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# HEAVY METAL ACCUMULATION IN THE SKELETON OF *Porites lutea* FROM NGAM ISLAND, TRAT PROVINCE, THAILAND

# การสะสมโลหะหนักในโครงร่างแข็งของ *Porites lutea* เกาะง่าม จังหวัดตราด ประเทศไทย

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## Abstract

For investigating variation of heavy metal concentration in growth bands of coral skeletons, Poriteslutea samples were collected from Ngam Island, Trat province, Thailand. The skeleton samples were cleaned using oxidative and reductive treatments to effectively eliminate detritus and organic materials and were acid-digested. Five heavy metals, cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and zinc (Zn), in the growth bands of *Porites lutea* were analyzed using Flame Atomic Absorption Spectrometry (FAAS) and Graphite Furnace Atomic Absorption Spectrometry (GFAAS). As a result, the range of heavy metals found in coral skeletons (µg/g as dry weight) was: Cd (0.01-0.19), Cr (0.28-2.25), Cu (2.40-7.71), Pb (0.18-1.13), and Zn (7.64-15.05). The levels shown in descending order were as follows: Zn > Cu > Cr >Pb> Cd. All metals in this study were found in lower concentration when compared with other studies in a polluted area. This study indicated that *Porites lutea* a good environmental indicator of marine pollution in Ngam Island, and can be useful for past proxy data.

**Keywords:** coral, heavy metal, growth bands, *Porites lutea*, Ngam Island, Trat

## บทคัดย่อ

การตรวจสอบความผันแปรของความเข้มข้นโลหะหนักที่แบนเจริญเติบโตในโครงร่างปะการังตัวอย่าง *Porites lutea* เก็บจากเกาะง่าม จังหวัดตราดประเทศไทย โครงร่างปะการังได้ทำความสะอาดโดยการออกซิเดทีพและค่อย ๆ ลดการปฏิบัติลงอย่างมีประสิทธิภาพในการกำจัดวัสดุเศษซากและอินทรีย์และทำการย่อยโดยกรดโลหะหนัก 5 ชนิด แคดเมียม (Cd) โครเมียม (Cr) ทองแดง (Cu) ตะกั่ว (Pb) และ สังกะสี (Zn)ในแบนเจริญเติบโตของ *Porites lutea* ทำการวิเคราะห์โดยเครื่องมือ Flame Atomic Absorption Spectrometry (FAAS) และ Graphite Furnace Atomic Absorption Spectrometry (GFAAS) ผลการศึกษาพบว่าค่าพิสัยของโลหะหนักที่พบในโครงร่างแข็งหน่วยเป็น(มคก/ก น้ำหนักแห้ง)มีค่าดังนี้ แคดเมียม (0.01-0.19) โครเมียม (0.28-2.25) ทองแดง

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(2.40-7.71) ตะกั่ว (0.18-1.13) และสังกะสี (7.64-15.05) ลำดับของการสะสมจากมากไปน้อยคือสังกะสี >ทองแดง >โครเมียม>ตะกั่ว>แคดเมียม การสะสมของโลหะหนักในการศึกษานี้ต่ำกว่าเมื่อเปรียบเทียบกับแหล่งที่มีมลภาวะจากการศึกษาอื่นๆ การศึกษาครั้งนี้ชี้ให้เห็นว่า Poriteslutea เป็นตัวชี้วัดทางสิ่งแวดล้อมที่ดีของมลภาวะทางทะเลที่เกาะง่าม และสามารถใช้เป็นประโยชน์สำหรับข้อมูลในอดีต

**คำสำคัญ**: ปะการัง, โลหะหนัก, แบนเจริญเติบโต, *Porites lutea*, เกาะง่าม, ตราด

## Introduction

Coral reefs are a high biodiversity of marine ecosystem having the greatest number of marine species[1]. They serve as natural barriers and substantial resources such as food, trade items, building material, and tourist attractions. In general, they are found in tropical regions, including Thailand, where approximately 1800 $km^2$ of coral reefs grow along Thailand's coastal line in the Gulf of Thailand and the Andaman Sea[2] and only in some areas of temperate regions at a depth of less than about 100 m.

