Team First project: Water Tornado experiment

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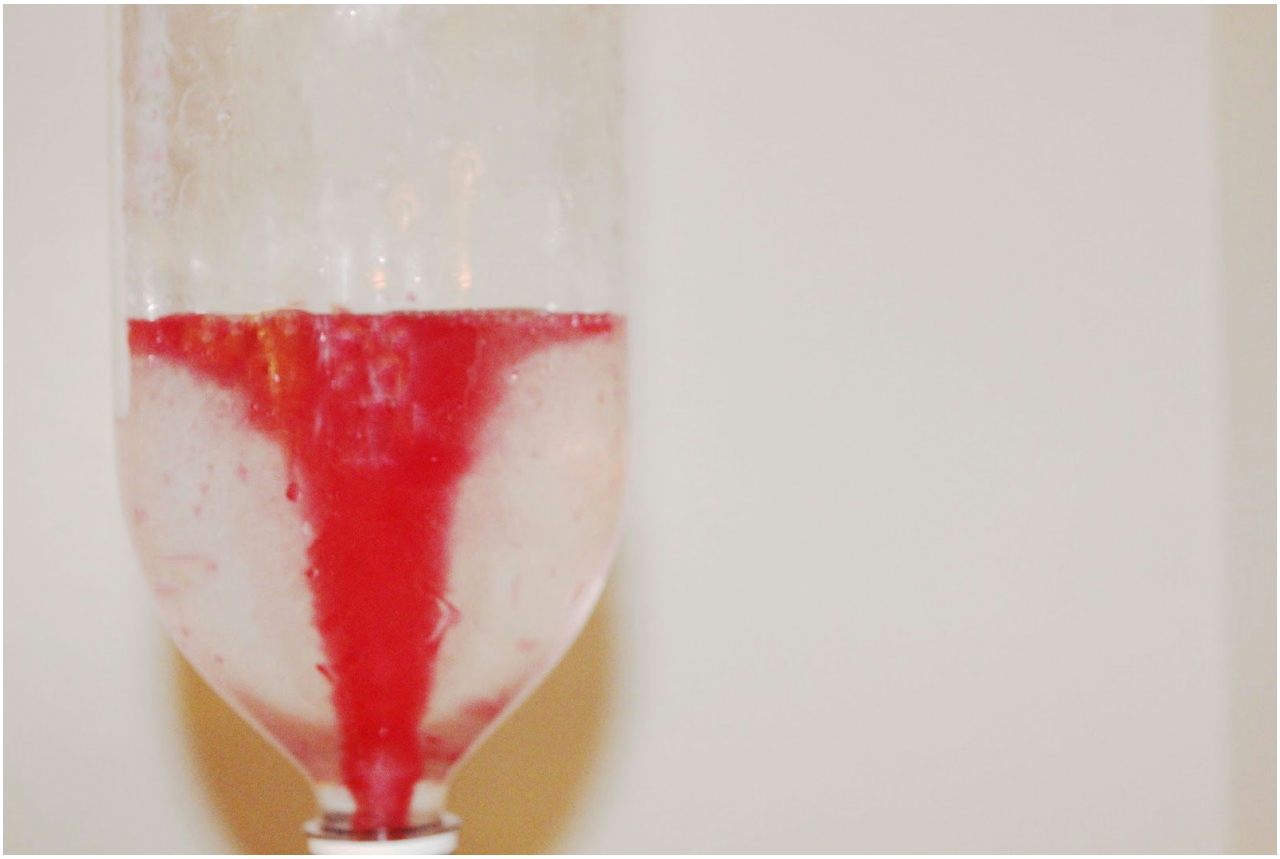

Introduction

For the first team project, I choose to take a photo of water tornado. Since the water vortex is very interested to me and during the class, professor Hertzberg also talked a lot about vortex. The materials required for this experiment is also easy to prepare. So, I decide to do this experiment for my first team project.

Materials

Material	**Amount**
1L water bottles	2 bottles
lamp oil	5 drops (20 ounces)
Water	500 ml
Duct tape or sillicon tape	

Table 1. Materials list

Procedure:

The procedure of the experiment is simple. First of all, fill one of the bottles with ¾ full of water (750ml) and drop about 20 ounces of lamp oil into the water. Then place the second bottle on top of it and use hot glue to attach them. After that, seal two bottles with sillicon tape. After that, flip over the bottom bottle, so that the water-filled bottle is on top and swirl it firmly just like you would spin a hula-hoop. Finally, the water vortex is created and use a camera to take a photo of it. [1]

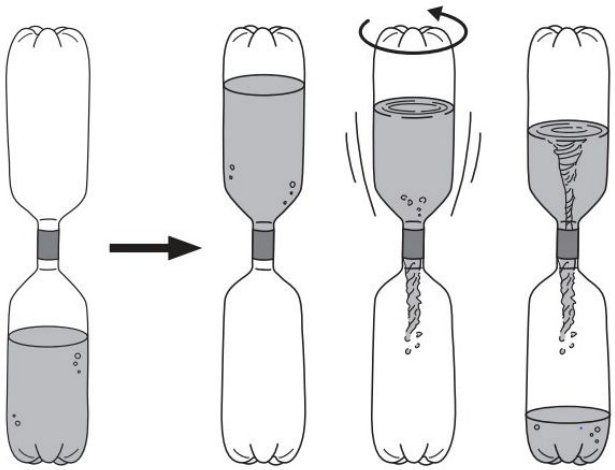

Fig 1. Procedures sketch for vortex experiment

Fluid Dynamics

In general, swirling the water in the bottle while pouring it out causes the formation of a vortex. The vortex looks like a tornado in the bottle. The formation of the vortex makes it easier for air to come into the bottle and allows the water to pour out faster. If you look carefully, there is a hole in the middle of the vortex that allows the air to come up inside the bottle. If you do not swirl the water and just allow it to flow out on its own, then the air and water have to essentially take turns passing through the mouth of the bottle.

