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RAIN-FALL AUGMENTATION BY CLOUD SEEDING WITH CHEMICALS



The water droplets in the clouds are so small (10 micro-meters in radius) that they cannot reach the earth without evaporating. Hence if large rain drops (500 micro-meters in radius) that fall on the earth without evaporating are to be formed, about a million small cloud droplets must coagulate and for this purpose mere adhesion and condensation are not enough. There are 2 theories about the mechanics of rain-drop formation, each of which is valid under different climates.

The first theory of rain-drop formation is based on "Langmuir chain-reaction" that mostly occurs in the hot, humid atmosphere of the tropics. The larger droplets fall much faster than the smaller ones such that bigger drops in a cloud overtake and absorb all the smaller drops found in their downward path. In a rising cloud, the up-currents hold the big-drops in suspension while the smaller ones are caught up and merge with the big ones. If the large drops become too big, they burst into fragments that again collide and coalesce with small droplets and ultimately fall to earth as rain-drops.

The second theory of rain-drop formation is based on "Bergeron chain-reaction" that mostly occurs in the temperate zones. The clouds that precipitate consist at the higher levels, of ice crystals. For the formation of big droplets in the cloud an ice-phase is a precondition and for this transition from the liquid to solid phase a freezing nucleus is essential. The freezing nuclei allow supercooling of water droplets upto 15 degree centigrade before ice-formation occurs. In fact pure water suspended in air does not freeze until it touches about -40 degrees centigrade temperature. The ice-crystals grow rapidly by absorbing all the supercooled droplets on their way down and unwieldy lumps of ice are formed and they melt at about zero degree centigrade to become rain-drops that fall on earth.

These basic mechanisms by which precipitation occurs are often called the "Warm-rain" and "Cold-rain" processes. The rain in the tropical regions from clouds whose tops never touch the freezing level is known as "Warm-rain"(Langmuir chain-reaction) while the "Cold-rain" occurs when temperatures in all or some parts of the clouds are colder than the freezing levels (Bergeron Chain-reaction).

In warm clouds to be seeded there is a serious shortage of large water droplets over 20 microns in diameter and this reduces the efficiency of the cloud to give rain. In order to induce such clouds to give rain the coalescence mechanisms have to be stimulated by injecting the clouds with the hygroscopic sodium chloride particles from a small aircraft.

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The Langmuir chain-reaction gets a boost and the clouds which were formerly unproductive become productive. Similarly the dearth of ice-crystals in cold clouds is removed by seeding them with silver iodide to ensure one nucleus per litre of cloud air so that such seeding generates additional ice-crystals and thereby accelerates the rain-forming processes.

CLOUD SEEDING FOR ARTIFICIAL RAINS:

Since salt crystals are abundant in oceanic regions they favour larger cloud droplets that collide and coalesce to initiate rain fall well within the life time of the clouds. But the atmosphere over continental regions generally contain much smaller and more numerous condensation nuclei and hence the medium sized clouds formed in such regions usually dissipate before coalescence mechanism has had a chance to initiate rain.

Cumulus clouds formed by uplift of warm moist air masses or by the passage of a cold or warm front through any region, can be seeded when their tops touch -5 degrees Centigrade or when they are growing with indications that they will reach that temperature level in the atmosphere. When right conditions exist, the cumulus clouds can be stimulated to grow larger and last longer. It must be remembered that the freezing of millions of droplets in the cloud release enormous latent heat energy and that makes the cloud buoyant, causing it to grow larger, thereby efficiently processing more water for a longer time period than would have occurred without the cloud-seeding process.

COLD-CLOUD SEEDING:

Introduction of massive dosages of silver iodide into the clouds at -10 degrees Centigrade at the rate of 100 to 1000 nuclei per liter of cloud air is known as dynamic seeding. In this process the conversion of super-cooled water in the cloud into ice-crystals (through Bergeron-Findeisen reaction mechanism) release latent heat that increases buoyancy, thereby increasing the size of the cloud with better organisation of low level inflows with the probability of cloud-merger and area wise enhancement of rain-fall. Dynamic seeding of individual clouds on a random basis in USA, indicated significant increase in rain-fall by a factor of three.

