The approach for SDGs based on cultivation of *Suizenji-nori*, as a raw material of the ingredient, Sacran, for cosmetics

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Abstract

In 2015, United Nations Sustainable Development Summit was held and the agenda of SDGs (Sustainable Development Goals) is accepted unanimously. Cosmetic companies all over the world are considering the natural environment and it is very important for them to establish sustainable schemes for the production processes.

Sacran is very unique natural polysaccharide, which has utilized as an ingredient for skin care cosmetics because of its very superior water retaining property and the other unique properties, is extracted from *Suizenji-nori*, which is a Japanese inherent alga designated as endangered species. Nowadays, *Suizenji-nori* is cultivated and survives with the electrically pumping up fountain water from the deep stratum related to Mt. Aso, which is well-known volcano in Kyushu.

In this study, we have proposed and established the scheme, in which the totally natural cultivation process of *Suizenji-nori* in Mt. Aso Caldera Area. We have succeeded in the cultivation of *Suizenji-nori* only utilizing the sun light and naturally gushing fountain water without using generated electricity in our recent demonstration trials.

From now on, we will have co-development action with the government, local municipality and local farmers, then aim at the protection of endangered species, the maintaining of fountain water and the industrial revitalization in Mt. Aso area. This movement will lead to the sustainable growth for middle and long term following the SDGs concept. As the result, the cultivation of *Suizenji-nori* would expand employments in Mt. Aso area, and finally the ecosystem around Mt. Aso area will be sustained for good.

Keywords: *Suizenji-nori* (*Aphanothece sacrum*), Sacran, barrier effect, environmental conservation, SDGs

Introduction & Objective

The agenda of SDGs should be completed by the end of 2030, approved in United Nations in 2015 [1]. As everyone knows, there are 17 objects and 169 targets in this agenda, in which all countries and stake holders should work on.

In the cosmetics industry the microplastics issue has become the significant concern, since microplastics are formulated in final cosmetics. After washing out, these are wasted in the ocean. In this moment, the usage of microplastics in leave-off cosmetics are banned, and near future the usage of microplastics for all cosmetic formulations will be banned. And also, palm oil has been utilized in cosmetics for long time. However, recently palm oil which certified with RSPO (Roundtable on Sustainable Palm Oil) certification should be required and used in the cosmetics field. In these streams, the actions for SDGs in the cosmetics field has been getting very important to make business. This means that the developments and constructions of ingredients which are natural origins, the production process and scheme which is considered of the natural environment must be the main objects for the cosmetics industry.

Suizenji-nori (*Aphanothece sacrum* (Sur.) Okada) is a Japanese inherent alga which glows in fresh water and eatable (Fig. 1). This alga had been recognized and named in Lake Ezu, Kumamoto-City, in 1872, by Dr. Suringar who was the botanist in Netherland. And he introduced this all over the world. However, the history of this alga as a food is much older than the recognition by Dr. Suringar. This alga has been eaten at least from 16 century as a luxury food and had been presented to Shogun in the Edo Period [2]. This alga had been widely and wildly seen in Lake Ezu a lot.

Fig. 1 *Suizenji-nori* (*Aphanothece sacrum* (Sur.) Okada)

However, in recent years (after around 1990), the area for this alga to glow has been getting decreased and limited, since the quality of the fountain water in Kumamoto City has been contaminated because of the enlargement of housing area, decreasing rice field and using pesticides. In this moment, the cultivation of this alga has been continued only 2 small places in Kumamoto and Fukuoka Prefectures in Kyushu, Japan, where the fountain water can be pumped from the stratum bedrock of Mt. Aso, and designated as “The Endangered Species I (CR+EN)” by Ministry of Environment in Japan [3]. This category will mean that this species will be extinguished.

Suizenji-nori consists of some kinds of clusters, green-brown or brown. In these clusters there are some cocoon type of cells, and in the cell division into 2 cells this cell will yields the viscous material out of the cell [2]. This material is the inherent polysaccharide, Sacran. This polysaccharide had been firstly extracted by the team of Dr. Okajima in Japan Advanced Institute of Science and Technology (JAIST) in 2006 [4].

