

Cloud Seeding: A Holy Grail For A Colossal Problem?

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Problem-Introduction

My project focuses on how cloud seeding, a weather modification that forces clouds to rain or snow, can help lessen the effects of smog. Smog is an outcome of climate change, made up of fog and smoke and a mix of harmful chemicals and pollutants. The idea of cloud seeding focuses on how to come up with an affordable, accessible and effective solution for one of the largest problems to this day. The ultimate goal is for the most polluted countries to get word of this technology, taking one step at a time to make our Earth a better place.



Smog we see these days is called *photochemical smog*, which is produced when a nitrogen oxide chemical reacts with a volatile organic compound, or VOC. This reaction creates ground-level ozone, which greatly affects human health. The nitrogen oxides and other harmful chemicals in smoke can come from factory smoke, cars and other fume producers.



My hypothesis is that if rain can settle down fog, then it could settle down smog because it is fog with suspended pollutants. Therefore, if rain producing clouds aren't present at the time, can we make artificial clouds to produce rain which could settle the smog?

Smog-Introduction



Smog is one of the consequences of global warming. It is made up of fog and smoke which contains particulate matter such as harmful pollutants. Visibility is greatly reduced when smog is present, increasing risks in driving and many other daily activities. Although this type of smog is still present, *photochemical smog* is more common these days. This is produced when sunlight reacts with nitrogen oxides and a volatile organic compound (VOC). When the reaction happens, ground-level ozone, or smog. Traditionally, the ozone layer protects humans from harmful ultraviolet rays, which is high up in the atmosphere. However, when ozone is closer to humans, it causes harm.

Many large cities such as Lahore, Pakistan, Delhi, India and Shanghai, China are blanketed in smog. These cities have huge populations, large factories and immense vehicle usage, leading to lots of air pollution. This pollution causes lots of deaths and lung diseases.

Fig. 2: An image showing how many fumes are released into the atmosphere from factory smoke.
(<https://www.smiletemplates.com/images/a-factory-with-a-lot-of-smoke-coming-out-of-it/162690/>)

Problem-Effects and Possible Solution

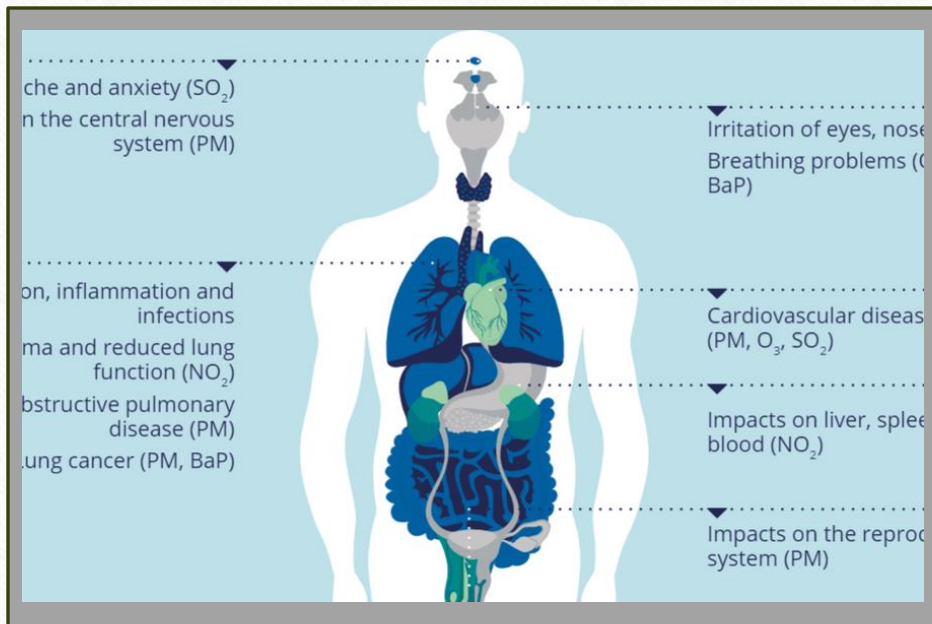


Fig. 1: An image showing how and which body parts are affected by smog. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4534272#:~:text=Combining%20an%20instrumental%20variable%20strategy,traffic%20accidents%20within%20one%20day

Due to the high content of dangerous particulate matter in smog, many people start to develop respiratory issues, cancer, stroke and inflames the issues of asthmatics. The density of smog in some cities can also cause an increased risk in visibility whilst driving, causing more accidents.

Not only are humans exposed to smog's dangers but so is wildlife. It can cause respiratory issues, fertility and birth problems for them too, causing extinction of species. This has decreased the diversity of wildlife we have on Earth. Effects can also outlast the food cycle, starving some species, while an overpopulation of another. Plants, too, are affected with having a slower growing rate. This can cause their death.

With the possible solution of cloud seeding, which can help with reducing the effects of smog, we can have a safer, stronger and cleaner environment for the future.

