Importance and requirements of water environmental sciences essay

Cloud SeedingIntroductionNowadays, 40% of the world population is suffering from a shortage of water for drinking and irrigation. In addition, each Water Conference is warning that most of the countries all around the world are going to face water shortages within 25 years. They suggest rainmaking (cloud seeding) as a countermeasure for this problem. Rainmaking is a technique, which involves sowing artificial cloud seeds and making rain fall over a specific region where a cloud layer has formed, but lacks condensation nuclei, which are needed for clouds to develop raindrops. When artificial cloud seeds are sown, small water droplets are drawn together from the cloud. They then freeze and become heavy. Finally they become raindrops after falling and melting. The methods used for artificial rainmaking can be divided into two main categories: flight and surface methods. Rainmaking by flight involves using an airplane to pour cloud seeds into a cloud. Because this way is very effective, it is used all around the world. Surface methods can be divided into two subcategories: Rockets and Ground generators.[1]Analysis shows that there has been a 10-20% increase in annual rainfall on the average through cloud seeding. According to the results of surface methods carried out for the US drinking and farm water supplies, about 600, 000 dollars has been invested per year, which produced about 50 million tons of water. Therefore, it cost about 1. 3 cents to produce one ton of water in rainfall, which is highly economical. According to the results of the flight methods that Australia used to raise electric power output based on waterpower generation, 640, 000 dollars was invested per year, which produced 240 million tons of water. This economic investment was excellent, costing about 0. 3 cents per ton of water. Finding a solution to the water shortage is seen as the most urgent need sooner. So, all countries of the world must apply rainmaking techniques to the fullest.[2]Dr. Vincent J. Schaefer, the father of modern weather modification, conducted the first field experiments following his basic discoveries in 1946 at the General Electric Laboratory in Schenectady, New York. Since 1946, various inorganic and organic materials have been known to alter the physical processes which lead to the formation and growth of water droplets and ice crystals in clouds. In more recent years, extensive scientific experiments and the application of scientific concepts have led to the development of techniques which can provide predictable results when applied under proper supervision. Cloud and storm-related events which are often the target for cloud seeding programs include rainfall, snow, fog, lightning, hail and devastating winds from severe storms.[3]AimTo unravel the concept of cloud seeding with a view to understanding the phenomenon of artificial weather modification. Some Important Facts regarding WaterQur'an about Water.[4]Some verses from the Holy Qur'an about water are worth considering here:-……………We made from water every living thing. [Sura Anbiyaa (21: 30)]………… The companions of the fire will call to the companions of the garden. " Pour down to us water or anything that God doth provide for your sustenance". They will say: " Both these things hath God forbidden to those who rejected Him". [Sura Araf(7: 50)]………… And further, thou seest the earth barren and lifeless, but when We pour down water on it, it is stirred (to life), it swells, and it puts forth every kind of beautiful growth. [Sura Hajj (22 : 5)]………… The son replied: " I will betake myself to some mountain. It will save me from the water". Noah said: " This day nothing can save from the command of God, any but those on whom He hath mercy. [Sura Hud (11: 43)]Distribution of Water on Earth.[5]About 70% of the earth's surface is covered with water. The total quantity in the oceans, ice caps, rivers, lakes, underground and atmosphere is estimated to be around 1. 4 billion cubic kilometers. The break-up is as follows:-Oceans and inland seas .... ~ 97. 21%. Ice-caps and glaciers .... ~ 2. 16%. Surface and underground .... ~ 0. 63%. Atmosphere .... ~ 0. 001%.

Total: 100%.

