Biological Rain

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Recurrent droughts in several regions of the world and its disastrous impacts on survival of life have necessitated to look for a viable option for harvesting atmospheric moisture. Human efforts have been made to make rain artificially through physical and chemicals means. Recently, in addition to these two, biological agents are also being exploited at experimental levels for harvesting atmospheric moisture. The biological alternative specifically termed as "Bioprecipitation" proved to be economically feasible and practically viable.

INTRODUCTION

Water/moisture is the foremost necessary clause for existence of life on any planet. Earth and its atmosphere have enough moisture / water to support life, but still there is severe scarcity of water in several regions and due to which habitat suffers a lot. Ways and means have been exploited from time immortal by several creatures including human in search of moisture / water to sustain their life. Establishment of many ancient cities on the bank of rivers to have easy and economic access of water exemplified the human efforts in the history. Consequent upon industrial revolution and intensive agriculture, demand of water has increased exponentially that made the scenario for natural rainfall as insufficient to fulfil this demand. All these led to put pressure on human to invent methods to harvest available atmospheric moisture or create rain artificially.

The harvesting of atmospheric moisture / water has been a major challenge in arid and semi-arid regions of the world where water level is abnormally low on account of scanty rainfall. Therefore, an easier and less expensive way must be ascertained to get moisture/water. During the last two decades, several experiments to harvest the atmospheric moisture have been tried and attempts were demonstrated to sustain the habitats' life. These experiments mainly encompassed use of chemical nucleators and other machines and biologically active microorganisms and plants. Chemicals such as silver iodide (AgI), finely powdered sodium chloride (NaCl), solid carbon dioxide (CO_2) mediated artificial rain experiments and were successfully demonstrated the possibility of harvesting atmospheric moisture but proved to be quite expensive and have some harmful consequences to human and environment also, therefore not much preferred. Many plant pathogens and plant surfaces have cutting edge over chemical means owing to their economical and eco-friendly approach. Numerous plant pathogens and plant surfaces have super-hydrophilic or hygroscopic properties and are thus likely to be able to absorb water from atmosphere. The bacteria *Pseudomonas syringae* and *Pseudomonas fluroescens migla* (plant pathogen) and the bromeliads (plants of Bromeliaceae family) are among the best-known examples. These biological classes

that make rain given way to a novel concept of Bioprecipitation.

PHYSICS OF PRECIPITATION

Clouds are aggregate of minute water droplets suspended in the atmosphere. Droplets produced by the condensation process are indeed very small in size, averaging less than 10 microns in diameter, seem to float in the air. Rain drops have diameters ranging from about 200 microns up to 700 microns. The drops larger than this upper limit (500 microns) have capability to fall against air updraft motion. The cloud droplets to join to from large rain drops capable of failing to earth as precipitation. In certain type of clouds, the water droplets do not tend to coalesce and all the time they are kept floating in the air and no precipitation is released from them. On the contrary, in certain cloud forms, the droplets tend to join together, and big size rain drops develop and they are producers of precipitation. Two mechanisms have been proposed to explain these processes namely ice-crystal theory of Bergeron (for clod clouds) and Collision-coalescence theory of Bowen (for warm clouds). Either to condense, to grow or to coalescence, a hygroscopic nucleus is required to be present in the atmosphere.

RAINFALL AND ICE CREATING BACTERIA

Atmospheric moisture varies between 0.2 to 4 per cent and harvesting it through experiments other than chemical means namely water house, wind turbine and bacterial use are some of the recent developments in the field of research aiming to achieve artificial rain. Looking to the severity of demand and its eco-viable vista, research efforts leading to microbes mediated artificial rain or very specifically bioprecipitation has fetched wider global attention. The first ever concept of bioprecipitation was enunciated by David Sands.

The concept of biological rain through bacteria materialized from the basic natural phenomenon that, before a cloud can produce rain or snow, rain drops, or ice particles must form. This requires the presence of tiny particles that serve as the nuclei for condensation. Traditionally minerals were thought to be the dominant ice nucleators in the atmosphere, however, airborne microbes like bacteria, fungi or tiny algae can do the job just as well. Unlike mineral aerosols, living organisms can catalyse ice formation even at temperatures close to 0°C. The new research finding also support that a large variety of macro-organisms including bacteria, fungi, diatoms, and algae, persist in the clouds can be used as precipitation starters. A few physiologically distinct groups of bacteria associated with plants are reported to be capable of ice nucleation “in vitro” and “cause” frost injury of plants. Some of the Bacteria like *Pseudomonas syringae*, *P. fluorescens migla* and *Erwinia herbicola* serve as effective ice nucleators even at relatively high temperatures of –1 to –2 degree Celsius. There is also a remarkable fact that, most known ice-nucleating bacteria are plant pathogens. A recent study confirmed that the rain making bacteria that live in clouds might have evolved the ability to impel showers to disperse them worldwide. Some very potent ice nucleators in decaying plant matter were found that made the surprising discovery that they came from microbes. A few years later, the bacteria *Pseudomonas syringae* was identified as the source of these nucleators; parallelly, Deane Arny discovered that more frost formed on plants infected with *P. syringae*. The rain making potential of

bacteria lies on a mechanism that the bacteria produce a special protein, InaZ, which can act as an ice nucleus at the relatively warm temperature of – 2°C, probably because its repetitive shape is just right for coaxing water molecules into a crystalline arrangement. Air, including clouds, is usually full of micro-organisms like bacteria and fungi, some of which produce ice-nucleators. Ice crystals which form in clouds will grow until they are big enough to fall as either rain or snow depending on whether they melt on the way down. Researchers have detected *P. syringae* in fresh rain, snow, and ice from a wide range of locations including Louisiana, the French Alps and even Antarctica.

MICROBE WATER CYCLE AND BIOPRECIPITATION

Like natural water cycle there exists microbe water cycle also, but in this cycle microbes (Bacteria, Fungi) do not change their physical status. These bacteria and fungi are found as high as 30,000 feet in the atmosphere. The researchers found air mass and hurricanes that spew these bacteria from water and land surfaces into atmosphere. It was observed that mostly marine bacteria, and terrestrial bacteria were originated over water and land. These bacteria were dynamically mixed with other particles and in terms of distribution, there were about 144 bacteria cells found in every cubic foot of air. Reported information suggests that the bacteria get out of clouds and back to Earth and on plants through rain and thus complete the cycle. Like the natural phenomenon, bioprecipitation also requires a source of nucleation; such sources exist both outside and within plants. Outside sources of nucleation include dust particles, organic matter, bacteria and even gas bubbles. These bacteria populate on the surface of many plants' species, and frost formation on such plant surfaces bears a logarithmic relationship to the number of ice nucleating bacteria on the plant surface. A reduction in number of such bacteria on plant surfaces reduces the threshold temperature for frost formation. The same bacteria that cause frost damage on plants can help clouds to produce rain and snow. Studies on freshly fallen snow suggest that 'bio-precipitation' might be much more common than was suspected.

CONCLUSION

Demand of water has increased tremendously, and, in some regions, natural precipitation is not enough to sustain lives. The artificial rain making is a tool and possesses the potential to fulfil, to some extent, the demand of water, but is quite expensive and has limited applicability due to its environmental effects. Bio-precipitation emerged out as a new hope for water harvesting, though it's pro and cons have not been fully evaluated but seems to be economically feasible and practically viable for water harvesting. However, before materializing the concept, a scientifically sound risk-benefit assessment must be executed leading to an explicit prospect of Bioprecipitation.

"Any Error in this manuscript is silent testimony of the fact that it was a Human Effort"

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