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# Comparison of Metal Contents in Seaweeds Collected from the Busan Coastal Area

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## Abstract

For the purpose of safety identification, the concentrations of heavy metals in seaweeds collected from Busan Gijang coastal area were investigated. The average concentration of metals had a level of as high as the order of manganese (2.76 ppm)>zinc(2.11 ppm)>copper(0.59 ppm)>arsenic (0.092 ppm)>lead(0.06 ppm)> mercury(0.03 ppm)>cadmium(0.026 ppm). The contents of manganese and zinc were highly detected from *P. elliptica*, copper and mercury from agar, cadmium from sea mustard and arsenic from wild sea mustard, respectively. The metal contents of seaweeds varied with kinds of samples, but high level for the safety can be found in these samples. Because *P. elliptica* had shown a clear selectivity for both manganese and zinc, this seaweed could be useful as a bioindicator for these two metal pollution.

**Key Words :** Metal contents, Metal pollution, Safety of seaweeds, Bioindicator

## 1. Introduction

Seaweeds have become important as an edible marine vegetation from the past. According to growing up the cultivation technology, the production of seaweeds is significantly increased as much of five hundred thousands tons yearly. In Korea, the annual per capita consumption of seaweeds is about 6.7 kg and Korea is one of the most consuming country of seaweeds in the world[1].

Seaweeds fluently contain not only common nutrition components such as proteins, lipids and carbohydrates, but also various essential trace elements than those of agricultural vegetables contain. Any seaweeds have physiologically or pharmacologically active constituents, and are focused on the functional food materials for the healthy or dietary foods, for the prevention of adult disease and corpulence[2,3].

In recent, because of the increasing pollution of the coastal area, it is inevitable to be exposed for seaweeds to harmful heavy metals. Heavy metals were non-destructive components unlike any organic substances or nutriments. They transferred to human being directly or indirectly through the bioconcentration and food chain processes according to the metal-accumulating characteristics of seaweed body itself from the marine habitat environment[4,5]. Although some essential metals play potential roles to control the physiological functionality with extremely small amounts, they often caused any diseases in human bodies. Especially, if physico-chemically or genetically toxic metals are induced to human body, it might lead to the more critical state because they are rarely discharged from body causing the obstacle of the function of human body or causing the genetically serious influences[6,7].

Because the pollution of seaweeds is anticipated from the status of the industrial development and the management condition of the environments around coastal area although it is inevitably necessary to intake the seaweeds guaranteed the sanitary safety for the safe

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and healthy lives, the actual countermeasures are needed to diminish the pollution of coastal area and the secure research on the actual condition are also needed to decrease the heavy metal pollution of seaweeds[8,9].

In this study, to prepare the fundamental data for the safety of seaweeds, the contents of seven heavy metals i.e., lead, cadmium, zinc, copper, manganese, mercury and arsenic were determined and compared for five seaweeds such as sea mustard, sea tangle, agar, *Pachymeniopsis elliptica* and wild sea mustard collected from Busan Gijang coastal area.

## 2. Materials and Methods

### 2.1. Materials

Five seaweeds used in this study were sea mustard (*Undaria pinnatifida*), sea tangle (*Laminaria japonica*), agar (*Gelidium amansii*), *Pachymeniopsis elliptica* and wild sea mustard (*Undaria pinnatifida*) which were supplied from "K" marine company with dried state products collected from Gijang coast in 2006. Each seaweed was washed with distilled water two times, dipped into the distilled water for 24 hours, and dried at 105°C for 1 hour. And then, it was crashed with a blender(Waring 24CB10, USA) and sieved to 4~10 meshes size. The dried slices were weighed to 50 g for digestion with the conical quartering method.

### 2.2. Experimental method

The sieved seaweed samples were digested with the nitric acid-sulfuric acid digestion method (Fig. 1)[8]. Five grams of sieved powder samples were poured into 250 ml Erlenmeyer flask, and then 50 ml distilled water and 20 ml nitric acid (Matzmura GR, Japan) were added, respectively.

