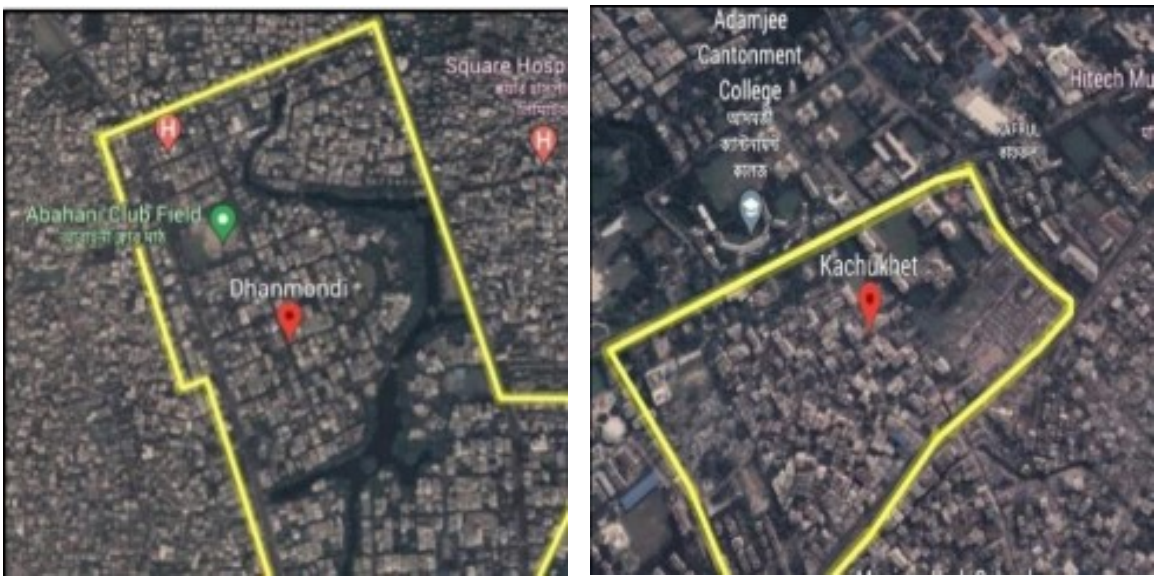

Figure 1: Google Earth aerial view of two sites (Dhanmondi, Mirpur)

The overhead tank material at Dhanmondi is made of RCC, while that at Mirpur is made of plastic which is shown in Figure 2.

Figure 2: Overhead tanks: (a) RCC tank at Dhanmondi; (b) Plastic tank at Mirpur

2.2 Device Description

2.2.1 Liquid Temperature Sensor (GX-701 T)

GX-701 T series Temperature sensor adopts high performance diffused silicon piezoresistive pressure sensor as the measuring element series pressure transmitter is high reliability, high- stability, high accuracy and small volume level transmitter with part structure. Widely used in the measurement of liquid pressure and height in small inside diameter pumps as well as the level height of liquid reservoirs, such as water, oil, and mild corrosive liquid. This product is generally used in Water plant,

chemical plant monitoring and control, sewage disposal, deep well, dam, control flood, irrigation. Typical liquid temperature sensor used in our study is shown in Figure 3.

Figure 3: Liquid Temperature Sensor and Air Temperature Sensor

2.2.2 Air Temperature Sensor (BGT-WSD2)

BGT-WSD2 Atmospheric Temperature Sensor is a professional measurement of ambient temperature. Sensors are built-in; the water-proof and anti-UV shelter 7 plate radiation shield is used to protect weather sensors and provides more accurate measurement results. The shield minimizes radiation reaching the sensor, minimizes radiation absorbed by the shield, and maximizes ambient airflow around the sensor. It is widely used in agriculture, forestry, meteorology, climate chamber, warehousing, and other places. A typical air temperature sensor used in our study is shown in Figure 3.

2.2.3 Enviro Sampler

Enviro sampler is a low-powered advanced data acquisition system and Telemetry controller that can connect to any type of sensor that supports RS485 protocol, and I2C protocol and can reliably store and send data to its cloud companion in a failsafe way.

2.3 Data Collection Method

Liquid temperature sensors have been inserted in overhead and underground water storage tank. Air temperature sensor is placed in the outdoor ambient above the weather station. All the three sensors relate to Enviro Sampler that communicates with sensors via RS485 Modbus (a wire connected protocol) and stores the data locally. Then it transmits the data to cloud server via GSM Communication and user is then able to download/ analyze the data from cloud server. The entire system is fed solely by solar panel. All three sensors are connected to Enviro Sampler. It communicates with connected sensor via RS485 Modbus (wire connected protocol) and stores locally. Then it transmits data to cloud server via gsm communication and user can download. The sensor provides accurate temperature measurement data at 15min interval. So, each hour 4 data points are given as output.