6Importance and Requirements of Water

All living things (i. e. zoological and botanical) cannot survive without water, except perhaps the computer viruses! Great civilizations had their beginnings where water-supplies used to be plentiful, and had fallen when these supplies disappeared. As water is essential for life, there have been instances where people have killed one another for a glass of water! 5 per cent of the land contains half the population of the world, due to uneven distribution of water. There is as much water on earth today as there ever was and ever will be. The same water that was dirty is purified by the great water-cycle, over and over again, since the formation of the water body. If the rain fell uniformly all over the earth, it would receive 26 inches a year. Every glass of water that we drink contains water-molecules that had been used countless times before. Part of the water that you used today might have been used by Pharaoh or perhaps Adam thousands of years ago! For a balanced diet and reasonable living, more than 2000 gallons is required per person per day:-Diet..................................... ~2000 gallons. Domestic & Industrial............ ~200 gallons. As the total usable quantity of water is fixed and the population is increasing, additional water resources are needed for about 80 million people added annually in the existing world-population. 7Natural Phenomenon of Cloud Forming and Rain MakingBefore proceeding any further, it would be better if we briefly study the natural phenomenon of formation of clouds and raining:-Relative Humidity. To some degree, all air contains moisture (water vapor). The meteorologist calls this degree of moisture relative humidity, and it is extremely important to the formation of clouds. The colder the air, the less water vapor it can hold before clouds form. If a parcel of air at 80°F (27°C) has a relative humidity of fifty percent, it means the air contains half the water vapor it can hold at that temperature. If this air parcel cools, the relative humidity increases and at 60°F (16°C) it reaches 100%. If further cooling takes place, the water vapor may condense and form cloud droplets. Condensation and Ice Forming Nuclei. These cloud droplets are formed around microscopic particles—dust, smoke, salt crystals, soil and other materials that are always present in the atmosphere. Scientists classify these particles as cloud condensation nuclei and without them there would be no clouds. Among the total particles in the atmosphere, there are a few special kinds known as ice nuclei, on which cloud droplets freeze or ice crystals form directly from the water vapor. Generally, there is an abundance of condensation nuclei in the air, but a scarcity of the special ice-forming nuclei. Composition of Clouds. Clouds are made up of billions of these tiny water droplets or ice crystals and sometimes combinations of both. The cloud droplets are so small it may take a million or more to produce a single raindrop. Millions of tons of water in the form of water vapor, liquid droplets and ice particles constantly flow in the atmosphere around the world. Prerequisites for Precipitation. Sometimes precipitation only occurs in small amounts, or not at all, because certain required conditions are not present. Of prime importance for determining both the initiation and amount of precipitation from the cloud system are:- The vertical and horizontal dimensions of the clouds. The lifetime of the clouds. The sizes and concentrations of cloud droplets and ice particles. Under proper conditions, one or more of these three factors can be favorably modified by seeding the cloud with appropriate nuclei. Mechanisms of Precipitation. There are two basic mechanisms by which precipitation forms in clouds. These are called the " warm rain" and the " cold rain" processes:- Warm Rain. The term " warm rain" was derived after scientists noticed that rain in tropical regions often fell from clouds with temperatures never colder than 32°F (0°C). Rain is formed in these warm clouds when larger droplets collide with and absorb smaller cloud droplets in a process known as coalescence. Cold Rain. The " cold rain" process occurs when temperatures in all or parts of the clouds are colder than 32°F. In these colder regions the clouds are usually composed of both ice crystals and liquid water droplets. The ice crystals which form in this super-cooled region grow rapidly, drawing moisture from the surrounding cloud droplets, until their weight causes them to fall. These falling ice crystals may melt and join with small liquid cloud droplets, growing to raindrops in a manner similar to the warm rain process. If the ice crystals do not melt, they may grow to large snowflakes by agglomeration and reach the ground as snow. Factors Determining Efficiency of a Cloud System. Compared to the amount of water that is visible as clouds or that falls to the ground as precipitation, the atmospheric reservoir of water above the earth is large. The sizes, types and concentrations of nuclei present in the atmosphere play an important role in determining the efficiency with which a cloud system forms and ultimately produces rain or snow. For instance, salt crystals acting as giant condensation nuclei are abundant in the oceanic regions. These allow larger cloud droplets to form and the subsequent coalescence process initiates rainfall well within the lifetime of the clouds. Conversely, the atmosphere over continental regions usually contains much smaller and more numerous condensation nuclei. Medium-sized clouds formed in these regions normally dissipate before the coalescence mechanism has had a chance to initiate rain. Likewise, many regions have only a few ice nuclei in the atmosphere which further reduces the efficiency of the cold rain process. Understanding Cloud SeedingWhere Does Cloud Seeding Fit In? The technology of " Cloud Seeding" may best be described as simply lending Nature a helping hand. Man can assist nature by furnishing appropriate types and numbers of nuclei through " seeding" the clouds at the proper time and place. Seeding with very large condensation nuclei (hygroscopic particles such as salt crystals) can be done to accelerate the warm rain process. Seeding with proper ice nuclei (such as silver iodide or dry ice) to supply naturally deficient clouds with the proper concentration of ice crystals will increase rainfall through the cold rain process.

