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Determination of Free Chlorine Water Content in Jalandhar City Using Colorimeter

Vaidehi Sanjaybhai Vekariya[1], Rajdeep Singh Sikh[1], Wani Shruti Jaykumar[1], S. Ravichandran[2,*]

Abstract

Water is the ultimate source of life on this universe. Water is vital for the survival of humans, animals, and plants, and the issue of freshwater is becoming increasingly critical in society. With the human body composed of 64% water, contaminated water, inadequate waste disposal, and poor water management contribute to severe public health issues such as cholera, typhoid, and malaria annually. Globally, the quality and quantity of water are declining due to rapid urbanization, population growth, and industrialization. While most countries recognize the importance of freshwater, it now demands the highest priority. Chlorine, commonly used as a disinfectant, plays a significant role in maintaining hygienic conditions within public water networks. Despite concerns, at low levels in drinking water, chlorine is deemed safe and effective by health authorities. The World Health Organization sets a maximum guideline of 5 mg/l for residual chlorine in drinking water to ensure safety standards are met. Maintaining free residual chlorine in water is essential for disinfection and upholding safety standards. In this case study, we aim to determine the free chlorine residual content in the water of Jalandhar city, Punjab, India. In this study, we employed a colorimetric method coupled with a calibration curve to accurately determine the free residual chlorine content in a given water sample. The calibration curve was constructed using standard solutions of known chlorine concentrations, and absorbance measurements were obtained using a colorimeter across a range of wavelengths. Subsequently, the absorbance values of the water sample were compared to the calibration curve to interpolate the corresponding free residual chlorine concentration. The experiment demonstrated a reliable and precise method for assessing chlorine levels in water, essential for ensuring its suitability for various applications, including drinking water treatment, swimming pools, and wastewater treatment. This approach offers a cost-effective and efficient means of monitoring chlorine levels, contributing to the maintenance of water quality and public health. The findings provide valuable insights into the quality of drinking water in Jalandhar city and contribute to efforts aimed at ensuring safe water to the residents. By conducting colorimetric analysis on water to assess the efficacy of chlorination at Jalandhar city and contribute to the understanding of water quality.

Keywords: Free Residual Chlorine, Water Quality, Colorimetric Analysis, Public Health, Drinking Water Safety

***Author for Correspondence**
S. Ravichandran
E-mail: ravichandran.23324@lpu.co.in

[1]Student, B.Tech. Aerospace Engineering, School of Mechanical Engineering, Lovely Professional University, Jalandhar, Punjab, India
[2]Professor, in Chemistry, Lovely Professional University, Jalandhar, Punjab, India

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INTRODUCTION

Due to contamination[1-4] in the drinking water uses face the challenge of providing good quality water to the entire world. The municipality water sources contain disease causing bacteria which need to be removed before the water can be used in domestic use. Some of the chlorine initially reacts with organic materials and metals in the water, when chlorine is added to water. Therefore chlorine is not available for disinfection. There are two types of disinfectants[5-11] are most commonly utilized today. They are chlorination and chloramination.

Chlorination is a commonly adopted method for water disinfection due to its effectiveness in removing harmful pathogens. However, it is essential to maintain an adequate residual concentration of chlorine to ensure continued protection against microbial contamination throughout the distribution system. In Jalandhar city, where water is sourced from various surface and groundwater reservoirs, monitoring the free chlorine residual content is critical to safeguard public health. Utlization of chlorination requires great understanding of the mechanism. In India about 40 crore people do not have access to safe and reliable supply of drinking water. Almost in all the cities in India the municipal water supply available for a few hours per day and the water supply is of questionable quality. This research aims to ascertain the residual free chlorine content in the water supply of Jalandhar, Punjab, India (Figure 1).

Chlorination involves the addition of chlorine gas or oxidizing chlorine compounds to water samples for treatment. Among the commonly used compounds are chlorinated lime or bleaching powder ($Ca(OCl)_2$), renowned for its high percentage of free active chlorine, and High-Test Hypochlorite (HTH), which offers a purer and more stable form of chlorine. Additionally, the introduction of hypochlorous acid (HOCl) proves highly advantageous, as it liberates free chlorine upon contact with water.

Figure 1. Jalandhar city.

