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Cloud Seeding; Its Prospects and Concerns in the Modern World -A Review

Shaista Malik[1], Haleema Bano[1], Rauoof Ahmad Rather[2*] and Shakeel Ahmad [3]

[1,2*]Division of Environmental Sciences, SKUAST K Shalimar, Srinagar, J & K, India

[3]College of Agricultural Engineering Skuast-K

*Corresponding Author E-mail: hortsuren@gmail.com

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ABSTRACT

Cloud seeding is a form of weather modification, a way of changing the amount or type of precipitation that falls from clouds, by dispersing substances into the air that serve as cloud condensation or ice nuclei, which alter the microphysical processes within the cloud. The most common chemicals used for cloud seeding include silver iodide, potassium iodide and dry ice. Liquid propane, which expands into a gas, has also been used. Cloud seeding is used to increase precipitation in an area, to evaporate fog and clouds to keep an area dry by precipitating out, for reducing the cloud cover, to clean out the pollution, to help put out wildfire by making it rain. Cloud seeding has never been statistically proven to work but it is claimed to increase precipitation (Pelley, 2016). Since India is not very water rich, the cloud seeding technology is very closely associated with water resource management that is the major requirement for India. Under the guidelines of the Clean Water Act by the EPA, silver iodide is considered a hazardous substance, a priority pollutant and as a toxic pollutant. Chronic ingestion of iodides may produce skin rashes, running nose, headache and irritation of the mucous membranes.

Key words: *Glaciogenic and Hygroscopic Seeding, Rivers, Populations*

INTRODUCTION

Water is one of the most basic commodities on earth sustaining human life. In many regions of the world, traditional sources and supplies of ground water, rivers and reservoirs, are either inadequate or under threat from ever-increasing demands on water from changes in land use and growing populations. Only a small part of the available moisture in clouds is transformed into precipitation that reaches the surface[21]. This has prompted scientists and engineers to explore the possibility of augmenting water supplies by means of cloud seeding. This presentation provides current scientific status of weather modification activities to enhance precipitation for both glaciogenic and hygroscopic seeding experiments. It is important to emphasize that although funding for scientific studies has decreased substantially during the past decade, operational programs have actually increased.

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During the last 10 years there has been a thorough scrutiny of past experiments involving experiments using glaciogenic seeding. Although there still exists indications that seeding can increase precipitation, a number of recent studies have questioned many of the positive results, weakening the scientific credibility. As a result, considerable skepticism exists as to whether these methods provide a cost-effective means for increasing precipitation for water resources. Recent results from hygroscopic seeding experiments provided for some renewed optimism in the field of precipitation enhancement. Although promising results have been obtained to date, some fundamental questions remain that need to be answered in order to provide a sound scientific basis for this technology.

Methodology of Cloud Seeding:

A rainstorm occurs after moisture collects around naturally occurring particles in the air like dust sand, causing the air to reach a level of saturation point at which it can no longer hold in that moisture and droplets fall in the form of rain. Cloud seeding essentially helps that process along, providing additional "nuclei" around which water droplet can reside and condensation occurs. These nuclei can be salts, dry ice or silver iodide. The most common chemicals used for cloud seeding include silver iodide, potassium iodide and dry ice (solid carbon dioxide). Liquid propane, which expands into a gas, has also been used. This can produce ice crystals at higher temperatures than silver iodide. After promising research, the use of hygroscopic materials, such as table salt, is becoming more popular. During cloud seeding, increased snowfall takes place when temperatures within the clouds are between 19 and −4 °F (−7 and −20 °C). Introduction of a substance such as silver iodide, which has a crystalline structure similar to that of ice, will induce freezing nucleation. There are three methods by which cloud seeding is done:

- Static cloud seeding
- Dynamic cloud seeding
- Hygroscopic cloud seeding

Static Method:

This method involves spreading a chemical like silver iodide into clouds. The silver iodide provides a crystal around which moisture can condense. The moisture is already present in the clouds, but silver iodide essentially makes rain clouds more effective at dispensing their water. Physical studies and inferences drawn from statistical seeding experiments suggest that there exists more limited window of opportunity for precipitation enhancement by the static mode of cloud seeding than originally thought. The window of opportunity for cloud seeding appears to be limited to the static mode of cloud seeding has been shown to cause the expected alterations in cloud microstructure including increased concentrations of ice crystals, reductions of super cooled liquid water content, and more rapid production of precipitation elements in both cumuli[3] and orographic clouds;

(1) Clouds those are relatively cold-based and continental;

(2) Clouds having top temperatures in the range —10 °C to —25 °C;

3) A timescale limited by the availability of significant super cooled water before depletion by entrainment and natural precipitation processes.

This limited scope of opportunities for rainfall enhancement by the static mode of cloud seeding that has emerged in recent years may explain why some cloud seeding experiments have been successful while others have yielded inferred reductions in rainfall from seeded clouds or no effect. A successful experiment in one region does not guarantee that seeding in another region will be successful unless all environmental conditions are replicated as well as the methodology of seeding.

