Preliminary Study on the Potential Usefulness of Jellyfish as Fertilizer

Keiichi FUKUSHI *1, Nobuhiro ISHIO *1, Jun-ichi TSUJIMOTO *2, Kuriko YOKOTA *1, Terunobu HAMATAKE *1, Hiroya SOGABE *1, Ken-ichi TORIYA *1, and Tsukimi NINOMIYA *1

We will describe the potential usefulness of jellyfish (Aurelia aurita and Chrysaora melanaster), which have increased rapidly in coastal waters, as a fertilizer for vegetable fields. The jellyfish were found, by means of absorptiometry, flame photometry or ICP emission spectroscopy, to have five principal components of fertilizers: nitrogen, phosphorus, potassium, magnesium, and calcium. Concentrations of total nitrogen, total phosphorus, and potassium in Chrysaora melanaster (954, 153, and 667 mg/kg in fresh weight) were 2.8, 3.3, and 1.3 times higher than those in Aurelia aurita (336, 46, and 501 mg/kg), respectively. Concentrations of sodium, potassium, magnesium, and calcium were almost identical to those in seawater. Concentrations of chromium and cadmium in jellyfish were lower than the limit of quantification for ICP emission spectroscopy. Three kinds of vegetables, chingentsuai (a Chinese vegetable), green soybeans, and perilla were cultivated using a suspension of jellyfish as a fertilizer. Jellyfish are inferred to be effective for growth of vegetables, especially chingentsuai.

Key Words : Jellyfish, Fertilizer, Power plant, Recycle, Nutrients

1. Introduction

In recent years, jellyfish (Aurelia aurita and Chrysaora melanaster) populations have increased in worldwide coastal waters such as the Black Sea, Chesapeake Bay, the northern Gulf of Mexico, and the Bering Sea, as well as the Inland Sea of Japan. Whereas several reasons have been proposed for the increase of jellyfish in the Inland Sea of Japan, the primary one is eutrophication in sea areas. Jellyfish infestations of coastal waters inflict great damage to power plants and fisheries. Power plants located along the Japanese shore are sometimes obliged to decrease generating power because large numbers of jellyfish block coolant water intakes. To avoid such accidents, jellyfish adhering the intake are collected mechanically. The amount of collected jellyfish was 200 t per day or 2850 t per year at some power plants located in the coast along the Japan Sea; the amount is different according to the location, season, and year. Those that are collected are buried at a proper site inside the power plants or burned up as industrial waste. That is to say, large numbers of jellyfish carcasses collected at power plants have neither been used nor recycled. However, a proper disposition of the jellyfish carcasses has been recently required from Japanese society. In addition, it has been banned to throw away the jellyfish captured by fishing net at some area in Japan. Therefore, it is important to develop a proper way to handle the jellyfish, hopefully, a way to recycle it.

Effective use of jellyfish as food or as a feed for fish farming, a means to cleanse seawater, as medical supplies, etc., have been investigated. However, few reports have addressed the use of these jellyfish carcasses as a fertilizer in detail. A large occurrence of jellyfish is the result of human activities, as mentioned above, and nutrients in jellyfish are a limited resource. Therefore, it is proper to recycle jellyfish carcasses collected at power plants as a fertilizer. In this way, we can further the goals of a circulatory society, one that conserves natural resources. Our previous papers...
Jellyfish were taken from the freezer and defrosted in glass beakers (300 ml for *Aurelia aurita* and 1 l for *Chrysaora melanaster*) at room temperature (ca. 22 °C). Weights of *Aurelia aurita* and *Chrysaora melanaster* were 136 and 265 g, respectively. After defrosting, solutions containing solid bodies were gently stirred. Nearly uniform suspensions were obtained after one night. Producing a uniform suspension of *Aurelia aurita* seemed to be easier than for *Chrysaora melanaster*.