Smog-Dangerous Effects

Unfortunately, many things are greatly affected by smog. Humans can build up severe respiratory issues, due to the pollutant content in the atmosphere. Many cancers, such as lung cancer can develop, which can cause a staggering number of deaths. Those who suffer from asthma have an attack of breathing issues, making their life difficult. The decrease in visibility increases the amount of vehicle accidents as smog can cause itchy eyes or the drivers don't have enough visibility.

Smog may have a huge effect on humans, however vast amounts of wildlife is also affected. Animals can suffer from respiratory diseases, fertility problems and can cause extinction of species. These problems can majorly affect the food cycle. Disruption of the food cycle has consequences on the lives of other animals, increasing the population of one while killing another species. Our oxygen producers, plants, don't get saved from smog either. Smog can force them to develop dead tissue, causing their leaves to yellow. The ground-level ozone affects the growth of the plant, eventually causing its death.



Fig. 3: An image displaying the immense visibility issues due to the effects of smog.
(<https://meersens.com/smog-sources-of-pollution-and-health-environment-impact/?lang=en>)

Smog-Prevention/Reduction Methods

- In an effort to reduce the effects of smog, there are many precautions that humans should take. First of all, we should drive our vehicles less, which produce fumes. We can bike or walk to our destinations, especially if it is near. We should also carpool if you and someone else are going to the same place. For example, you can take your co-worker in your vehicle, to reduce the amount of fumes. Next time you buy a vehicle, you should consider switching to an electric vehicle, which doesn't produce fumes. If you own a gas-powered vehicle, make sure to keep it well maintained, especially as years pass, as they can potentially start to create more harmful fumes. Additionally, try not to keep your vehicle idling for too long, which also lets out lots of fumes.
- When sorting out your garbage, always make sure to put it in the correct bins. Never always put all your disposal in the garbage, as recycling and composting can eventually be turned into new things. Garbage is burnt, adding pollution to the atmosphere.
- You should always use fire with responsibility, especially outdoors. Always be careful if you have a campfire, barbeque or use a cigarette. Make sure to take the fire out before you leave the area unattended. Additionally, make sure to have an adult supervising you if you are using anything powered or used with fire or that can cause a fire.
- Not harming our oxygen-producing plants, such as trees, can help keep the Earth cleaner. They produce the very gas that we need to live. On that note, using electrically powered devices and machines can also be an additional step to saving our future.



Smog-Technologies to Combat

Catalytic Converters

As vehicles are such a major component of carbon emissions and climate change, some new technology had to come into play. Ever since the birth of internal-combustion vehicles, inefficient fluids and gasses have been used to power vehicles. Although we have more refined gasses to fuel our vehicles with, fumes still affect the environment. This device lies before the exhaust, catalyzing a redox reaction, removing most harmful gasses from the fumes, which then exit the vehicle.

These days, vehicles are usually equipped with a three-way converter. Firstly, exhaust from the engine is exposed to the catalyst, which lowers the energy which is needed to activate a reaction. This enables a reaction in which carbon monoxide is converted to carbon dioxide and nitrogen oxide is converted to nitrogen and carbon dioxide. As the original gasses are extremely harmful to the environment. This is proof that catalytic converters are an excellent device, created to help improve the environment.

However, it has a few disadvantages. Catalytic converter can limit the amount of exhaust flowing out the car, reducing the performance and fuel efficiency of the vehicle. Additionally, catalytic converters have a warm up phase when the car releases the pure exhaust, and its harmful contents. This releases all its pollutants into the atmosphere, causing harm. The metals used to create these converters create pollution, also adding to its disadvantages.



Smog-Technologies to Combat

Scrubbers

Scrubbers are a device that helps remove harmful pollutants from industrial exhausts. Such pollutants are: sulfur dioxide, chlorine, hydrogen sulfide, and hydrogen chloride.

Traditionally, there are two types of scrubbers used: wet scrubbers and dry scrubbers. Wet scrubbers use water to absorb pollutants and gas particles from a stream of air exiting the exhaust. However, more commonly used are low energy wet scrubbers. It works by passing the exhaust through a vessel which sprays a liquid. This liquid collects particles and can target a selected gas. Dry scrubbers have a similar process, however, instead of a liquid, it sprays a dry reagent. This dry reagent counteracts the gasses passing through before they reach the outside.

Scrubbers are an amazing development as it helps keep communities near industrial factories safe, separating the harmful chemicals and pollutants. Additionally, they don't disrupt the efficiency of the factory in any way, shape or form. This is an astounding creation, benefiting all sides.



Smog-Technologies to Combat

Chlorofluorocarbon (CFC) and Hydrochlorofluorocarbon (HCFC) Substitutes

Commonly referred to as CFCs and HCFCs, they are used as solvents, refrigerants, propellants and in modern science. Their usage has widely affected the protective ozone layer. The Montreal protocol of 1987 restricted the use of these substances to help protect and conserve the environment.