Meanings of Cloud Seeding

Dictionary Meanings

A technique of stimulating or enhancing precipitation by distributing dry ice crystals or silver iodide particles over developing storm clouds in a specific area of the atmosphere.[8]A technique for producing rain by dropping chemicals or small objects into clouds.[9]

Encyclopedia Meaning

Encyclopedia Britannica. Deliberate introduction into clouds of various substances that act as condensation nuclei in an attempt to induce precipitation. The first experiments with cloud seeding were conducted in 1946; since then seeding has been done from aircraft, rockets, cannons, and ground generators. Many substances have been used, but solid carbon dioxide and silver iodide have been the most effective; when used in super-cooled clouds (composed of water droplets at temperatures below freezing), they form nuclei around which raindrops coalesce. Attempts have been made to use these substances to prevent hail.[10]Encyclopedia Wikipedia. Cloud seeding is the attempt to change the amount or type of precipitation that falls out of clouds or the structure of clouds by using certain chemicals dispersed by various means. The most common chemicals used for cloud seeding include silver iodide and dry ice (frozen carbon dioxide). These chemicals may be dispersed by aircraft or by dispersion devices located on the ground. For example, silver iodide flares will be ignited as an aircraft flies through a cloud. When released by devices on the ground, air currents may pull the fine particles up into the air. These chemicals provide a nucleus for moisture in the cloud to form around, which in turn will usually cause the precipitation to increase from the clouds or cause the clouds to become less dense. While cloud seeding has shown to be effective in reducing the amount of cloud cover, it is more controversial whether cloud seeding increases the amount of precipitation from a cloud. Part of the problem is that it is impossible to know how much precipitation would have occurred had the cloud not been 'seeded'. The first attempt at cloud seeding was in the state of Massachusetts in 1946. A plane 'seeded' a cloud with crushed dry ice; snow began falling out of that cloud. An attempt by the US to modify hurricanes in the Atlantic basin using cloud seeding in the 1950's was called Project Stormfury. Only a few hurricanes were tested with cloud seeding because of the strict rules that were set by the scientists of Project Stormfury. It was unclear whether this project was successful; hurricanes appeared to change in structure slightly, but it appeared to only be a temporary effect. The fear that cloud seeding could potentially change the course or power of hurricanes and negatively affect people in the storms path stopped the project. Today, cloud seeding is used to increase precipitation in areas experiencing drought, to reduce the size of hailstones that form in thunderstorms, and to reduce the amount of fog in and around airports.[11]12Different Cloud Seeding Agents. Some important cloud seeding agents are:-Silver Iodide. Calcium Chloride. Salt. Dry Ice. Liquid Carbon Dioxide. Dust.

13Different Methods of Clouds Seeding

Airborne. By using aircraft. Ground base. By using generators or Rocket Technology.

14Different Categories of Clouds

Warm Clouds

Base warmer than +10 ° C. Top warmer than + 0 ° C. Super-Cooled Clouds. Base & Top colder than - 0 ° C.

Types of Super-Cooled Clouds

Deep Stratiform Clouds. Shallow Stratiform Clouds. Cumuliform Clouds.

15Methodology for Cloud Seeding Operation

Identification of a suitable situation. Arrangement of an appropriate seeding agent. Successful transport and diffusion or direct placement of the seeding agent to the super-cooled regions of the clouds. Adequate time and super-cooled liquid and vapour must be available to provide precipitation-size particles. Eventual fall of rain on the ground in the desired location, before evaporation or being transported out of the target area.