Sacran is the only one natural polysaccharide which contains 11 kinds of saccharides, in which there are the one contains sulfate group and carboxylic group. Sacran is a ultra huge molecule whose molecular weight is round 16-27 MDa and length is around 10 μm [4]. Because of Sacran's very unique structure of the molecule, it shows very high water retaining, mending effect for the sensitive skin and film forming property on skin. With these pieces of evidence, the effectiveness to formulate Sacran in skin care cosmetics as a kind of barrier of the skin is recognized and utilized in cosmetics [5-11]. Since Sacran is a natural ingredient, the utilization in cosmetics has been relatively growing in these days.

However, since *Suizenji-nori* can only grow in the condition of very high quality and pure of ground water and fountain water from the bedrock stratum from Mt. Aso, the amount of the yielding is getting limited. It is the big challenge and concern for us to secure *Suizenji-nori* itself and improve of the amount of the yielding of *Suizenji-nori*.

Mt. Aso is the volcano accompanied with caldera placed in the almost center of Kyushu Island, Japan (Fig. 2). The average amount of the annual rainfall is about 2,400 mm, which is relatively high in Japan. In the caldera area of Mt. Aso, there are about 1,500 places fountaining ground water (this means that there is plenty of ground water under the ground of this caldera area.) [12] (Fig. 3). These fountain water makes 6 rivers, which are categorized "Class A" in Japan (Class A river; specified waterways of special importance protected by the government) and end up to the sea. These ground fountain water from Mt. Aso Caldera Area supplies the 480 million habitants in foot area of Mt. Aso. This is the very important natural source for their living and agricultural activities.

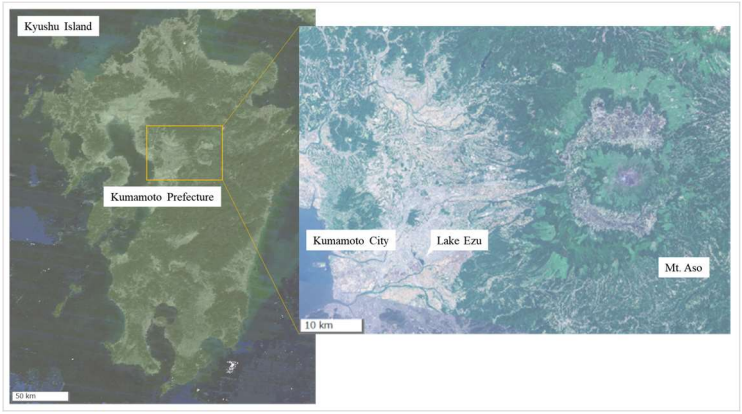

Fig. 2 Location of Lake Ezu and Mt. Aso (created by processing aerial photographs taken by the Geographical Survey Institute)

Fig. 3 Shirakawa Suigen (the representative wellspring at Aso)

In Kumamoto, the rainfall in Mt. Aso Caldera Area and westside of out-ring mountains of caldera precipitate and penetrate underground. Some ground water gushes up in Mt. Aso caldera and Kumamoto-City where is in the downstream area of River Shirakawa, which is consisted with fountain ground water in Mt. Aso caldera and streams out in Ariake Sea through Kumamoto-City. Kumamoto-City is the number one city where the almost 100 % of living water for about 970,000 habitants is supplied from underground water from Mt. Aso (the fee of potable water is free in Kumamoto-City.) [13]. Lake Ezu is placed almost center of Kumamoto-City and consisted with 100% fountain water from Mt. Aso. Since in this lake the enough much of fountain water is always supplied from Mt. Aso, it would be suitable to grow *Suizenji-nori*, actually *Suizenji-nori* was used to grow naturally. Table 1 shows the quality evaluations of water in Lake Edu, whose water temperature and pH are almost always stable at 18-19 °C and 7-8 for year around, compared with in 1990 and 2005. However, the electric conductivity had been increased from about 0.19 mS/cm in 1990 to 0.23 mS/cm in 2005, and T-N (Total Nitrogen content) had been also increased from 2.9~3.1 mg/L to 3.8~4.3 mg/L. This would suggest that the fountain ground water had become nourishment. And on the other hand, the amount of fountain water in Lake Ezu had been significantly decreased from about 890,000 m^3/day in 1960s to about 400,000 m^3/day. These significant unpreferable change might be caused by the increase of using ground water for living and industry in Kumamoto-City, the decrease of agricultural rice fields in Mt. Aso Caldera Area and around middle streaming area of River Shirakawa, and the increase to use too much amount of nitrogen fertilizers in rice fields [13].

