Content of Cr, Cu, Pb, and Zn on Pacific white shrimp cultured in modern farm at BLUPPB, Karawang, West Java

N D Takarina₁,*, A Rahman₁, T Siswanto₂ and T J Pin³

₁Marine Science, Postgraduate Program, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok, Indonesia
₂Department of Mathematics, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok, Indonesia
³Department of Geography, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok, Indonesia

*Corresponding author: noverita.dian@sci.ui.ac.id

Abstract. Heavy metal is one of the hazardous substances which often found in shrimp farm. Since this shrimp become mostly favorable food, it is necessary to determine the content of metal in this shrimps. This research was aimed to determine the content of Cr, Cu, Pb, and Zn on Pacific white shrimp cultured on the modern farm at BLUPPB, Karawang, West Java. Samples were taken from five farms. During transport, samples were kept in a more relaxed box. Farms used were designed using black plastic as the bottom layer to separate contact with soil. Heavy metal of Cr, Cu, Pb, and Zn on shrimp meat was analyzed using Atomic Absorption Spectrophotometry method. The content of Cr was ranged from 0.06 – 0.38 ppm and Pb were 0.02 – 0.05 ppm. The content of Cu was ranged from 1.89 – 15.25 ppm and Zn were 2.16 – 3.92 ppm. According to government rules and literature, those content were below a threshold which was 0.4 ppm for Cu, 0.5 ppm for Pb, 20 ppm for Cu and 0.2 ppm for Zn.

1. Introduction

Based on FAO data, capture and aquaculture fisheries supplied approximately 110 million tonnes of fishery products in 2006 with an estimated 47%. Furthermore, aquaculture performed faster growth rate compared to another sector which was 8.8% per year since 1970 and in 2014 reach 101. 1 million which continuously increasing [1, 2].

Shrimps including Pacific white one are classified as shrimp consumption because it has a high nutrient including its mineral content [3-5]. The shrimp is also Indonesia's leading fishery export commodity. Based on data from the Directorate General of Competitiveness Improvement, Ministry of Marine Affairs and Fisheries, it was noted that Indonesia's shrimp exports experienced an average increase of 8.7% per year. Based on the statistical data of fishery cultivation in 2015, West Java is the largest contributor to Indonesia's shrimp production of 113637 tons. Karawang is one of the districts in West Java that has great potential in the development of Pacific white shrimp farming. From about 18.275 ha of land, nearly 86.61% has been utilized for this shrimp farming business with production reaching 11756.61 tons.

Most of the shrimp ponds in this district are located in the intertidal zone which affected by the tides and the surrounding river water. According to [6], the ponds which located close to urban
activities are potentially experienced pollution damage. In the Cilebar district, ponds are influenced by the Citarum River. This river has been exploited by local people in various aspects of life such as irrigation, aquaculture, water supply, industry, and power plant. Some of the industries located in the stream are textiles, pulp-paper, automotive, metal, and leather tanning. Most of the industries produce waste containing metals such as cadmium (Cd), lead (Pb), mercury (Hg), and chromium (Cr) [7].

Heavy metals enter into aquatic systems through human activities that generate waste such as industry, household, and mining [8]. The absence of appropriate treatment for this waste causes contamination in living biota such as fish, shrimp, oysters and crabs [9]. The presence of heavy metal content in aquaculture products such as shrimp is one form of threat to food security [10]. The shrimp is capable of accumulating heavy metals which are unsafe for consumption [11]. Based on RI Law No. 7 of 1996 [12], food security is defined as an effort or condition in preventing the occurrence of biological contamination, chemical or other objects on the food that causes and harm human health. This issue becomes an emerging problem in the marketing activities of fishery products. According to Darmono 2010 [13], the presence of heavy metal contamination can affect the economic aspects of the decline in the selling value and production of fishery products. This study aims to determine and evaluate the content of copper, lead, chromium, and zinc on Pacific white shrimp took from ponds of Cilebar, Karawang, West Java.

2. Methods
The research was conducted on Pacific white shrimp farms in Cilebar, Karawang, West Java. The farms were owned by BPLUPPB Karawang, West Java. Sampling was done during March 2017 for every two weeks.