On the other hand, corals are sensitive to physical and chemical changes in the marine ecosystem including global warming, pollution, and new diseases. Thus, corals can be used as environmental indicators because they remain in the same place throughout their lifetime[3] and their skeletons assimilate records of certain metals over hundreds of years[4].

Scleractinian coral, for example *Porites* corals, have been proved to be useful for the study of heavy metal contamination in an aquatic environment [5 – 8]. In the case of the east coast of the Gulf of Thailand, Chang Islands, a group of Islands, are the marine national park in Trat province that are located at latitude 11°45' to 12°10' N and longitude 102°15' to 102°31' E. Chang Islands cons ist of over 40 large and small Islands. The majority is Chang Island (212.4 $km^2$) with a registered population of approximately 7,770 people[9]and the other main Islands in the group are Chang Noi, Wai, Lao Ya, Mai Si, Rang, Koom, and Ngam.

Coral reefs (fringing reef) are widely distributed in Chang Islands and there is abundance of marine biodiversity. Unfortunately, at present the coral reef is deteriorated by the impact of bleaching, industrial tourism, new construction, coastal development, and fishery.

Therefore, this research investigates heavy metal concentration in the skeleton of *Porites lutea* to estimate marine pollutant from Ngam Island.

## Materials and methods

### Collection site and coral sample

Ngam Island is located on the south of Chang Island, Trat province, Gulf of Thailand (Figure 1). The island has an area of about

9600 $m^2$. The topography has sand bar, which connects between two small parallel mountains. There are two small beaches and a resort on Ngam Island where the water around is very clear. Fringing reef is found around the island and most corals are in shallow waters (<20-30 m in depth). Moreover, *Porites lutea* is the most dominant species, which covers approximately 0.178 $km^2$ [10]. On July 15, 2010, three coral samples of living *Porites lutea* (approximately 10-20 cm in diameter) were collected from Ngam Island at a depth of about 5-8 m by SCUBA diving.