Table 1 The quality of water on the *Suizenji-nori* generation ground in 1990 and 2005.

	1990	2005
Water temperature (℃)	18.2	18.4
pH	7.2	7.4
EC (mS/cm)	0.19	0.23
DO (mg/ℓ)	10.7	8.9
SS (mg/ℓ)	1.2	6.8
COD (mg/ℓ)	2.1	3.2
T−N (mg/ℓ)	2.9~3.1	3.8~4.3
Ca (mg/ℓ)	17.5	17.2
Mg (mg/ℓ)	5.4	6.5

Although a large amount of wild *Suizenji-nori* had been used to grow in Lake Ezu area, in these days it cannot be seen anymore, even in somewhere around, because of the worsening the quality and the decrease of the ground fountain water [13]. In the recent days, there are only 2 small places to cultivate *Suizenji-nori* with electrically pumping up ground water from Aso's stratum, Kumamoto and Fukuoka Prefectures. In these places *Suizenji-nori* has been survived and maintained limitedly.

On the other hand, there are some naturally shing fountain water places in Mt. Aso Caldera area without using for any industries. From this point of view, we have proposed and made our plan to utilize these natural gushing fountain water sources effectively, which leads to maintain *Suizenji-nori* in Mt. Aso Area and construct a new cultivation industry for cosmetics and so on based on the concept of the environmental conservation and protection.

In this study we report our trials and developments of the cultivation of *Suizenji-nori* in Mt. Aso Area, based on the reconstruction, progress and activation in local societies, like Mt. Aso Area following on SDGs concept. As the result, we may achieve the protection and the maintaining endangered species, natural fountain water, the activation of industry in local for middle range term and in order to do so we will achieve SDGs.

Result & Discussion

The establishment and trial actions for sustainably cultivating *Suizenji-nori* in Mt. Aso Area

In order to accomplish the increase of the yielding of Sacran, which is natural origin and a very effective ingredient in cosmetics, and consistently supplying this ingredient in the world, and maintain and sustain the natural environment in Aso Area, we have proposed our original scheme of the sustainable cultivation of *Suizenji-nori* (Fig. 4). Since *Suizenji-nori*, which is the raw material alga of Sacran, is designated as an endangered species grown in the very limited natural environment, to discover and create the places and environment will mean the protection and the maintaining of natural species and the sustainable ecosystem in the area. And because of wealthy amount of fountain waters in Mt. Aso Caldera, we have considered and made our plans to establish a new sustainable industry by utilizing these fountain waters for the cultivation of *Suizenji-nori*. In this concept (or scheme), it will be the fundamental and very important that the habitants in Aso area will be the persons to make cultivation of *Suizenji-nori*. In this area, since these natural fountain water places belong to designated persons, it would be very difficult for all persons to use. Therefore, we will establish the basic technology to cultivate *Suizenji-nori* in Aso Area, and then we will transfer our how-how technology and scheme to local persons, especially the persons who own the fountain water places. There are two reasons (objects) ;

(1) By stabilizing the cultivation of *Suizenji-nori* as the very important local industry, for habitants in this area to recognize and be pound of as the very important, special and sustainable product for good. These movements lead to yield employment, namely the solution of the big concerns in rural area

(Aso Area), such as depopulation and aging society.