Dynamic Cloud Seeding:

Dynamic cloud seeding aims to boost vertical air currents, which encourages more water to pass through the clouds, translating into more rain. Up to 100 times more ice crystals are used in dynamic cloud seeding than in the static method. The process is considered more complex than static clouding seeding because it depends on a sequence of events working properly. Dr. William R. Cotton, a professor of atmospheric science at Colorado State University, and other researchers break down dynamic cloud seeding into 11 separate stages. An unexpected outcome in one stage could ruin the entire process, making the technique less dependable than static cloud seeding.

Hygroscopic Cloud Seeding:

The term "hygroscopic seeding" has been associated with warm cloud seeding. The objective is to enhance rainfall by promoting the coalescence process using hygroscopic salt nuclei generated by pyrotechnic flare or a fine spray of highly concentrated salt solution. In addition, Cooper *et al.*[4] illustrated that hygroscopic seeding might have a beneficial effect on precipitation development through either of two distinct mechanisms:

(i) Introduction of embryos on which raindrops form.

(ii) Broadening of the initial droplet size distribution resulting in acceleration of all stages of the coalescence process.

In 1990, G. Mather reported a case of inadvertent seeding of clouds by hygroscopic particles emitted from Kraft Mill in South Africa that resulted in enhanced coalescence and rainfall. This observation led to further hygroscopic cloud seeding experiments in South Africa,[4, 9], Thailand[18], Mexico[1] and India with highly encouraging results. Additional experiments have been conducted more recently in Texas using powdered salt having particle diameters of 2 to 5 microns.

Indian History of Cloud Seeding

In India, pioneering attempts in the field of rainmaking were made by Tata firm in 1951 over Western Ghats using ground based silver iodide generators. Dr. Banerji in the year 1952 attempted cloud seeding with salt and silver iodide by means of hydrogen filled balloons released from the ground. The committee on the Atmospheric Research of the Council for Scientific and Industrial Research (CSIR) recommended in 1953 that a rain and Cloud Physics Research (RCPR) unit be set up for undertaking extensive scientific studies on cloud physics and rainmaking. RCPR conducted long term cloud seeding programme over north India using ground based salt generators during the period 1957-1966. The results showed an increase in rainfall by 20% [11]. RCPR later became part of IITM. IITM conducted similar experiments over Tiruvallur (state of Tamilnadu), during 1973, 1975-1977. The seeding experiments were also done over Mumbai in the monsoon seasons 1973 and 1974 [5]. In the same years IITM carried out cloud seeding operations over Rihand 4 catchment in the state of Uttar Pradesh. In 1975, operational programme of cloud seeding was conducted over Linganamakki catchment area in the state of Karnataka. These programs were operational; hence their effect in increase in rainfall could not be assessed. IITM carried out cloud seeding experiment over Baramati region of the Maharashtra state during the period 1973-74, 1976, and 1979-86. The results showed 24% increase in the rainfall[10].

Need of cloud seeding:

Drought in India is a regular event occurring almost every year in some Indian states. Because droughts are a normal part of virtually any climate, it is important to develop plans to reduce their impacts. However, Drought declaration and response management in India have always been a large and complex operation, requiring close, often challenging and co ordination between various government levels. It has been observed that affected rural communities suffer from scarcity of drinking water, non-availability of fodder for cattle, migration along with families, and increased indebtedness. Each of these situations has a negative impact on education, nutrition, health, sanitation and the care and protection of children. Drought has resulted in tens of millions of deaths over the course of the 18th, 19th, and 20th centuries in India. Indian agriculture is heavily dependent on the climate of India: a favorable southwest summer monsoon is critical in securing water for irrigating Indian crops. In some parts of India, the failure of the monsoons result in water shortages, resulting in below-average crop yields. This is particularly true of major drought-prone regions such as southern and eastern Maharashtra, Karnataka, Andhra

Pradesh, Gujarat, Odissa, Telangana and Rajasthan[19].

Meteorological drought adversely affects the recharge of soil moisture, surface runoff and ground water table. Soils dry up, surface runoff is reduced and ground water level is lowered. Rivers, lakes, ponds and reservoirs tend to dry up wells and tube-wells are rendered unserviceable due to lowering of the ground water table. Indian agriculture still largely depends upon monsoon rainfall where about two-thirds of the arable land lack irrigation facilities and is termed as rain fed. The effect is manifested in the shortfalls of agricultural production in drought years. Social and economic impact of a drought is more severe than the physical and agricultural impacts. A drought is almost invariably associated with famine which has its own social and economic consequences. The total drought-prone area in India amounts to 10.7 lakh square kilometers. On an average, one in every five years is a drought year.