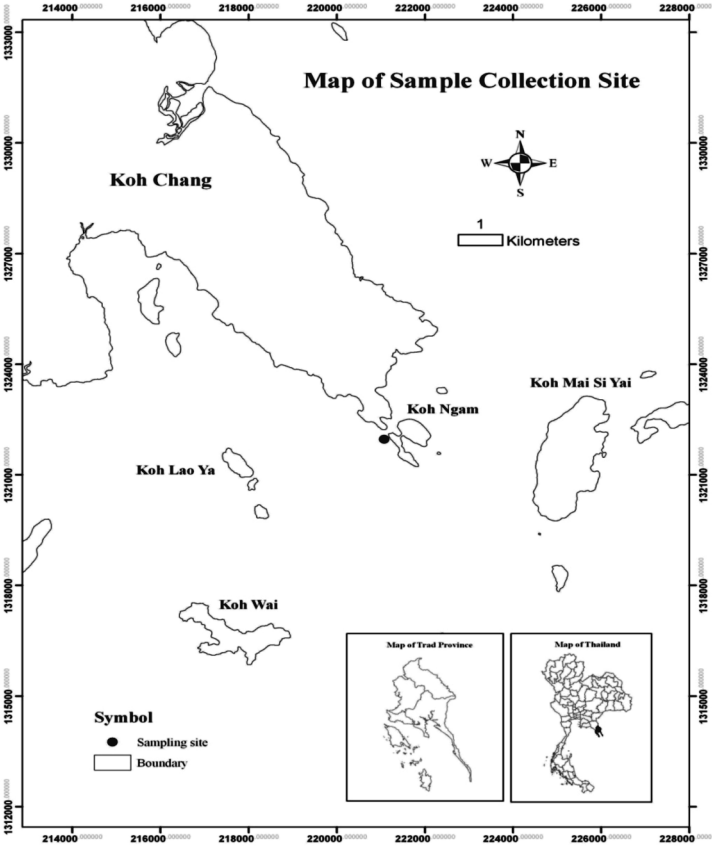


Figure 1 Map showing the location of sampling

### Analytical methods

Coral samples were cut approximately 1 cm with a rock saw along the coral's maximum growth axis. Then, coral slabs were cleaned with distilled water in an ultrasonic bath for 20 min and dried in an oven at 60°C for 48 h. Each slab was X-rayed and etched using a carbide-tip dental drill along the best line of annual growth bands that revealed high- and low-density bands on the X-radiographs (Figure 2). About 1 cm × 1 cm cross-section size was picked out for heavy metal analysis, and coral powder was put into an acid-cleaned glass vial.

The coralline powder was cleaned following the procedure of Al-Rousan, et al.[11]. Then, coral powder from each section, 0.25 g (dry weight), was digested with microwave using an in-house method based on EPA #3050B[5]. All samples were analyzed in triplicates. Cd, Cr, and Pb were determined by Graphite Furnace Atomic Absorption Spectrometry (GFAAS). Cu and Zn were determined using Flame Atomic Absorption Spectrometry (FAAS).