Shrimps were collected randomly from 5 farms. The farms used were a modern farm which equipped with plastic mats as the ground layer. Shrimps were taken 250 grams from each farm. During transport, shrimps were kept in a cooler box. Their meat was taken and cleaned for heavy metal measurement. The meats were kept in the freezer before heavy metal measurement.

Heavy metals measurements were carried out in AffiliateLaboratorium of Department of Chemistry, University of Indonesia. Heavy metals measured were copper (Cu), lead (Pb), zinc (Zn), and chromium (Cr). The measurement was performed using AAS Shimadzu 6300 and according to the method by SNI. The sample was measured Duplo and stated in ppm. Data analysis using one way ANOVA to know whether there is the difference between metal content with one another.

3. Results and discussion
The content of heavy metals in Pacific white shrimp taken from Cilebar farms was shown in Table 1. Chromium in Pacific white shrimp was highest in farm 4 (0.38) whereas the lowest concentration was undetectable in farm 3. The highest copper content in shrimp was in pond 3 (15.25 ppm), while the lowest concentration was found in pond 5 (1.89 ppm). Lead content can almost be negligible in the farm 1, 3, and 5. The zinc content did not vary much among the farms with a range of 2.16 - 3.92 ppm.

|     | Farm 1 | Farm 2 | Farm 3 | Farm 4 | Farm 5 | Average |
|-----|--------|--------|--------|--------|--------|---------|
| Cr (ppm) | 0.06 | 0.38 | Nd | 0.38 | 0.16 | 0.24 |
| Cu (ppm) | 5.45 | 4.63 | 15.25 | 3.76 | 1.89 | 6.19 |
| Pb (ppm) | Nd | 0.02 | Nd | 0.05 | nd | 0.03 |
| Zn (ppm) | 3.38 | 3.19 | 3.91 | 3.92 | 2.16 | 3.31 |

Based on average values, heavy metal content in Pacific white shrimp showed that copper concentration of 6.19 ppm was the highest concentration compared to other metals. Table 2 shows the results of ANOVA test related to significant differences between the metal content of one another in Pacific white shrimp. Based on the table, it seems that there was a significant difference in the inter-
metal content in Pacific white shrimp \((p = 0.005, p \leq 0.005)\). Table 3 performed result of Scheffe test. Based on Table 3, it showed it is significantly different between the content of chromium \((1,00)\) with copper \((2,00)\) and copper \((2,00)\) with lead \((3,00)\).

### Table 2. Result of ANOVA test to heavy metal content based on metal type

| Source of Variation | SS     | df  | MS | \(F\) | \(P\)-value | \(F\) crit |
|---------------------|--------|-----|----|------|-------------|------------|
| Between Groups      | 128,9425 | 3   | 42,98082 | 6,158745 | 0.005502 | 3.238782 |
| Within Groups       | 111,6612 | 16  | 6,978828 |        |            |            |
| Total               | 240,6037 | 19  |    |      |             |            |

### Table 3. Result of posthoc ANOVA test to heavy metal based on metal type

| Mean Difference (I-J) | (I) Heavy \_metal | J | Std. Error | Sig. | (J) Heavy \_metal |
|-----------------------|-------------------|---|------------|------|-------------------|
| 2.00                  | -2.88400          | 1.67079 | .343      |      | 3.00              |
| 3.00                  | -3.11600          | 1.67079 | .356      |      | 4.00              |
| 4.00                  | -2.88400          | 1.67079 | .309      |      | 2.00              |
| 2.00                  | -6.00000*         | 1.67079 | .021      |      | 3.00              |
| 3.00                  | 6.18200*          | 1.67079 | .017      |      | 4.00              |
| 4.00                  | -1.82000          | 1.67079 | .421      |      | 1.00              |
| 3.00                  | -6.18200*         | 1.67079 | .021      |      | 2.00              |
| 4.00                  | -3.29800          | 1.67079 | .309      |      | 3.00              |
| 4.00                  | 3.11600           | 1.67079 | .356      |      | 1.00              |

Table 4 showed the results of ANOVA test about significant differences in the metal content of the Pacific white shrimp based on the farm. Based on the table, it can be seen that there was no significant difference \((p = 0.69, p \leq 0.05)\). Moreover, Table 5 showed that based on Scheffe test, there is no difference between each farm correspondingly.