CLOUD-SEEDING EXPERIMENTS:

The augmentation of rain-fall from the cold-clouds is based on the assumption that there is a deficiency of ice-crystals and this deficiency has to be rectified by introducing artificial ice-nuclei like silver-iodide into suitable clouds to produce the required ice-crystals for improving the rainfall. One nucleus per litre of cloud air is required for an efficient precipitation under the static approach. But the dynamic cloud seeding approach involves the injection of 100 to 1000 nuclei at -10 degrees Centigrade per litre of cloud air. In the process the conversion of super cooled liquid water to ice-crystals releases the latent heat of fusion which in turn increases the cloud buoyancy. Such buoyancy invigorates the cloud and extends its life-time, resulting in increased convergency at the base of the cloud. Moreover, such dynamic seeding ultimately results in better collection of the low level in-flow, thereby increasing the probability of merger of several nearby clouds and enhancement of rain-fall. Cold cloud seeding was done notably in

Australia, USA, USSR, Canada and Israel where convincing and significant increases in rain fall were observed on seeded days.

The augmentation of rain-fall from the warm clouds is based on the assumption that there is a deficiency of giant hygroscopic nuclei to change cloud-drops into the rain-drops and if salt particles are injected into suitable clouds, they will grow by condensation and then by collision and coalescence mechanisms that initiate rain-fall within the life time of the clouds. In India, notable experiments on warm-cloud salt-seeding, using ground-based generators, were under-taken by the Rain and cloud physics Research Unit of the National Physical Laboratory during 1957-1966 in North India and the results indicated about 20% increase in rain-fall. The salt-seeding of warm clouds from an air-craft over the catchment of Rihand reservoir in Uttar Pradesh was executed by the Institute of Tropical Meteorology during the monsoons of 1973 and 1974 and the results showed an increase of rain-fall by 17% to 28%. Similar experiments conducted during the monsoon of 1975 over the catchment of the Linganmakki reservoir in Karnataka registered 20% additional rainfall. When Tamil Nadu Government, with the assistance of Atmospherics Incorporated, USA, used silver iodide for seeding the cold-clouds during the monsoon of 1975 the Radar observations indicated 20% to 25% additional rainfall. Cloud seeding experiments in Australia showed 15% to 20% extra rain-fall in the water storage reservoirs of Tasmania. Similar experiments in Israel indicated extra rain-fall of about 15% over the catchment of Tiberias lake at a highly statistical significance. Dynamic seeding of convective clouds in South Florida indicated 20% extra rainfall over the target area and 50% more in the area defined as the floating target.

South West Monsoon winds lift over 7,700 billion cubic meters of moisture from the Arabian sea (half the amount comes from the Bay of Bengal) during June to September. Both South-West and North-East monsoons bring over India 11,000 billion cubic meters of moisture of which 2,400 billion cubic meters is released as rain fall. The remaining moisture in the atmosphere is transported by the winds to other countries and if 2% of such moisture is harnessed through artificial rains, the water scarcity problems of South India can be solved.

A cloud seeding experiment is very inexpensive and highly successful provided it is undertaken after making the pre-requisite scientific studies including modelling. The rain clouds of Israel are 6 to 9 km high and contain 0.5 million cubic meters of water. By dynamic aerial seeding with silver iodide, the heights of the clouds are raised by 2km and their water content increased to more than 1 million cubic meters. Studies in Ukraine indicate that while seeding a single cloud increases precipitation by about 25% over that of an unseeded cloud, the seeding of multi-cell clouds leads to very high precipitation as compared to single cell clouds. Thus cloud seeding has been successful in several countries including USA, Israel, Russia, Canada, Australia and India.