The density of suspension of *Aurelia aurita* and *Chrysaora melanaster* were 1.017 and 1.019 g/cm³, respectively, at 25 °C. Total nitrogen in the jellyfish suspensions was determined by the following procedure. The suspension (0.5 ml) was taken in a heat and pressure proof glass bottle (100 ml) and diluted to 50 ml with water. Ten milliliters of alkaliified potassium peroxodisulfate solution was added to the above solution and mixed well. Heating at 120 °C for 30 min using an MLS-2420 autoclave (Sanyo Electric Co., Ltd., Osaka, Japan) decomposed the mixed solution. Five milliliters of water and 5 ml of 0.7 mol/l hydrochloric acid were added to 20 ml of the decomposed solution in a test tube with a ground stopper. The absorbance of the solution was determined at 220 nm using a UV-visible spectrophotometer (UV-160A; Shimadzu Corp., Kyoto, Japan). The nitrogen concentration was calculated using a calibration graph.

Total phosphorus in the jellyfish suspensions was determined by the following procedure. The suspension (0.5 ml) was taken in a heat and pressure proof glass bottle and diluted to 50 ml with water. We added 10 ml of potassium peroxodisulfate solution (40 g/l) to the above solution and mixed well. The mixed solution was decomposed by the same procedure used for total nitrogen determination. The supernatant (10 ml) was taken into a test tube with a ground stopper and diluted to 25 ml with water. The mixture (2 ml) of ammonium molybdate and ascorbic acid was added to the above solution, shaken, and allowed to stand for 15 min. The solution absorbance was determined at 880 nm. The phosphorus concentration was calculated using a calibration graph.
The suspension of jellyfish was decomposed by the following procedure to determine constituent quantities of sodium, potassium, magnesium, calcium, chromium, and cadmium. Ten milliliters of water was added to 5 ml of the suspension in a beaker (300 ml) and the solution was heated on a hot plate until the volume decreased to ca. 5 ml. Then 5 ml of nitric acid was added to the above solution and heated until the volume decreased to 2-3 ml. The heating procedure with the addition of nitric acid was repeated four times. The decomposed solution was diluted to 50 ml with water. Concentrations of sodium and potassium in the solutions were determined by flame photometry using an atomic absorption spectrometer (Z-6000; Hitachi, Ltd., Tokyo, Japan); concentrations of magnesium, calcium, chromium, and cadmium were determined using an ICP-emission spectrometer (ICPS-1000IV; Shimadzu Corp.). Water content of the jellyfish was determined by drying 10 ml of the suspension at 60-90°C.

Concentrations of ammonia nitrogen, total phosphorus, and water-soluble potassium in a chemical fertilizer (blended fertilizer, N:P:K=9:6:7) were determined by the following procedures. A small amount of the chemical fertilizer (0.5 g) was dissolved with 100 ml of water; it contained an insoluble part. Concentration of total phosphorus was determined using 5 ml of the solution and the procedure described above. After the above supernatant solution was diluted 50-fold with water, the ammonia nitrogen concentration in the diluted solution was determined using 1 ml of the solution and indophenol absorptiometry; concentration of water-soluble potassium was determined by flame photometry described above.

### 2.3 Cultivation of vegetables

At first, seedlings of chingentsuai, green soybeans, and perilla were grown using mixed soil of Akadama soil, leaf mold (available on the market) with 7:3 in the volume, and 30 g / 10 l dolomite (basic soil). Soil used for planting the seedlings was prepared by the following procedures. The suspensions of *Aurelia aurita* and *Chrysaora melanaster*, which contained small amount of body parts, were added to the basic soil and mixed well as the base fertilizer at the ratio of 16.7 and 13.5 volume %, respectively, in plastic vessels for gardening (the amount of soil, 15 l). The suspensions were saturated at these ratios. Soils containing the chemical fertilizer at the concentration of 20 g / 10 l and without a fertilizer were also prepared using the basic soil. It might be better to use the same volume of *Aurelia aurita* as that of *Chrysaora melanaster* and/or to use the same content of total nitrogen for the jellyfish and chemical fertilizer for the precise comparison of those effects. However, the concentrations of nitrogen in the jellyfish seemed to be not high enough for the growth of vegetables as shown in Section 3.1. Therefore, the suspensions were mixed to the soil as much as possible. It can be presumed if the jellyfish has the potential usefulness as a fertilizer using the present way. Then the seedlings were transplanted in the above soils. The number of seedlings was five, two, and three for chingentsuai, green soybeans, and perilla in each soil, respectively. The number was determined according to the size of the vegetables after growing. Growth of vegetables was periodically recorded by measuring the length of leaves, height, and the diameter of the stalks. As additional fertilizers: for green soybeans, 1 l of the suspensions and 10 g of the chemical fertilizer were added to the soil in the plastic vessels later two times; for perilla, 1 l of the suspensions and 10 g of the chemical fertilizer were added later. However, the additional fertilizer was not used for chingentsuai. Finally, the vegetables were harvested. We weighed the edible portion of chingentsuai, beans for green soybeans, and the leaves for perilla.