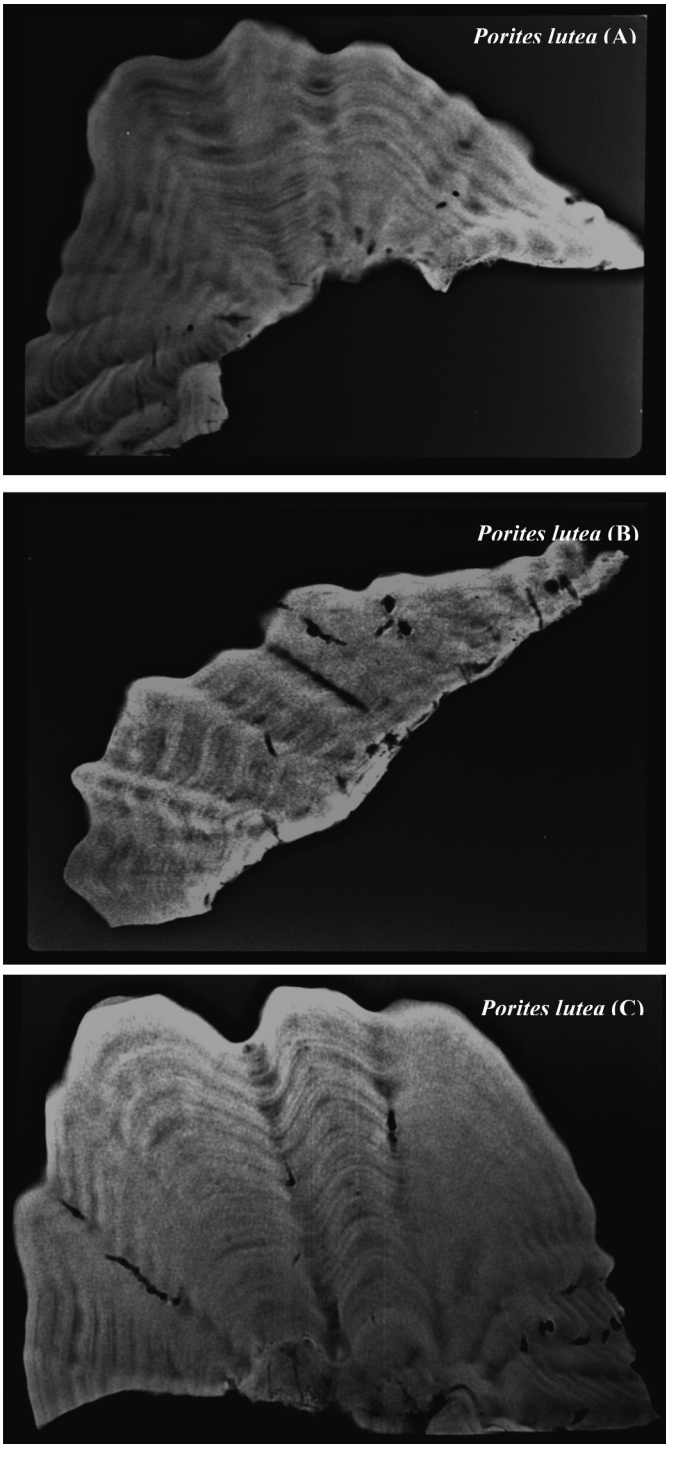


Figure 2 X-radiographs of coral slabs

## Results and Discussion

All three coral samples showed that Zn concentration was the highest when compared with Cu, Cr, and Pb, while Cd concentration showed the lowest value (Table 1). In addition, the variation of heavy metals content in the skeleton of *Porites lutea* (A, B, and C) presented a high variation in Zn and Cu, while Cr, Pb, and Cd found little variation (Figure 3). All results presented that the Zn contents vary in a range of 7.64-15.05 µg/g, Cu contents vary from 2.40 to 7.71 µg/g, Cr contents vary from 0.28 to 2.25 µg/g, Pb contents vary from 0.18 to 1.13 µg/g, and Cd contents vary from 0.01 to 0.19 µg/g, respectively. The results did not show a clear fluctuating trend because of the different growth rates in each *Porites lutea's* colonies that contribute to the high peak metal values in the same interval, not even three colonies of the same species. In general, massive corals have linear extension rates of about 1-3 cm/yr[12]and their growth rates are controlled by several environmental factors, such as seawater temperature, light, salinity, carbonate saturation stage, water motion, and water quality[13].

Due to increase in Zn levels in contemporary scleractinian, coral skeletons normally have strong anthropogenic sources[3,12,14] and its response is an increase in sewage discharge[8]. These probably imply that pollution source of anthropogenic activities, especially sewage discharge, contribute to the high Zn value increase in seawater and coral skeleton from Ngam Island. In addition, high Cu in seawater affects coral reproduction and coral growth rate[15].

In contrast, the content of Cd, Cr, and Pb in the coral skeleton was found to be in less variation than others. Because the study site is located far from a main river run off in the estuarine area, it probably causes low Pb value in coral skeleton due to the Pb contents in the coral skeleton being affected by river run-off in estuarine areas and Pb in seawater is absorbed on particles by scavenging processes[16].

As shown in Table 2, comparison with previous studies in Thailand found that the average of all heavy metal concentration values, except Zn, were lower than the study from KhangKhao Island, Chonburi province, that referred to polluted area, and Tao Island, Suratthani province, an unpolluted area[17] and also from Chueak Island, Suratthani province[18]. These probably imply that this study site is lower contaminated by heavy metal in seawater than KhangKhao Island, which is located in the Upper Gulf of Thailand, and affected by main river run-off, for example Chao Phraya, Mae Klong, and Bang Pakong, from the untreated domestic and industrial sewage discharge to the estuarine areas. Furthermore, comparison

with other countries showed that our results were within the range and the average of all heavy metal concentration values were less than other studies that were reported in polluted zones[5,16,19-23].

