

# CONSIDERATION ON ARTIFICIAL RAIN SYSTEM BY MEANS OF SEA WATER VAPOR EQUIPMENT HEATED BY SUNLIGHT

Hideyo Murakami \*

Touhwa University, 1-1-1 Tsukushigaoka, Minami-ku Fukuoka-City, Japan

## 1. INTRODUCTION

An artificial rain technology has been developed and applied in many countries, and it changes existing cloud to rain by means of seed augmentation in many cases. Amount of artificial rain depends on existing cloud, and timing and area of artificial rain is not controlled by the existing artificial rain technology.

A Vapor Equipment was proposed by Dr. Hideyo Murakami as one of the new artificial rain technologies. This Vapor Equipment forms one part of the new artificial rain technology. Under sunlight this Vapor Equipment makes a huge amount of vapor of sea water in order to design and control amount, timing and area of rain. When the Vapor Equipment is large, a huge amount of vapor is made and carried way in the sky, and it could become a cloud. This cloud is transported to any region which requires rain by means of wind such as westerlies. Wind has characteristics (direction, speed and so on) which depend on a region, seasons and so on. Therefore, setting place of the Vapor Equipment is designed on the basis of those characteristics.

This paper proposes Vapor Temperature Control Equipment as another part for a new artificial rain technology and considers how to design and control direction and speed of wind which includes vapor made by Vapor Equipment for the new artificial rain system

## 2. New Artificial Rain Technology

### 2.1 Principle of Vapor Equipment

In many cases, the sea or a lake is large and more than 10 meters deep. There are waves, and water of them is moved and mixed. Therefore, temperature of surface water does not become high under sunlight energy.

However, if water film, which is made of the sea water or lake water, is set under sunlight energy, then the water film becomes hot, and is changed to vapor effectively. The water film is produced continuously, and vapor is also continuously made. When Vapor Equipment is large, a huge large amount of vapor is made and carried way in the sky, and it could become cloud. This cloud is transported to any region which requires rain by means of wind such as westerlies. Wind has characteristics (direction, speed and so on) which depend on a region, seasons and so on.

\*Corresponding author address: Hideyo Murakami,  
4-2-4-1 Jigyuu Tyuou-ku, Fukuoka-city, Japan  
E-mail: muroku@oregano.ocn.ne.jp

Therefore, setting place of a Vapor Equipment is designed on the basis of those characteristics.

Even if a huge amount of vapor is transported to a region which requires rain, there is some possibility that no rain is expected in the region. The Vapor Equipment changes water to vapor under sunlight in every fine day and vapor becomes a cloud with some probability. Then the region may have rain in fine days with some probability. If the region needs to have rain in all days of fine days, seed augmentation methodology is useful, because there is vapor or a cloud which includes a designed amount of water.

An example of the Vapor Equipment is shown in Figure 1. The Vapor Equipment is composed of floating material F and sheet S which has capillary action and continuously makes water film on floating material F. The floating material has capability of floating on water. In this example, floating material F is an air mat. Sheet S is cotton cloth.

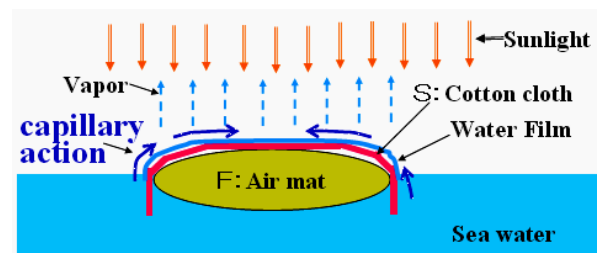


Figure 1 Vapor Equipment

This Vapor Equipment uses only sunlight energy, makes water film hot and changes water to vapor. Necessary energy for changing 1kg water to 1kg Vapor is about 630 watt x hour. A vapor amount per meter square of the Vapor Equipment depends on power of sunlight energy. A total amount of vapor which is made by the Vapor Equipment group depends on a size of the Vapor Equipment group. Figure 2 shows an example of the Vapor Equipment group. In this example, a length of the Vapor Equipment group is 36,000 m, and a width of it is 1 m. This group consists of 10,000 sets of Vapor Equipment. An interval between Vapor Equipment is 1 m. A size of the Vapor Equipment group is 20,000 x 36,000 m square. If the Vapor Equipment group size is controlled day by day, a rain amount can be controlled by a size of the Vapor Equipment group under sunlight.

