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Flow Visualization
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Salt/Freshwater Diffusion

This image came as a result of the first group project in which we experimented with both dyed saltwater diffusing into freshwater and dye diffusing into corn syrup. Originally, we were trying to observe the 'fingering' effect when a lower density fluid diffuses into a higher density fluid. However, as soon as we began experimenting with the salt/freshwater setup, we noticed that there was a whole host of unexpected effects taking place—with most of the interesting things happening after we had left the experiment for long lengths of time. The diffusion of the dyed freshwater into the saltwater provided some incredibly delicate, intricate, and interesting images. Even though the images are very static, they convey a very dynamic feel.

For this project setup, we used the Hele-Shaw cell apparatus, but mainly for its lighting capabilities. On top of the acrylic plate we placed approximately 400 mL of fresh tap water with 200 grams of iodized table salt dissolved into it, and let it pool into a roughly circular shape. Underneath the acrylic plate, we had a high-wattage halogen light. Using a small diameter syringe, we randomly dropped green food coloring into the water, and observed the effects. The freshwater had an approximate depth of 1 cm. The flow speed was incredibly slow, the diffusion of the dye into the water occurred at roughly 0.10 cm/s. When freshwater diffuses into saltwater, the differences in density of the respective fluids combined with the polarity of water produce an effect known as 'upconing'[1], which is similar to 'fingering'. This is what produces the distinctive patterns that you are seen in the image.

The visualization technique used was dye injection. By placing the phenomenon on a flat back-lit plate, very delicate and intricate phenomenon can be visualized. The lighting used was simply the high-wattage halogen light, and no camera flash.

The exposure time was 25/10000ths of a second, the aperture was 63/10, the focal length was 80 mm, the pixel dimensions were 3008 on the x-axis and 2000 on the y-axis, the ISO setting was 400, and the camera was a Nikon D50. The field of view in this image is about 4 cm by 6 cm. The distance from the object to the lens is about 10 cm. The image was converted to black and white, and a curves adjustment was made.

What I particularly like about this image is the strong dynamic feel to it, even though the flow behavior being visualized is almost static. I think that the physics shown are relative to the image—images that better conveyed the physics of the flow did not have nearly the same potential for composition and artistic intent. I think the strong presence of negative space and the symmetry within the pattern of the flow creates a very aesthetically pleasing image. One thing that I did not quite understand about the flow is what created the subtle rippling patterns present in this streak. I'm sure it's due to diffusion, but the specifics did not seem to be addressed on the web-research level. Overall, I fulfilled my artistic intent fairly well with this picture, but I think the physics present could have been better. I think that salt/freshwater diffusion has a lot of potential for the future, and that if I experimented with different densities of saltwater more, I could create some images that were equally artistically pleasing but conveyed more physics information.

References

1. http://water.usgs.gov/ogw/gwrp/saltwater