In the above experiment, the soil has already contained the suspension of jellyfish before the seedlings were transplanted in the soil. To confirm the effects of jellyfish as an additional fertilizer, after the chingentsuai seedlings were transplanted into the basic soil (without jellyfish) in gardening pots
Table 1 Analytical results of various jellyfish components in fresh weight

<table>
<thead>
<tr>
<th></th>
<th>Aurelia aurita (mg/kg)</th>
<th>Chrysaora melanaster (mg/kg)</th>
<th>Seawater (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (weight %)</td>
<td>96.6</td>
<td>96.4</td>
<td>-</td>
</tr>
<tr>
<td>Total N&lt;sup&gt;a&lt;/sup&gt;</td>
<td>336</td>
<td>954</td>
<td>0.5&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total P&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46</td>
<td>153</td>
<td>0.07&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Na&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8850</td>
<td>8440</td>
<td>11050</td>
</tr>
<tr>
<td>K&lt;sup&gt;a&lt;/sup&gt;</td>
<td>301</td>
<td>667</td>
<td>416</td>
</tr>
<tr>
<td>Mg&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1082</td>
<td>981</td>
<td>1326</td>
</tr>
<tr>
<td>Ca&lt;sup&gt;a&lt;/sup&gt;</td>
<td>382</td>
<td>343</td>
<td>422</td>
</tr>
<tr>
<td>Cr&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt;0.5&lt;sup&gt;e&lt;/sup&gt;</td>
<td>&lt;0.5&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.0006&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cd&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt;0.2&lt;sup&gt;e&lt;/sup&gt;</td>
<td>&lt;0.2&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.00005</td>
</tr>
</tbody>
</table>

<sup>a</sup>Cited from the literature<sup>15</sup>.
<sup>b</sup>Analyzed by absorptiometry.<sup>4</sup>
<sup>c</sup>Analyzed by ICP emission spectroscopy.<sup>8</sup>
<sup>d</sup>Liable to variation.
<sup>e</sup>Limit of quantification.

(1) The amount of soil, 1.41), suspensions were added to the soil in the pots two times (the first time, 150 ml and the second time, 50 ml). The chemical fertilizer was also applied to another seedling in a different pot two times (2 g the first time; 0.7 g the second time). No fertilizer was applied to one other seedling. Each pot held one seedling.

3. Results and discussion

3.1 Jellyfish components

Table 1 summarizes the analytical results of the jellyfish constituents. Concentrations of total nitrogen, total phosphorus, and potassium in *Chrysaora melanaster* were 2.8, 3.3, and 1.3 times higher than those in *Aurelia aurita*, respectively. Concentrations of sodium, potassium, magnesium, and calcium were almost identical to those in seawater. Concentrations of chromium and cadmium were less than the limit of quantification for the ICP emission spectroscopy. These results indicated that jellyfish might be a useful fertilizer for vegetables, but vegetable growth might be somewhat hindered by the high sodium chloride concentration in jellyfish. It is well known that nitrogen, phosphorus, potassium, magnesium, and calcium (five principal components of fertilizer) are very important for the growth of plants. Masui et al.<sup>14, 15</sup> described the effects of nitrogen, phosphorus, potassium, magnesium, and calcium on the growth of muskmelon plants. For example, the main effects of increasing the levels of nitrogen were to depress soluble solids and the external appearance, to increase nitrogen amounts in the whole plants, to decrease the leaf, stem, and fruit weights, and to decrease the potassium, calcium, and magnesium amounts in the whole plants. On the other hand, high concentrations of sodium chloride depress the growth of plants (salt injury) because the high osmotic pressure prevents the water absorption by roots<sup>16</sup>.

