Household phenomenon observed by Leonardo da Vinci finally explained

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A hydraulic jump is created by water flowing into a sink. Credit: James Niland

An everyday occurrence spotted when we turn on the tap to brush our

teeth has baffled engineers for centuries—why does the water splay when it hits the sink before it heads down the plughole?

Famous inventor and painter Leonardo da Vinci documented the phenomenon, now known as a hydraulic jump, back in the 1500s. Hydraulic jumps are harmless in our household sinks but they can cause violent waves, turbulence and whirlpools in deeper water.

Since the 1820s scientists have believed that hydraulic jumps occur partly as a result of the gravitational pull. But a paper published in the *Journal of Fluid Mechanics* has disproved this longstanding theory.

Rajesh Bhagat, a Chemical Engineering Ph.D. student at St John's College, University of Cambridge, and first author of the paper, fired jets of water upwards and sideways onto flat surfaces, and witnessed exactly the same hydraulic jumps as those when the water flowed downwards.

But what was causing it? Bhagat suspected they could all affected by the same factors—surface tension and viscosity.

By altering these attributes of the water he was able to accurately predict the size of the hydraulic jumps, regardless of which direction the water was moving—debunking the 200-year-old gravitational theory as the cause of a kitchen sink type hydraulic jump. This kind of hydraulic jump is known as a circular hydraulic jump.

Professor Paul Linden, Director of Research at the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge and an author of the paper, described Bhagat's findings as 'ground breaking'.

He explained: "His experiments and theory show that the surface tension

of the liquid is the key to the process and has this has never before been recognised even though the problem was discussed by da Vinci and many others since. This work represents a remarkable achievement in our understanding of the dynamics of thin layers of fluid."

Bhagat predicts that his findings could have wide reaching consequences for industries that have high levels of water consumption.

He said: "Knowing how to manipulate the boundary of a hydraulic jump is very important and now with this theory we can easily extend or reduce the boundary.

"Understanding this process has big implications and could reduce industrial water use dramatically. The new theory is already being used in practical work in the Chemical Engineering department. People can use this theory to find new ways to clean everything from cars to factory equipment."

Bhagat hopes his research will also be used to find new ways to help us use less water in the average household.

More information: Rajesh K. Bhagat et al, On the origin of the circular hydraulic jump in a thin liquid film, *Journal of Fluid Mechanics* (2018). DOI: 10.1017/jfm.2018.558

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