Pre-requisites for a Successful Cloud Seeding Experiment

Correct estimation of the seed-ability of the cloud. To identify the optimum location to seed. Correct estimation of quantity of the seeding material required. Identification of best time to start seeding. Distinguishing between operational and non-operational days. 16Major Modes of Cloud SeedingThere are three modes of seeding clouds. The first two are related to super-cooled clouds and are called the " static mode" of cloud seeding and the " dynamic mode" of cloud seeding. The third one is the modification of warm clouds by " hygroscopic seeding". Static Mode of Cloud Seeding. The main objective of the " static mode'' of cloud seeding is to increase the efficiency of precipitation formation by introducing an " optimum'' concentration of ice crystals in super-cooled clouds by cloud seeding. It was originally thought that clouds were deficient in ice nuclei and therefore additions of modest concentrations of ice nuclei should result in a more efficient precipitation-producing cloud system. All that was needed was to introduce seeding material from the ground or at the base of clouds which would then enhance ice crystal concentrations and thereby increase rainfall. It was concluded in 1995 that physical studies and inferences drawn from statistical seeding experiments over the last 50 years suggests that there exists a much more limited window of opportunity for precipitation enhancement by the static-mode of cloud seeding than was originally thought. The window of opportunity for cloud seeding appears to be limited to:-clouds which are relatively cold-based and continental; clouds having top temperatures in the range -10 to -25o C; a time scale limited by the availability of significant super-cooled water before depletion by entrainment and natural precipitation processes. This limited scope of the 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 other seeding experiments 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. This, of course, is highly unlikely. The success of a cloud seeding experiment or operation requires a cloud forecast skill that is far greater than is currently in use. As a result, such experiments or operations are at the mercy of the natural variability of clouds. The impact of natural variability may be reduced in some regions where the local climatology favors clouds which are in the appropriate temperature windows and are more continental. A ‘ time window' may still exist, however, and this will yield uncertainty to the results unless the field personnel are particularly skillful in selecting suitable clouds. The Dynamic Mode of Cloud Seeding. While the fundamental concept of the " static mode" of cloud seeding is that precipitation can be increased in clouds by enhancing their precipitation efficiency, alterations in the dynamics or air motion in clouds due to latent heat release of growing ice particles, redistribution of condensed water, and evaporation of precipitation is also inevitable. Alterations in the dynamics of clouds, however, are not the primary aim of the strategy. By contrast, the focus of the " dynamic mode" of cloud seeding is to enhance the vertical air currents in clouds and thereby vertically process more water through the clouds resulting in increased precipitation. The main difference in implementation of the strategy is that larger amounts of seeding material are introduced into clouds. A goal in the static mode of seeding is to achieve something like 1 to 10 ice crystals per liter at temperatures warmer than -15o C. In the dynamic mode of seeding the target ice crystal concentration is more like 100 to 1000 ice crystals per liter, which corresponds to seeding as much as 200 to 1000 grams of silver iodide in flares dropped directly into the high super-cooled liquid water content updrafts of cumuli. In the 1960's to the 1980's, the hypothesized chain of physical responses to the insertion of such large quantities of seeding materials as summarized by Woodley et al. (1982) included the following:-The nucleated ice crystals glaciate a large volume of the cloud releasing the latent heat of freezing and vapor deposition. This warms the cloud yielding