The substitute used today for these chemicals is hydrofluorocarbon (HFCs), which lacks chlorine. The chlorine present in CFCs and HCFCs was responsible for the destruction of the ozone layer. HFCs have successfully and effectively replaced the harmful effects on ozone. However, because of their longevity and stability, they produce long-term effects on climate change.



Smog-Technologies to Combat

Low-Emitting Stoves and Heaters

Indoor air pollution is as harmful as the outdoor pollution present in our atmosphere. As the name implies, the improper cooking routine that takes place because of burning of solid fuels in an enclosed space leads to the buildup of indoor pollutants. It is blamed for 3.8 million premature deaths.

Evolution of stoves and alternate fuels have made cooking safer and efficient. Secondary combustion fans or insulated chambers have revolutionized indoor cooking by burning of unused fuel and ventilation, making biomass stoves a considerable option.

Another factor leading to indoor air pollution is heating. To combat this challenge, solar water heaters and cooling systems, stove hoods and chimneys are used as effective measures.

Smog-Technologies to Combat

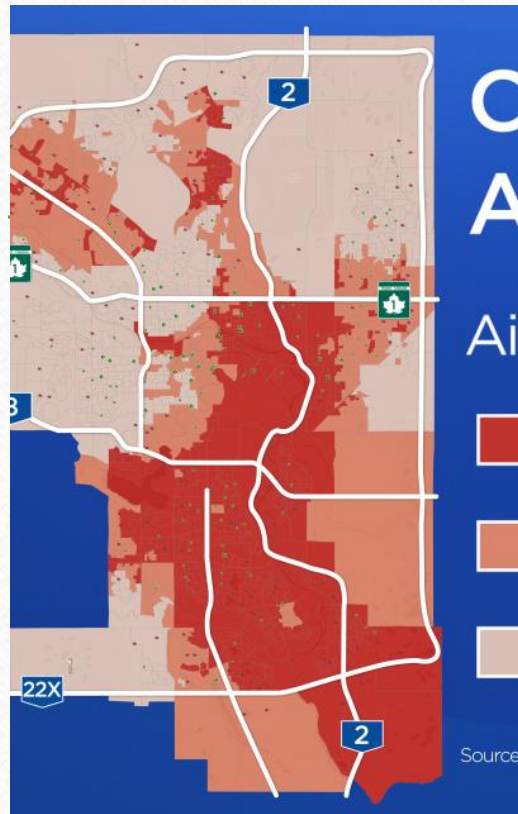
VOC-Free Consumer and Building Products

Another type of compound, volatile organic compound (VOCs), used frequently in paints, cleaners, adhesives, sealants, furniture and flooring. VOCs can lead to indoor pollution by building up in inner space in the absence of proper ventilation. Due to this harmful impact, the need for safer consumer products and building materials has led to VOC-free guidelines. These guidelines help determine if a product is low-emitting. There are special incentives offered to ensure the usage of low-emitting products.

Renewable Energy Sources

Biofuels have developed over centuries under great pressure and heat. These fuels cannot be replenished in a short amount of time. Eventually, this leads to the surge of other renewable energy sources such as solar, wind and hydraulic power. Significantly, this reduces the levels of pollution emitted by traditional power plants.

Smog-Technologies to Combat



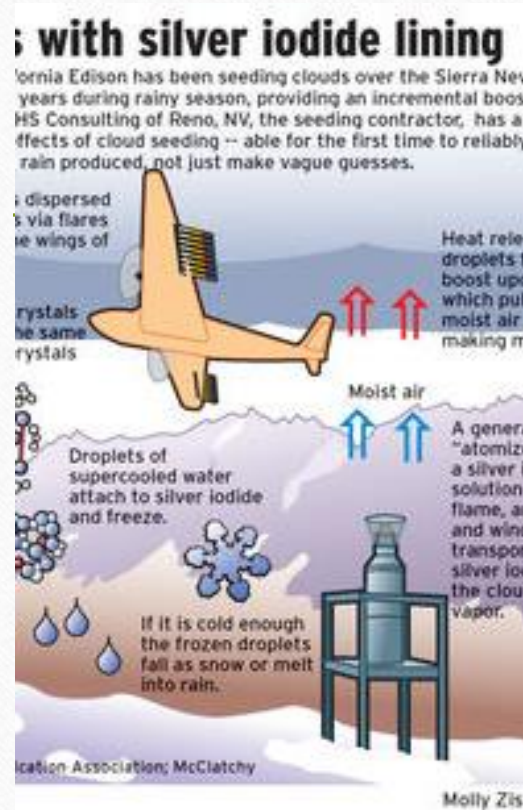
Air Quality Sensors

These devices measure the air quality and sense the level of pollutants in the air. The sensors help isolate and identify the areas with high levels of air pollution, providing an opportunity to curb the pollution levels by implying different solutions. Furthermore, it can help advise the population at risk, preventing the exposure and negative outcome.