(2) To expand the sustainable concept based on SDGs, the protection and the maintaining natural fountain waters, since *Suizenji-nori* is the creature, which is very sensitive for the natural environment condition (worsening condition). To broaden the cultivation of *Suizenji-nori* with natural fountain waters, must mean the same action to protect and maintain the natural and sustainable environment condition. We are expecting that the recognition of the owners of fountain waters in this area would be strengthened as a stakeholder to obtain the benefit from the sustainable nature by broadening the cultivation of *Suizenji-nori*.

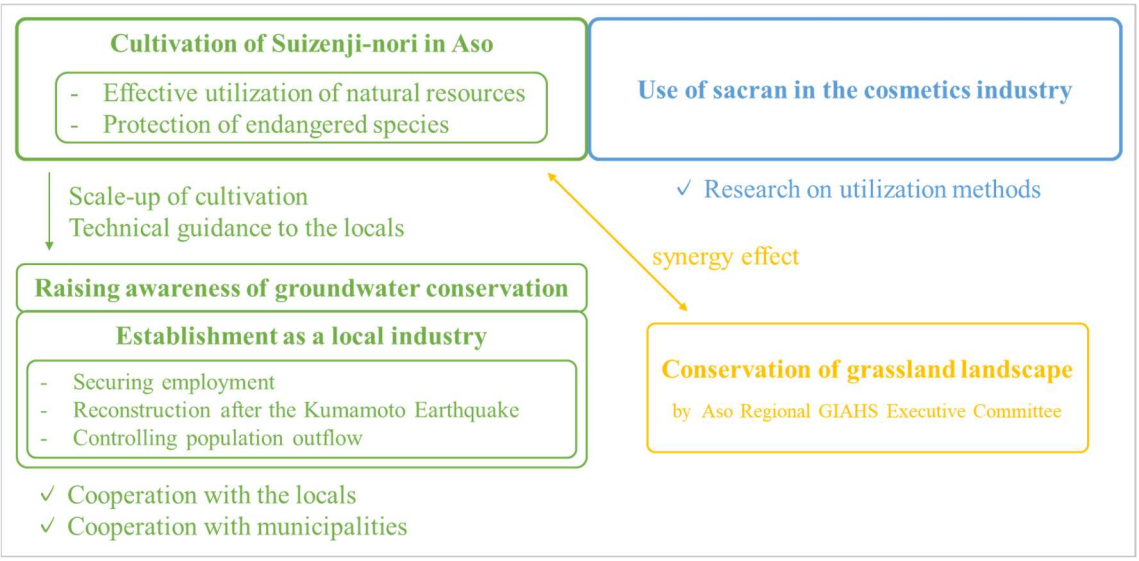

Fig. 4 Our scheme of the sustainable cultivation of *Suizenji-nori* in Aso area

In Fig. 4 our proposing sustainable cultivation scheme of *Suizinji-nori*. In order to achieve this proposing scheme, we had required the cooperation of the local municipality and agricultural habitants in Aso Area for our action. Then, we had made evaluations in the fountain water gushing places of the quality of fountain waters, amount of gushing, water temperature, temperature in atmosphere and amount of sunshine, which are belonged to the local municipality and agricultural habitants. We found and designated some capable places to grow *Suizenji-nori*, and made preparations (Fig. 5). As the results of our demonstration experiments from 2019, we have found 4 suitable places to sustainably cultivate *Suizenjin-nori* in Mt. Aso Caldera Area. However, the water temperature in Mt. Aso area is relatively lower than that of Kumamoto-City area, around 18-22 °C (suitable temperature for the cultivation [14]) in the downstream, because of its relatively high elevation, 400 m above sea level. Although the evaluation results so far had been recognized that this lower water temperature is not suitable to cultivate sustainably, we have succeeded to cultivate sustainably by covering cultivation units with insulating material, such as agricultural plastic sheets, in order to increase water temperature using energy from the sun. Since

originally in Mt. Aso Area naturally gushing fountain water is used, we have succeeded in the cultivation without electrically generated energies. This scheme must be suggested can be said that the cultivation is successfully and sustainably carried out.