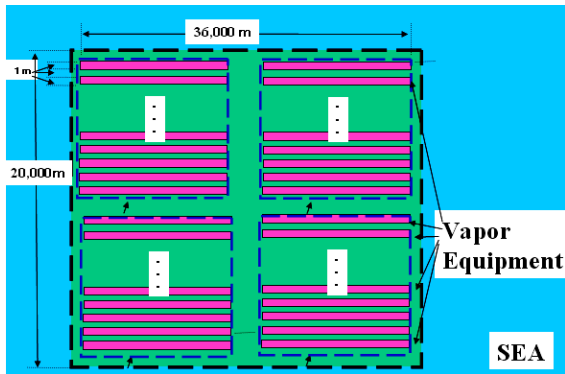


Figure 2 Setting Vapor Equipment in the SEA

In Fukuoka prefecture of Japan, the Vapor Equipment group changes about 0.8 kg of water to vapor per hour per one meter square. The maximum power of sunlight energy in Fukuoka prefecture of Japan is about 800 watt per one meter square. So the Vapor Equipment group as shown in Figure 2, size of which is 720 kilometer square, could make about 1,440,000,000 kg vapor per day (5 hours). This vapor can make a cloud, and the cloud could change to 1,440,000,000 kg of precipitation. When a place and timing of the Vapor Equipment group setting is selected and designed, an area, an amount, timing of artificial rain could be controlled.

Figure 3 shows an image of vapor movement. When wind speed is 1 meter/sec, wind goes through 3600 meter per hour on the Vapor Equipment group. It takes one hour for wind to go over the Vapor Equipment group. During one hour the Vapor Equipment group changes 0.8 kg water to vapor. Therefore, an amount of vapor, which is accumulated at the end of the Vapor Equipment group, is 0.8 kg in one meter square.

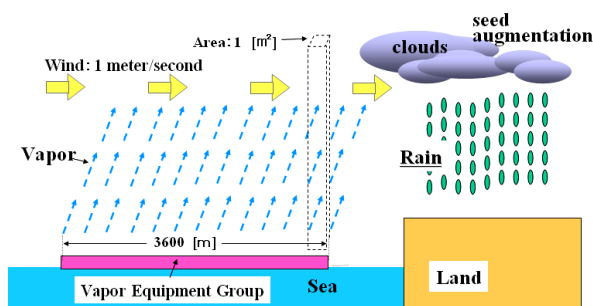


Figure 3 Image of Vapor Movement

In many regions, wind blows from the sea to a land in the daytime. It is called a sea breeze. Therefore, in many cases, vapor, which is made by the Vapor Equipment group, is transported to land by a sea breeze.

Direction, height or speed of a sea breeze depends on a region. The prevailing westerly or trade winds constantly blow; direction or speed of them is constant in many cases. However these winds are changeable according to seasons.

Vapor is transported to a land by these winds. Setting of the Vapor Equipment group is adjusted to characteristics of these winds on a case by case basis. If direction and speed of wind is designed and controlled, more precise design and control of an amount, timing and an area of rain by means of the new artificial rain technology could be done.

## 2.2 Proposal on Vapor Temperature Control Equipment

Vapor Temperature Control Equipment is proposed for the new artificial rain system. This Vapor Temperature Control Equipment supports design and control of wind which carries vapor to land. The Vapor Temperature Control Equipment is composed of only floating body as shown in Figure1 and surface of body is colored. For example, surface of floating body is colored black. Then all of sunlight energy could be changed to heat energy which heats surrounding air including vapor. If sunlight energy is 1 kilowatt per 1 meter square, then heat energy of the Vapor Temperature Control Equipment could be equal to 1 kilowatt per 1 meter square. Total heat energy to be made by the Vapor Temperature Control Equipment depends on a size of the Vapor Temperature Control Equipment.

This energy amount is very large to heat surrounding air and increase air temperature to some degrees. High temperature air is lighter compared surround air, and climbing speed of carrying up vapor is high. Wind blows from a cool temperature area to a hot temperature area. Therefore, not only setting position and amount of the Vapor Temperature Control Equipment can be designed, but direction and speed of wind can be designed and controlled.

An example is shown in Figure 4. The Vapor Temperature Control Equipment is set between land and the Vapor Equipment group. Vapor is heated by the Vapor Temperature Control Equipment; its temperature depends on the size of the Vapor Temperature Control Equipment. Wind goes from the sea to the land according to setting of the Vapor Temperature Control Equipment.