3. ILLUSTRATIONS

3.1 Figures and Graphs

After obtaining 15-minute interval data for each day from March, 2023 to October, 2023 we analyzed to get the pattern of air temperature and tank water temperature of two sites. Here in Figure 4, hourly averaged data points are plotted. The first hour data corresponds to average of 245 day's first hour temperature. Thus 24 datapoints are obtained corresponding to 24 hours of a day. Similar process is followed for overhead and ground water tank temperature. Three temperatures are superimposed for two stations in Figure 4.

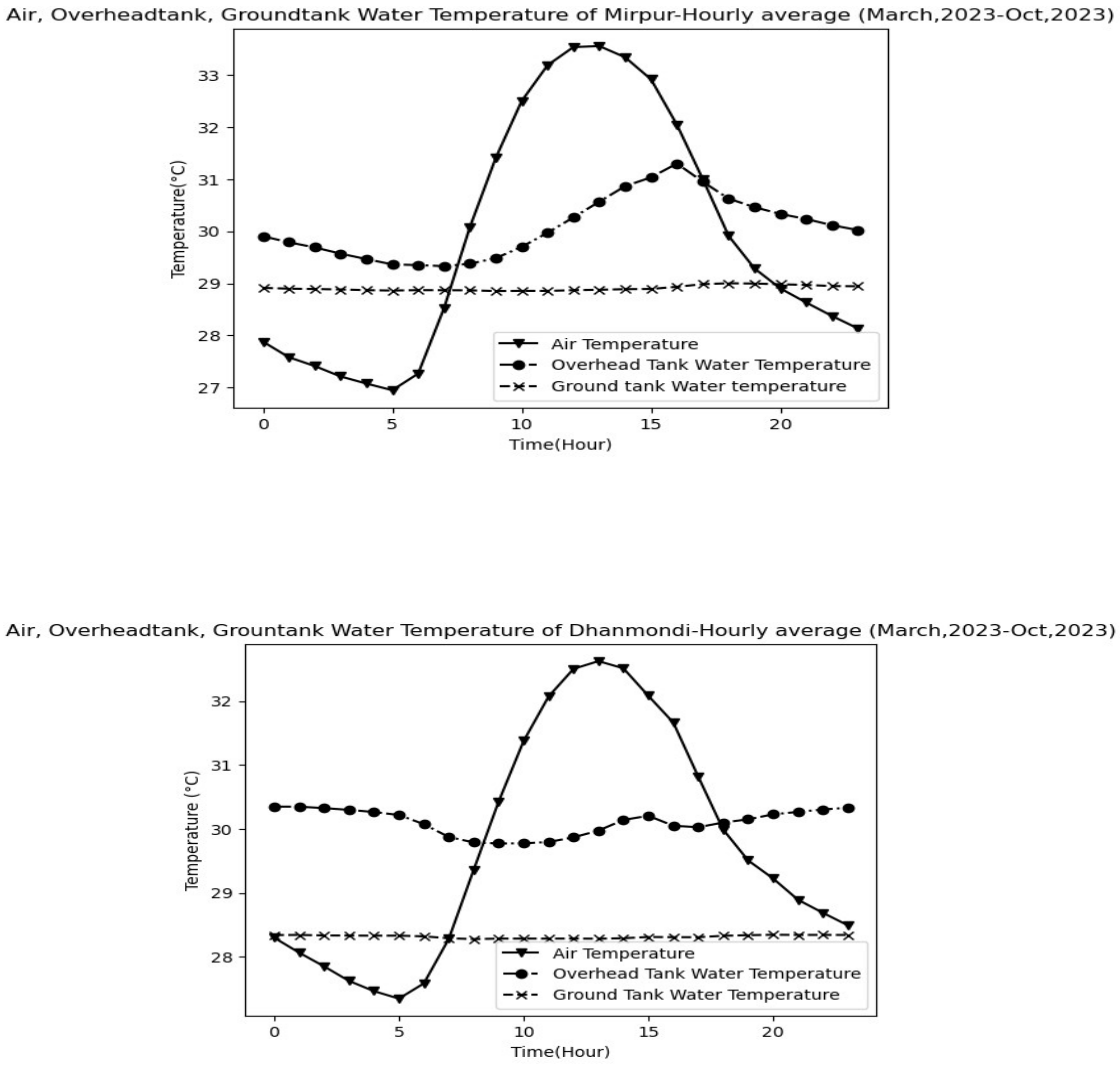

Figure 4: Hourly averaged air, groundwater and overhead tank (Plastic) water temperature and Mirpur (above) and Dhanmondi (below)

