Heavy metal compositions in Green turtle (Chelonia mydas) eggs from nesting beaches in Peninsular Malaysia

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This study investigates the concentration of heavy metals in fresh and un-hatched green turtle eggs from two major nesting beaches in (Ma’ Daerah, Terengganu and Cherating, Pahang) Peninsular Malaysia. All five heavy metals (Mn, Cu, Zn, Cd and Pb) were detected in the eggs. Statistical analysis shows no significant difference of heavy metals concentration between the yolk of rotten and fresh eggs. Therefore, the yolk of rotten eggs can be used as heavy metals indicator for future study without sacrificing fresh eggs. The level of lead detected exceeded the permissible limits of the Malaysian Food Regulation 1985. The presence of toxic contaminants in sea turtle eggs can be attributed to the chemical pollutants present in their feeding and breeding sites. Sea turtles have long lifespan and can bio-accumulate contaminants from their food, sediment and water. The presence of toxic metals in green turtle eggs may cause health problem for those who likes to consume turtle eggs. This finding is important to increase public awareness on the danger of eating sea turtle eggs as well as to reduce egg collection for human consumption in Malaysia.

The green turtle, Chelonia mydas is listed as endangered species in IUCN Red List of threatened species and under the Appendix I of CITES. This species is threatened by all factors that threaten other sea turtles, including exploitation for eggs, meat, curio trade, loss of nesting and foraging habitat, incidental capture in fishing gears and marine pollution. In Peninsular Malaysia, one of the major reasons that contributed to the decline of green turtle nesting is the excessive collection of eggs for local consumption. Until recently, except for the leatherback turtle eggs, commercial sale of sea turtle eggs are still allowed in Peninsular Malaysia. Only Sabah and Sarawak had the total protection for these endangered marine animals. Differences in legislation to protect sea turtles by each state in Malaysia had accorded different protection to these animals.

In Peninsular Malaysia, the States Fisheries Department will issue license for egg collectors. Eggs collected must then be sold back to the Fisheries Department and incubated in the hatchery. However, the presence of many illegal egg collectors and sometimes lack of funding from the government to buy the eggs for incubation had resulted to high number of eggs being sold in the local market. In recent years, the protection of green turtle eggs in Peninsular Malaysia had increased where all the major nesting beaches were gazetted as turtle sanctuary. Yet, because of the high demand for sea turtle eggs in Peninsular Malaysia and no existing legislation to ban the selling of eggs, smuggling of turtle eggs had increased. WWF-Malaysia (2009) reported that most of the eggs sold in Pasar Payang, Kuala Terengganu were smuggled illegally from Sabah and the Philippines. Due to lack of enforcement and legislation, harvesting of turtle eggs had contributed as one of the major factor to the decline of sea turtle nesting in Peninsular Malaysia.

Previous studies had reported that sea turtle eggs are affected from toxic contaminants (Sakai et al., 1995, Godley et al., 1999 and Lam et al., 2006). Heavy metals measured in the egg yolks of sea turtles could be used to predict body burden in nesting females (Sakai et al., 1995 and Sakai et al., 2000). A study on the level of trace elements in green turtle eggs collected from Hong Kong shows that concentrations of Selenium (Se), Lead (Pb) and Nickel (Ni) in the eggs were generally higher (Lam et al., 2006). The fact that sea turtles have a long lifespan and high mobility increase their chances of being exposed to environmental toxicants. In today’s modern world, most of the industrial, agricultural, aquacultures and others human activities waste were easily discharged into the sea without having proper treatments. Most of the waste contains toxic metals compositions that will accumulate in the marine environments or habitat of sea turtles. Off-shore mineral and oil explorations as well as the discharge of waste from oil tankers further complicate the marine pollution problems. Long range transport of pollutants is also a threat to aquatic species as well as humans (Serfoh-Armah et al., 1999). Besides from polluted environments, feeding behavior can also influence the accumulation of heavy metals in sea turtles. The diets of green turtle are mainly consists of marine algae and seagrasses, which are known to have the ability to accumulate heavy metals in their cells or tissues (Valchos et al., 1998; Khristoforva and Kozenkova, 2002). These heavy metals can also be transferred from the mother to their eggs. Essential metals such as Fe, Mn, Zn and Cu are used in the development of the embryo within the eggs. As for toxic metals such as Cd, Pb and Hg, limited amounts will be transferred from the mother to the eggs. Non – essential and essential metals can act as toxicants at elevated concentrations in organisms (Devkota and Schmidt, 1999; Kobayashi and Okamura, 2004). The study of heavy metal composition in green turtle eggs in Peninsular Malaysia is potentially important for both conservation of sea turtles and for public health awareness. Information obtained in this study may stop the consumption and collection of sea turtle eggs in Peninsular Malaysia.
RESULTS AND DISCUSSION