Water covers 70% of our planet, and it is easy to think that it will always be plentiful. However, freshwater we drink, bath in, and irrigate our farm fields is incredibly rare. Only 3% of the world's water is fresh water, and two-thirds of that is tucked away in frozen glaciers or otherwise unavailable for our use. As a result, some 1.1 billion people worldwide lack access to water, and a total of 2.7 billion find water scarce for at least one month of the year. Inadequate sanitation is also a problem for 2.4 billion people—they are exposed to diseases, such as cholera and typhoid fever, and other water-borne illnesses. Two million people, mostly children, die each year from diarrheal diseases alone[16].

Many of the water systems that keep ecosystems thriving and feed a growing human population have become stressed. Rivers, lakes and aquifers are drying up or becoming too polluted to use. More than half the world's wetlands have disappeared. Agriculture consumes more water than any other source and wastes much of that through inefficiencies. Climate change is altering patterns of weather and water around the world, causing shortages and droughts in some areas and floods in others. At the current consumption rate, this situation will only get worse. By 2025, two-thirds of the world's population may face water shortages. And ecosystems around the world will suffer even more[17].

The Himalayan state of Jammu and Kashmir receives 30% of its annual rainfall in the winter. Several studies indicate that most parts of the Himalayas are getting warmer at a rate faster than the average warming of the earth. Patterns of rain and snow vary throughout the mountains as weather is controlled by dramatic changes in topography and the presence of distinct microclimates in many parts. Climate change also magnifies intense weather making it more destructive. "When weather conditions are leading to a very heavy event, even a 10% boost of that because of climate change could be extremely damaging and could lead to a disaster,"

In the run-up to the 2008 Olympics in Beijing, more specifically the opening ceremony, and the Chinese government openly operated their cloud seeding program so that the first day of the Olympic Games would not be marred by rain or any other unsavory weather. Over 1,000 rockets were fired into the air in the days leading up to the ceremony in an effort to disperse rain clouds that were threatening to dampen the event.

The Government of Andhra Pradesh has declared nearly 555 Mandals under Rain Shadow in the year 2005. Cloud seeding was done from 2004-2009.Farmers have been instructed to dial a helpline if they sight clouds that appear to be rain-bearing, so that the moisture can immediately be precipitated through aerial seeding. Two aircraft loaded with flares were equipped to take off at a moment's notice to seed the clouds. Cloud Seeding was effective in Ananthapur, Cuddapah, Kurnool, Mahbubnagar, Nalgonda and Ranga Reddy districts.

ADVANTAGES OF CLOUD SEEDING:

1. Creates Rain:

Where rain is badly needed, cloud seeding is perhaps the only way to produce rain. People use silver iodine to induce rain production in areas where there is barely any precipitation. Rain is important for keeping the area hydrated and fertile for growing crops and other plants.

2. Boosts Economy:

Where there is rain, there is farm produce. Farms that yield better can help the local economy and feed the people (and even animals). Cloud seeding can greatly improve the living conditions in dry, arid places.

3. Regulates Weather:

Cloud seeding in a way, gives us the ability to control the weather condition in a particular area. It does not just make rain; it also regulates water vapor that in turn prevents damages brought by destructive hails and storms.

4. Makes Dry Places More Livable:

Local people have an impressive way of adapting to their natural environment. But inhospitable places rarely visited by rain can be inhospitable to tourists and foreigners. Cloud seeding can make such places livable.

DISADVANTAGES:

1. Requires Potentially Harmful Chemicals:

Chemicals used in cloud seeding can potentially damage the environment, especially the plants cloud seeding is intended to protect. There is no substantial study done on the implications of silver iodine on the environment. Silver iodine may cause "iodism," a type of iodine poisoning where the patient exhibits running nose, headache, skin rash, anemia, and diarrhea, among others. It has been found to be highly toxic to fish, livestock and humans.

2. Is Not Fool proof:

Cloud seeding requires rainclouds. It cannot work on just any other cloud formations. Also, seeded clouds may actually travel to another location and do not cause precipitation on the intended location. Therefore, it can be argued whether or not cloud seeding is truly effective in producing rain.

3. Costs a Lot:

It is very expensive to produce artificial rain. The chemicals have to be delivered to the air via planes, which are hard to come by in places with very minimal income. Poverty-stricken areas suffering drought or famine may need external funding to have cloud seeding.

4. Poses Weather Problems:

If not regulated or controlled properly, cloud seeding may cause undesirable if not altogether destructive weather conditions such as flooding, storms, hail risks, etc. Places that naturally do not get much rain or no rain at all usually do not have the infrastructure to handle so much precipitation. With cloud seeding, these areas may become flooded quickly, causing more harm than good.

CONCLUSION

- More the water resource of a nation the higher will be the opportunities for achieving high rates of progress in agriculture sector and industrial growth
- Indian water resources are declining and India is going to be water stressed country till 2025.
- 16 percent of total area is drought prone and farmers are committing suicide so cloud seeding becomes the necessity to tackle this critical situation.
- The cloud seeding technology is very closely associated with water resource management - major requirement for India.

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