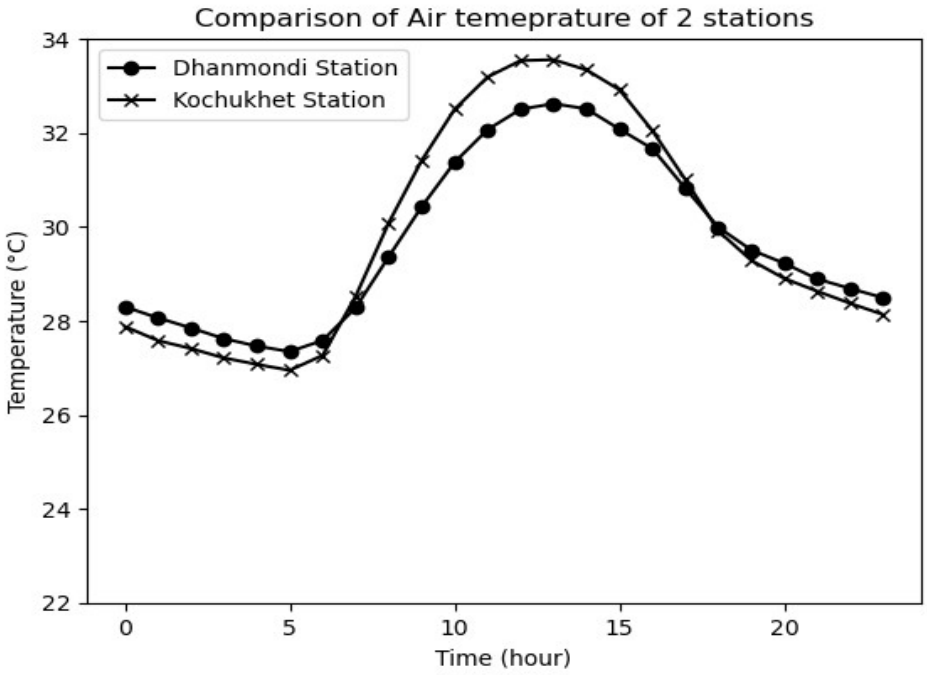

Figure 5: Comparison of Air temperature of two stations

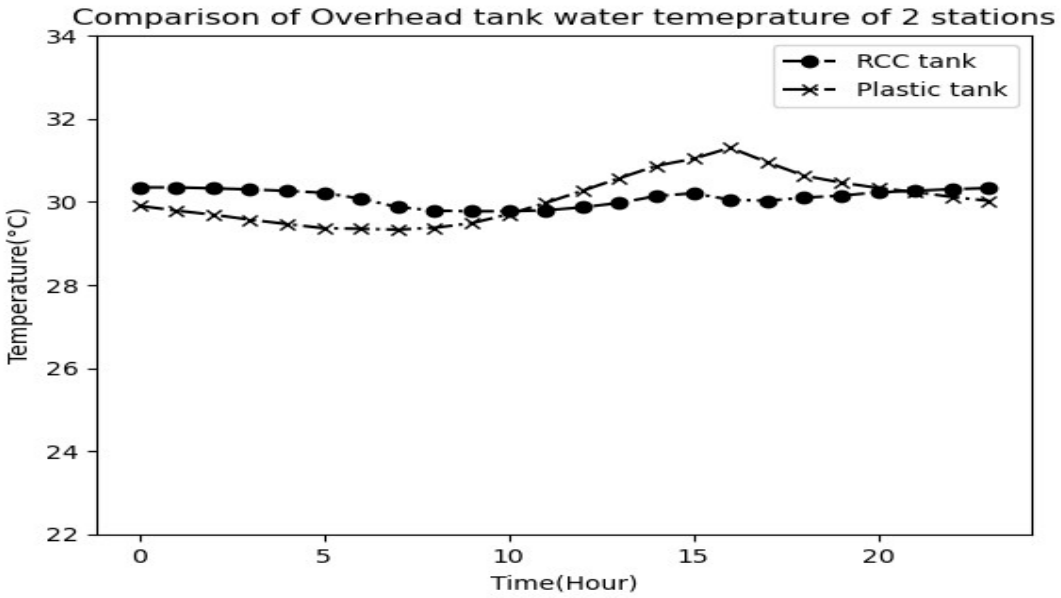

Figure 6: Comparison of Overhead Tank Water temperature of two stations

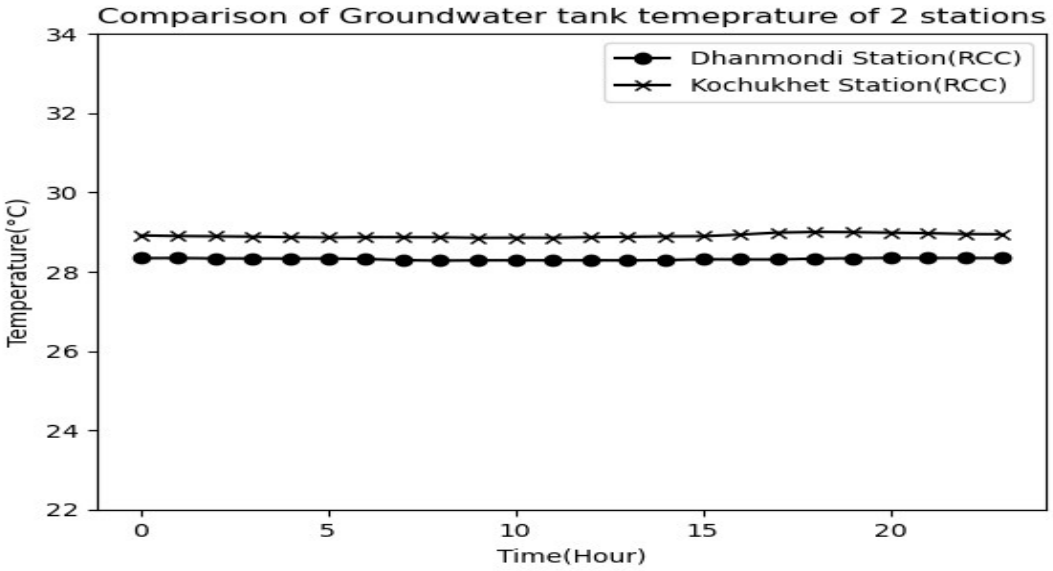

Figure 7: Comparison of Groundwater Tank Water temperature of two stations

For comparison of temperatures in two station the above figures are plotted (Figure 5 to Figure 7). In all plots the dotted datapoints corresponds to Dhanmondi and crossed data points corresponds to Mirpur station. Important outputs are arranged in Table 1. Air temperature is quite similar in two stations as they are both in Dhaka city. However due to highly sensitive senor deviation of 1 degree C is observed. Groundwater tank temperature remains almost constant throughout the day. It generally obtained 28.3°C.

However, the overhead temperature shows some different patterns in two different tanks (RCC and Plastic). The pattern of plastic overhead tank's temperature follows ambient air however there is a little curve in RCC tank. In RCC tank the overhead temperature takes much more time to reach its maximum temperature than Plastic tank. Similarly cooling down of water takes longer time in RCC than in Plastic. Which denotes that in RCC tank heat is retained longer time in water than in Plastic tank but water is heated quickly in Plastic tank. So, for future water quality parameter assessment in household level the sensor obtained data could be a valuable resource.

Table 1: Table shows the temperature of air, groundwater tank and overhead water tank of two different stations. Air temperature is quite similar in two stations as they are both in Dhaka city.