Essential and non-essential elements in eggs

Results from this study showed high concentration of essential elements such as Zn and Cu. These metals were detected in all eggs compartments. Concentration of Zn, Cu and Mn were higher in egg shell, albumen and egg yolk of fresh eggs collected from Cherating compared to those that collected from Ma’Daerah (Figure 1). Zn was detected as the highest element in the egg yolks of fresh eggs. The concentration detected was 84.61 µg g\(^{-1}\) (Cherating) and 66.54 µg g\(^{-1}\) (Ma’Daerah). This result is an agreement with other studies. According to Lam et al., 2006) the concentration of Zn in the egg yolk of green turtle eggs collected from Hong Kong was significantly higher than those of the albumen and egg shell. In this study, higher concentration of Cu and Mn were detected in the egg shell compared to albumen and egg yolk (Figure 1). Study on the concentration of heavy metals from green turtle eggs in Turkey shows a high concentration of Cu in egg shells compared with other eggs compartments (Celik et al., 2005). According to Storelli and Marcotrigiano (2003), sea turtle’s egg shell contained highest levels of Cu and Mn. Stoneburner et al., 1980 suggested that the concentration levels of these essential metals were necessary for successful embryonic development. Zn is an important element in the development of yolks, whereas Cu and Mn is an important element in the development of egg shell.

Non essential elements such as Cd and Pb were detected in all samples in this study. Concentration of Cd was higher in the egg shell and egg yolk of fresh eggs collected from Cherating compared to those collected from Ma’Daerah. The concentration of Cd detected in egg yolk of fresh eggs from Cherating was 0.34 µg g\(^{-1}\) while 0.23 µg g\(^{-1}\) from Ma’Daerah. For rotten eggs, the concentration of Cd was higher in albumen for samples from Ma’Daerah and Cherating which is 0.42 µg g\(^{-1}\) and 0.60 µg g\(^{-1}\) respectively. Pb concentration are higher in all part of fresh eggs collected from Ma’Daerah with the range from 5.06 µg g\(^{-1}\) to 6.21 µg g\(^{-1}\) compared to Cherating (3.56 to 4.78 µg g\(^{-1}\)). As for rotten eggs, higher concentration of Pb detected in egg yolk and albumen collected from Cherating compared with Ma’Daerah. Concentration of Pb detected in egg yolk and albumen of rotten eggs from Cherating were 9.37 µg g\(^{-1}\) and 11.43 µg g\(^{-1}\) respectively. While for Ma’Daerah, concentration detected was 5.72 µg g\(^{-1}\) (egg yolk) and 9.56 µg g\(^{-1}\) (albumen). Overall Cd and Pb concentration were highly detected in rotten eggs compartments compared to fresh eggs compartments (Figure 1). Statistical analyses (ANOVA – univariates) shows significance difference (p < 0.05) in concentration of heavy metals between egg shell, albumen and egg yolk of fresh eggs collected from Ma’Daerah and Cherating Turtle Sanctuary. Differences in heavy metals between individual turtles may be due to their behavior which is highly mobile where the distance between breeding and feeding grounds can be hundreds to
Heavy metal compositions in *Chelonia mydas* eggs

It is possible that the contaminants found in the tissues of marine turtles can be attributed to chemical pollutants present in both their feeding range and breeding sites (Lam et al., 2004). Feeding behavior can also influence the accumulation of heavy metals in sea turtles. The main diets of green sea turtle are marine algae and seagrasses. Marine algae and seagrasses are known to have ability to accumulate heavy metals in their cells or tissues (Valchos et al., 1998; Khristoforova and Kozhenkova 2002). Celic et al. (2005) found high concentrations of Cd, Pb and Fe in the sea grass, *Posidonia oceanica* around the nesting environment of green turtles in Turkey. Since the adult green turtles are herbivorous and feed mainly on seagrass, they might be affected from heavy metal contamination (Celic et al., 2005). Benthic macroalgae can concentrate metal ions from seawater and thus, macrophytic algae, especially green and brown seaweed have been widely used as indicators of trace metal pollution (Stivalingam and Ismail, 1981; Ho, 1990).

Heavy metals are not sequestered equally in eggs (Burger, 1993). Maternal transfer of energy, nutrients and trace elements during egg production could be especially high in leatherback turtle (*Dermochelys coriacea*) because they have the highest reproductive output among reptiles (Miller, 1997). Leatherback turtle has a bigger eggs size and can accumulate and eliminate high concentration of heavy metals compared to green turtles. Study by Aguirre (1994) reported that the concentration of Cd in kidney of green turtle (39.4 µg g⁻¹) was higher compared to the concentration detected in liver (9.30 µg g⁻¹) and muscle (0.062 µg g⁻¹). Therefore, maternal transfer is likely to depend on the species accumulation and elimination capability, the level of contamination and the nature of the element considered.

