

## Year 10 Investigation

### What Makes Ice Melt Fastest?

By Rebecca Hogan

**MY WEBSITE:** <http://whatsubstancemeltsicefastest.weebly.com/>

#### Nature of Investigation:

What keeps us cool on hot days? What is used in our cool, refreshing beverages? ICE What is used when we injure ourselves and we want to stop swelling, bruising or used to numb the pain? ICE However, Ice will eventually melt.

Don't you love a refreshing beverage on a hot summer's day or when you're hot and bugged after an intense workout? I know I do. But don't you hate it when you look in your cup and your ice has melted. Have you ever wondered if different substances melt your ice faster than others and if some substances actually keep ice cooler for longer? Well, in this investigation we will find out what common substances will affect the rate at which ice melts.

#### Background Research:

**Ice** - A phase change is when a substance changes from one state of matter to another. Ice is a phase change of water. When water, the liquid form of H<sub>2</sub>O, reaches a cold enough temperature (usually 0°C) it freezes and goes from liquid state into solid state. This phase can be reversed. When a solid turns to a liquid, it goes through a phase change called melting. The normal freezing point of water is 0 degrees Celsius, so if the temperature is above that then ice will melt.

**Salt** - If you live in an area where there is ice or snow on the roads, you have probably seen salt spread on the roads to melt the ice. This is because salt is used to melt ice/snow and keep it from freezing. Salt is also used in making home-made ice cream. In both of these cases, salt is used to lower the melting or freezing point of water. Ice forms when water reaches 0°C but when you add salt that temperature drops. (E.g. A 10% solution freezes at -6°C and a 20% solution freezes at -16°C). Salt dissolves into the water of the ice and lowers the freezing point so you can melt it. The term for this effect is "freezing point depression".

**Sand** – Sand can melt ice if heated from the sun or by a warm temperature. Like any other substance that is warmer than ice, the substance may heat the ice, causing it to melt. The actual texture of sand does not cause ice to melt. However, sand can cause the ice to melt faster if it was placed in direct sunlight as sand heats up very quickly, acting as a warm blanket on the ice. The direct sunlight on ice does not have as good an effect, as ice reflects light off its surface and doesn't absorb it very well.

**Sugar** – Sugar and anything else capable of being dissolved in water will melt ice. Sugar melts ice by lowering water's melting and freezing points, just like salt. Sugar dissolves on ice and interferes with the water molecules. The water molecules are needed to bind the ice crystals in order for it to freeze. The presence of sugar requires a much lower temperature before the water molecules come into contact with the ice crystals. With that said, sugar will melt ice but is not as effective as salt because salt breaks down into sodium and chloride ions so when one molecule of salt dissolves into the ice, it will add two components to the solution which provide more interference in preventing the water molecules from freezing.

**Coffee** - "Anything that is capable of dissolving in water will melt ice." Like salt and sugar, instant coffee granules are also capable of dissolving in water, so therefore it is capable of melting ice. The freezing point of a solution is always lower than the freezing point of the pure solvent so the freezing point of a solution, where you have solute masses (e.g. sugar, instant coffee granules) in a pure solvent (e.g. water), is less than 0°C.

**Soil** – Soil does not dissolve in water so it will not melt ice. It has no properties that will affect how ice melts and will not speed up or slow down the process of melting ice.

**Cotton** – Cotton has air pockets as cotton molecules are made up of long, twisted chains of cellulose twisted together and leaves spaces that hold air. When these fibres of long molecules are twisted further to be woven into a cloth, more air is held. The pockets of air capture heat from the body and slow down its radiation into the environment, but can also do the opposite where it can insulate the skin against hot environments whilst absorbing moisture. This goes the same for cotton on ice. When cotton is placed on ice, its air pockets are used and can insulate the ice, keeping it cooler for longer (also absorbing the water) and it will trap the warmer temperature away from the ice, acting as a barrier between the air and the ice.

