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# Cadmium, Lead and Mercury Concentrations in the Hooded Rock Oyster *Saccostrea Cucullata* (Born, 1778) From the Oman Coast of the Arabian Sea

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**Abstract**
The concentrations of cadmium (Cd), lead (Pb) and mercury (Hg) were estimated in the soft tissue of the hooded rock oyster *Saccostrea cucullata* from four sites in Dhofar on Oman coast, that were collected monthly from June 2009 to July 2010. The mean concentrations in µg/g dry weight of Pb, Hg and Cd were: 0.013±0.004, 0.015±0.001 and 3.41±0.15 (±SD), respectively. The concentrations of Hg and Pb were close to background levels, indicating no anthropogenic contamination, while concentrations of Cd exceeded the permissible level by approximately 3.4 times. Comparison between concentrations of heavy metals in different sites by ANOVA and Turkey post hoc tests, indicated significant differences between some sites for Cd, while differences for Hg and Pb were not significant. Meanwhile, no significant seasonal differences were reported in concentrations of the studied heavy metals. Generally, metal concentrations in the soft tissues of the examined oyster in Dhofar were found to be lesser than in other regions of the Indian Ocean and in previous surveys in Oman.
**Keywords:** *Saccostrea cucullata*, heavy metals, concentration, Oman.

## 1. Introduction

Water pollution is a global environmental problem that is created mainly by man and can also be controlled by man. The most dangerous pollutants damaging ocean ecosystems due to their toxic, mutagenic or carcinogenic effects on living organisms are hydrocarbons (pesticides, oil and petroleum products), toxic heavy metals (mercury, lead, cadmium, arsenic, etc.) and radioactive elements. There are two main sources of heavy metal contamination in aquatic ecosystems: firstly natural processes such as physical and chemical weathering of rock, leaching of soil, volcanic eruptions, forest fires, and secondly anthropogenic activities (mining, smelting, combustion of fossil fuel, industrial, agricultural and domestic wastes disposal, etc.). In contrast to most organic pollutants, heavy metals are not usually eliminated from the marine ecosystems by natural processes and tend to accumulate in sediments and tissues of hydrobionts to subsequently be transferred through the food chain to higher trophic levels. Both benthic and pelagic species may thus become contaminated by direct uptake and or through biomagnifications. Consumption of metal rich organisms could transfer biomagnified metals to humans and therefore pose a threat to human health as well (Kumar *et al*., 2008). The accumulation of heavy metals by different marine organisms depends on many environmental factors (temperature, pH, salinity, etc.), and biological factors, for example; species features, age, sex, sexual maturity, etc. Some marine organisms have higher abilities to accumulate heavy metals and other pollutants from surrounding water and sediments, and are most useful as bioindicators of the quality of the marine environment. These organisms include bivalve molluscs (especially oysters and mussels), that are sedentary filter feeders that can filter dozens of liters of water per day, absorbing heavy metals. As a result they are commonly considered as good biomonitoring agents for heavy metals in marine ecosystems (Gupta and Singh, 2011) used to measure hazard levels and risk assessments. On the other hand, these molluscs are valuable food items for human being.

The hooded rock oyster *Saccostrea cucullata* (Born, 1778) is a tropical edible species widely distributed in the littoral zone of Indo-Pacific, Eastern Atlantic, and the Mediterranean (Poutiers, 1998). It is common on rocky shores and around mangrove roots, at depths of 0-15 m and is popular for collection and cultivation in many countries (Thailand, Australia, New Zealand). Oysters are highly valued sea food and are considered a delicacy in the USA, Europe, Japan, etc. beside the growing demand for their meat in many countries in recent years.

The Arabian Peninsula has vast reserves of oil and natural gas and produces about 30% of the world's oil. Rapid economic development of Arabian states and establishment of large amounts of land-based and sea-based activities (petroleum, power, desalination and petrochemical plants) significantly increase the degradation of the marine environment. The region is a considered a hot spot in this regard and has one of the highest potential risks of contamination in the world. To better understand problems facing the marine environment and to coordinate common activities in protection of the water quality as well as marine living resources and to abate the pollution caused by industrial development, the eight coastal states of the region (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) created the Regional Organization for the Protection of the Marine Environment (ROPME) in 1979. Under the auspices of the ROPME, Gulf countries started monitoring of pollution in coastal and marine waters of the member states. ROPME requested the Member States to do their maximum efforts to protect the marine environment and prevent the causes of pollution. The Omani regulations on environmental protection, control and management are covered under the basic law viz., the "Law for the Conservation of the Environment and Prevention of Pollution" promulgated in November 2001 as Royal Decree (RD) 114/2001.