When the water is not rotating, surface tension creates a skin-like layer of water across the small hole in the center of the connector.

If the top bottle is full, the water can push out a bulge in this surface to form a bulbaccous drop, which then drops into the lower bottle. As water drops into the lower bottle, the pressure in the lower bottle increases until air bubbles are forced into the upper bottle. The pressure that the water exerts on the surface in the

connector decreases as the water level in the upper bottle drops. When the water level and pressure drop low enough, the water surface can hold back the water and stop the flow completely. If you spin the bottles around a few times, the water in the upper bottle starts rotating. As the water drains into the lower bottle, a vortex forms. The water is pulled down and forced toward the drain hole in the center by gravity. If we ignore the small friction forces, the angular momentum of the water stays the same as it moves inward.[2] This means that the speed of the water around the center increases as it approaches the center of the bottle. (This is the same reason that the speed of rotating ice skaters increases when they pull in their arms.)

To make water move in a circle, forces called centripetal forces must act on the water. These “center-pulling” forces are created by a combination of air pressure, water pressure, and gravity.[3]

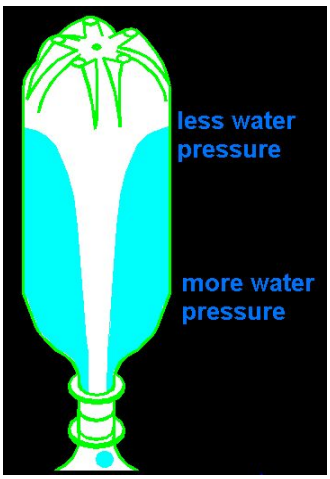

Fig 2. Graphically explanation of the vortex experiment

Camera Settings

The setting of the shutter speed is critical in this experiment, since the water vortex is in motion, which would easily cause the blur of the picture. Also, the Iso is

required to set in a comparatively high value, since in my experiment, the flash light wasn't fired, so that the light sensitivity should be adjusted in a high value.

Camera	Canon EOS Rebel T2i
Shutter Speed	1/200 sec
ISO	3200
Focal length	40mm
Lens	EF-S18-55mm f/3.5-5.6 IS
Resolution	72 Pixel per Inch
Image Size	3456x2304 (pixels)

Table 2. Camera settings

Postprocessing

In photoshop, I used curve tool to adjust the brightness and contrast of the photo. Also, I used lasso tool to erase the oil spot on the surface of the bottle to make the picture clearer. I am pretty comfortable with my post-processing done on this assignment. I think the overall quality of the final image meet my own expectation.

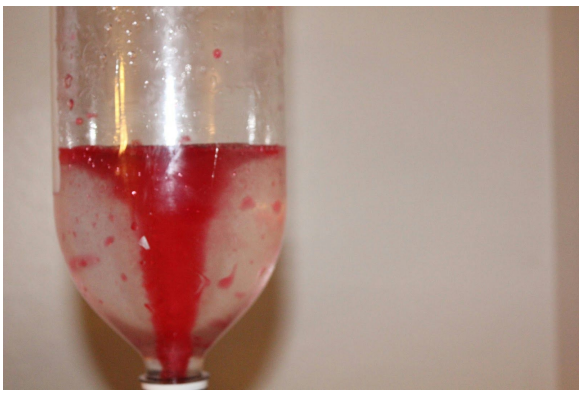

Fig 1. Team 1 original

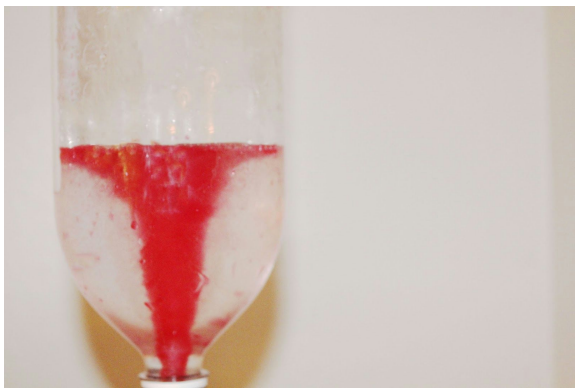

Fig 2. Team 1 edited

Reference

[1]http://www.sciencekids.co.nz/experiments/makeatornado.html
[2]Andrew Selle,Nick Rasmussen,Ronald Fedkiw, A Vortex Particle Method for Smoke, Water and Explosions,ACM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH 2005
[3]JS Turner, DK Lilly - Journal of the Atmospheric Sciences, 1963 - journals.ametsoc.org