

Cloud Seeding: A Boon or Bane?

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Abstract: Cloud seeding is a scientific process that improves the ability of the cloud to produce more snow or rain and can control other weather events. It is applied in areas which do not have enough rain and supply of natural water. Scientists use silver iodide in the top of growing cloud because its structure is very similar to ice crystals. As a result, the ice crystals grow into heavy, large raindrops falling on to the ground. One gram of silver iodide can create up to 10 trillion artificial ice crystals. This article discusses the beneficial and adverse impact of cloud seeding on environment.

Key words: Cloud seeding, Dubai, Silver iodide

Prologue

The recent flooding in Dubai in 16th April 2024, a record-breaking 254 millimetres of rainfall in 75 years raised a debate among scientists whether cloud-seeding is responsible for the unprecedented rains. After much debate it is confirmed that the deadly storms that left Dubai under water and killed more than 20 people in Oman were due to El Nino which has turned more intense due to climate change. This region of the Persian Gulf is one of the driest places on Earth, also known for powerful rain and flash flooding every few years, particularly during El Niño phases. Heat pumped into the atmosphere by human activities caused record rainfall 10-40% heavier and the intense storms.

Clouds are made up of tiny water droplets or ice crystals that form when water vapour in the atmosphere cools and condenses around a tiny particle of dust or salt floating in the atmosphere. Without these particles, known as ice nuclei, raindrops or snowflakes cannot form and precipitation will not occur. Cloud seeding is used all over the world as a method for enhancing winter snowfall and increasing mountain snowpack, supplementing the natural water supply available to communities of the surrounding area. The dispersing salt particles are sodium chloride (NaCl), calcium chloride (CaCl₂), silver iodide (AgI), potassium iodide (KI), sulphur dioxide (SO₂), frozen carbon dioxide – dry ice (CO₂), bismuth tri-iodide (BiI₃), propane (C₃H₈) etc.

What is Cloud seeding?

Cloud seeding is referred to as man-made precipitation and artificial rain making. It is a type of weather modification that aims to change the amount or type of precipitation, mitigate hail or disperse fog. Cloud seeding is one manifestation of a techno-scientific array of solutions to climate change called geoengineering.

The usual objective is to increase rain or snow, or to prevent precipitation from occurring in days afterward. It is possible to produce more rain or snow by introducing tiny ice nuclei into certain types of subfreezing clouds. These nuclei provide a base for snowflakes to form. After cloud seeding takes place, the newly formed snowflakes quickly grow and fall from the clouds back to the surface of the Earth, increasing snowpack and streamflow.

During dry winters when storm systems are absent for long periods, cloud seeding cannot be done, because cloud seeding requires the presence of moisture-filled clouds. Cloud seeding is avoided during times when additional precipitation would be problematic, such as times of high flood risk or during busy travel periods. Cloud seeding chemicals may be dispersed by aircraft or by dispersion devices on the ground (generators or canisters fired from anti-aircraft guns or rockets). For release by aircraft, silver iodide flares are ignited and dispersed as an aircraft fly through the inflow of a cloud.

When released by devices on the ground, the fine particles are carried downwind and upward by air currents after release.