Concentrations of ammonia nitrogen, total phosphorus, and water-soluble potassium in the chemical fertilizer were 9.3, 3.0, and 6.7 weight %.

In this experiment, the chemical analysis was performed immediately after getting the uniform suspension of jellyfish. However, the possibility of degradation of components in jellyfish is present during storage. Therefore, it will be necessary to carry out chemical speciation of nitrogen etc. in jellyfish under storage. In addition, the suspensions were analyzed without separating insoluble substance from soluble one. However, it will be useful to analyze both substances after separation to develop an effective way to use jellyfish as a fertilizer for vegetable fields.

3.2 Vegetable growth

Figure 1 depicts the increase of the leaf length of chingentsuai after transplanting. The leaf length is
the average of the maximum length in each chingentsuai. It increased slightly up to 9 days, then rapidly up to 16 days, but then almost leveled off in the four kinds of soil. The order of the length after 21 days was as follows: the length in case of chemical fertilizer (15.3 cm) = Chrysaora melanaster (15.1 cm) > Aurelia aurita (14.2 cm) > without fertilizer (10.3 cm). Chingentsuai was harvested after 22 days and the weight of the edible portion on the ground was measured. Table 2 shows those results. The order of the average weight was as follows: chingentsuai cultivated in soil containing Chrysaora melanaster > chemical fertilizer > Aurelia aurita > without fertilizer. The results obtained were statistically analyzed). There was no significant difference among the average weight of chingentsuai cultivated with Aurelia aurita, Chrysaora melanaster, and the chemical fertilizer with 1% significant level. Figure 2 is a photograph of chingentsuai 14 days after transplanting. Total contents of nitrogen, phosphorus, and potassium used in the cultivation of chingentsuai were calculated using concentrations of these constituents in jellyfish and the chemical fertilizer and their respective amounts used. Table 3 summarizes those results. In spite of the difference of the total contents, there was no statistical difference among three kinds of chingentsuai as mentioned above. The following two reasons can be considered, although it will be important to use proper amount of fertilizers to evaluate the effects precisely. This might be due to other components such as magnesium and calcium which were contained in Aurelia aurita and Chrysaora melanaster. Alternatively, it may suggest that the jellyfish

**Table 2 Weight of chingentsuai of the edible portion on the ground after harvesting (g)**

<table>
<thead>
<tr>
<th>Stump No.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67</td>
<td>124</td>
<td>73</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>104</td>
<td>88</td>
<td>39</td>
</tr>
<tr>
<td>3</td>
<td>93</td>
<td>81</td>
<td>121</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>62</td>
<td>102</td>
<td>78</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>85</td>
<td>88</td>
<td>71</td>
<td>33</td>
</tr>
<tr>
<td>Average</td>
<td>75</td>
<td>100</td>
<td>86</td>
<td>28</td>
</tr>
</tbody>
</table>

*a22 days after transplantation.*
A: Cultivated in soil containing Aurelia aurita; B: cultivated in soil containing Chrysaora melanaster; C: cultivated in soil containing a chemical fertilizer; D: cultivated in soil without a fertilizer.

**Table 3 Total contents (mg) of nitrogen, phosphorus, and potassium used for the cultivation of chingentsuai as base fertilizers**

<table>
<thead>
<tr>
<th></th>
<th>Aurelia aurita</th>
<th>Chrysaora melanaster</th>
<th>Chemical fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1026</td>
<td>2236</td>
<td>2790</td>
</tr>
<tr>
<td>P (as P₂O₅)</td>
<td>646</td>
<td>1645</td>
<td>4124</td>
</tr>
<tr>
<td>K (as K₂O)</td>
<td>3686</td>
<td>3768</td>
<td>4842</td>
</tr>
</tbody>
</table>

*a,b,c Analytical methods as in Table 1.
Ammonia nitrogen, analyzed by indophenol absorptiometry.*
contains some trace components such as iron and manganese etc. which are also necessary for plant growth. It will be essential to determine the trace components in the jellyfish to make clear the effectiveness of the jellyfish. In addition, the total contents of nitrogen and phosphorus for *Chrysaora melanaster* were 2.2 and 2.5 times larger than those for *Aurelia aurita*, while the total content of potassium was almost equal for both *Chrysaora melanaster* and *Aurelia aurita*. It might be helpful to evaluate the effectiveness if two times amount of *Aurelia aurita* is also used at the same time.