MY EXPERIENCES IN CLOUD SEEDING AT HYDERABAD AND ANANTAPUR:

The Andhra Pradesh State Government constituted a working group

for the preparation of a report on the Plan of Action to be taken for making Artificial Rains at the conclusion of a National Seminar on Artificial Rains held at Hyderabad on 19th March 1988. The working group consisted of the following members;

1. Prof.T.Shivaji Rao,
Professor of Environmental Engineering,Andhra University.
2. Prof.P.Koteswaram,
Retired Director General, Indian Meteorological Department & former Vice-President, World Meteorological Organisation.
3. Mr.J.Raja Rao,
Ex-Chief Engineer for Irrigation and Secretary to the Government, Irrigation and Command Area Development.

The expert committee report on artificial rains was submitted to the Chief Minister on 24th March 1988 and a photograph taken on the occasion was published in the local daily Newspaper Andhra Patrika on 1st April 1988. Although the Chief Minister openly declared his consent to sanction the project on cloud seeding, the officials obstructed the programme. Subsequently Dr.P.Sankara Rao, Minister for Irrigation took interest and requested the experts to conduct cloud seeding experiments to fill one of the twin lakes which were the sources of drinking water for the state capital. The experimental work was done from 27th July 1993 to 29th July 1993 in the Osmansagar lake catchment with the assistance of Mr.Shantilal Meckoni, an expert on using ground generators for cloud seeding. The seedability of clouds was determined by obtaining the weather radar data from the local observatory. The Cumulo Nimbus clouds must grow so that their bottoms will be within about 1 km from the ground surface. The relative humidity must be above 75% and the wind velocity about 15 to 20kms per hour, the bright sunshine shall not be present. The depth of the clouds must be about 7 to 10kms. The ground generators consisted of hot ovens with a blower and coke was filled in the hot oven and heated to a temperature of 1200 degrees centigrade. The generators were located about 15 to 20kms at 4 locations on the periphery of the Osmansagar lake while another station was located in the catchment of the Himayatsagar lake. The monsoon winds were blowing from south-west direction. Suitable conditions for the experiments prevail at about 5 PM just before the sunset and hence the blowers were started at all the stations and the temperature of the hot coals in the oven touched about 1200 degrees centigrade when silver iodide powder was sprinkled over the hot coals in dosages of about 20grams slowly for about 5 to 10minutes and about 180 to 200 gms was sprinkled in a duration of 45 minutes. The chemical fumes rose from the oven into the dark clouds with a depth of about 7 to 9 kms with their bottoms located at about 1 to 1.5km from the ground. The relative humidity was about 80% and the wind speeds were less than 20kms per hour. Within 45 minutes the clouds responded by providing very heavy down pour which lasted for about 30 to 40 minutes. As a consequence of the experiment the water level in the Osmansagar lake increased by about 2ft, i.e. from a reduced level of 1753.80ft. to 1755.70ft. Surprisingly there was no rain in the adjacent Himayatsagar lake. The rain extended for a long length on the East and North-East as well as West and South-West directions of the experimental stations. The number of rain gauges were observed to have received this rainfall and the rain water samples were sent for chemical examination to determine whether the rains were due natural

causes or due to the artificial rain making experiments. The chemical analysis confirmed the presence of traces of silver and consequently the experiments were pronounced successful. Although the cloud cover on the twin lakes was similar the rainfall increase was recorded only in the catchment of Osmansagar where the experiments were conducted. Hence artificial rain making under suitable conditions are bound to be successful provided the methodology is properly followed.

When the Chief Minister of A.P.State Government Dr.N.T.Rama Rao made a request at the behest of the former Minsiter Mr.Paritala Ravi from Anantapur the Cloud Seeding experiments were conducted when abundant rain fall was recorded at Anantapur and the surrounding areas during July 1995.

For more details see the annexures at the end of the article.