Statistical analyses (ANOVA – univariates) shows that there was no significance difference (p > 0.05) in concentration of heavy metals between egg shell, albumen and egg yolk of rotten eggs collected from Ma’Daerah and Cherating Turtle Sanctuary. Generally, Cd is highly toxic to wildlife and potentially causing mutation. It is associated with increased mortality, growth reduction and reproduction (Eisler, 1985). At the biochemical level, Cd can negatively affect DNA, RNA, and ribosome synthesis (Gerhard et al., 1998), as well as deactivate several enzyme systems (Doi et al., 1993). At the organism level, Cd is known to be tetrao- genic and embryotoxic (Sundermann et al., 1995). In addition chronic Cd exposure results in lower fecundity and decreased overall reproductive success in marine organisms (Singhal et al., 1985). Birds and mammals suffer effects from Pb poisoning such as damage to the nervous system, kidneys, liver, sterility, growth inhibition, developmental retardation, and detrimental effects in blood. Pb poisoning in higher organisms such as green turtles primarily affects hematologic and neurologic processes (Eisler, 1998).

**Potential adverse effects of green turtle eggs consumption to humans**

In this study, toxic contaminants such as Cd and Pb were detected in green turtle eggs. Figure 2 shows the concentration of heavy metals in albumen and egg yolk of fresh sea turtle eggs found in this study. Table 1 shows the comparison of Cd and Pb concentration detected in this study with the permissible value from the Malaysian Food Regulation (1985). The concentration of Pb in green turtle eggs exceeds the permissible limits of Pb, however the Cd concentration was below the concentration of permissible limits. Even though Cd concentration is low, Cd has the ability to accumulate in human’s body. The presence of Pb and Cd in green turtle eggs might cause and adverse effects to human health due to the eggs consumptions.

<table>
<thead>
<tr>
<th>Element</th>
<th>Malaysian Food Regulation (1985) (mg kg⁻¹) (wet weight)</th>
<th>Metal level of green turtle eggs (this study) (µg g⁻¹) (dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>3.00</td>
<td>25.74</td>
</tr>
<tr>
<td>Zn</td>
<td>100.00</td>
<td>106.23</td>
</tr>
<tr>
<td>Cd</td>
<td>1.00</td>
<td>0.61</td>
</tr>
<tr>
<td>Pb</td>
<td>2.00</td>
<td>9.46</td>
</tr>
</tbody>
</table>

**Figure 2.** Overall concentration of heavy metals in fresh sea turtle eggs (albumen + egg yolk).

Environmental contaminants such as heavy metals may be transferred to humans upon consumption of contaminated seafood. Heavy metals persist and bioaccumulate in marine ecosystems and this compound reach especially high concentrations in long-lived organisms such as sea turtles. Pb toxicity can caused adverse behavioral, physiological and biochemical effects on humans. Neurological impacts of Pb include hyperactivity, poor attention span and low IQ especially in children. Besides, Pb can also disrupt the enzymes activity. It’s inhibited the haemoglobin synthesis and caused insufficient transport of oxygen and anemia. Anemia caused children fatigue easily and are less able to learn well (Bradl, 2005; Wright and Welbourn, 2002; Landis and Yu, 2003). Exposure of Cd in humans’ body system can contribute to renal dysfunction, increased risk of osteoporosis, possible link to type –2 diabetes, renal and prostate carcinogen (Jarup et al., 1998; Goyer et al., 2004; Kazantzis, 2004).

**CONCLUSION**

The concentrations of heavy metals (Mn, Cu, Zn, Cd and Pb) were detected in all fresh and rotten eggs compartments. Most of the elements detected were found
accumulated in the yolk compared to albumen and egg shell. The highest element concentration detected was Zn and the lowest concentration of element detected was Cd. Concentration of Zn and Cu was high due to their character as an essential element for the development of eggs. Statistical analyses (ANOVA – multivariate) shows that there was no significance different (p > 0.05) in heavy metal concentration between egg yolk of fresh and rotten eggs. However, there was a significance different (p < 0.05) in heavy metal concentration between albumen and egg shell of fresh and rotten eggs. Thus, egg yolk of rotten eggs is suitable for heavy metals indicator compared to shell and albumen. In future study, instead of sacrificing fresh eggs, rotten eggs can be used as heavy metal indicator in green turtle. The presence of non – essential elements such as Cd, and Pb in green turtle eggs can posedangerous affect to human health. As such, the public should be informed about this and to stop the consumption of sea turtle eggs. When collection and consumption of sea turtle eggs had stopped, indirectly this will help the conservation of sea turtles in Malaysia.

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REFERENCES