When chingentsuai was cultivated using *Aurelia aurita*, *Chrysaora melanaster*, and the chemical fertilizer as additional fertilizers, the leaf length did not increase for the first 6 days; it then increased for 17 days, but afterward almost ceased to grow. The leaf length of the chingentsuai that was cultivated without a fertilizer was nearly constant. The growth pattern was slightly different from that shown in Fig. 1. The seedlings used in this experiment were transplanted 15 days later than those used in the former experiment. The difference might be caused by the above fact and the different cultivation conditions described in Section 2.3. After 21 days, the leaf length and weight of the chingentsuai that were cultivated using *Aurelia aurita*, *Chrysaora melanaster*, chemical fertilizer, and no fertilizer were 12.5, 11.2, 13.5, and 5.8 cm, and 25, 48, 76, and 6 g, respectively; the weight of chingentsuai cultivated using *Aurelia aurita* was not larger than expected because the central part of the chingentsuai was damaged by worms. It can be presumed that chingentsuai is highly tolerant to salt injury.

Figure 3 depicts the increase in green soybeans height after transplanting. It increased rapidly from 7 to 20 days, then slightly increased to 35 days; it then nearly ceased in the four kinds of soil. After 35 days, the heights of green soybeans cultivated using *Aurelia aurita*, *Chrysaora melanaster*, chemical fertilizer, and no fertilizer were 29.5, 34.0, 34.5, and 29.0 cm, respectively. The stalk diameter of green soybeans increased for the first 35 days, but then almost ceased in the four kinds of soil. The stalk diameter was measured at a height of 5 cm above the soil surface. After 35 days, the stalk diameters of green soybeans that were cultivated using *Aurelia aurita*, *Chrysaora melanaster*, chemical fertilizer, and no fertilizer were 4.0, 4.6, 5.0, and 3.6 mm, respectively. After 46 days, the total weight of edible beans that were cultivated using *Aurelia aurita*, *Chrysaora melanaster*, chemical fertilizer, and no fertilizer were 8.0, 15.3, 22.3, and 9.2 g (average weight for two stumps), respectively. It was reported that excess chloride in the soil depressed the growth and bean weight of green soybeans. This is presumably the reason why the suspension of jellyfish was not so effective for green soybeans as observed for chingentsuai.

The height and stalk diameter of perilla increased for the first 49 days in the four kinds of soil. The stalk diameter was measured at a height of 2 cm above the soil surface. After 49 days, the heights and stalk diameters of perilla that were cultivated using *Aurelia aurita*, *Chrysaora melanaster*, chemical fertilizer, and no fertilizer were 26.7, 35.2, 44.5, and 33.5 cm, and 7.3, 8.8, 11.3, and 7.2 mm, respectively. Figure 4 shows the increase of the stalk diameter of perilla after transplanting. The perilla leaf length increased for the first 28 days, but then nearly ceased in the four kinds of soil; after 28 days, the leaf lengths of perilla that were cultivated using *Aurelia aurita*, *Chrysaora melanaster*, chemical fertilizer, and no fertilizer were 11.2, 11.8, 16.3, and 11.5 cm, respectively. After 49 days, the total weight...
of leaves of plants that were cultivated using *Aurelia aurita*, *Chrysaora melanaster*, chemical fertilizer, and no fertilizer were 19.3, 28.7, 57.9, and 19.8 g (average weight for three stumps), respectively.

In these experiments, statistical analysis of the results could not be performed except for the results shown in Table 2 because of the lack of number of stumps cultivated. It will be desirable to cultivate more stumps of vegetables for precise evaluation of the cultivation results. An overall effectiveness of *Chrysaora melanaster* as a fertilizer seems to be superior to that of *Aurelia aurita*, even though a further study will be necessary. This might reflect the higher concentrations of nitrogen, phosphorus, and potassium in *Chrysaora melanaster* than those in *Aurelia aurita*.