additional buoyancy in the seeded updrafts. The updrafts with enhanced buoyancy accelerate causing the cloud towers to ascend deeper into the troposphere. Pressure falls beneath the seeded cloud towers and convergence of unstable air in the cloud will develop as a result. Downdrafts are enhanced thereby forming new towers. The cloud will widen, and the likelihood that the new cloud will merge with neighboring clouds will therefore increase. The increased moist air is processed by the cloud to form rain. In recent years the dynamic seeding strategy has been applied to Thailand and West Texas. No results are available yet from Thailand but some results from exploratory dynamic seeding experiments over west Texas have been reported by Rosenfeld and Woodley (1989; 1993). Analysis of the seeding of 183 convective cells suggests that seeding increased the maximum height of the clouds by 7%, the areas of the cells by 43%, the durations by 36%, and the rain volumes of the cells by 130%. Hygroscopic Seeding. The dominant process for precipitation formation in warm clouds is collision and coalescence. We have seen that this process is very effective in clouds which are warm-based and maritime, or have substantial liquid water contents. The collision and coalescence process among liquid drops is also an important contributor to rain formation in many mixed-phase clouds, and the presence of super-cooled drizzle-drops and raindrops enhances the rate of formation of precipitation in super-cooled portions of clouds as well. One method of seeding clouds to enhance precipitation is to introduce hygroscopic particles (salts) which readily take on water by vapor deposition in a supersaturated cloudy environment. The conventional approach is to produce ground salt particles in the size-range of 5-10 microns, and release these particles into the base of clouds. These particles grow by vapor deposition and readily reach sizes of 25 to 30 microns in diameter or greater. They are then large enough to serve as " coalescence" embryos and initiate or participate in rain formation by collision and coalescence. Various physical and statistical experiments have been carried out on this method over the years. The results of the statistical experiments were generally inconclusive though some suggested positive effects. Observational and modeling studies provide further support that at least in some clouds; the addition of hygroscopic seeding material can broaden drop-spectra and at least hasten the onset of precipitation formation. It has been concluded that there appears to be a real opportunity to enhance rainfall through hygroscopic seeding in some clouds. However, it has not been determined how open the " window of opportunity" actually is. In warm-based, maritime clouds the rate of natural production of rainfall may be so great that there is little opportunity to beat nature at its own game. On the other hand, some cold-based continental clouds may have so many small droplets that seeding-produced big drops cannot collect them owing to very small collection efficiencies. Thus there probably exists a spectrum of clouds between these two extreme types that have enough liquid water to support a warm cloud precipitation process that can be accelerated by hygroscopic seeding. The problem is " to identify those clouds, and deliver the right amount of seeding material to them at the right time". 17Cloud Seeding in PakistanGeneral. Pakistan possesses diversified climatic conditions, mostly Arid & Semi-arid. Some areas receive meager amounts of rainfall during the year, insufficient to sustain agriculture and to meet civic water requirement. Conditions become vulnerable to drought if two rainfall seasons fail to yield, in succession. Pakistan had its worst ever drought, starting mid 1998 to mid of 2001. Origin of Cloud Seeding in Pakistan. The science of cloud seeding has made considerable progress in many parts of the globe since 1940. Pakistan Meteorological Department (PMD) being the pioneer organization in Cloud Seeding experiments had conducted these experiments as early as 1953. Previous Cloud Seeding Experiments in Pakistan. PMD conducted Cloud Seeding experiments from 1953 to 1956 as under:-

