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Published in:
Physical Review Fluids

Link to article, DOI:
10.1103/PhysRevFluids.1.050507

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Pollen, water, and wind: Chaotic mixing in a puddle of water

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(Received 11 August 2016; published 12 September 2016)

This paper is associated with a poster winner of a 2015 APS/DFD Gallery of Fluid Motion Award. The original poster is available from the Gallery of Fluid Motion, http://dx.doi.org/10.1103/APS.DFD.2015.GFM.P0014

DOI: 10.1103/PhysRevFluids.1.050507

Water puddles are ubiquitous and provide a habitat for a vast array of living organisms, for instance, as breeding grounds for mosquitoes of the genus Anopheles that transmit malaria,
a disease responsible for 214 million cases and 438,000 deaths in 2015 [1]. The mosquito larvae feed on algae and bacteria in the surface layer. However, flow dynamics and nutrient distribution patterns in water puddles remain poorly understood.

The photograph (Fig. 1) shows how pine pollen grains have dispersed in an approximately 1 m wide and 1 cm deep water puddle. The pollen has mixed due to wind blowing across the liquid surface, revealing a strikingly complex flow pattern. The flows revealed by nature’s tracer particles may influence circulation and nutrient distribution in puddles and small ponds.

The flow patterns in Fig. 1 are generated by wind blowing across the puddle surface. This causes a shear stress at the atmospheric interface, which drives a flow in the liquid below. Chaotic mixing can occur if the wind direction changes over time [2]. A fluid patch is repeatedly stretched and folded into itself, resulting in a drastic reduction of the length over which molecules have to diffuse.

Pollen from pine trees was unusually abundant in 2012 when the photograph was taken, due to a largely dry spring which brought more than usual [3]. Pine pollen (Fig. 2) is winged, and typically measures ~50 μm in diameter. Pollen is transferred from a pollen cone to the ovule by wind or insects, and produces male sperm cells [4].

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