Buoyancy Battle

Amount of time demo takes: 3-5 minutes

Try this at home!

Lesson's Big Ideas

- The beverage cans are the same volume, but depending on the ingredients of the liquid inside them, their densities can vary.
- Cans of regular soda contain a lot of sugar and thus are usually more dense than water, so they sink. Diet sodas, use artificial sweeteners, and require fewer grams of the sweetener to achieve the same taste (see below for more info about the densities of each!).

Materials

- Clear tank (ex. a 10-gallon fish tank)
- Enough water to fill the tank
- Canned beverages with various sugar contents
    - 2 Coke, 2 Diet Coke, 2 Coke Zero
    - Other recommended beverages: Mountain Dew, Lemonade, bottled water
- Optional:
    - Water resistant gloves for volunteer
    - 20-30 sugar packets
    - Digital scale (grams measurement scale)
    - Small container to hold sugar packets
- Towels (to dry the table)

SAFETY!

- Clean up any spills as they occur!

Background Information

- More dense objects will sink and less dense objects will float in water.
- It is also very interesting to note that if you trap an air bubble under the bottom of the can when you put the 'regular'/non-diet cans into the tank, the can will float. The buoyant force of the air bubble offsets, almost exactly, the additional density of sugar.

- $density = (mass/volume)$
- Densities:
    - Sodium: 0.968 (g/cm^3)
    - Glucose ($C_6H_{12}O_6$): 1.1 (g/cm^3)
    - Water (H_2O): 1.0 (g/cm^3)
    - Aspartame (artificial sweetener) ($C_{14}H_{18}N_2O_5$): 1.35 (g/cm^3)
        - Again: Cans with “normal” sugars require a lot of sugar to make the drink tasty - there’s so much in it that the drink becomes more dense than the water. Even though aspartame is more dense than glucose, the drink requires a lot *less* of the sweetening agent to achieve the taste. So, there isn’t much in the beverage to make it very dense overall.
- Molar Masses
    - Sodium (Na): 23g/mol
    - Glucose ($C_6H_{12}O_6$): 180g/mol
    - Aspartame (artificial sweetener) ($C_{14}H_{18}N_2O_5$): 294.303 g/mol
    - Sucrose (sugar) $C_{12}H_{22}O_{11}$: 342.296 g/mol

Setup Instructions

1. Fill tank with water
2. Place one set of the cans (one each of a standard, diet, and zero sugar beverages) on the table for students to arrange, and the other set near you to place in the fish tank.
3. Optional: Sugar content activity
    a. Method 1: Prepared Sugar Content (best for busy events)
        i. Check the nutrition facts to see how many grams of sugar are in one can of full-sugar soda.
        ii. Calculate how many packets of sugar are consumed when drinking a can of ‘regular,’ full-sugar soda (the sugar packets contain 3.5 grams each).
        iii. Put the equivalent amount of sugar packets in the container to show students after they see that a can of regular soda sinks to the bottom of the fish tank.
    b. Method 2: Students calculate sugar content (best for small groups or classrooms)
        i. Set out a handful (20 - 30 packets) of sugar packets
        ii. Set out digital scale in grams measurement setting

iii. After the demonstration, have the students put the sugar packets on the scale to determine the equivalent amount of sugar in the soda.

Instructional Procedure

1. Have students make a prediction:
    a. Hold up a can of regular (full-sugar) soda and ask the students if they think it will float when placed in water. Have them give their input and explain why they choose the way they do. OR,
    b. Have the students select which cans will float and sink out of the set of the cans in front of them.
2. Have them put a can of regular soda in the water (it will sink). Repeat with a different kind of regular (full-sugar) soda, then with diet soda, etc.

3. Discuss any patterns they see. Did certain kinds of beverage sink more often? Why do some float?
4. Take the cans out of the water and compare what is different between the drinks, especially between diet and non-diet beverages. The main difference will be the amount of sweetening agent in each.
    a. Cans with “normal” sugars will sink because it requires a lot of grams of sweetener to make the drink tasty - there’s so much in it that the drink becomes more dense than the water.
    b. Cans with artificial sweeteners taste the same, but they require a lot less of the sweetening agent to achieve the taste. So, even though the sweeteners themselves are very dense, there isn’t much in the beverage to make it very dense overall.

    Make sure to take the cans out of the tank for the next group of students.
5. Optional: Have students guess how many packets of sugar are in one ‘regular’ can of soda. Reveal the number of packets in the jar (Method 1) or have them weigh out the equivalent weight on the digital scale (Method 2). They (and their parents!) will probably be surprised at how

much sugar is consumed by drinking just one can of 'regular' soda.

Assessment Questions

1. Do you think the can will sink/float and why?
2. Why does the regular soda can sink?
    a. It's full of sugars! Even though sugar isn't super-dense, there's so much of it that the drink becomes more dense.
3. Why does the diet soda can float?
    a. It takes very little artificial sweetener to make a drink tasty. So, it's not as "heavy"/dense as a full-sugar drink.
4. What do you think about the amount of sugar that is in a can of pop?

Careers & Real-World Applications

- Engineer: it's important for engineers to know the densities of materials they are working with.
- Chemist: different chemicals have different densities.When you make compounds of certain chemicals their densities may change.
- Dietician or Nutritionist: These professionals help individuals make better nutrition choices to lead healthier lives

Clean Up

- Remove cans from tank, put lid on container of sugar packets, dry off table if it gets too wet.
- At the end of the day
    - Remove cans from tank and dry them off, then put them in the bin.
    - Put all sugar packets into the container and put the lid on.
    - Dump the water out of the tank and dry it out.
- When completely finished gather all materials listed for this demonstration and make sure everything is accounted for. If something was used up, broken or damaged, let someone know so it can get replaced or fixed.

References

- http://scifun.chem.wisc.edu/homeexpts/cans.htm
- http://www.youtube.com/SpanglerScienceTV#p/u/87/MzsORE0ae10
- Formulas and molar masses calculated using WolframAlpha

Related Next Generation Science Standards

- K-5
    - 2-PS1 Matter and Its Interactions
- 6-8
    - MS-PS1 Matter and Its Interactions