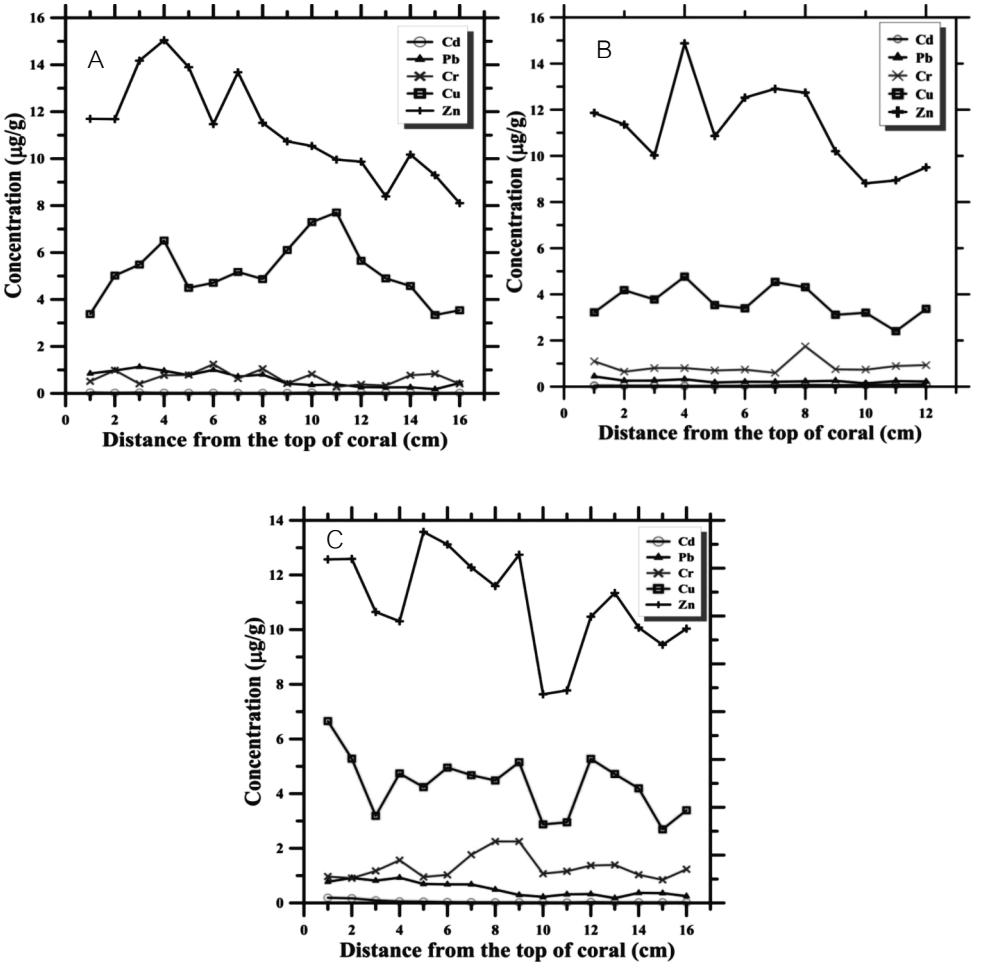


Figure 3 Variation of heavy metal concentrations in *Porites lutea* (A, B, C)

**Table 1** Range and mean values (±SD) of heavy metal concentrations (µg/g) dry weight in skeleton of *Porites lutea* from Ngam Island.

| Parameter | | Concentration (µg/g) dry weight | | |
|---|---|---|---|---|
| | | *P. lutea*(A) | *P. lutea*(B) | *P. lutea*(C) |
| Cadmium | Range | 0.01-0.04 | 0.03-0.10 | 0.01-0.19 |
| (Cd) | Mean±SD | 0.02±0.01 | 0.05±0.02 | 0.02±0.05 |
| Chromium | Range | 0.28-1.24 | 0.60-1.75 | 0.84-2.25 |
| (Cr) | Mean±SD | 0.70±0.29 | 0.78±0.31 | 1.66±0.44 |
| Copper | Range | 3.34-7.71 | 2.40-4.77 | 3.37-7.62 |
| (Cu) | Mean±SD | 4.96±1.27 | 3.46±0.68 | 4.82±1.24 |
| Lead | Range | 0.18-1.13 | 0.14-0.44 | 0.18-0.92 |
| (Pb) | Mean±SD | 0.58±0.32 | 0.23±0.08 | 0.43±0.26 |
| Zinc | Range | 8.10-15.05 | 8.81-14.87 | 7.64-13.58 |
| (Zn) | Mean±SD | 11.10±2.06 | 11.11±1.84 | 11.00±1.79 |