### Table 4. Result of ANOVA test to heavy metal content based on the farm
| Source of Variation | SS   | df | MS            | F         | P-value | F crit |
|---------------------|------|----|---------------|-----------|---------|--------|
| Between Groups      | 31.25117 | 4  | 7.812793 | 0.559783 | 0.695343 | 3.055568 |
| Within Groups       | 209.3525 | 15 | 13.95684 |           |         |        |

Total 240.6037 19

**Table 5.** Result of posthoc ANOVA – Scheffe test to heavy metal content based on the farm

| Multiple Comparisons | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound |
|----------------------|-----------------------|------------|------|------------------------------------|
| (I) Heavy_metal_1    | (J) Heavy_metal_1     |            |      |                                    |
| 1.00                 | 2.00                  | .16750     | 2.64167 | 1.000     | -9.0679 |
| 3.00                 | 2.00                  | -2.56750   | 2.64167 | .914      | -11.8029 |
| 4.00                 | 5.00                  | .19500     | 2.64167 | 1.000     | -9.0404  |
| 2.00                 | 1.00                  | -1.16750   | 2.64167 | .995      | -8.0654  |
| 3.00                 | 2.00                  | -2.73500   | 2.64167 | .914      | -11.9704 |
| 4.00                 | 5.00                  | .02750     | 2.64167 | 1.000     | -9.2079  |
| 5.00                 | 1.00                  | 1.00250    | 2.64167 | .997      | -8.2329  |
| 3.00                 | 1.00                  | 2.56750    | 2.64167 | .914      | -6.6679  |
| 2.00                 | 2.00                  | 2.73500    | 2.64167 | .894      | -6.5004  |
| 4.00                 | 5.00                  | 2.76250    | 2.64167 | .891      | -6.4729  |
| 5.00                 | 3.00                  | 3.73750    | 2.64167 | .736      | -5.4979  |
| 4.00                 | 1.00                  | -1.19500   | 2.64167 | 1.000     | -9.4304  |
| 2.00                 | 2.00                  | -0.02750   | 2.64167 | 1.000     | -9.2629  |
| 3.00                 | 3.00                  | -2.76250   | 2.64167 | .891      | -11.9979 |
| 5.00                 | 5.00                  | .97500     | 2.64167 | .998      | -8.2604  |
| 5.00                 | 1.00                  | -1.17000   | 2.64167 | .995      | -10.4054 |
| 2.00                 | 2.00                  | -1.00250   | 2.64167 | .997      | -10.2379 |
| 3.00                 | 3.00                  | -3.73750   | 2.64167 | .736      | -12.9729 |
| 4.00                 | 4.00                  | -.97500    | 2.64167 | .998      | -10.2104 |

The results of this study were consistent with [9] which reported copper concentrations were high in Pacific white shrimp. The high content of copper in Pacific white shrimp can be caused due to routine use of copper sulfate in overcoming the existing diseases. At the time of the sampling process, some symptoms or indications are categorized as one of these diseases. e.g., Bordeaux solution containing 1-3% CuSO4. This solution is used to eradicate snails as hosts of parasitic worms, as well as to treat foot rots in sheep [14]. Our result was similar to [15] which showed that the content of metals in muscle shrimp was Cu > Zn > Pb.
In contrast to the study [1], which showed that copper, chromium, and zinc content were higher than this study, except for lead. The results of this research also differed with [14] with Cu content of 0.2953 ppm and Pb of 0.1007 ppm. Moreover [16] also reported that Zn > Cr > Cu > Pb in shrimp. The difference of metal content can occur since the accumulation is also different in tissue. Factors like size, feeding habits, or ecological zone can affect how those metals accumulated in shrimp [17,18]. Based on [19], the content of Zn was the highest one, but the content of Cr was higher than Cu (Zn > Cr > Cu > Pb). The unessential elements like Pb are usually less accumulated compared to essential elements like Zn, Cu, and Cr in various shrimps.

