

Article



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# Correlation Between CO<sub>2</sub>, Temperature and Salinity

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**Abstract:** An experiment entitled the corellation between  $CO_2$ , temperature, and salinity was conducted to determine the interrelationship among carbon dioxide concentration  $(CO_2)$ , temperature, and salinity in seawater. The instruments used in this experiment included an Erlenmeyer flask, volumetric flask, drop pipette, funnel, and sample bottle. The materials used were seawater, phenolphthalein indicator (PP), sodium hydroxide (NaOH), and sodium carbonate  $(Na_2CO_3)$ . The method applied in this experiment was titration using NaOH solution. The results showed that the seawater sample tested positive for the presence of  $CO_2$ , as indicated by no color change after the addition of the phenolphthalein indi-

cator. The removal of  $CO_2$  from the sample was observed when the solution turned pink after titration with NaOH, confirming the success of the experiment.

Keywords: Seawater sample, CO<sub>2</sub>, temperature, salinity, NaOH titration

## 1. Introduction

Water serves as an essential solvent for life, composing a significant portion up to 90% of the biomass in organisms such as plants and microorganisms. The types and concentrations of substances dissolved in water critically influence the biological processes within aquatic ecosystems. One of the most crucial dissolved substances is oxygen  $(O_2)$ , which is vital for cellular respiration across various aquatic organisms [1]. Dissolved oxygen (DO) concentration is a principal indicator of water quality and is subject to variation due to multiple environmental factors, which include temperature, atmospheric pressure, salinity, water movement, and climatic patterns [2]. When DO levels drop below thresholds essential for survival, aquatic organisms suffer, leading to disrupted physiological functions and imbalances in ecological systems. Furthermore, low DO conditions can become a limiting factor for many species, emphasizing the necessity for monitoring these levels to maintain ecological health [1].

Salinity represents another fundamental factor influencing aquatic ecosystems, reflecting the concentration of dissolved salts. It is primarily regulated by the dynamics of evaporation and precipitation, regions with high evaporation rates tend to have elevated salinity levels, while those experiencing heavier rainfall generally see lower salt concentrations [3]. Additionally, salinity is affected by freshwater inflows, ocean currents, and varying climatic conditions. Understanding the interplay between temperature, salinity, and gases like CO<sub>2</sub> and O<sub>2</sub> is pivotal for assessing overall water quality and predicting the health of aquatic ecosystems, as these factors directly impact the solubility and availability of dissolved gases [4]. This investigation aims to deepen our understanding of how these variables interact within marine and freshwater ecosystems. It underscores the significance of continuous water quality assessments, as they can elucidate the physical and chemical processes governing these environments. By monitoring parameters such as DO and salinity, alongside biochemical indicators like BOD (Biochemical Oxygen Demand), researchers can effectively gauge the organic strength of pollutants and evaluate the ecological degradation of aquatic habitats [5], [6]. Moreover, the outcomes of such studies can support pollution management and conservation efforts. For instance, quantifying BOD offers insights into organic pollution levels, while understanding salinity variations can inform the ecological implications of freshwater inflows and the overall dynamics within these aquatic ecosystems [6], [7]. The integration of these parameters provides a more holistic view of water quality, which is crucial for making informed management decisions aimed at protecting and preserving aquatic

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environments. In summary, the essential role of dissolved oxygen and salinity in shaping the health of aquatic ecosystems cannot be overstated. Ongoing research and monitoring efforts are vital for securing water quality standards and ensuring the sustainability of these environments, ultimately supporting biodiversity and human health alike.

#### 2. Results

#### 2.1. Observation Results

In the first treatment, 25 mL of seawater mixed with 4 drops of phenolphthalein appeared clear, indicating an acidic pH and suggesting the presence of dissolved  $CO_2$ , with a measured concentration of 0.44 ppm. In the second treatment, the addition of 5 mL of NaOH to the first sample caused the solution to turn pink, confirming a shift to basic pH due to the neutralization of carbonic acid; the  $CO_2$  concentration was not measured in this step. The results obtained from this experiment are as follows

No Treatment Observation Concentration (colour)

25 mL seawater + 4 drops of phenolphthalein

Table 1. Observation Results

0.44 ppm

Clear

Pink

## 3. Discussion

1

2

+ 5 mL NaOH

Carbon dioxide  $(CO_2)$  plays a crucial role in aquatic ecosystems, functioning both biologically and chemically. Structurally,  $CO_2$  consists of one carbon atom covalently bonded to two oxygen atoms. In natural waters, its primary sources include respiration by aquatic organisms, decomposition of organic matter, and atmospheric diffusion. Additionally, anthropogenic activities, such as industrial emissions, agricultural runoff, and combustion processes, including forest fires and fossil fuel utilization, contribute significantly to  $CO_2$  levels in aquatic environments [8]. In aquatic ecosystems, phytoplankton and aquatic plants utilize  $CO_2$  during photosynthesis, converting it into organic compounds vital for sustaining the food web [9]. The carbon cycle in aquatic systems is intricately linked to biological processes, characterized by the release of  $CO_2$  through respiration and decomposition, its uptake by photosynthetic organisms, and various chemical transformations. One notable transformation in this process is the formation of carbonic acid  $(H_2CO_3)$ , which subsequently dissociates into bicarbonate  $(HCO_3^-)$  and carbonate  $(CO_3^{2-})$  ions. These bicarbonates serve as a carbon source for autotrophs like algae, promoting primary productivity within these ecosystems [10], [11].