Air Quality Maps

Just like the air quality sensors, these maps help identify areas with high levels of pollution which can alert authorities and the public to take certain measures. For example, in parts of Pakistan, people work from home and students attend online school to curb emissions.

Cloud Seeding- Initiation



Cloud seeding can be initiated by a variety of substances. One of the most commonly used is silver iodide, which is a crystalline. Being a crystalline type of chemical, this allows it to attract suspended water particles in the cloud. Silver iodide can be induced by planes with flares, rockets, or generators placed on top of skyscrapers.

This weather modification allows water particles not heavy enough to precipitate and stick onto the ice nuclei, making it heavy enough for gravity to pull down. Thus allowing non-precipitating clouds to precipitate.

Fig. 6: An image explaining the process of cloud seeding with the induction of silver iodide. (<https://www.drishtiiias.com/daily-updates/daily-news-analysis/cloud-seeding-1>)

Silver Iodide-Introduction

Silver iodide is a chemical compound made up of silver and iodine which imparts it the properties making it a commonly used chemical. This yellow colored substance has a crystalline structure. It exists naturally in low quantities, making it less probable to be harmful. Silver iodide is mostly produced in labs and used for various purposes. It has been used as pesticide for agricultural protection, a nucleus in cloud seeding, a chemical in photography and as a disinfectant.



Silver Iodide-Chemical Composition, Structure and Attributes

Silver iodide is made up of two elements: silver (metal) and iodine (non-metal).

Silver is a metal valued for its electrical conductive and beauty properties. This makes silver one of the most popular metals in the scientific community. It has been recognized by its symbol, Ag, located in group 11 lb and in period 5 of the periodic table. Silver has been used for its gleaming white color, resistance to oxidation malleability and ductility in order to create ornaments, jewelry and coins. Silver is known for its ability to conduct electricity and thermal heat. For silver to conduct electricity and be able to be pliable, it needs to be combined with other materials such as nickel or palladium, made into an alloy. Silver also tends to be the least reactive of any chemical that can have a bond. In addition, it can only be found naturally in mines with other substances such as lead, copper and zinc. Mexico is the largest producer of silver, with a whopping 5,600 metric tons worth of it.

Iodine is a non-metal element that is categorized in period 17 of the periodic table. It is also classified as a member of halogen elements, which don't occur naturally, unless in a combination.

Silver Iodide-Chemical Composition, Structure and Attributes

Iodine doesn't usually occur naturally, with the exception of a small amount in seawater. In addition, iodine is formed with seaweed, oysters and cod livers, with a tiny amount being present in the human body. Iodine also has medicinal uses, allowing one to locate brain or liver tumors.

Iodine is black when at room temperature and also has a shining crystalline appearance. When in an open vessel, the substance slowly sublimates into a violet vapor which is irritating to the eyes, nose and throat. Due to this, iodine is usually combined with potassium to lessen its effects. Iodine is also slightly soluble in water, and when done, gives a brownish-yellowish tint.

Iodine is found in natural brines, which can be found naturally or extracted from oil. The top producers of these brines include Chile, Japan, China, Russia and Azerbaijan.

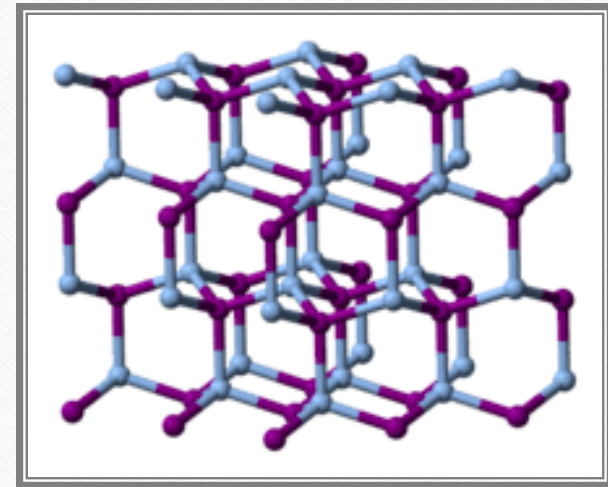
Silver iodide produced as a result of the combination of the elements mentioned above, has properties attributed to both. Silver iodide gets its crystalline structure and disinfectant properties due to the iodine presence. This crystalline structure is similar to the framework of ice. The silver in silver iodide imparts the chemical disinfectant quality as well.