**Table 2** Heavy metal concentrations from comparative worldwide studies of *Porite* ssp.

| Reference | Species | Location | Concentration (μg/g dry weight) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Cadmium | Chromium | Copper | Lead | Zinc |
| This study | *Porites lutea* | Ngam Island | 0.01-0.19(0.03)* | 0.28-2.25(0.87)* | 2.40-7.71(4.51)* | 0.18-1.13(0.36)* | 7.64-15.05(11.10)* |
| Lifen et al., 1997 | *Porites* sp. | Nansha Island, China | 0.5-120 (8.2)* | 1.40-237 (58.6)* | 12.5-880 (202)* | 38-1790 (233)* | 11.8-960 (172)* |
| Bastidas and GarcÍa, 1999 | *Porites* sp. | Punta Brava, Venezuela | NA | 0.16-2.58 (0.797)* | 3.33-89.57 (16.33)* | 0.031-1.413 (0.208)* | 3.59-42.45 (10.67)* |
| | | BajoCaimán, Venezuela | | 0.22-23.90 (1.952)* | 3.53-36.95 (12.52)* | 0.029-4.740 (1.037)* | 0.83-23.10 (9.12)* |
| Chunying et al., 2001 | *Porites* sp. | Daya Bay, China | 0.3-5.2 (1.1)* | NA | 50-66.2 (25.7)* | 5-85.7 (15.7)* | NA |
| Fallon et al., 2002 | *Porites* sp. | Misima Island, PNG | NA | NA | NA | (0.47)* | (19.9)* |
| Chodthanom, 2002 | *Porites lutea* | KhangKhao Island | (6.17)* | (4.20)* | (6.03)* | (51.48)* | (10.29)* |
| | | Tao Island | (1.40)* | (0.97)* | (5.03)* | (12.05)* | (8.76)* |
| David, 2003 | *Porites* sp. | Caganhao Reef, | NA | NA | (0.7)* | NA | (1.0)* |
| | | Ulan Reef, | | | (3.1)* | | (1.8)* |
| | | Ihatub Reef, Philippines | | | (1.4)* | | (2.0)* |
| Zicheng et al., 2006 | *Porites lutea* | Dafangji Island, China | 0.54-2.49 (0.97)* | 5.3-17.0 (10.8)* | 28.2-297 (117)* | 7.5-72.4 (16.2)* | 42.0-551 (169)* |
| Al-Rousan et al., 2007 | *Porites* sp. | Gulf of Aqaba, Jordan | (3.38)* | NA | (4.14)* | (40.94)* | (5.93)* |
| Lee and Mohamed, 2009 | *Porites* sp. | Palau Tioman, Malaysia | NA | NA | NA | NA | (23.73)* |
| Tanaka et al., 2010 | *Porites* sp. | KhangKhao Island | NA | NA | NA | (3.55)* | NA |
| | | Rukan-sho Island, Japan | NA | NA | NA | (0.132)* | NA |
| Sirianansakul, 2011 | *Porites lutea* | Chueak Island | 0.04-0.18 (0.10)* | 1.53-4.50 (2.76)* | 6.66-25.36 (13.41)* | 0.44-1.53 (0.82)* | 1.35-8.15 (3.52)* |

Note: NA = No Analyse , *= Numbers in brackets are mean value

## Conclusion

The accumulation of five heavy metals in the skeleton of *Porites lutea* showed that the average concentration of Zn was the highest, while Cd showed the lowest value. Even though the content of Cd, Cr, and Pb in the coral skeleton was found in less variation than others and it seems that there is no serious pollution, these are toxic or poisonous to aquatic biota and humans at low concentrations. In this study, all results found low values when compared with worldwide studies in highly polluted areas and also indicated that *Porites lutea* is a good environmental indicator of marine pollution in Ngam Island.

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