Parameters	Dhanmondi			Mirpur		
	Air	**Ground tank**	**Overhead tank**	**Air**	**Ground tank**	**Overhead tank**
Maximum hourly temperature	32.62°C at 1 pm	28.34°C	29.07°C at 12 am	33.56°C at 1 pm	29.0°C	31.3°C at 4 pm
Minimum hourly temperature	27.34°C at 5 am	28.28°C	29.77°C at 9am	26.95°C at 5 am	28.85°C	29.3°C at 7 am
Average hourly temperature	29.7 °C	28.30°C	30.1°C	29.86°C	28.9°C	30.07°C
Lag between air and overhead in hour (max temp)	11 hours			3 hours		
Lag between air and overhead in hour (min temp)	4 hours			2 hours		

4. CONCLUSIONS

From the observations of ambient air temperature and overhead water tank temperature it is clear that overhead water tank temperature is influenced by ambient air temperature. This behaviour of overhead water tank temperature is depended on the tank materials. Monitoring of water temperature in water tanks revealed that while water in plastic tank is heated up quickly, the water in a RCC tank retains the heat for a longer period of time. Lag between obtaining maximum air and maximum overhead water tank temperature in plastic water tank is only three hours, while in RCC tank it is eleven hours. It can be said that the materials of these tanks have an effect of the storage tank's water temperature. This is likely to have implications for water quality (including concentration of chlorine and bacterial activity). As different types of water quality parameters are temperature sensitive. So, variation in water temperature has an effect in temperature sensitive water quality parameters.

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