## 2.3 Conditions I on the new artificial rain technology

This new artificial rain technology can control an amount, timing and an area of rain. In this technology, the Vapor Equipment group is set on a surface of water such as sea salt water or lake water. This Vapor Equipment group changes water to vapor by means of sunlight energy.

This new artificial rain technology is studied and designed from cost, energy and environment point of

view. Under the hypothesis that any region, which requires precipitation, is near the sea and has sunlight, following Conditions I on this new artificial rain technology are accomplished:

- (1) Enough amount of precipitation is realized in any region which requires artificial rain, when precipitation is required.
- (2) An artificial rain system can be stopped when precipitation is not required.
- (3) An artificial rain system is made at lower cost, uses clean energy, and does not make CO<sub>2</sub>.
- (4) An artificial rain system does not degrade global environment.

### 3. Artificial rain by means of the new artificial rain technology

When the Vapor Equipment group shown in Figure 2 is applied to a region, how much amount of precipitation is expected in the region? Under the following hypothesis, precipitation can be estimated.

- (1) In the region, there is a sea breeze, and speed of it is equal to 10 meter per second, and the Vapor Temperature Control Equipment group supports design and control wind.
- (2) During from 10 to 15 o'clock, sunlight energy is more than 800 watt, for example 1.2 k watt.
- (3) The Vapor Equipment group changes 1.0 kg sea water to vapor per meter square per hour under sunlight.
- (4) At 18 o'clock, it becomes cool and rains in a region where cloud exists.

Total precipitation (Tp) of artificial rain is shown by equation Eq (1), if Tp is equal to a total amount of vapor changed by the Vapor Equipment group.

·  $Tp = Vo \times Vw \times Vlen \times Vd \times 5$  ----- Eq (1)  
 Vo : An amount of vapor which the Vapor Equipment group changes water to per hour per meter square.  
 Vw : A width of the Vapor Equipment group  
 Vlen : A length of the Vapor Equipment group

The maximum density of artificial rain precipitation (Pm) is shown by equation Eq (2).

$Pm = Vo \times Vd \times Vlen / Wsp$ , if  $Vlen / Wsp < 5$

Vd : Density of the Vapor Equipment group.

Vd = a width of the Vapor Equipment / (a width of a Vapor Equipment + an interval of them)

=  $Vo \times Vd \times 5$ , if  $Vlen / Wsp > 5$  ---- Eq(2)  
 Wsp : Speed of Wind (m/hour)

An artificial rain area in this region is considered as shown in Figure 4. Tp is equal to 1,800,000,000 kg, and Pm is equal to 0.5 kg per meter square, when Vo=1.0 kg/hour/m<sup>2</sup>, Vw=20,000 m, Vlen=36,000 m, Vd=0.5, Wsp=36,000 m/hour.

When a cloud is made by means of the Vapor Equipment group shown in Figure 4 is small, precipitation could not be realized. In this case, length of the Vapor Equipment group should be longer than that of Figure 4. For example, length of it (: Vlen) is equal to 72 kilometer in stead of 36 kilo meter. In this example, Pm is equal to 1.0 kg per meter square.

In the example shown in Figure 4, a rain area is clear. However, a real rain area is distributed at the center of a rain area shown in Figure 4. Precipitation of a rain area is also distributed.

### 4. Consideration and Discussion

- (1) The Vapor Equipment group and the Vapor Temperature Control Equipment group meet Conditions I for this new artificial rain technology shown in section 2.
- (2) Introduction of the Vapor Equipment group is easy. The Vapor Equipment group does not require an area, building, equipment and energy in a land. On the other hand a large area of a sea surface, for example 20 km x 36 km square, is required for setting the Vapor Equipment group.
- (3) An interval between the Vapor Equipments shown in Figure 2 is equal to 1 meter, and then some part of sunlight goes through sea water and gives