Silver Iodide-Physical Properties

- It has a light yellow color which darkens at the exposure of light hence used in photography.
- It is odorless i.e it has no distinct smell
- It has a hexagonal structure
- It is insoluble in water making it a good choice for use in cloud seeding process
- It is soluble in alkali cyanides, thiosulfates and iodides
- It has a high melting point of 1026°F (552°C)
- It is not flammable under normal conditions
- It is stable under normal conditions

Silver Iodide-Chemical Properties

- It is stable under normal temperatures and pressure
- It is incompatible and sensitive to sodium and potassium
- When silver iodide is exposed to sunlight, silver breaks down to silver metal and iodide ions reduce oxidize to iodine gas



Chemical-Silver Iodide's Bond

The formula of silver iodide is AgI which reveals that there is one atom of silver (Ag) to one atom of Iodine (I). These atoms are attached through a polar covalent bond having a strong ionic character. It has a hexagonal lattice structure similar to that of ice.

The bond silver and iodine is strong and this makes it sparingly soluble in water. This also makes it insoluble in clouds or on the ground, making it less likely to contaminate the environment. The resemblance between the crystal lattice of silver iodide and ice is the basis of it being used as a common cloud seeding chemical.

Silver Iodide-Other Applications

Silver iodide has been used in photography since the early nineteenth century by a French scientist, Louis Jacques Mande Daguerre. He prepared a sheet of silver covered copper metal which he exposed to iodine vapors. This exposure led to the production of silver iodide. The process is utilized in photography and is initiated by exposure to light. It leads to the conversion of silver ions to silver iodide. The plate is then treated with magnesium, which adheres to parts exposed to light. The rest of the silver iodide is washed off, thus revealing the image taken.

Silver iodide is also used as a disinfectant. The nanoparticles of silver iodide inhibit the growth of disease-causing bacteria such as, *E. coli*, *Vibrio cholerae*, *Salmonella typhi*, and *P. aeruginosa*. Silver iodide produces free radicals and oxidative stress that leads to the inhibition of microbial activity.

Other medical uses of silver iodide include treatment of the infections of the mucous membrane. Also, it is used in ointments to treat inflammatory conditions of the eye, ear and nose.

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Silver Iodide-Harmful Effects



Silver is a very toxic heavy metal which affects microorganisms and fish. Although it is an insoluble compound and less likely to cause contamination, it can retard growth of algae, fungi, bacteria and fish. This disruption can lead to interference in the nutrient cycle.

Silver iodide can attach to the suspended particles in the air and inhalation of such contaminated particles could cause irritation and deposition in the lungs. It can cause nausea, vomiting, diarrhea, eye irritation and headaches. Rarely but the toxicity can cause serious effects on health like developmental defects, reproductive disorders and cancer. The toxicity of silver iodide can be characterized by coughing, wheezing, and difficulty in breathing. If inhaled, it can prove fatal. It can cause burns if the skin comes in contact, leading to discomfort.

Cloud Seeding-History

In 1891, Louis Gathmann proposed the idea of shooting liquid carbon dioxide at clouds to make them rain. During the 1930s, a theory suggested by Bergeron-Findeisen stated that supercooled water droplets are formed which causes precipitation upon exposure to ice crystals.

In 1946, an American chemist and meteorologist, Vincent J. Schaefer conducted his first experiments which led to the discovery of cloud seeding. It occurred to him whilst climbing Mount Washington in New Hampshire that cloud seeding can be induced by using a deep freeze unit of potential agents to initiate the growth of ice crystals. He used table salt, talcum powder, soils, dust and other chemical substances with minor effects. He was unable to produce a cloud by using a deep freezer. He augmented the process by the addition of dry ice to drop the temperature inside the freezer. He repeated the experiment and breathed into the freezer, realizing that he found a way to transform supercool water into ice crystals.

Bernard Vonnegut came up with the discovery of the use of silver iodide to produce ice crystals. Thus dry ice and silver iodide both became known as the agents for induction of artificial rain (cloud seeding).

Cloud Seeding-History

- From 1967 to 1972, silver iodide was used by the U.S. military in war against Vietnam. This resulted in an increase in the monsoon period, making mud a barrier.
- Lake Carl Blackwell watershed was the main water supply for Oklahoma. During 1972 to 1973, the water level was depleting. A company from California carried out successful cloud seeding for the rescue.
- In the 1960s, Project Stormfury was attempted by the U.S. military to modify hurricanes in the Atlantic basin.
- In the United States, from 2000 to 2006, the Weather Damage Modification Program was started to answer questions in regard to weather modification.
- Thailand has had a Royal Rainmaking Project since 1955 to oblivate the effects of drought.
- The largest user of cloud seeding is China. They have been using cloud seeding on a regular basis. They used it in 2008 to have a dry olympic season, to fight drought in Beijing and to decrease smog.
- India has been using cloud seeding since 1983 due to drought and recent increase in smog.
- Pakistan has recently, for the first time, used cloud seeding with aid of the U.A.E in the city of Lahore.
- The U.A.E has used cloud seeding to meet the water challenges faced in the country. They use weather radars in order to locate clouds in order to cloud seed. Then, they send planes to spray silver iodide.