Chlorine Chemistry

Chlorine is added to water as chlorine gas or as sodium or calcium hypochlorite.

Chlorine Gas

$Cl_2 + H_2O \rightarrow HOCl + HCl$

Sodium Hypochorite

$NaOCl + H_2O \rightarrow Na^+ + HOCl + OH$

Yet, the effectiveness of chlorination is influenced by various factors, including sunlight exposure, redox reactions with inorganic and organic materials present in the water, and out-gassing, collectively known as the chlorine demand. Consequently, only a portion of the added chlorine remains available for disinfection, termed as the Total Residual Chlorine.

Total Residual Chlorine, subjected to factors such as temperature, pH, and the presence of ammonia or ammonium compounds, generates two forms of active chlorine disinfectants: Free Available Chlorine (FAC) and Combined Available Chlorine. FAC denotes residual chlorine available to react with new contaminants after meeting the chlorine demand. The chemistry of chlorination is further nuanced by water properties, notably pH and temperature. At pH values between 6.5 and 8.5, the equilibrium between hypochlorous acid (HOCl) and hypochlorite ions (OCl-) persists, with the distribution of each species influenced by pH. However, at higher pH ranges exceeding 8.5, the proportion of hypochlorite ions significantly outweighs that of hypochlorous acid.

Methodology

1. *Sample collection*: Water sample is collected from Jalandhar city.
2. *Finding maximum optical density wavelength (λ_{max})*: Before conducting the colorimetric analysis, the wavelength at which the optical density of normal tap water is maximum is determined. This is achieved by scanning the water sample across a range of wavelengths using colorimeter and recording the absorbance values. The wavelength corresponding to the peak absorbance is identified as the maximum optical density wavelength (λ_{max}).
3. *Preparation of reagents*: A standard chlorine solution is prepared by adding 50 ml chlorine solution, 5ml of potassium Iodide (KI), 5ml of phosphate buffer (pH 6.5) and 5ml of DPD reagent. This solution serves as a reference for calibrating the colorimeter

Colorimetric analysis: A colorimeter based on the DPD (N, N-diethyl-p-phenylenediamine) method can be used to analyze the water samples. This method involves adding DPD reagent to the samples, which forms a coloured complex in the presence of free chlorine. The amount of free chlorine present directly correlates with the color's intensity (Figure. 2).

Figure 2. Calorimeter.

4. *Calibration:* Prior to analysing the water sample, the colorimeter is calibrated using the standard chlorine solution at λ_{max} for various concentrations. A calibration curve is plotted by measuring the absorbance of standard solutions with known chlorine concentrations (Figure.3).

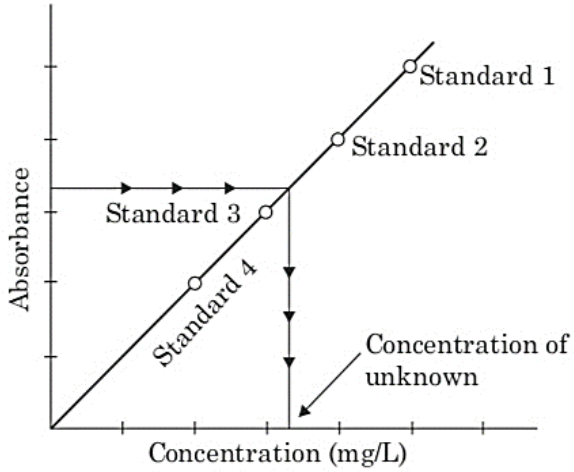

Figure 3. Calibration curve.

5. *Sample analysis*: The water sample is analysed using colorimeter. The absorbance readings obtained from the colorimeter are recorded.
6. *Data analysis*: The absorbance value obtained from the water sample is compared to the calibration curve to determine the concentration of free chlorine residual in that sample.

Observation

The λmax and optical density at λmax was determined and a calibration curve was plotted shown below.

