Designing smart functionalised surfaces for water harvesting

Project Background Information/Introduction:

The United Nations estimates that over one in ten people across the world do not have access to clean water. Hence, affordable, eco-sustainable methods for water collection are a major global challenge facing society today, especially in developing countries. In this project, we will focus on Indonesia. Indonesia is the fourth most populous country in the world with 260M people, and it is estimated that more than 27M Indonesians still lack access to clean water. Insects and plants, faced by similar environmental stresses, have evolved extraordinary surface properties in order to collect, direct and generally manipulate the behaviour of water on their surfaces. We have recently outlined the mechanical, physical and chemical processes which enable this behaviour. In particular, inspired by Thuja plicata, a coniferous tree whose natural habitat is North Western America, the Badyal group has recently fabricated an easily fabricated mesh with efficient water collection behaviour (e.g. from fog and rainwater) using 3D printing technique [1]. The major ambition of this project is to demonstrate that bio-inspired surfaces can be harnessed to help solve the clean water and water scarcity problem.

Research Aim/Objectives/Questions/Hypotheses:

The goals of this project are two-fold. The first goal is to optimise the design of the bioinspired surfaces for water harvesting using computer simulations based on the lattice Boltzmann method [2]. We will explore the effects of the size, shape and opening angle of the mesh; we will study whether adding chemical patterning can further improve the efficiency; and we will investigate the optimal arrangements when multiple mesh structures are used. The results of the simulations will then be used to guide experiments in fabricating the next generation of mesh structures. Different countries in Africa, Asia and Latin America have different climates (temperature, humidity, rainfall, etc), and as such, provide different challenges for water harvesting. The second goal is to develop specific surface solutions needed for water harvesting in Indonesia. This will be co-developed with our local project partner at Pertamina University. We will scope potential exploitations of the mesh structures in regions and communities in Indonesia where access to water remains difficult. We also plan to explore bio-inspired surface structures based on biodiversity in Indonesia.

Data/Methods/Analysis:

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Contributions to the SDGs:

The overall goal of this project is to develop and provide an optimised mesh structure for water harvesting in developing countries, particularly Indonesia. Harnessing the mesh structure, we aim to provide safe water in regions with water scarcity problem in Indonesia, therefore fulfilling the UN Sustainable Development Goal (SDG) No. 6, "Ensure availability and sustainable management of water and sanitation for all". Furthermore, clean water is essential to the realisation of all human rights. Without it, many of the simplest tasks such as drinking, washing, cooking, and farming are a major challenge. Unsafe water is also major source of sicknesses and diseases. In contrast, provision of clean water will underpin success in economic development and welfare through its supply for human consumption, agriculture, and sanitation. It also helps to stem the movement of populations away from water-stressed regions. Thus, our project can contribute to UN SDG No. 3, good health and wellbeing, and UN SDG No. 11, sustainable cities and communities.

Project Information:

- Supervisors/partners:
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    - Prof Jas Pal Badyal FRS, Department of Chemistry, Durham University, Durham DH1 3LE, UK (https://community.dur.ac.uk/jps.badyal/)
    - Dr Yudi Rahmawan, Department of Mechanical Engineering, Universitas Pertamina, Jakarta 12220, Indonesia Project Duration: 3 Years
- Project Resources (funded by): Durham University
- Author: Raymond Christianto, Department of Physics (raymond.christianto@durham.ac.uk)

References:

[1] R. M. Von Spreckelsen, M. T. Harris, J. M. Wigzell, R. C. Fraser, A. Carletto, D. P. Mosquin, D. Justice, and J. P. S. Badyal, "Bioinspired breathable architecture for water harvesting," Scientific reports, vol. 5, p. 16 798, 2015.

[2] M. Wöhrwag, C. Semprebon, A. M. Moqaddam, I. Karlin, and H. Kusumaatmaja, "Ternary free-energy entropic lattice Boltzmann model with a high density ratio," Physical review letters, vol. 120, no. 23, p. 234 501, 2018.