Fig. 5 Experimental cultivation equipment for *Suizenji-nori*

Utilization of Sacran

Sacran, which is the natural polysaccharide and extracted from *Suizenji-nori*, is attracted because of its unique molecular structure, and has been researched in cosmetic field and so on. Sacran shows higher water retaining property, 5 times as much as that hyaluronic acid [5], and film forming effect on skin from the gel solution in water/polyol mixture media [6]. In moisture lotion formulation of Sacran, this film on skin works as barrier against unfavorable chemical components in usage as cosmetics and restrain moisture evaporation. In demonstration usage of Sacran formulated skin lotion for the sensitive skin whose barrier effect is weakened, the trapping effect against unfavorable stimulants is recognized. This can be the proof that Sacran might be penetrated in corneocytes and also make barrier film on skin [7].

There is the other research reporting that because of Sacran thin film on skin in application of Sacran moisture lotion tabaco smoke which is well known one of air polluted is trapped and the skin damage by tabaco smoke has been decreased [8]. In recent days because of COVID-19 people wear masks. Wearing masks induces skin damage. In the evaluation of the effectiveness for this induced damage in application of Sacran moisture lotion before wearing masks the moisture content in corneocytes is retained and the transepidermal water loss (TEWL) is lower, namely the skin damage has been decreased [9]. This means that Sacran moisture lotion will improve the unmatured skin condition, retain moisture and lessen the stress by reactive oxygen on skin. We can see the report which says that in clinical demonstration test in dermatology in application of Sacran moisture lotion, there might be effects against allergic dermatitis and atopic dermatitis [10] [11].

The results of these above studies are suggesting that Sacran has some effective properties on skin, such as the protection effect against unfavorable chemical components from outside of skin and the adjustment

and the amendment of corneocytes to mature normally and wealthy. Our sustainable cultivation scheme and movement based on SDGs concept will not be achieved without effective utilization of Sacran in cosmetics. We are expecting that our proposing scheme and object will contribute the development of superior skincare cosmetics and improve QoL of mass consumers all over the world.

Future vision & Final target

In this study, we have explored and investigated the approach and the scheme to protect and sustain the biodiversity, its ecosystem and the quality of fountain water, and to make activation of the local industry and agriculture in Mt. Aso Area with the cultivation of *Suizenji-nori*, which is the endangered species in Japan. Our approach and scheme have been well recognized by the local agricultural habitants and the municipality. And we have been able to get the cooperation by them to proceed our approach in Mt. Aso Area. This would be the very significant and meaningful procedure to utilize the natural sources and the protection and maintaining the endangered species. However, there are some subjects we have to solve, from the viewpoint of achieving the sustainable environment and ecosystem. At first, we have to realize the cultivation of *Suizenji-nori* by the local habitants in Mt. Aso Area. This is very important to disseminate the cultivation and increase the yield of *Suizenji-nori*. The increase of the persons to cultivate *Suizenji-nori* and the broadening of the cultivation in Mt. Aso Area should lead to maintain the local employments and suppress the outflow of the local habitants. This is very significant and desperate issue in Mt. Aso Area, since Mt. Aso Area had been significantly suffered and damaged by "The 2016 Kumamoto Earthquake" and still in this moment the reconstruction has not been completed. Especially, the declines in the tourism and the agriculture in Mt. Aso Area are still big issue and concern. From this point, to rise up novel creative industry following SDGs concept, such as the cultivation of *Suizenji-nori* must be inevitable to make the reconstruction from the damage by the earthquake. Furthermore, the improvement and the recognition of the protection and the maintaining of the quality of fountain waters in Mt. Aso Area by the local habitants will be expected. This concept and action would be broadened in the downstream area, in Kumamoto-City and so on related to Mt. Aso stratum.