The flask was covered with a watch glass and heated

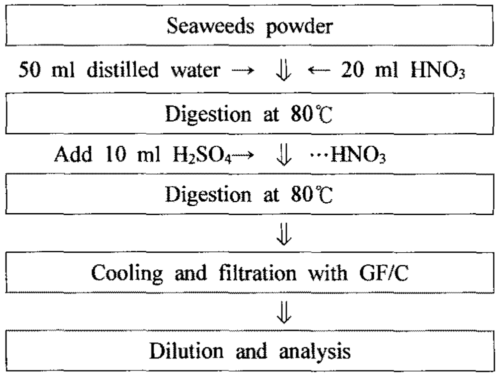


**Fig. 1.** Digestion procedure of seaweeds with a nitric and sulfuric acid digestion.

at 80°C on hot plate (Hana HMS-10). 10 ml sulfuric acid (Daejung RC) were added, and samples were digested under the drop of nitric acid until the colour of mixed solution was weak yellow. After leaving the mixed solution to room temperature, it was suction-filtered over Whatman GF/C filter paper with a vacuum pump(Masuda MSV 50, Japan).

After 25 ml of above filtrate solution were transferred to a 50 ml Bayer bottle and diluted to 50 ml with distilled water, they were analysed to determine the metal contents with ICP(TJA Polyscan 61E, USA). The metal contents were calculated on established calibration curve. The analytical conditions of ICP operation were shown as Table 1.

## 3. Results and Discussion

### 3.1. Average contents of metals

The average contents of seven metals in five seaweeds were shown as Table 2. The deviations of metal contents were diverse as each seaweed.

From the comparison of the average metal contents,

**Table 1.** Analytical condition of ICP operation

| Condition \ Metal | Pb | Cd | Zn | Cu | Mn | Hg | As |
|---|---|---|---|---|---|---|---|
| Wave length (nm) | 220.3 | 228.8 | 213.8 | 324.7 | 257.6 | 193.7 | 253.7 |
| Model | TJA(USA) Polyscan 61E | | | | | Millenium Merlin System | Millenium Excaliber System |
| Gas flow (ℓ/min) | 0.5 | | | | | 0.3 | |
| Ref. power (W) | 950 | | | | | | |
| Nebulizer pres. (psi) | 30 | | | | | | |

**Table 2.** Average contents of metal in five seaweeds

| Contents(ppm) \ Metal | Pb | Cd | Zn | Cu | Mn | Hg | As |
|---|---|---|---|---|---|---|---|
| This work | 0.06 | 0.026 | 2.11 | 0.59 | 2.76 | 0.03 | 0.092 |
| Korean coast[2] | 1.28 | 0.67 | 48.02 | 6.29 | 34.63 | 0.02 | ND[a] |
| Hong Kong coast[2] | 18.96 | 0.90 | 75.62 | 21.43 | 134.33 | ND | ND |

[a]ND: no data

the levels were lowly ranged over 0.03~0.09 ppm below to 0.1 ppm for cadmium, mercury, lead and arsenic. But the average contents of the essential trace metal elements; manganese, copper and zinc were relatively high. Consequently, the order of average contents level was manganese(2.76 ppm)>zinc(2.11 ppm)>copper (0.59 ppm)>arsenic(0.092 ppm)>lead (0.06 ppm)>mercury(0.03 ppm)>cadmium(0.026 ppm).

In Table 2, these results were compared with the average metal contents in the seaweeds of Korean coast over fourteen areas including Gangwon, and Hongkong coast[2], respectively. The average level in this work was almost equal to that of Korean coast for mercury, but the average levels were beneath by far than those of Korean and Hongkong coasts. The contents order of manganese>zinc>copper>lead>cadmium in this work was same as that of Hongkong, but the content of zinc was highest over Korean coast. From these results, the contents of metals in seaweeds from Korean coast were exceedingly low than those of Hongkong. Moreover, because the contents of metals in the seaweeds from Busan coast were remarkably low than those of Korean coast, the safety level of the seaweeds from Busan was highest among these three areas. This may mean that the marine habitat environment is the most safe in Busan coast.

### 3.2. Metal contents

The contents of metal in seaweeds considerably varies with the kinds of seaweeds, the property of individual seaweed, the marine habitat environments such as the coast conditions and the depth of sea, and the season of collecting, etc.. Manganese and zinc are highly contented in seaweed, and especially the concentration of manganese ranges extensively according to the kinds of seaweeds[2,10].