ROLE OF SCIENTISTS AND INTELLECTUALS:

It is a pity that while there is plenty of deep cloud cover over India during South West monsoon which lift about 3 lakh TMC (Thousand Million Cubic ft., equivalent to about 28.3 million cubic meters) and the North-East monsoon lifts about 1 lakh TMC of moisture into the clouds over India only about 80,000 to 1 lakh TMC of moisture falls as rain over India and the rest of the moisture is transported over the Bay of Bengal downwind. One TMC of water is used to produce crops in 10,000 acres for dry crops or 6,000 acres for wet crops and its economic value is about Rs.12 crores (equivalent to about \$2.4 million. About 65,000TMC of rain water flows into the rivers and lakes. Since only 10% of the rain water is stored in the reservoirs. Most of the water flows wastefully into the sea. Since adequate water is not available at the required places in the required time it is inevitable for man to use his intellengence to seed the clouds in proper time to obtain sufficient water for his needs by augmenting the annual rainfall by seeding the clouds. This can be done by using common salt with soap stone powder to seed the warm clouds and silver iodide has to be sprinkled into the cold clouds. Either aeroplanes or ground generators can be used some times used of rockets filled with the chemicals can be used on the same lines followed by some countries like Ukraine. Unfortunately most of the politicians and some officials in poor countries like India do not prefer taking up these inexpensive methods because some of them expect that the famines and floods provide them with an oppportunity to demand sanction of financial grants by the Central Governemnts as relief aid which will provide them with an opportunity to make some money for their personal and election expenses. By remaining as silent spectators the scientists, the technologists, the academicians and the educated elite in poor countires like India are not working in public interests but are indirectly promoting the vested interests of the contractors and the politicians and some times the officials. So the concerned scientists and social activists who plan to elimiante poverty, reduce floods and famines, minimise unemployment and opt for adequate water supplies and food production must debate on the problems of cloud seeding and create awareness among the people on the advantages of cloud seeding so that they can exert pressure on their elected representatives to take up this work on similar lines followed in countries like Israel, United States, Canada, South Africa, China,

France, Mexico, Argentina and Pakistan. Better late than never.

**COST BENEFIT RATIO FOR WARM CLOUD SEEDING
EXPERIMENTS,INDIA**

The cost benefit ratio for the warm cloud seeding experiment based upon the data collected by the Institute at Pune for the increase in precipitation of about 20% works out as follows (1986 rates)

i)cost of the experiment for 11 years (monsoons) Rs.58 lakhs

ii)Expenditure incurred during 1986 Rs. 8 lakhs

Assuming 20% increase out of the annual average rainfall of 346mm recorded in the experimental field during the monsoon for 1986,

Volume of additional water produced = (Target area x rainfall)

additional water (1600 x 1000 x 1000 x 346 x 20)/(100 x 1000)

which is equal to 110720 x 10 x 10 x 10 cubic meters

Cost of expt/additional water = Rs.8 lakhs/(110720 x 10x10x10)

Therefore cost benefit ratio for artificial rains is 1:60

References:

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ANNEXURES:

Annexure-I

GOVERNMENT OF ANDHRA PRADESH

ABSTRACT

Water Resources Management – Artificial Rain –
Formation of an Advisory Committee to take further action for
implementation of the “Expert Committee on
Artificial Rain and Aerial Seeding” – Orders –
Issued.

ENERGY,FOREST, ENVIRONEMNT, SCIENCE & TECHNOLOGY
DEPARTMENT

G.O.Ms.No.178 Date 9-6-1988

----- Read the following:-

Report of the Expert Committee on Artificial Rains and Aerial Seeding,
dt. 23-3-1988.

ORDER:

A seminar was held at Hyderabad on 19-3-1988 (organized by the Forest Development Corporation) under the Chairmanship of the Hon’ble Minister for Forests, so as to explore the possibility of obtaining artificial rain in the state. It was attended by eminent Meteorologist Padmabhushan P.Koteswaram, former Direction General of Meteorological Department, Government of India, Prof.T.Shivaji Rao, Eminent Environmentalist, Shri.J.Raja Rao, Former Chief Engineer, Irrigation & Ex-officio Secretary to Government, Dr.A.S.R.Murthy, who has experience of this work at Indian Institute of Tropical Meteorology, PUNE and the Prl.Chief Conservator of Forests & Ex-officio Secretary to Government (Forest) Chief Engineer, Hyderabad Metro Water Works., etc.