Seeding of Warm Clouds during Monsoon Season

In Mardan district of the NWFP, in 1953 by using two aircrafts loaned for the purpose from the PAF Academy Risalpur. In central Punjab plains and hills, from ground generator in 1954. Repetition of the above in 1955. Repetition of the above in 1956.

Seeding of Cold Clouds in the Winter Season

From the hill top behind the Meteorological Institute, Quetta, in 1955. Repetition of the above in 1956. Recent Experiments. In the recent drought conditions which affected various parts of the country, Pakistan Meteorological Department had initiated Cloud Seeding experiments from June 2000 to augment rainfall over drought-hit areas of the country. Results of 71 experiments recently conducted are shown in Tables-1 and 2. These show success rate of 65%.

Phase 1 (Seeding of Warm Clouds)

Table – 1: Phase -1 (Seeding of Warm Clouds)Total Experiments Conducted48Highly Successful30Limited Success14Failure due to Technical Reason4

Phase 2 (Seeding of Cold Clouds)

Table – 2: Phase 2 (Seeding of Cold Clouds)Total Experiments Conducted23Successful9Limited Success6Failed8We may conclude that so far, the experiments on warm clouds have given reasonably good results, with 30 successes out of 48 experiments i. e. 63%. Other Countries18A brief status of countries involved in weather modification experiments is appended below:-Japan. Japan conducted Cloud Seeding of snow cloud in

Central Japan for enhancing the snowfall in catchment areas of Dams in 1974 to 1997. Mexico. 1997; Program for the Augmentation of rainfall in Coahuila was conducted and initial results were encouraging. China. China is successfully using rain enhancement techniques in their arid areas since 1990. Thailand. Thailand is successfully using weather modification techniques since 1994. Israel & USA. They have done lot of research work in the field of weather modification during the last 40 years. 19Economic Benefits of Cloud SeedingThe primary motivation for cloud-seeding is the Economic Benefits associated, viz:-Increased hydro-Electric power and agriculture production. Salinity reduction. Strengthened sky industries as:-A study showed that an additional 10% of precipitation over the growing season would mean an increase of revenue by $10M to $ 43M. Another study in U. S. A showed that added rainfall of 20mm In June – July and 30 mm for June – August would increase the economy by over 0. 5 billion. The other direct benefit is from the augmentation of snowfall, which results in additional stream-flow for generation of hydro-electric power and increased irrigation water. Military Applications – Weather ModificationIn 2025, US aerospace forces can " own the weather" by capitalizing on emerging technologies and focusing development of those technologies to war-fighting applications.[20]21From enhancing friendly operations or disrupting those of the enemy via small-scale tailoring of natural weather patterns to complete dominance of global communications and counter space control, weather-modification offers the war fighter a wide-range of possible options to defeat or coerce an adversary. Some of the potential capabilities a weather-modification system could provide to a war-fighting commander in chief are listed in following table:-Degrade Enemy ForcesENHANCE FRIENDLY FORCES

Precipitation Enhancement

Precipitation Avoidance

Flood Lines of CommunicationMaintain / Improve Line of ContactReduce PGM / Recce EffectivenessMaintain VisibilityDecrease Comfort Level / MoraleMaintain Comfort Level / Morale

Storm Enhancement

Storm Modification

Deny OperationsChoose Battle space Environment

Precipitation Denial

High Altitude Weather

Deny Fresh WaterImprove Communication ReliabilityInduce DroughtIntercept Enemy Transmissions

High Altitude Weather

Revitalize Space AssetsDisrupt Communications/Radar

Fog and Cloud Generation

Disable/Destroy High Altitude AssetsIncrease Concealment

Fog and Cloud Removal

Fog and Cloud Removal

Deny ConcealmentMaintain Airfield OperationsIncrease Vulnerability to PGM/RecceEnhance PGM Effectiveness

Table 3 - Operational Capabilities Matrix

ConclusionOnly a small part of the available moisture in clouds is transformed into precipitation that reaches the surface. This fact has prompted scientists and engineers to explore the possibility of augmenting water supplies by means of cloud seeding. If more water could be transformed into precipitation, the potential benefits appear very attractive. The ability to influence and modify cloud microstructure in certain simple cloud systems such as fog, thin layer clouds, and small cumulus clouds, has been demonstrated and verified in laboratory, modeling, and observational studies. Although past experiments suggest that precipitation from clouds may be increased, decreased, and/or redistributed, the response variability is not fully understood. It appears to be linked to variations in targeting, cloud selection criteria, and assessment methods.[22]The fact that many operational programs have been ongoing and have increased in number indicates the ever increasing need for additional water resources in many parts of the world. It also emphasizes the fact that the potential technology of precipitation enhancement is very closely linked to water resources management. It is thus important that the users of this potential technology are integrated into programs at a very early stage in order to establish the requirements and economic viability of any program. In addition, the continued need for additional water and the fact that most programs currently ongoing in the world are operational programs emphasizes the need for continued and more intensive scientific studies to further develop the scientific basis for this technology.[23]FREQUENTLy asked questions (FAQs)

24What are clouds?