The results measured in this work for seven metals were shown as Table 3 and Fig. 2~6, respectively. The contents of metals according to the kinds of five seaweeds were high for manganese, zinc and copper, but low for lead, arsenic, cadmium and mercury. For sea mustard, the content of copper was highest but mercury was lowest in seven metals, and ranged in the order of copper>zinc>manganese>lead=arsenic>cadmium>mercury. For agar and *P. elliptica*, the content of manganese was highest but cadmium was lowest, the content order was manganese>zinc>copper>mercury>lead>arsenic>cadmium for agar, and was manganese>zinc>copper>lead>arsenic>mercury=cadmium for *P. elliptica*, respectively. For sea tangle and wild sea mustard, the content of zinc was highest but mercury was lowest. The content order was zinc>manganese>copper>arsenic>lead>cadmium>mercury for sea tangle, and was zinc>manganese>arsenic>copper>lead>cadmium>mercury for wild sea mustard.

### 3.3. Comparison of metal contents

The contents of manganese were the highest among

**Table 3.** Metal contents in seaweeds from Gijang costal area (ppm)

| Seaweeds(common name) \ Metal | Pb | Cd | Zn | Cu | Mn | Hg | As |
|---|---|---|---|---|---|---|---|
| *Undaria pinnatifida*(sea mustard) | 0.08 | 0.042 | 0.86 | 0.90 | 0.72 | 0.018 | 0.080 |
| *Laminaria japonica*(sea tangle) | 0.06 | 0.024 | 0.46 | 0.18 | 0.40 | 0.034 | 0.096 |
| *Gelidium amansii*(agar) | 0.06 | 0.024 | 2.00 | 1.66 | 3.60 | 0.070 | 0.056 |
| *Pachymeniopsis elliptica*(P.elliptica) | 0.08 | 0.024 | 4.82 | 0.16 | 8.60 | 0.024 | 0.072 |
| *Undaria pinnatifida*(wild sea mustard) | 0.02 | 0.016 | 2.42 | 0.06 | 0.50 | 0.005 | 0.156 |