2. The Seminar made a number of recommendations regarding the taking up of the seeding of clouds in A.P. on experimental basis and also to set up a committee for drawing up an Action Plan.
3. The proposal was also mooted at the world Forestry Day held on 21st March, 1988 which was inaugurated by the Hon’ble Chief Minister. It is desired that the proposal be examined and a report prepared regarding the feasibility of the project atleast on an experimental basis.
4. Accordingly, a committee of experts was formed and a report including the proceedings of the Seminar, the resolutions as well as its recommendations has been prepared.
5. The report was presented by the Hon’ble Minister for Forests along with the members of the Expert Committee to the Hon’ble Chief Minister on 24-3-1988. While appreciating the efforts it is considered desirable that further action may be taken in regard to the recommendations.
6. As per the recommendations of the Committee WALAMTARI was recommended as Nodal Agency for implementing the Action Plan and to initiate further immediate action in this regard.
7. The Government hereby constitute Advisory Committee, to take further action for implementation of the report, consisting of the following:-

Shri.Gali Muddu Krishnam Naidu --- Chairman
Minister for Forests.

Prof.P.Koteswaram --- Member
Retired Director General
Indian Meteorology Department &
Ex.Vice President,
World Meteorology Organisation.

Prof.T.Shivaji Rao, --- Member
Prof.of Environmental Engineering,

Andhra University.

Shri.J.Raja Rao, --- Member
Retd.Commissioner of Project,
Formulation and Ex.Officio Secretary,
to Government Irrigation & CAD Dept.

Chief Engineer. --- Member
Hyderabad Metro Water Works.

Shri.Pushpakumar IFS., --- Member
Chief Conservator of Forests

Shri.T.Hanumantha Rao, --- Member
Chairman, Water & Land Management
Training and Research Institute.

8. The Government further order that the WALAMTARI (water and Land Management Training and Research Institute) shall be the Nodal Agency for implementation of this project.

9. While long term proposals contained in the report of the Experts Committee will be taken up by the EFES&T Department immediate action will be taken by the HMA&UD Department on the short-term programme proposed by the Committee regarding artificial rain experiment on a trial basis in the catchment areas of twin cities water-supply reservoirs. Viz., Osman Sagar, Himayatsagar and Mir Alam Tanks. The experiemental work is already entrusted to WALAMTARI by the HMA&UD Department.

10. The non-official members are eligible for air fare to and fro whenever they perform journey in connection with the meetings of the Committee and for sitting fee of Rs.100/- for each sitting of the Committee. D.A. will not be allowed to non-official members on the days on which sitting fee is paid to them.

11. The expenditure on TA and sitting fee incurred in respect of the meetings of the Committee shall be met by the WALAMTARI initially pending reimbursement from the Government. The expenditure is debitable to the head of the Account No.”3425 other scientific research – 60 – Others 200 Assistance to other scientific Bodies – Schemes included in the plan S.H. (05) Assistance to Institutions for Scientific and Technological Research – 092 – other Grants – in aid” and will be borne by the Department within its budget. The Assistant Secretary to Government, EFES&T Department will draw and disburse the amount to the WALAMTARI whenever claim received from the WALAMTARI.

The order issues with the concurrence of Finance and Planning vide their U.O .No.032 A/268/T.A./88, dt.9-6-1988.

(BY ORDER AND IN THE NAME OF THE GOVERNOR OF ANDHRA PRADESH)

V.P.RAMARAO,
PRINCIPAL SECRETARY TO GOVERNMENT.
To
All the Members of the Committee.

Copy to:
Finance & Planning (TA) Department.
Finance & Planning (PW) Dept.
Pay&Accounts Officer. Hyderabad.
Accountant General, A.PHyd.
The Prl.Chief Conservator of Forests, Hyderabad.
Irrigation & CAD IV Dept. Hyderabad.
HMA&UD Department, Hyderabad (A.II)

All Departments, Secretariat, Hyderabad.
EFES&T (Claims)Department, Hyderabad.

Secretary to Chief Minister, Hyderabad.
P.S. to Minister Forest
P.S. to Minister (Municipal Admn) A.P.Hyderabad.
P.S. M&MI, Hyderabad
P.S. to Minister (Minor Irrigation) A.P.Hyderabad.

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