**Conclusion:** Salt and sugar both causes freezing point depression, therefore making the ice melt faster, however salt is more effective as salt dissolves into two components and creates more interference in preventing water from freezing. Sand melts ice by absorbing heat which will bring it to a higher temperature than ice, causing it to melt. Soil has no effect on ice whatsoever and cotton will serve as an insulator, acting as a barrier between the ice and the warmer temperature so the ice will stay cooler for longer.

## **Planning Log:**

2/08/2014 – Nature of investigation was written up, Background Research was started

3/08/2014 – Background Research was completed (Effects of Each Substance on Ice), Materials were confirmed available

9/08/2014 – Experiment was Conducted, Results Recorded, Pictures Taken

10/08/2014 – Formal Experiment Was Recorded (Aim, Hypothesis, Materials, Method, and Results Table)

13/08/2014 – Formal Experiment Continued (Results were Graphed, Conclusion)

14/08/2014 – Reflection, Discussion

15/08/2014 – Risk Assessment, Variables (Dependent and Independent), Experimental Controls, Validity, Reliability

16/08/2014 – Weebly Website Started

17/08/2014 – Weebly and editing

20/08/2014 – Bibliography, Photo Uploads, Weebly was completed and word document was converted to PDF format

## **Risk Assessment:**

- Ice is very cold and can cause frostbite. In order to eliminate this risk, gloves are recommended and it is recommended not to hold ice for a long period of time to prevent hands from freezing.
- Water is extremely slippery. To avoid causing slippery accidents like someone slipping over on the floor and getting hurt, make sure not to get the floor wet. When the ice melts, the water must be carefully poured down the drain. If it is accidentally spilt, make sure to mop it up immediately.
- Plates made out of glass or ceramic can crack if dropped. The shards are very sharp and can cut easily. To prevent this risk, handle with care, wear protective gear such as gloves and apron and be aware of your surroundings (so as not to bump into things). If plate is dropped, keep clear and ask adult for help to clean up immediately.
- If one has a wound, be aware not to get substances in the wound. Salt will cause wound to sting and substances like soil and sand may infect wound. To eliminate these risks, be aware of wound and cover it up accordingly. E.g. If wound is on hand, wear gloves.
- Wear enclosed leather shoes to cover up feet in case something heavy is dropped on toes (e.g. the block of ice)
- To avoid substances coming in contact with eyes (eg sand getting in eyes) wear goggles.

## **Variables:**

### **Independent Variables:**

The independent variable is the variable that is being changed in the experiment to test the effects it has. It is varied during the experiment and is what the investigator thinks will affect the dependent variable. In this experiment, the independent variables are the substances being tested (salt, sand, sugar, soil, cotton, coffee). These substances are used to see if they will cause a different outcome for the experiment.

### **Dependent Variables:**

The dependent variable is the variable that 'depends' on the independent variable. It is the variable that is being tested and measured. It is what the investigator thinks will be affected in the process of the experiment and it is this variable that will be observed and recorded. The dependent variable in the experiment is the weight of the blocks of ice. The weight of the block of ice is dependent on what independent variable (substance) was being tested on that block. The weight is the measurement that is observed throughout the experiment and recorded.

### **Experimental Control:**

A control is a group that is separated from the rest of the experiment so the independent variable being tested may not influence the results of the control. The control is used to compare with the experimental results to find explanations of the results found. The experimental control in this experiment was the block of ice that was a pure solution with no added substances or external factors that changed it or how it melted.

### **Validity and Reliability:**

In order to ensure validity, the test was conducted with the only change being the independent variable (substances tested). The independent variable was only changed one at a time and everything else remained the same. Therefore all factors were kept constant except those that were being investigated (the independent variables – salt, sand, sugar, etc.).

