## 1.3) INSTRUCTOR'S GUIDE TO WATER SAMPLE ANALYSIS

**Overview:** Alkalinity and hardness can be tested easily with test strips containing multiple tests, but it is better to test pH separately for greater accuracy.

Carbon dioxide (responsible for the gas in sparkling water) lowers pH on the basis of the following reversible reactions:

$$H_2O + CO_2 \leftrightharpoons H_2CO_3 \leftrightharpoons H^+ + HCO_3^-$$

Boiling increases the pH of carbonated water because it removes most of the dissolved carbon dioxide that is responsible for the formation of carbonic acid.

Alkalinity, pH, and hardness can be tested conveniently with colorimetric testing strips that are commonly available at pet shops. Unfortunately, colorimetric test strip readings for pH and alkalinity from these kits are often vague and inaccurate. Liquid colorimetric pH indicators the involve dropper bottles are more accurate. These pH indicators can also be used for an alternative method for measuring alkalinity that involves counting the drops of 0.1M hydrochloric acid needed to lower the pH of a 10 mL portion of your sample. Based on this titration" strategy, 1, 3, and 9 drops were needed to acidify distilled water, tap water, and seawater (See table). For sodium bicarbonate solution you will need more than 1000 drops of this titrant to change the pH (students need not exceed 100 drops to understand this). This titration strategy is explained in detail in Lab Exercise 2.3.

If you do not have a conductivity meter you can measure conductivity by passing a 9-12 volt current through your solution and using a multimeter to measure the amps passing through the solution (data on second table below). During the process of electrolysis hydrogen bubbles appear at the anode (black electrode). The composition of the gas bubbles that appear on the cathode depend on the composition of the electrolytes (chlorine in the presence of chloride salts, oxygen in the presence of most other electrolytes). I recommend graphite electrodes because they do not get corroded during electrolysis. An added bonus to this method is that the hydrogen bubbles produced during electrolysis give students a real-time visual on how much current is passing through the solution. Do not use more than 9-12 volts!

**Sample Results for Prepared Solutions**

| Solution | Specific Gravity in ppt* | Conductivity in microSiemens per Cm | Hardness in ppm | Alkalinity in ppm | pH |
|---|---|---|---|---|---|
| Distilled | 0 | 19 | 0 | 0 | 8 |
| Tap | 0 | 449 | 120 | 120 | 8 |
| Fresh Sparkling | N/A | 773 | 300< | 120 | 5 |
| Boiled Sparkling | 0 | 821 | 300< | 120 | 8 |
| SW aquarium | 35 | 60,000 | 300< | 300< | 8 |
| Sugar Solution | 15 | 29 | 0 | 0 | 7 |
| $NaHCO_3$ Solution | 9 | 29,000 | 0 | 300< | 8 |
| $MgSO_3$ Solution | 9 | 17,000 | 300< | 40 | 8 |

**Sample Results Using Alternate Methods**

| Solution | Conductivity (amps) | Alkalinity (drops HCl) |
|---|---|---|
| Distilled | 0 amps | 1 drop 0.1 M HCl needed to acidify 10 mL sample |
| Tap | 0.006 amps | 2 drops 0.1 M HCl needed to acidify 10 mL sample |
| SW aquar. | 0.56 amps | 9 drops 0.1 M HCl needed to acidify 10 mL sample |

**Sample Results for Natural Waters**

| Sample | Turbidity (JTU) | Phosphate (ppm) | Nitrate (ppm) | BOD ($\Delta O_2$ ppm) |
|---|---|---|---|---|
| FW aquarium | 0 | 10< | 20 | N/A |
| 1 (pond A) | 40 | 0 | 0 | 5.2 |
| 2 (pond B) | 60 | 5 | 0 | 6.7 |
| 3 (pond C) | 20 | 0 | 0 | 5.5 |
| 4 (creek A) | 0 | 0 | 20 | 1.5 |
| 5 (creek B) | 10 | 0 | 0 | 0.7 |
| 6 (Lake) | 30 | 0.25 | 0 | 3.9 |

**Answers to Questions:** 1) Seawater, due to high concentration of electrolytes. Conductivity is increased by the presence of electrolytes. 2) Distilled water, due to low solute concentration. 3) Sucrose solution and seawater due to their high solute concentrations. 4) Distilled or tap water, but your answer may depend on the sensitivity of your instrument. 5) Not always; this depends on whether or not the solute is an electrolyte. 6) Typically seawater and boiled sparkling water have the highest pH due the presence of basic salts. 7) Fresh sparkling water has the lowest pH due to the $CO_2$. 8) It drives out the $CO_2$. 9) Ponds with high nutrient concentration are more likely to have high turbidity readings during the warmer months. 10) Answers will vary. Ponds that receive large amounts of runoff are more likely to have high turbidity. 11) Pond B, possibly because the pond is eutrophic. 12) Creek B (based on table). 13) Turbidity often does play a large role in BOD due to the phytoplankton. 14) Nutrient pollution the main contributor to algae blooms that result in eutrophication.

**Product Guidelines:** Most testing kits can be purchased at an aquarium store. For guidelines on the oxygen meter see the "Instructor's Guide" for Lab 1.2.

**Logistics:** In order to complete everything other that BOD in one period, you can have different groups carry out different tests.

**Degree of Difficulty:** 2—This lab is fairly easy to do. Most of the instructor's work involves preparation of the solutions. Take some sample readings before class to make sure there are no problems with your measurement equipment.

**Materials:** A kit for testing pH, turbidity, alkalinity, and hardness; a conductivity meter; an aquarium hydrometer (for testing salinity by means of specific gravity); and screw-top 100-200-mL bottles with plastic caps (no metal) for BOD.