Smog And Cloud Seeding- Relationship

- In 2021, on July 1, the Chinese Communist Party marked 100 years of their party with a celebration. The only hurdle in the celebration's success was the unpredictable weather of humid summer. In an effort to ensure successful celebration, cloud seeding was conducted which led to a decrease of air pollution. A two hour cloud seeding operation was launched on June 30. Rockets carrying silver iodide were induced. As a byproduct, a decrease in air pollution levels was noted significantly. This marks an example and a new chapter in the use of cloud seeding.
- On the ideology of fog, cloud seeding has been used for the first time in Lahore, Pakistan, one of the largest cities in the country. It stands at number 1 as the most polluted city in the world. Lahore has been enveloped in a toxic smog due to the low-grade diesel fumes, seasonal crop burn-off and cold temperatures in winter making stagnant clouds of smog. This has led to respiratory diseases in around 11 million people of the city. The cancer-causing microparticles that can enter the bloodstream through the lungs were 66 times higher than the WHO accepted limits. The planes were used for cloud seeding which flew over the east part of the city. The drizzling started in 10 areas of Lahore, impacting a radius of 15 kilometers (9 miles). Around 48 flares were used. It is speculated that even a modest amount of rain can effectively bring the pollution levels down. In addition to cloud seeding with planes, the city plans to install smog towers and large-scale air purifiers.
- India has been experiencing the same level of environmental issues in New Delhi. Scientists have suggested and hoped to relieve the effects of smog with the use of artificial rain. They estimate that it will be a costly weather modification as it could come out to 10 million rupees. However, some environmentalists believe that it is an ineffective approach as it is a temporary solution . When the rain stops, the polluted particles re-enter the air which means that the decrease in emissions is the actual solution.

Other Implications-Hailstorms

Cloud seeding has been used to decrease the size of hail in hailstorms. This operation has been extensively carried out in Alberta, Canada, where hailstorms have had one of the largest impacts. Between 2019 and 2021, the average cost of hailstorm damage has been \$870 million and the Calgary hailstorm of 2020 had damages adding up to \$1.2 billion.

Hailstorms affect many citizens each summer, with wrecked cars, damaged houses and even severe injuries. These can include dents, broken windows and windshields and concussions. Insurance costs skyrocket and people have trouble keeping up with the bills. However, cloud seeding has been proven to reduce this huge mess.

When silver iodide is induced into the cloud by either rockets, ground-based generators or planes and flares, the chemical acts like an ice nuclei. Ice attracts water molecules, forming thousands of smaller, less damaging hail. This is better than the droplets clumping into large, destructive ones.

Other Implications-Drought

- **Drought has been an increasing problem ever since the global crisis of climate change. As the Earth is heating up, countries and whole continents have been suffering from its wrath. However, cloud seeding is a considerable option.**
- **Many countries are heavily affected by drought. Canada, Spain, Brazil, countries in Africa, the United States of America and many others Drought can affect the daily lives of everyone. When farmers try to grow crops, vegetables, fruits and other items, they require a rich, damp ground to plant their crops. This allows them to grow high quality crops to provide for their families and the public. Drought causes all moisture in the ground and the air to dry up, leaving dry, crumply dirt. In these conditions, nothing would survive and livestock could also start to suffer from the lack of food. All this greatly affects plants, animals and ultimately, humankind. Cloud seeding, however, has a chance to save us all.**
- **Seeding a cloud to produce rain can allow the environment to thrive and provide ideal conditions. It would make the air more moist, the ground damper and provide food for livestock. However, clouds are necessary for this to proceed.**
- **The United Arab Emirates is placed in a desert climate, where it doesn't rain that often. This forces them to import food and other necessities so they can provide for their citizens. Importing drives prices up, forcing the government to make things expensive. However, cloud seeding can change that.**
- **The U.A.E government has employed a special weather monitoring team which scans for possible clouds to seed. When they spot clouds to seed, they send a plane into the skies, in an effort to increase the amount of rainfall by 10 -15%.**

Cloud Seeding & Wildfires

Due to the increase in the amount of heat from climate change, many countries have to suffer from its effects. The greenhouse effect has led to a decrease in rain, dry conditions and high temperatures. These are favorable conditions for a fire to happen. Firefighters and special forces work day and night, in an effort to put the fires out. Cloud seeding can help with settling them even faster and efficiently. They force evacuations, damage trees, leading to further oxygen depletion, loss of essential species in a biosystem and an increase on the greenhouse effect.

Some of the largest wildfires have been recent ones, including the 2023-2024 Australian bushfire season, the 2023 Canadian wildfires season and the 2020 Californian wildfires. Thousands had to evacuate their homes, being forced to live in camps and care centers. Citizens have passed away in these fires too.