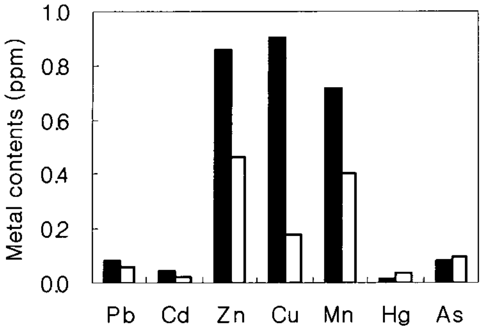


**Fig. 2.** Metal contents in sea mustard(■) and sea tangle (□).

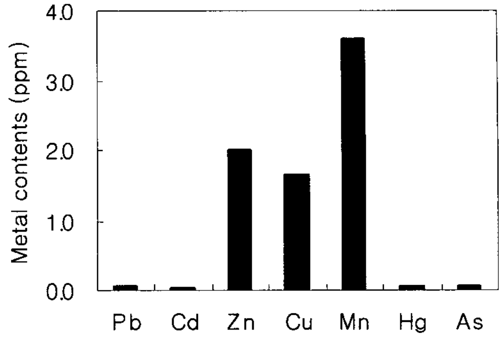


**Fig. 3.** Metal contents in agar.

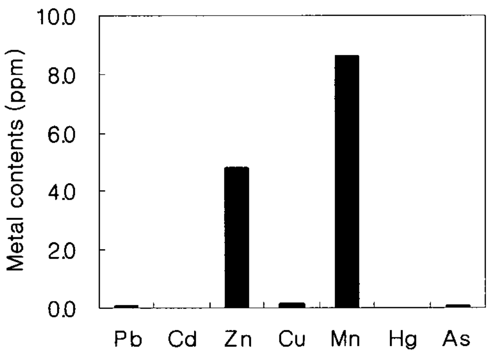


**Fig. 4.** Metal contents in *P. elliptica*.

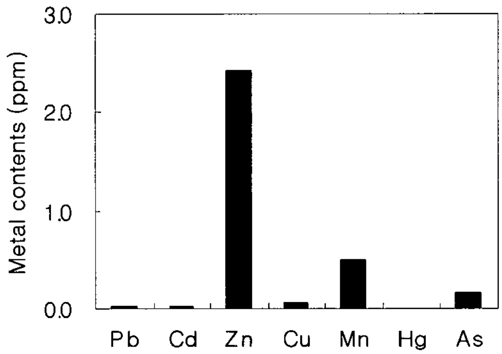


**Fig. 5.** Metal contents in wild sea mustard.

seven metals over five seaweeds, ranged from 0.40 ppm for sea tangle to 8.60 ppm for *P. elliptica* with most broad deviation. The order of contents was *P. elliptica*(8.60 ppm)>agar(3.60 ppm)>sea mustard(0.72 ppm)>wild sea mustard(0.50 ppm)>sea tangle(0.40 ppm). As shown in Table 3, *P. elliptica* included the highest contents of manganese compared to other seaweeds, the contents of manganese were the highest than those of six metals. Therefore *P. elliptica* could be useful as a bioindicator for manganese pollution[2].

Zinc ranged from 0.46 ppm for sea tangle to 4.82 ppm *P. elliptica* as a secondly high metal component. The order of contents was *P. elliptica*(4.82 ppm)>wild sea mustard (2.42 ppm)>agar(2.00 ppm)>sea mustard(0.76 ppm)>sea tangle(0.46 ppm). Therefore *P. elliptica* could be useful as a bioindicator for zinc pollution, too.

The contents of other five metals were relatively lower than those of manganese and zinc. The content range of copper was from 0.06 ppm for wild sea mustard to 1.66 ppm for agar, with the order of agar(1.66 ppm)>sea mustard(0.90 ppm)>sea tangle (1.08 ppm)>*P. elliptica*(0.16 ppm)>wild sea mustard(0.06 ppm).

Lead, cadmium, mercury and arsenic had still more lower contents than copper. The order of lead contents was *P. elliptica* and sea mustard(0.08 ppm)>sea tangle and agar(0.06 ppm)>wild sea mustard(0.02 ppm). The order of cadmium contents was sea mustard(0.042 ppm)>sea tangle, agar and *P. elliptica*(0.024 ppm)>wild sea mustard (0.016 ppm). In the case of mercury, the order was agar(0.07 ppm)>sea tangle (0.034 ppm)>*P. elliptica*(0.024 ppm)>sea mustard(0.018 ppm)>wild sea mustard (0.005 ppm). And the order of arsenic contents was wild sea mustard(0.005 ppm)>sea tangle(0.096 ppm)>sea mustard(0.08 ppm)>*P. elliptica*(0.072 ppm)>agar(0.07 ppm).

The guidelines of safety levels of harmful heavy metals were not established yet in Korea for the seaweeds studied in this work. The allowable residual concentrations of heavy metals for fishes and shellfishes, however, were 0.5 mg/kg for mercury, 2.0 mg/kg for lead and cadmium, respectively, on the basis of living body[9,11]. The content values measured in this study were much lower than above allowable concentrations. Therefore the seaweeds from Busan coast were very safe from heavy metal pollution.

## 4. Conclusions

For assuring the safety of the seaweeds collected from Busan coastal area, five seaweeds were digested with nitric acid and sulfuric acid, and the contents of seven metals were measured and compared each other. The average contents of metals were high in the order of Mn>Zn>Cu>As>Pb>Hg>Cd, but showed very safe levels in these seaweeds tested. The ppm order of Mn contents in seaweeds were *P. elliptica* (8.60)>agar(3.60) >sea mustard(0.72)>wild sea mustard(0.50)>sea tangle(0.40). The order was *P. elliptica* (4.82)>wild sea mustard(2.42)>agar(2.00)>sea mustard(0.86) >sea tangle(0.46) for Zn, agar(1.66)>sea mustard(0.90)>sea tangle(0.18)>*P. elliptica* (0.16)>wild sea mustard(0.06) for Cu, *P. elliptica* and sea mustard(0.08)>sea tangle and agar(0.06)>wild sea mustard(0.02) for Pb, wild sea mustard (0.156)>sea tangle(0.096)>sea mustard(0.08) >*P. elliptica*(0.072)>agar(0.07) for As, agar(0.07)> sea tangle(0.034)>*P. elliptica*(0.024)>sea mustard(0.018)> wild sea mustard(0.005) for Hg and sea mustard (0.042)>sea tangle, agar and *P. elliptica*(0.024)> wild sea mustard(0.016) for Cd, respectively. Because *P. elliptica* had shown a clear selectivity for both Mn and Zn, this seaweed could be useful as a bioindicator for these two metal pollutions.

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