Table 1. Determination of λ_{max}

Wavelength (λ) in nm	Optical Density (O.D)
420	0.24
480	0.38
500	0.57
520	0.33
540	0.30
620	0.05

Table 2. Determination of optical Density at λ_{max} for various concentrations

Concentration (in mg/L)	Optical Density (O.D)
0.4	0.06
0.8	0.10
1.2	0.13
1.6	0.16
2.0	0.21
2.4	0.22
2.8	0.27
3.2	0.31
3.6	0.33
Unknown concentration	0.25

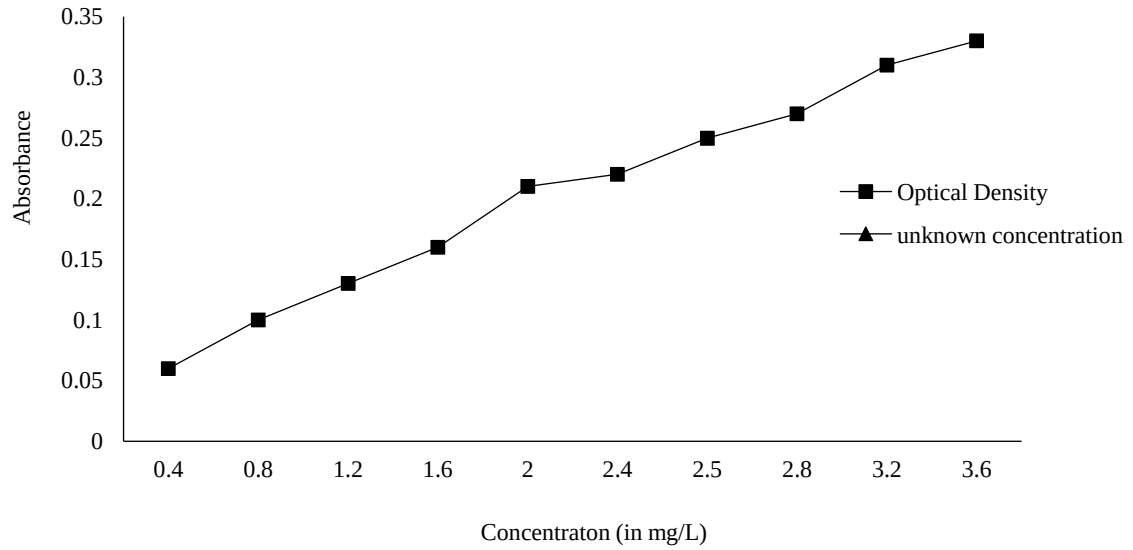

Figure 4. Chlorine water calibration curve.

RESULTS AND DISCUSSION

The colorimetric analysis of a water sample collected from Jalandhar city gave an absorbance value of 0.25. By correlating this absorbance value with the calibration curve generated using standard chlorine solutions of known concentrations, the concentration of free chlorine residual in the sample

was determined (Figure.4) to be 2.5 mg/L. This result (Table 1 and 2) provides insight into the free chlorine residual content in Jalandhar water, indicating its effectiveness in disinfection and contributing to the overall assessment of water quality in Jalandhar city. The presence of chlorine residual in water at a concentration of 2.5 mg/L (milligrams per litre) can have several effects:

Disinfection: At 2.5 mg/L, chlorine is typically sufficient to achieve effective disinfection.

Taste and odour: At 2.5 mg/L, the taste and odour are usually within acceptable limits for most people, but some individuals may still perceive a slight chlorine taste or odour.

Health considerations: Chlorine at appropriate levels, such as 2.5 mg/L, is generally considered safe for consumption according to regulatory standards.

Overall, the presence of a chlorine residual at 2.5 mg/L in water helps to ensure its safety for consumption by effectively disinfecting and controlling microbial growth while also improving water quality through oxidation.

CONCLUSION

In conclusion, the determination of free chlorine residual content in the water of Jalandhar city using a colorimeter serves as a valuable tool for monitoring water quality and safeguarding public health. By employing this analytical technique, authorities can identify and address potential challenges in maintaining adequate chlorination levels throughout the distribution network. Continued monitoring and proactive measures are essential to ensure the provision of safe and potable water to the residents of Jalandhar city. The detection of a chlorine concentration of 2.5 mg/L in Jalandhar city water shows the importance of effective water treatment and disinfection practices for ensuring public health and safety. It highlights the ongoing efforts of water treatment authorities to provide clean and safe drinking water to the residents of Jalandhar city while adhering to regulatory standards and addressing taste and odour concerns.

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