The cultivation of *Suizenji-nori* will contribute to make synergy effect with the other actions and attempts of SDGs. The total ecosystem in Mt. Aso Area, "The maintaining of the Aso meadow and the sustainable agricultural process" has been certified in "Globally Important Agricultural Heritage Systems = GIAHS" by FAO (The Food and Agriculture Organization of the United Nations) in 2013, as the traditional agricultural ecosystem to maintain and take over to the future generations [15]. Mt. Aso Area is consisted with the huge and wide meadow area in Mt. Aso itself, rice fields in the plain caldera area and the out-ring mountains of caldera. The very broad meadow area, 22,000 ha, in Aso Caldera Area for over 1,000 years has been existing and maintaining. The vegetation of very wide meadow area has been constructed by not only its unique nature seasonable condition but also the traditional actions by human beings. If there were only the natural seasonable conditions, such as temperature, amount of rainfall, Aso Caldera Area must be

only covered only deep forest. However, Aso Caldera Area is covered by only wide and huge meadow. This means that there is the effect of the volcanic activity of Mt. Aso, such as the unique geography which shows easy rainfall transparency and also the human activities from the ancient days, such as open burning, grazing and weeding. This is the ecosystem in Aso Caldera Area for over 1,000 years. These weeds had been used to utilize to ceiling of houses and fertilizer for horses, army and agricultural, nowadays utilizing to fertilizer for edible beefs. It is the proof that the huge and wide meadow area in Mt. Aso Area has been maintained for long time with coexisting the nature and the human activities. However, since it is becoming very difficult to maintain this huge and wide meadow area because of the decrease of the agriculture population and the transition of the usage of the weed, the maintaining and sustaining actions will be required.

The fountain water from Mt. Aso Area which is inevitable for the cultivation of *Suizenji-nori* has been recharged by this meadow which has been maintained by half natural ecosystem condition [16]. If the meadow in At Aso would not be maintained and remained, it would be possible that the unique and precious biodiversity and ecosystem would be lost and disappeared. Our new challenge and action to cultivate *Suizenji-nori* in Mt. Aso Area will result in the recognition of the significant importance for the maintain and sustaining the traditional meadow.

There is the concept, “land scale approach”, which is the scheme to find out the solution of some issues and problems in local areas, such as the decrease of population and/or the decline of the agriculture and industry, with treating both human activities and the natural conditions totally [17]. This is the very important and meaningful considering way to construct the sustainable and ecofriendly social system, maintaining biodiversity, solving climate change and sustainable consumption system, by The Ministry of Environment.

Namely, our proposing scheme, the cultivation of *Suizenji-nori* in Mt. Aso Area, will not only bring novel sustainable industry, but also achieve to protect and sustain the precious and traditional ecosystem.

Conclusion

We have carried out our proposing scheme to cultivate *Suizenji-nori* in Mt. Aso Area in order to achieve SDGs action, which are to sustain the biodiversity in this area, to maintain the quality of fountain water and to activate the local industry. Obtaining the understandings and cooperation of the local municipality and agricultural habitants for our activity, we have achieved the cultivation of *Suizenji-nori* utilizing fountain water in Mt. Aso Area. This cultivation method will not use the generated electricity, since the naturally gushing fountain water and the sun light. We will make our consecutive challenge to broaden this scheme in Mt. Aso Area, making the cooperation with the local municipality and agricultural habitants. And we will make this cultivation the Aso’s unique and sustainable industry for good and contribute the increase of employment and the growth of the local economy following SDGs concept. The consciousness of the

local habitants to maintain the quality of fountain water will improve with the growth of *Suizenji-nori*, as a barometer of the quality of fountain water. And our scheme will give the synergy effect to the sustained ecosystem for long time in Mt. Aso Area. This means that the promotion of the cultivation and utilization of *Suizenji-nori* are effective and important for SDGs' achievement. Sacran which is extracted from *Suizenji-nori*, as a cosmetic ingredient, uniquely shows very high water-retaining effect and the protection effect against unfavorable chemical materials in the atmosphere with film-forming property on skin. It will be suggested that our study and challenge will have the possibility to develop a new sustainable industry and to create new unique cosmetic formulations, maintaining the natural conditions. Namely, utilization of Sacran will lead to the effective action for SDGs' achievement.

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