Although Cr, Cu, and Zn are an essential element, in excessive amount, those elements can harm living organism [20]. Considering, health risk assessment, the content of metal in shrimps should be under the threshold. The content of copper and lead in shrimp in this research was still below the set threshold [21,22] of 20 ppm and 2 ppm. Based on [23], the content of Cr and Zn in shrimp was also still below the threshold.

4. Conclusion
Copper concentration in Pacific white shrimp was the highest concentration which was 6.19 ppm compared to zinc (3.31 ppm), chromium (0.24 ppm), and lead (0.03 ppm). Metal concentrations in Pacific white shrimp below the threshold indicate that shrimp was still safe for consumption.

Acknowledgement
We acknowledge Directorate Research and Community Engagement, Universitas Indonesia for its PITTA Grant Fiscal Year 2017 with contract number 671/UN2.R3.1/HKP.05.00/2017.

References
[1] Wu X Y and Yang Y F 2011 J. Food Compos. Anal. 24 62
[2] León J A, Silvas S G, J F Sañudo F, Lagarda M M, Valdés T D and Osuna F P 2017 Environ. Monit. Assess. 189 69
[3] Budiarti A, Kursni and Musinah S. 2010. Prosiding Seminar Nasional Sains dan Teknologi Fakultas Teknik vol I (Semarang: Wahid Hasyim University Press)
[4] Baboli, M J and M Velayat zadeh 2013 J. Animal Plant Sci. 23 786
[5] Djohan and Rahardjo D 2016 Int’l J. Adv. Chem. Engg. Biol. Sci. 3 2349
[6] Diodato S, Comoglio L, Camilli C and Amin O 2012 J. Exp. Mar. Biol. Ecol. 436 11
[7] Balai Besar Wilayah Sungai Citarum 2016 Data spasial online access
[8] Meshram L N, Udawant S M, Pawar S and Mishra P S 2014 Int. J. Adv. Res. 2 548
[9] Dadar M, Peygham R and Memari H R 2014 Bull. Environ. Contam. Toxicol. 93 339
[10] Olgunoğlu M P, Olgunoğlu I A and Bayhan Y K 2015 Pol. J. Environ. Stud. 24 631
[11] Fallah A A, Saedi-dehkordi S S, Nematollahi A, and Jafari T 2011 Microchem. J. 98 275
[12] Republic of Indonesia Regulation No. 7 Year 1996 Food 1(4)
[13] Darmono 2010. Lingkungan Hidup dan Pencemaran (Jakarta, UI Press)
[14] Napitu W T 2012 “Analisis kandungan logam berat pb, cd, dan cu pada bandeng, belanak, dan udang di kawasan silvo fishery belanakan subang” Undergraduate Thesis (Bogor, Bogor Agricultural University)
[15] Silvaa E, Vianab Z C V, Onofrec C R E, Kornec M G A and Santsocde V L C 2016 Braz. J. Biol. 76 194
[16] Mortuza M G and Al-Misned F A 2017 J. Aquat. Pollut. Toxicol. 1 1
[17] Kwok C, Liang Y, Wang H, Dong Y, Leung S 2014 Ecotox. Environ. Safe. 106 62
[18] George R, Hsu S C, Nair S M, Martin G D and Nair K K C 2011 Environ. Forensics 12 162
[19] Anandkumar A, Nagarajan R, Prabakaran K and Rajaram R 2017 Reg. Stud. Mar. Sci. 16 79
[20] Tawfik M S 2013 J. Food Technol. 11 95
[21] National Agency of Food and Drug Control Regulation No. Hk.00.06.1.52.4011 Establishment on maximum ambient of chemical and microbial contaminant in food
[22] Decree of Directorate General of National and Drug Control Department of Health Republic of Indonesia No: 03725/B/SK/1989 Maximum ambient of metal contaminant in food

[23] Darmono 2001 Lingkungan Hidup dan Pencemaran: Hubungannya dengan Toksikologi Senyawa Logam Jakarta, UI Press