In the experiment reported, a 25 mL water sample was analyzed for  $CO_2$  concentration using phenolphthalein as an indicator. The sample remained clear, indicating the presence of free  $CO_2$ . Upon titration with sodium hydroxide (NaOH), the solution turned pink, confirming the presence of carbonic acid. The calculated  $CO_2$  concentration was found to be 0.44 ppm, which may be below the minimum recommended level of 2 ppm needed to support optimal photosynthesis and growth in aquatic organisms [12]. This low concentration suggests a state of carbon limitation within the water body, potentially hindering photosynthetic activity and impacting oxygen production and nutrient cycling, both essential for sustaining aquatic life. The interplay between  $CO_2$ , temperature, and salinity is also notable, as higher  $CO_2$  concentrations are often recorded with increased temperature and salinity. Such conditions generally result in lowered dissolved oxygen (DO) levels, primarily due to the decreased solubility of gases like oxygen at higher temperatures and salinities. This inverse relationship intensifies competition among aquatic organisms for oxygen, raising the risk of hypoxic conditions [12]. Moreover, elevated  $CO_2$  levels may lead to reduced water pH, potentially harming marine organisms and disrupting their metabolic and enzymatic functions.

Conversely, moderate levels of  $\mathrm{CO}_2$  are beneficial, as they facilitate bacterial decomposition of organic matter, thereby supporting nutrient cycling within the ecosystem. Consequently, maintaining balanced  $\mathrm{CO}_2$  concentrations is imperative for the health of aquatic ecosystems, ensuring both biological productivity and ecological resilience [12]. In conclusion, the experimental finding of 0.44 ppm  $\mathrm{CO}_2$  suggests a carbon-deficient state in the tested water sample, which poses potential challenges to biological productivity and overall ecosystem function. Regular monitoring of  $\mathrm{CO}_2$  levels, in conjunction with measurements of  $\mathrm{DO}$ , temperature, and salinity, remains essential for evaluating aquatic health and identifying any stressors or imbalances impacting water bodies [9], [8].

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## 4. Materials and Methods

#### 4.1. General Experiment

The experiment was conducted at the Lhok Mata Ie, Aceh Besar Coastal to reflect natural marine conditions. The purpose of this experiment is to determine the relationship between the solubility of carbon dioxide  $(CO_2)$ , temperature, and salinity in aquatic environments.

## 4.2. Experimental Method

Three Erlenmeyer flasks are prepared. A total of 25 ml of seawater is measured and placed into each 50 ml Erlenmeyer flask. The salinity and temperature of the seawater sample in the first flask are measured. Next, 3–4 drops of phenol-phthalein indicator are added to detect the presence of  $CO_2$ , and the color change is observed. If the seawater turns pink, the experiment is considered complete. However, if it remains colorless, the procedure continues with titration using NaOH. The concentration of  $CO_2$  in the seawater sample is then recorded.

### 4.3. Data Analysis

The calculation for determining CO<sub>2</sub> concentration using NaOH titration is as follows:

$$CO_2 = \frac{Vtitran \times Ntitran \times 22}{Vsample}$$

 $V_{\text{titrant}}$  = volume of titrant (NaOH) used (mL)

 $N_{\text{titrant}}$  = normality of the titrant (N)  $V_{\text{sample}}$  = volume of the sample (mL)

## 5. Conclusions

The results of this experiment indicate that the concentration of carbon dioxide  $(CO_2)$  in the Alue Naga seawater sample was 0.44 ppm, which is categorized as low. In aquatic environments, the minimum  $CO_2$  concentration required is 2 ppm to support normal biological processes, particularly photosynthesis. The  $CO_2$  concentration should not exceed 15 ppm, as excessive amounts can become toxic and lead to respiratory competition among aquatic organisms, potentially resulting in mortality. The relationship between  $CO_2$ , temperature, salinity, and dissolved oxygen (DO) demonstrates that when  $CO_2$  levels are high, both temperature and salinity tend to increase, while DO levels decrease. Furthermore, insufficient  $CO_2$  in water can disrupt the photosynthetic process in aquatic plants and phytoplankton, thereby slowing their growth and reducing the overall productivity of the ecosystem.

**Author Contributions:** I.I and S.S contributed to the conceptualization of the study. Methodology, formal analysis, investigation, data curation, visualization, and original draft preparation were performed by I.I. Validation was carried out by I.I, and S.S. All authors have read and agreed to the published version of the manuscript

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