### 3.3 Comparison with fish fertilizer

Fish fertilizer, which is made of skipjack, mackerel, and sardines etc., has been widely used as an organic fertilizer. It is, therefore, worthwhile to compare the jellyfish components with the components of these fish. The concentrations of protein, total phosphorus, potassium, and calcium are 19.2-25.8% (2.8% in *Aurelia aurita*), 1600-2700 mg/kg, 3000-4100 mg/kg, and 100-700 mg/kg in edible portion of the raw fish, respectively

It can therefore be presumed that fish fertilizer is superior to jellyfish as an organic fertilizer. However, residual fish has to be transported to a fertilizer factory for processing it to fertilizer. On the other hand, jellyfish could be used as fertilizer without any special processing as demonstrated above. Even if it would be necessary to process jellyfish to decrease sodium chloride content in jellyfish, there is no need to convey jellyfish because exhaust heat in power plants can be used for the purpose. We have already found that it was possible to decrease the sodium chloride content by heating the jellyfish suspension in a vacuum; some aspects of that process are being patented.

As described above, jellyfish was roughly compared with fish from the standpoint of a fertilizer. It is well known that nitrogen and phosphorus are absorbed as ammonium ion, nitrate, and phosphate, respectively, through roots of plants. Therefore, further study, such as speciation of nitrogen and phosphorus in jellyfish, analysis of trace components in jellyfish, including methods to process jellyfish and to use the processed one, will be necessary for the precise comparison.

### 4. Conclusions

We found that *Aurelia aurita* contained 336 mg/kg total nitrogen, 46 mg/kg total phosphorus, and 667 mg/kg potassium in fresh weight. *Chrysaora melanaster* contained 954 mg/kg total nitrogen (2.8 times higher than that for *Aurelia aurita*), 153 mg/kg total phosphorus (3.3 times higher), and 501 mg/kg potassium (1.3 times higher). Both jellyfish also contained potassium, magnesium, and calcium with concentrations similar to those in seawater. We demonstrated that both *Aurelia aurita* and *Chrysaora melanaster* were effective as either a base or an additional fertilizer for chingentsuai. *Chrysaora melanaster* was also somewhat effective for green soybeans and perilla. It will be worthwhile to perform speciation of nitrogen and phosphorus in jellyfish under storage and its trace analysis. It will be also important to develop an effective way to use jellyfish as a fertilizer for vegetable fields. Regarding the jellyfish carcasses, decreasing the sodium chloride content and their volume are worthy subjects for future study. Decreasing the sodium chloride content and the jellyfish volume are desirable for preventing the salt injury and for transporting jellyfish inland from...
power plants and other locations to where they would be useful as a fertilizer, respectively. To this end, heating the jellyfish suspension in a vacuum is being investigated in detail.

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3) N. Haruki, personal communication
4) T. Aoki, personal communication

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要 旨

近年，沿岸海域において大量に発生しているクラゲ（ミズクラゲ及びアカクラゲ）の野菜の肥料としての潜在的有用性について検討した。クラゲを吸光光度法，蛍光光度法，ICP発光分光分析法により分析した結果，クラゲには肥料としての五要素（窒素，リン，カリウム，マグネシウム，カルシウム）が以下の濃度で含まれていた。ミズクラゲ及びアカクラゲ中の全窒素濃度は，それぞれ336 mg/kg (新鮮重量)，954 mg/kg（ミズクラゲの2.8倍），全リン濃度は，46 mg/kg及び153 mg/kg（ミズクラゲの3.3倍）であり，カリウム濃度は501 mg/kg，667 mg/kg（ミズクラゲの1.3倍）であった。ナトリウム，カリウム，マグネシウム，カルシウム濃度は，海水中のそれら濃度とほぼ同程度であった。クラゲ中のクロム及びカドミウム濃度は，定量限界以下であった。クラゲ懸濁溶液を肥料として，チンゲンサイ，エダマメ，シソを栽培した。その結果，クラゲは，野菜，特にチンゲンサイの生長促進に効果があることがわかった。

キーワード：クラゲ，肥料，発電所，リサイクル，栄養塩類