Artificial Rain: Is it Feasible?

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In view of the recurring droughts that have occurred in recent years, questions have been raised in many quarters regarding the possibility of producing artificial rain over the "dry zones" of the island by the seeding of cloud systems. This proposal was once made by a late Minister of the former U.N.P. Government, but his interest waned when it was pointed out to him that a certain period of preliminary research was necessary before any opinion could be given about the feasibility of the project. According to press reports the question has once again been raised by the present Minister of Irrigation, Highways and Power.

In the circumstances, the National Science Council of Sri Lanka has appointed an *ad hoc* Committee consisting of representatives of the Departments of Meteorology, Irrigation, the Water Resources Board and the National Science Council to study the question and prepare a report which will be submitted to Government in due course.

The views expressed in this article are personal to the author and do not commit any of the organisations above mentioned.

From time immemorial men have tried to "harvest" the clouds by such techniques as the firing of cannon, the ringing of church bells and other magical rites. These were *ad hoc* pre-scientific techniques, which on occasion, did yield rain showers—which, however, could be easily explained by natural causes without any reference to the superstitious methods adopted.

The first serious studies of the micro-physics of clouds arose during the 2nd World War as a result of investigations relating to the icing of aircraft flying through cold clouds, which provided a serious hazard. Since then, Cloud Physics has developed into an important scientific discipline, dealing with the particles constituting clouds, their origin, growth and decay, precipitation processes as well as the phenomena of lightning and the electrification of clouds.

We will not deal here in any detail with the classification of cloud forms: *stratus* clouds, forming at low and middle altitudes, layer-like and with horizontal extensions sometimes stretching to hundreds of miles; *cirrus* clouds, limited to high altitudes, feathery and sometimes veil-like in appearance; and *cumulus* clouds, with considerable vertical extension, cotton-woolly and turreted. These three main categories have been sub-divided into various genera and species. We shall limit ourselves here to *cumulus* and *cumulo-nimbus* clouds, those that produce heavy rain showers—grey and foreboding, rising up sometimes to elevations of 50,000 ft., often anvil-shaped at their summits on account of the strong winds prevalent at these altitudes. Lightning and thunderstorms are often associated with the latter species.

Another significant classification of clouds, important for "rain-makers" is based on the nature of their particulate composition. On the one hand, we have *water clouds*, consisting exclusively of minute water droplets ranging through a spectrum of sizes. On the other hand, there are the *super-cooled ice clouds*—clouds consisting of a mixture of minute ice crystals and super-cooled water droplets which often remain in the liquid state down to temperatures of -40°C. The nature of these clouds naturally depends upon the ambient temperatures — water clouds perhaps predominating over tropical countries such as Sri Lanka.

Water droplets in clouds are formed by the condensation of the water vapour present, and ice crystals by the freezing of these droplets. These processes are naturally dependent upon the prevailing relative humidity and the ambient temperatures. However, even under suitable external physical conditions, the condensation of water vapour into droplets and the freezing of the latter into ice crystals does not occur *per se*. Both processes require for their initiation minute solid particles normally present in the atmosphere, around which the condensation and freezing processes can make a start. *Condensation nuclei* are believed to be produced from fine particulate matter wafted into the atmosphere by winds, dust storms, industrial smoke, etc. Particles of sodium chloride resulting from, the evaporation of fine droplets rising from the oceans also constitute a significant part of these condensation nuclei. *Ice nuclei* have been found to consist of mineral matter, particularly of kaolin particles.

Natural rain is produced from clouds by two processes, as far as our present knowledge goes: the *Coalescence Process*, dominant in warm, water clouds, and the *Bergeron-Findeisen Process*, operative in super-cooled ice-water clouds. In the coalescence process, larger cloud droplets fall faster towards the ground than smaller droplets, as a result of atmospheric viscosity. The resulting collisions with smaller droplets produce still larger drops which may attain such sizes (approx. 2.5 mm. radius) that they fall out of the cloud base and reach the ground without evaporation as rain. The initiation of this processes, therefore, requires the presence of a sufficient number of large droplets.

In super-cooled clouds, where minute ice crystals co-exist with super-cooled water droplets, differential water vapour pressures over water and ice surfaces lead to the evaporation of water droplets and the growth of ice crystals. When the latter grow sufficiently large, they fall under gravity, linking with other ice crystals to form snowflakes. If ground temperatures are below 0°C, snowfalls occur. Otherwise, the snowflakes melt at the 0°C. level, are transformed into water drops and produce rain. This is the Bergeron-Findeisen process.

Our current knowledge of these natural processes has led to attempts to replicate nature and produce rain from clouds that would normally not have resulted in precipitation. In spite of the presence of sufficient water vapour in many clouds the reason why precipitation does not result is the absence of sufficiently large water droplets or ice crystals. Nature has then to be given a helping hand.

In 1946, Vonnegut in the U.S.A. found that particles of silver iodide, acting as ice nuclei, were capable of forming ice crystals out of water droplets at a temperature of —4°C. In the same year Vincent Schaefer, also in the U.S.A. discovered that dry ice (solid carbon dioxide), which exists below —70°C, when crushed and scattered in a cloud of super-cooled water droplets, produces ice particles which multiply very rapidly in numbers. Field experiments conducted by Langmuir and Schaefer showed that these techniques were reasonably successful in producing some degree of precipitation from ordinarily non-precipitating cumulus clouds.

Several techniques have been used in the "seeding" of ice clouds. For instance, fine particles of silver iodide or dry ice have been scattered from air-craft *flying at cloud base*, the reason being that the updroughts in the clouds tend to carry the seeding particles upwards and hence prolonging their life-time, and effiicacy within a particular cloud. In other experiments solutions of silver iodide in acetone have been burned by ground-based burners and the smoke allowed to rise into selected clouds. One gramme of silver iodide in such solution tends to produce 10^{16} particles of silver iodide smoke.

However, the techniques have to be quite different when dealing with warm, tropical water clouds. Here, much of the work has been conducted by the CSIRO in Australia. The techniques used depend on the spraying at cloud base of fine water sprays or scattering fine particles of hygroscopic sodium chloride in order to produce the large water droplets necessary to initiate the *coalescence process* which is dominant in tropical clouds.

A vast volume of data is necessary before any cloud-seeding venture could be embarked on. This includes cloud characteristics (including the particulate nature of clouds, temperature levels in the atmosphere, wind strengths and directions etc.) Up to date, scientists are grappling with the questions as to whether the results of their field trials have been the result of artificial cloud seeding, or whether they were the consequences of natural climatic and other factors. Statistics seem to show that artificial cloud seeding *does* have positive effects. But whether these effects can be differentiated from monsoonal and other natural factors affecting rainfall still remains at the statistical level.

Sri Lanka is a small island. Without a proper understanding of cloud dynamics, the large-scale character and movement of cloud systems, the meteorological factors involved, *ad hoc* attempts to produce rain cannot be properly assessed. For instance, the seeding of clouds over the "dry zone" may well result in enhanced rainfall over the Indian Ocean! Cloud Physics is still in its infancy. Nature does not respond to human efforts with ease, despite pressing political needs! A few years of research in the field are necessary before even the economic feasibility of artificial rain-making can be assessed. In the author's view, it is valuable and necessary to set up a network of observation stations which will collect data over a period of years. Our scientists are capable of such an exercise, provided the necessary facilities are provided. Impressionistic attitudes and hopes arising from results obtained in other countries are not sufficient. We have to make a feasibility study of conditions *in our own country*. Time, patience and funds are necessary before we can even think of artificial rain-making in Sri Lanka. We hope that scientific realities rather than short-term electoral hopes will guide the powers that be!