Cloud seeding can greatly help. When the cloud is forced to rain, it can help put the fires out targeting a larger area, making it quicker to put out a large fire. It help reduce the work of fire crews and special forces. Artificial rain can be cost effective as well as environment friendly. However, there are down sides and limitations to the use of cloud seeding for wildfires. In the area, clouds wouldn't be likely to develop due to the lack of moisture, or humidity in the air. This reduces the chances of clouds being formed to seed. An adaptation has been proposed to facilitate the use of artificial rain in the scenario of wildfires. According to the proposed plan, we can build water reservoirs that can store rain water. these reservoirs can be useful to help increase moisture in the area. This can be tried in the areas susceptible to repeated wildfries.

Cloud Seeding-Snowpack and River Flow

As the globe faces the challenges of climate change, snowpacks on mountains melt quicker than they should, ultimately reducing river flow. The snow doesn't always replenish because of precipitation in unwanted areas as low pressure systems develop in areas other than mountain ranges. There is a proper path of the water cycle that keeps the water in its natural cycle. This makes water available for human and plant use rather than getting wasted and ending up in the ocean. There are different projects around the world, ensuring the increase in snow pack.

Nonetheless, cloud seeding has got a solution for this global crisis. Cloud seeding has a solution to this problem. When the chemical is induced, it causes the cloud to increase the chance of precipitation by 10-15%. In turn, it could increase snowpack on mountains and increase river flow by the additional amount of water.

Projects Around The World

In 2017, Idaho experienced a light dusting of snow. However, it wasn't a natural phenomenon. This happened because clouds in the atmosphere above were seeded, causing them to precipitate. A team of researchers in Idaho had planned to carry out three cloud seeding procedures. This was in an effort to observe what signs does cloud seeding give and if the process actually works. Immediately, the researchers saw a zigzag pattern in the sky. They thought this was sure to be the effects of cloud seeding. This would not occur naturally.

In conclusion, they found that cloud seeding actually does work. Before these experiments, there were no actual signs of cloud seeding forcing a cloud to precipitate. However, there were signs of it increasing the amount of precipitation.

Snowy Precipitation Enhancement Research Project (SPERP) which was done in winter from May 2005 to June 2009 in the snowy mountains of southeastern Australia, and other long term projects in Nevada showed an increase in snowpack by 10% or more per year. These projects consume millions of dollars to augment snowfall in targeted areas. This indicates that glaciogenic seeding of clouds over mountains offers increased precipitation in an economical manner.

Projects Around The World

- A study in the snowy mountains of New South Wales in Australia was conducted for 5 years. The study resulted in a 14% snowfall increase. The snowfall was the result of artificial snow generated by the use of silver iodide as ice nuclei.
- In the United States, an experiment of cloud seeding was conducted for 10 years in Wyoming. This experiment, established in the snowy range by the Wyoming Weather Modification Pilot Program (WWMPP). They used a technology, "Orographic Cloud Seeding", designed to increase precipitation in winter storms. Silver iodide nucleated a significant number of ice crystals in clouds, otherwise too warm for the natural process of crystallization. Another program done in the Bridger Range of western Montana, showed augmentation of snowfall by 15%. This research used high-altitude remote control generators which are used in modern day cloud seeding projects.
- Since 1959, Argentina has been using cloud seeding in order to suppress hail damage. The projects are used to decrease the frequency of hailstorms, as well as to decrease the diameter of the hail. The projects are carried out by means of ground generators, aircrafts and rockets.
- Alberta has been using cloud seeding for an effective attempt to suppress hailstorms. This project is, Alberta Hail Suppression Projects. It covers areas from the north near Ponoka, south to High River, west to Sundre and east to Three Hills. An intense team effort between the air and ground crews helped meteorologists even before the invention of radars. The aircrafts are equipped with flares on the wings, which deliver silver iodide to the bottom of the storm, and canisters below the aircraft to inject product to the top of a storm cloud. A golf sized hail is reduced to the size of a pea. In 2022, 80 seeding flights were conducted in 63 storms within 27 days.

Conclusion

- **Cloud seeding has been around for decades, being used for increasing snowpack and riverflow, helping lessen the effects of drought, increasing the amount of rainfall, decreasing the size of hail and many other ways to modify weather. Since the 1940s, it has been in place in many parts of the globe to help solve several weather and climate problems. As the decades have passed, cloud seeding has become more advanced. This has enabled it the ability to help with solving the current deteriorating environmental conditions. Now, it is able to be initiated in a number of ways, allowing it to be flexible for any needs.**
- **Due to the increase of global warming, snowpack on mountains has decreased significantly. As there isn't enough snow, the amount of fresh water has been diminishing. This in turn impacts river flow into which fresh water empties into. Humans get their supply of fresh water from springs and rivers, and when they aren't able to find enough fresh water to supply, it leads to the scarcity of water for humans and animals. However, cloud seeding can help increase the amount of precipitation on mountains. This helps increase snowpack and river flow, making fresh water available to keep the water cycle running and providing for humans and animals.**