Fig.1. Cloud seeding can be done by ground generators, planes, or rockets

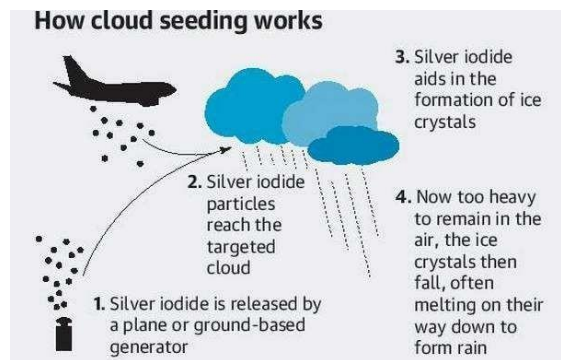


Fig.2. How Cloud Seeding functions

Cloud seeding techniques

To stimulate the precipitation process and form rain either dry ice or more commonly, silver iodide aerosols are spread into the upper part of clouds because its structure is very similar to natural ice crystals. Cloud seeding is undertaken by dispersing substances into the air that serve as cloud condensation or ice nuclei. Common agents include silver iodide, potassium iodide, and dry ice, with hygroscopic materials like table salt gaining popularity due to their ability to attract moisture. Liquid propane, which expands into a gas, has also been used. It can produce ice crystals at higher temperatures than silver iodide. After much 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 -20°C and -7°C . Techniques vary from static seeding, which encourages ice particle formation in supercooled clouds to increase precipitation, to dynamic seeding, designed to enhance convective cloud development through the release of latent heat. Cloud seeding uses planes or generators from ground to spray chemicals into the clouds.

There are 3 techniques.

- i) Hygroscopic cloud seeding aims at speeding up droplet coalescence in liquid clouds, leading to production of large droplets that start to precipitate. Large salt particles are dispersed to the cloud base.
- ii) In the other technique, Silver Iodide particles or dry ice (solid carbon dioxide) are dispersed into the cloud, causing heterogeneous ice nucleation.
- iii) Another method is to use liquid carbon dioxide which cools the cloud sufficiently so that the supercooled water droplets freeze homogeneously. Meteorologists monitor the weather throughout the season for appropriate cloud seeding conditions. Cloud seeding does not occur during times when additional precipitation would be problematic, such as times of high flood risk or during busy holiday travel periods.

Benefit of Cloud Seeding:

Cloud seeding can increase the overall snowpack by 10 -15% or more per year. Countries like the Russian Federation and Thailand are successfully using it for suppressing heatwaves and wildfires, while the USA, China, and Australia are applying its potential for maximizing water utilization during rainfall for drought mitigation. In the United Arab Emirates, the technique is actively used to expand its agricultural capabilities and battle extreme heat. The United Arab Emirates have been using drones equipped with a payload of electric-charge emission instruments and customized sensors that fly at low altitudes and deliver an electric charge to air molecules. This method produced a significant rainstorm in July 2021. The largest cloud seeding system is used by China. It is reported that cloud-seeding techniques to force rainfall by the Chinese government could lower the amount of PM_{2.5} pollution by more than two-thirds. That helped improve the air quality from "moderate" to "good". In India, cloud seeding operations were conducted during the years 1983, 1984–87, and 1993–94 by the Tamil Nadu Government due to severe drought. In the years 2003 and 2004 Karnataka and Maharashtra initiated cloud seeding. The company Srishti Aviation is actively involved in air defence with two aircrafts for its cloud seeding operations. The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) is the only international framework related to the regulation of weather and climate modification technologies.

Adverse Impact of Cloud Seeding on Health and Environment:

Environmental and health impacts are considered minimal due to the low concentrations of substances used. But concerns persist over the potential accumulation of seeding agents in sensitive ecosystems. Despite apprehension and debate over its efficacy and environmental impact, cloud seeding continues to be explored and applied in regions worldwide as a tool for weather modification.

Silver iodide exists naturally in the environment at low concentrations, and is not known to be harmful to humans or wildlife. There is also no evidence of harmful effects of silver iodide on the health and environment. The concentration of silver in a storm from cloud seeding is far below the accepted limit of 50 micrograms per litre. It would be wise for the nations to do due diligence in understanding and mitigating the repercussions of prolonged human exposure, who are going to adopt cloud seeding as a regular method in the coming years.

Epilogue

About 50 countries including US, China, Australia, UAE, Germany, India, Malaysia, Russia and Mexico employ cloud seeding. No doubt there are benefits of cloud seeding in specially creating more winter snowfall, enhancing the natural water supply to communities, decrease hailstorms by reordering water vapor in clouds, which breaks down large hailstones into small ones. But we have to be careful about the resulting silver toxicity which may adversely impact the environment. Meteorologists predict about the possibility of disturbance of the earth's natural balance among moisture, evaporation and precipitation in future.

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