Is the Heat Capacity of Ocean Water Affected By Salinity?

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Abstract

In an article in the *Times Colonist* on Wednesday January 11th, 2006, geologist Jim Teller states that the prehistoric Lake Agassiz, a massive freshwater reservoir, had gushed into the Arctic and Atlantic oceans, "[playing] havoc with ocean circulation patterns and salinity levels."

In light of the impending melting of the ice cap – which would include a large influx of fresh water and sediments into the oceans, the salinity of the oceans would once again be altered. This experiment set to investigate how salinity levels affected the specific heat capacity of water – which play a large factor in the direction of warm and cold water currents. Ocean water was collected from Oak Bay Beach on Vancouver Island, its specific heat capacity was then determined, along with different dilutions of the liquid, in an effort to find out how the ocean currents may be affected in such a time when salinity levels would be changed. Although our results were subject to some error, it was discovered that as the salinity increased, the specific heat capacity decreased - however, there is a point where both the specific heat capacity (SHC) and salinity increased.

Hypothesis

We believe that in increasing the salinity in the water, its SHC will increase – and similarly, the SHC will decrease as the salt water is diluted (as many relationships in science are linear).

Methods

By using the principles of Heat loss = Heat gain, and using this formula:

$(mc\Delta t\text{lost-})_{Fe} = (mC_{unkown}\Delta t_{gain})_{liquid} + (mc\Delta t_{gain})_{calorimeter}$

$$C_{liquid} = \frac{(mC\Delta t_{lost}\text{--})Fe - (mC\Delta t_{gain})_{calorimeter}}{(mC\Delta t_{gain})_{liquid}}$$

C = the specific heat capacity

Δt = temperature change

m = mass

Mass of calorimeter: 0.02297 kg

Mass of nut: 0.05025 kg

CAl: 903 kg-1Co-1

CFe: 450 kg-1Co-1

Procedure

Step 1 Obtain ocean water (we took a sample from Oak Bay Beach)

Step 2 Make dilutions using distilled water

Step 3 Heat metal nut in boiling water

Step 4 Take the temperature of water sample (in calorimeter)

Step 5 Place heated nut into water

Step 6 Record change in temperature

Repeat procedure for 5 different dilutions

- 30 ppt dilution of salt water
- 60 ppt concentration of salt water (via evaporation – using a hot plate)
- 15 ppt ½ dilution of salt water
- 7.5 ppt ¼ dilution of salt water
- Distilled water

Left: Calorimeter and nut used for heating

Right: Thermometer in calorimeter

Observations

DATA

Mass of calorimeter (cal.): 0.02297 kg

Mass of nut: 0.05025

C_{Al}: 903

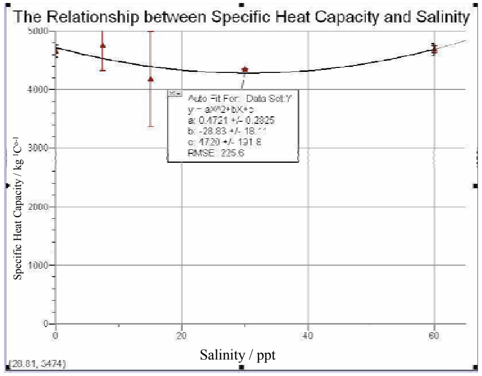
C_{Fe}: 450

Trial	Initial Temp of cal. and liquid /°C	Temp of nut /°C	Final temp of cal. and nut /°C	Mass of water and cal /kg	Mass of water /kg
1-Distilled water (100mL)	20.5	99	24	0.12341	0.10044
2-Distlled water (100mL)	20.5	102	24.2	0.11978	0.09681
3-60ppt salt water (50mL)	20.5	102	27	0.07361	0.05064
4-60ppt salt water (50mL)	26	102	32.2	0.07354	0.05057
5-30ppt salt water (100mL)	19.5	102	23.5	0.12069	0.09772
6-30ppt salt water (100mL)	20	102	24	0.11958	0.09661
7-15ppt salt water (100mL)	20.6	102	24.5	0.1263	0.09766
8-15ppt salt water (100mL)	20.5	103	24.7	0.12331	0.10034
9-15ppt salt water (100mL)	20.5	101	24.3	0.12783	0.10486
10-7.5ppt salt water (100mL)	20.2	102	24.2	0.11983	0.09686
11-7.5ppt salt water (100mL)	20.5	102	23.9	0.11924	0.09627

Calculations

Trial	Specific heat capacity /$kg^{-1}C^{o-1}$
1 (distilled water)	4617
2 (distilled water)	4697
Average of Distilled water	4657 ± 40
5 (60ppt [50mL])	4743
6 (60ppt [50mL])	4624
Average of 60ppt	4683 ± 59
3 (30ppt)	4340
4 (30ppt)	4349
Average of 30ppt	4345 ± 5
7 (15ppt)	4388
8 (15ppt)	3995
9 (15ppt)	4155
Average of 15ppt	4179 ± 816
10 (7.5ppt)	4320
11 (7.5ppt)	5173
Average of 7.5ppt	4748 ± 428

Conclusions



This experiment contained numerous sources of error (see discussion). Thus, it is extremely hard to predict the exact impact salinity would have on the specific heat capacity of ocean water. Nonetheless, we can hypothesize, from our results that to a certain extent the lower the salinity, the lower the SHC, up until a specific point, in which the specific heat capcity began to rise along with salinity. Nonetheless, substances with a lower specific heat, such as the diluted samples of salt water, would require less energy to increase its temperature. One can see from the graph and data, it is hard to predict this change and thus we cannot accurately project potential change.

Discussion

Due to numerous sources of error, such as heat loss (due to the inability to create an airtight atmosphere) it is extremely hard to predict the exact impact salinity would have on the specific heat capacity of ocean water. However, given the fact that salinity does in fact affect heat capacity, the relationship can be applied to predicting the ramifications of the polar ice cap's melting. Many currents would be affected, including those off of western Canada: the Alaska, the Bearing, and the North Pacific Drift. One possibility is that it would take less heat to warm the water the SHC having been decreased – affecting the latent heat effect that heavily influences coastal towns around the world. As well, as the SHC declines, it diminishes the ocean's ability to retain heat, ergo the ocean waters would be colder.

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