Conclusion

- **A recent decrease in rainfall has led to serious consequences. One of the consequences has been a scarcity of water for plants. In turn, the production of crops has decreased, forcing farmers to abandon their fields. Drought has hit many corners of the globe, impacting food production for humans to consume. In some cases, this has led to famine. Severe malnutrition, social unrest and destabilization have come as consequences from the scarcity of crops and water. Cloud seeding has been able to help with this problem. It can help in two ways. Firstly, it can force clouds passing by to precipitate, which makes the ground moist allowing crops to thrive. Secondly, in places where there is precipitation, cloud seeding can increase the amount of rainfall by 10-15%. This method has effectively been used in the United Arab Emirates to alleviate the effects of drought and combat the dry and high temperatures of the desert. However, it has a limitation. This is due to its dependence on passing-by clouds. If there aren't any clouds, the process isn't carried out immediately or effectively.**

Conclusion

- **Hailstorms are a dangerous and costly natural phenomenon. The tiny but dangerous hail can destroy houses, shatter glass and dent vehicles. It can even injure civilians. When these things occur, everyone files insurance claims. This inflates the insurance prices, forcing people to pay a higher amount of money, leading to strain on the economy. When multiple ice nuclei are induced into the cloud, they attract the suspended water droplets making several rather than few areas of nucleation. In turn, thousands of smaller hails are produced, reducing the size. Alberta receives a high number of hail storms because of the favorable conditions, hence the name 'Hail Storm Alley'. Alberta has been effectively using a hail suppression program for decades to mitigate its destructive and costly effects.**

Conclusion

Cloud seeding is being used all over the globe. Countries such as Canada, The United States, the United Arab Emirates and many other countries have been using this technology to fight their local problems, many different ways. There are different types of chemicals that can be initiated such as silver iodide, salt and other chemicals. There are different methods to cloud seeding. Ground-based generators are placed on top of skyscrapers, being able to 'shoot' the clouds with the substance. Rockets filled with a usable chemical are aimed at the air, which then explode, leaking the chemical. These methods show how cloud seeding is flexible for anyone's needs or budget. This provides no excuse for countries to start using this technology in order to keep a safe and cleaner environment for their citizens.

Nowadays, one of the largest and a very harmful problem is a result of climate change; smog. This is a mixture of fog and harmful particulate matter. Smog affects the daily lives of humans, especially those who suffer from asthma. It can also increase the chances of lung diseases and cancer. An increase of automotive accidents can also occur due to the decreased vision. Wildlife is also heavily affected with respiratory issues, fertility problems and many more. Not only wildlife but our oxygen producing plants start to yellow and can suffer from growth issues. In turn, plants die, reducing the amount of oxygen produced. At this rate, the existence of plants might perish, leaving us with no fresh oxygen source. Thus we should care about our actions and make sure to preserve the environment for future generations. Cloud seeding programs in an attempt to decrease the effects of smog have been recently initiated. When rain comes in contact with fog, it brings it down from being suspended in the air. In terms of smog, it is able to bring the fog content down as well as the pollutants suspended in the air. Cloud seeding is able to help with increasing the amount of rain in order to bring more harmful content to the ground instead of it being suspended in the air, harming the environment.

Conclusion

- Although it seems to be that cloud seeding has the capability to solve the largest climate-related problems we face, there is one large component missing; wildfires. Wildfires occur either naturally, which does not affect wildlife as it happens routinely, so plants and animals know when to prepare. Or there are human-caused wildfires that are started by simple mistakes, such as campfires. Climate change is another large reason for an increase in intensity and frequency of wildfires, which is also considered a major mistake made by humans. Wildfires force humans to evacuate the affected areas, even causing people to get trapped and die. Smoke from the fire forms, which greatly affects the cities in close proximity, as well as cities and areas which the smoke drifts away to. This smoke can cause major breathing problems for those with asthma and cause respiratory issues. Firefighters and special forces are required to work overtime in order to save homes and families. In human-caused fires, wildlife isn't prepared, causing deaths of many animals and plants species. When plants are destroyed, they don't re-grow easily, forcing us to lose our oxygen-giving friends. In the year of 2023, Canada faced its largest wildfire season yet with 18.496 million hectares burned. The most intense fires took place in Western Canada (British Columbia, Alberta, Northwest Territories) and their smoke crossed the Atlantic Ocean, reaching Europe. However, cloud seeding has the capability to help with this problem. When the cloud is forced to precipitate, it can help with putting out wildfires. In turn, this can lessen the work of firefighters and special forces. Yet, there is a limitation to this. There needs to be a cloud in the atmosphere to seed of which there is a slim chance due to the lack of moisture in the air. However, any sighting of a cloud in the atmosphere would be seeded in order to make an effect. Another preposition is to make water reservoirs near the areas with high-susceptibility to catch fire either because of increased temperatures, dry conditions or heavy human interference. The idea is to help retain the moisture in the event of a wildfire in the affected area. This is an amazing idea to propose, being able to put a positive effect on a major problem.