Clouds are composed of water droplets and sometimes ice crystals. The usual mechanism for cloud formation is for air that is rich in moisture near the Earth's surface, to be raised higher into the atmosphere either by an encroaching air mass or the heat of the sun. As the air is lifted, the pressure drops and the air is subsequently cooled. The combination of the two causes water vapour to condense into water droplets, which are visible to the naked eye.

25What types of clouds are suitable for seeding?

There are two main types of clouds suitable for cloud seeding:-Cumuliform Cloud. These clouds are characterised by a dense discrete appearance with sharp outlines, which develop vertically in the form of towers or domes. The sunlit part of the cloud is often a brilliant white while the bottom is a darker grey and flat in appearance. They are convective in nature with a great deal of vertical mixing present. Stratiform Cloud. These clouds are characterised by their layered structure. They are generally grey with a fairly flat base extending for many kilometres in all directions. Generally there is very little convective activity in the cloud.

Picture of Cumulus cloud (lower part) and Stratiform cloud (upper part)

26Are all clouds suitable for seeding?

No, not all clouds are suitable. Significant levels of super cooled liquid water have to be present in the cloud. The cloud must be deep enough and the temperature must be within a range suitable for seeding. The wind also has to be below a fixed value. Once all the criteria are met, cloud seeding can be successfully utilised to produce rainfall.

27How does cloud seeding work?

The theory of cloud seeding states that the number of naturally occurring ice nuclei present in a cloud is related the amount of rain the cloud can produce. The amount of these naturally occurring ice nuclei is generally much lower than the optimum number required for effective rain formation. Cloud seeding seeks to increase the number of nuclei present by putting into the cloud artificial cloud condensation nuclei.

A simplified diagram of the seeding process

The concept is that the cloud droplets form small ice crystals on the surface of the nuclei (natural and artificial). Ice crystals falling through the cloud collide with more cloud droplets and grow. Eventually when these ice crystals fall from the cloud they melts as they pass through the melting point (0ºC), and fall as rain or snow if the temperature is low enough.

28What cloud seeding agents are used?

Three types of seeding agent can be used:-Silver Iodide. It is very similar in structure to naturally occurring ice. Water deposits form on the surface of the silver iodide crystal and the ice crystals continue to grow as if they were naturally occurring ice crystals. Dry Ice (CO_2). It acts to cool the water far beyond 0ºC thereby causing the cloud droplets in the air to freeze, thus growing as water freezes on the surface of the ice. Hygroscopic Salts. Salts (KCl, $NaCl$) attract the water vapour to themselves, growing larger and eventually forming into raindrops.

29How long does take for cloud seeding to work?

Once the cloud is seeded it takes about 30 minutes for the ice crystals formed to grow to sufficient size and fall out of the cloud under their own weight. As ice falls, it passes through the melting level (0ºC) and becomes rain.

30What are the most common applications of cloud seeding technology?

The most common intended effects of cloud seeding include precipitation increase (rain and/or snow), fog dispersal (visibility improvement) and hail suppression. Of these, the majority of operational projects focus on precipitation increase.

31Do the commonly used seeding materials pose any direct health or environmental risks?

Many detailed studies have been conducted to address these questions. These efforts have ranged from chemistry-focused work to broad ranging environmental investigations. The bottom line is that no significant environmental effects have been observed. Seeding materials are applied in very small amounts relative to the size of the geographic areas being affected, so the concentrations of the seeding materials in rainwater or snow are very low. Using silver iodide (the most common seeding material) as an example, the typical concentration of silver in rainwater or snow from seeded cloud systems is less than 0. 1 micrograms per liter. This is much below the U. S. Public Health Service stated acceptable concentration of 50 micrograms per liter. As another example, the concentration of iodine in rainwater from seeded clouds is far below the concentration found in common iodized table salt.

32What does cloud seeding cost?

The cost of cloud seeding varies greatly, depending on a large number of factors, such as which seeding methods and materials are appropriate to a specific application, the frequency of seed-able conditions, the size of the intended area of effect and the duration of the project. Most cloud seeding projects carry favorable benefit/cost ratios, ranging over 20: 1 in some cases.