The reliability of the experiment was ensured as each substance was tested three times and the average of the tests carried out was calculated to give a more accurate and reliable result. The unit of measurement used to record the data was in percentage form as 'percentage' is a ratio expressed as a fraction of 100. By using percentage, we take into account the original weight of the block of ice to ensure fairness among the results. This way, it may eliminate the effects the different original weights of the blocks of ice have on the results. There were no bias factors or interference to give an inaccurate result either.

## **FORMAL EXPERIMENTAL RECORD**

**Aim:** To determine which of the added materials melts ice the fastest.

**Hypothesis:** The salt will be the substance that melts ice the fastest.

### **Materials:**

- Pencil and paper
- Blocks of Ice (21 blocks)
- Plates (identical)
- Measuring Spoon (Tablespoon)
- Timer (or clock)
- Scales
- Syringe
- Materials to test for insulating properties/freezing point depression:
  - Sand
  - Salt
  - Sugar
  - Coffee
  - Cotton wool
  - Soil

### **Method:**

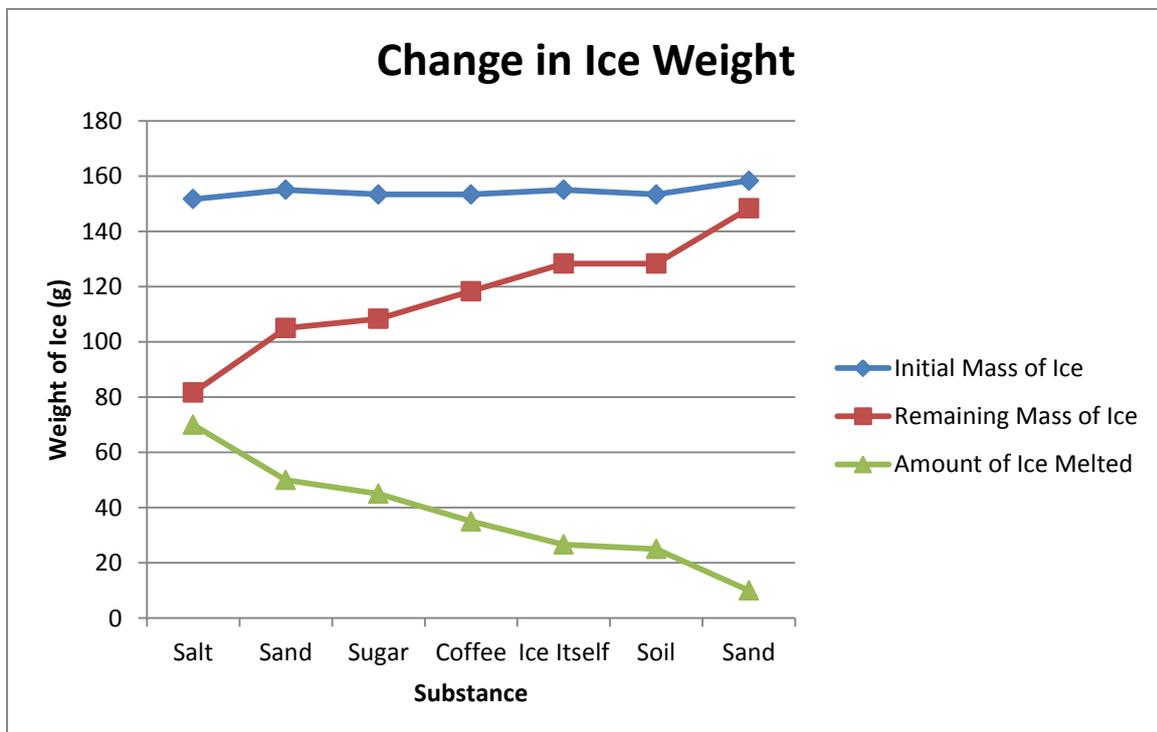
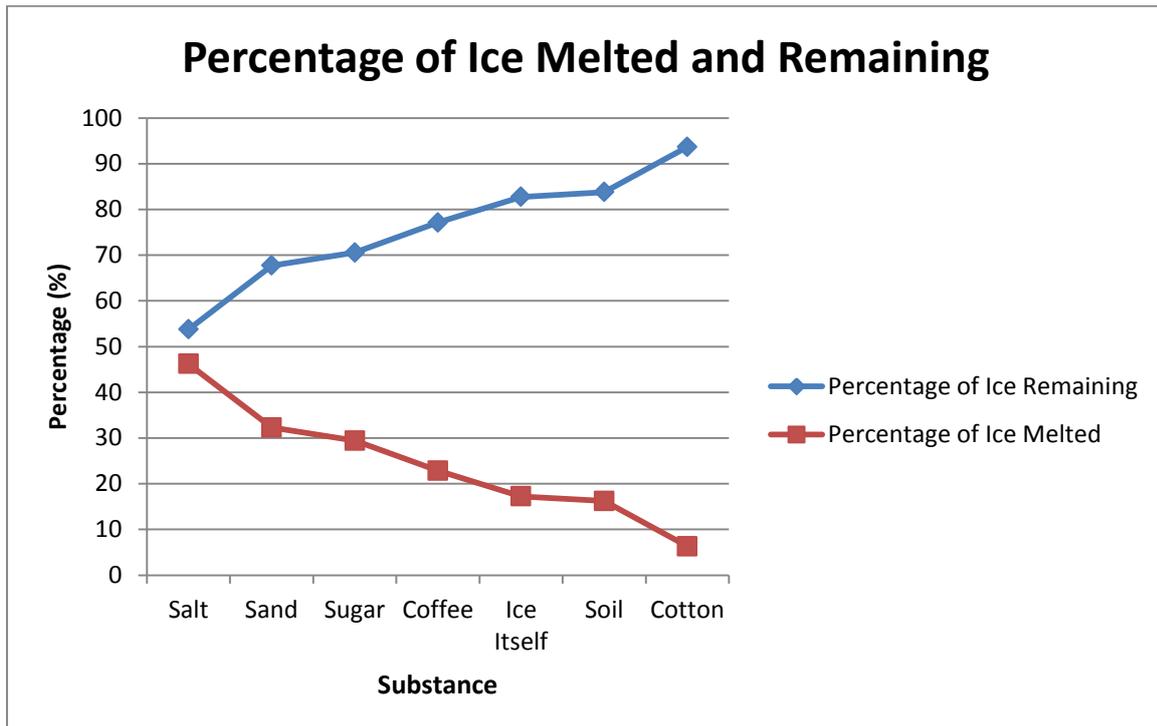
- 1) The block of ice was measured using the scale to find the initial mass of the ice cube and the ice was then placed on a plate.
- 2) The timer was started immediately as one tablespoon of the substance was sprinkled evenly on the block of ice.
- 3) As the time went on, a syringe was used to extract all the melted water.
- 4) After a period of one hour, the remaining block of ice was placed on the scales, weighed and the results were recorded.
- 5) The above method was repeated for each substance tested until three results were obtained for each test.
- 6) The control was tested by following the same procedure except the ice was left in its pure state without any substance added to it. This was tested three times.
- 7) For each test, the percentage of the ice remaining was calculated:  
(Remaining mass of ice cube)/ (Initial mass of ice cube) X 100
- 8) The results were recorded into a table and graphed.