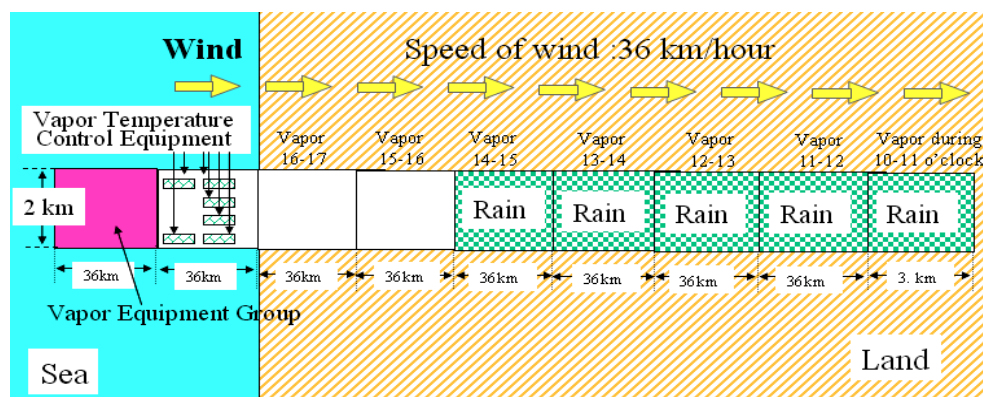


Figure 4 Image of Artificial Rain Area

sunlight energy to plants or animals in the sea. The Vapor Equipment group does not have an effect on sea environment.

- (4) The Vapor Equipment group does not produce CO<sub>2</sub>, because it uses only sunlight energy in order to make vapor.
- (5) Cost of energy for making vapor is free. Main cost of the Vapor Equipment group consists of floating material F such as air mat, and sheet S such as cotton cloth. A vapor amount is equal to 0.8 kg per 1 meter square in Japan. However, the maximum of it could be more than 1 kg per 1 meter square in the world.
- (6) Some regions are not cool and do not rain at night, even if the Vapor Equipment group makes a lot of vapor. In this case augmentation methodology could be applied.
- (7) The Vapor Temperature Control Equipment group is useful to design and control direction and speed of wind including vapor. How to use it is for further study.
- (8) The proposed artificial rain technology could not provide rain in some regions distant from the sea. However other regions near the sea could have so a large amount of precipitation that it could be transported to the regions distant from the sea by means of an irrigation canal.
- (9) How to control an amount of precipitation, timing and an area of rain could be done with some probability. It depends on temperature, humidity and wind characteristics of the region which requires artificial rain. Therefore, when the proposed artificial rain technology is applied to a region, the region may develop its own sophisticated method to control an amount of precipitation, timing and an area of rain on the basis of fundamental method.

## 5. Cost of 1 liter Artificial Rain

Cost of 1 liter artificial rain (C1) is equal to about 0.001USD, and is shown by Eq(3). This cost depends on Cost of 1 meter square of the Vapor Equipment (:VE), It could be lower.

$$C1 \doteq ( \text{Cost of VE Equipment} + \text{Cost of VE Operation \& Maintenance} ) / ( \text{Total amount of Artificial Rain during VE life time} ) \quad \text{----- Eq(3)}$$

$$\doteq ( \text{Cost of 1 meter square of VE} + \text{Cost of VE Operation \& Maintenance} ) / ( \text{Total amount of Vapor generated by 1 meter square of VE during VE life time} )$$

$$\doteq ( 2 \text{ US\$} + \text{Cost of VE Operation \& Maintenance} ) / ( 1 \times 10 \times 40 \times 5 )$$

$$\doteq 0.001 \text{ US\$} + \alpha$$

Note: - Amount of vapor generated by one meter square of VE during 1 hour is equal to 1 liter,

- Life time of VE is equal to 10 years, VE is used during 40 days per year, 5 hours per day
- $\alpha$  could be neglected, because cost of VE Operation & Maintenance of one meter square of VE is small.

## 6. Conclusion

- (1) The proposed artificial rain technology using the Vapor Equipment group and the Vapor Temperature Control Equipment is effective in order to get artificial rain, and is not dangerous. Introduction of the proposed artificial rain technology is at lower cost and easist.
- (2) The proposed artificial rain technology can provide a large amount of precipitation, and it may become one of the solutions for water shortage.
- (3) Maintenance of the Vapor Equipment group and the Vapor Temperature Control Equipment group is necessary. For example, floating material is large. Sometime it may be broken by fish. How to maintenance the Vapor Equipment group is for further study.
- (4) It is necessary that a large amount of the Vapor Equipment group and the Vapor Temperature Control Equipment are developed and experimented in order to study operation and maintenance technology for them.

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## Reference

Hideyo Murakami, 2008: Characteristic of Vapor Equipment for artificial rain, MSJ autumn Conf. B363.