## Results:

### Table

Substance	Trial No.	Initial Mass of Ice (g)	Remaining Mass of Ice (g)	Ice Remaining (%)	Ice Melted (%)
<b>Salt</b>	1	145	75	51.724	48.276
	2	160	90	56.25	43.75
	3	150	80	53.333	46.667
	<b>Average</b>	<b>151.667</b>	<b>81.667</b>	<b>53.769</b>	<b>46.231</b>
<b>Sand</b>	1	150	100	66.667	33.333
	2	160	110	68.75	31.25
	3	155	105	67.742	32.258
	<b>Average</b>	<b>155</b>	<b>105</b>	<b>67.720</b>	<b>32.280</b>
<b>Sugar</b>	1	150	105	70	30
	2	165	120	72.727	27.273
	3	145	100	68.966	31.034
	<b>Average</b>	<b>153.333</b>	<b>108.333</b>	<b>70.564</b>	<b>29.436</b>
<b>Coffee</b>	1	160	125	78.125	21.875
	2	145	110	75.862	24.138
	3	155	120	77.419	22.581
	<b>Average</b>	<b>153.333</b>	<b>118.333</b>	<b>77.135</b>	<b>22.865</b>
<b>Ice Itself</b>	1	160	135	84.375	15.625
	2	155	130	83.871	16.129
	3	150	120	80	20
	<b>Average</b>	<b>155</b>	<b>128.333</b>	<b>82.749</b>	<b>17.251</b>
<b>Soil</b>	1	160	130	81.25	18.75
	2	145	125	86.207	13.793
	3	155	130	83.871	16.129
	<b>Average</b>	<b>153.333</b>	<b>128.333</b>	<b>83.776</b>	<b>16.224</b>
<b>Cotton</b>	1	160	150	93.75	6.25
	2	155	145	93.548	6.452
	3	160	150	93.75	6.25
	<b>Average</b>	<b>158.333</b>	<b>148.333</b>	<b>93.683</b>	<b>6.317</b>

## Graphs



## **Conclusion:**

In the same period of time, the substance 'salt' melted the ice the fastest of the 6 substances. It melted 46% of the ice over a period of one hour and sped up the process of melting ice by around 29% on average. Sand was the second fastest substance to melt ice and sped up the process by 15%, closely followed by sugar with a 12% speed up. The substance 'coffee' was not far behind and sped up the process of melting ice by nearly 6%. The soil kept the ice slightly cooler and slowed down the melting process by approximately 1%. Cotton took the longest to melt the ice and kept the ice much cooler. It only melted around 6% of the block of ice over the one hour period and slowed down the melting process by approximately 11%.

From this experiment, we may conclude that freezing point depression properties are present in salt so salt is therefore great at lowering the melting/freezing point of ice. We may also conclude that cotton has great insulating properties and can keep ice in its solid state for longer.

## **Reflection:**

In the experiments, one major problem I faced was that the blocks of ice I froze were a little different. Although I had measured the same amount of water to freeze for each block of ice, the blocks of ice still had different weights. In order to resolve this problem, I decided to change my method of recording data to percentage form. That way, the original weight of the block of ice would be taken into account and therefore the results would be a fair test.

Another problem I faced was the amount of time it took to prepare and conduct the experiment. In order for the blocks of ice to freeze completely, it took over 12 hours and the I had waited 1 hour per block (although some blocks of ice were conducted simultaneously. I can minimise the amount it takes next time by freezing smaller blocks of ice and therefore it would not take as long to freeze or as long to melt, saving me a lot of time.

## **Discussion:**

The knowledge of how different substances may speed up or melt down the process of melting ice can be applied in numerous real life situations.

Firstly, an example of a real life situation where the freezing point depression property of salt is used is when there is a lot of ice/snow on the street and footpaths. In order to clear the ice/snow quickly to make way for cars and pedestrians, salt is spread all over it to melt it.

Another real life situation where salt is used for its freezing point depression property is in home-made ice cream. Salt is added to ice to lower the melting/freezing point of ice in order to freeze the ingredients to make ice cream. Without the effect of freezing point depression, the ice-cream would not have frozen. Watch the video on the right for more detail.

An example of a real life situation where you may use the insulating properties of cotton is whenever you want to keep something cool. E.g. when you have a cold drink and you want to keep it cooler for longer, you can wrap some cotton wool around it and that way, your hands won't get extremely col holding it either. The cotton will trap the heat out and trap the cold in.

## **Bibliography and Photos on Website**