First surveys of tar, hydrocarbon and metal pollution in the coastal water of Oman was conducted in 1982 (Burns *et al*., 1982). Data on the concentration of heavy metals in the rock oyster from four regions of the Oman coast (Musandan, Muscat, Masirah and Salalah) were presented by Fowler (1988, Fowler *et al*., 1993). Initial surveys of heavy metal and organic contaminants in sediments and biota were conducted in Iran, Oman and Qatar in 1997, and again in Oman in 2001. A comprehensive survey was undertaken between February-March 2005 for the same target analyzes in the key coastal sites of all ROPME- Member States.

The concentrations of toxic heavy metals of the hooded oyster *S. cucullata* were also studied from the coast of Australia (Mackay *et al*., 1975; Olivier, Ridd and Klumpp, 2002; Brown and Pherson, 2007), India (Vijayalakshmi and Krishnakumari, 1993; Barua *et al*., 2011), Hong Kong (Blackmore, 2001; Chu *et al*., 2007), Qatar (De Mora *et al*., 2004), China (Wang and Wong, 2006), Tanzania (Mtanga and Machiwa, 2007) and Iran (Peer *et al*., 2010).

The present study deals with the concentrations of three toxic heavy metals (cadmium, lead and mercury) in soft tissue of the hooded oyster *S. cucullata* from Dhofar region occupying the southern part of Oman along the Arabian Sea. The study includes contamination levels of this edible mollusc from several sites and during different seasons.

## 2. Materials and Methods

***Study sites***

The study was performed along the Arabian Sea coast, between parallels 17-18$^o$ N and meridians 53$^o$30 to54$^o$30 E. Samples of oysters were collected monthly from four sites of Dhofar (Mirbat, Sadah, Hadbin, Hasik) from June 2009 to July 2010. The positions and the names of each station are shown in Figure 1.

***Sampling and heavy metal analysis***

Oysters were sampled during low tide. To reduce possible variation in metal concentration due to size and age oysters of the same size were collected from each station. Sampling took place once or several times during a month.

The collected and separated oysters were placed in polyethylene containers and transferred to the laboratory using ice boxes. After washing with distilled water, the oysters were frozen to -20$^o$C and then transported for analysis to the Fish Quality Control Center in Muscat.

Soft tissues were separated from the shells and pooled together in order to obtain sufficient amount of tissues for metal analysis, then oven dried at 80$^o$C for 3 days until a constant weight was obtained. They were powdered using a glass mortar and then stored in polyethylene pill boxes until digestion.

For heavy metal analysis (mercury, cadmium and lead) tissue samples of 1 g were digested in pure nitric acid (%65-merck). After digestion, the samples were cooled to the laboratory temperature and diluted to a specific volume using double distilled water and filtered through filter paper. Heavy metals analysis was performed using an atomic absorption spectrophotometer.

***Statistical analysis***

Comparisons of the data were performed using One-way analysis of variance (ANOVA) (Zar, 1984). The level of significance for statistical analyses was set at $\alpha = 0.05$. If significant difference between the mean values of the heavy metals concentrations in all studied sites was observed, Tukey post hoc test was used to determine differences between study sites.

## 3. Results and Discussion

Heavy metals analysis in soft tissues of *S. cucullata* showed that the pooled mean concentrations in µg/g dry weight (±SE: standard error) from different sites were: lead (Pb) 0.013±0.004, mercury (Hg) 0.015±0.001 and cadmium (Cd) 3.41±0.15 (Table 1). The pattern of metal occurrence exhibited the following descending order: Cd > Hg > Pb.

The total level of Cd concentration appears to exceed the recommended value of 1.0 µg/g dry weight by approximately 3.4 times. Cadmium is known to be the most toxic element after mercury for both marine and human life. It is accumulated in the body of marine organisms due to their poor regulatory ability for this metal as recorded by Pentrath (1976).

Meanwhile, concentrations of Hg and Pb appeared similar to background levels, indicating no anthropogenic contamination. In most cases (84%), the Pb concentration was lower than the potential detected level of the atomic absorption spectrophotometer that was noted as 0.

There are low anthropogenic activities and no specific sources of heavy metal pollution in the seawater in these sites. There is a small fishing port in Mirbat, a very small fishing port in Sadah, and some construction of new buildings and roads in Hasik. Heavy metal contamination in the present oyster is probably partially caused by domestic discharge, by atmospheric input of local particulates from motor vehicles, and from drainage off the highland mountainous catchment regions from which water drains to the Arabian Sea through different vallies.

Results of the investigations for Mirbat, Sadah, Hadbin and Hasik sampled sites are presented in Table 1, Figure 2. On the latter figure, the estimated range of values was shown as standard error boxes and whiskers at 95% confidence intervals.

Concentrations of Cd in oyster flesh was found in the following order Hasik > Sadah > Hadbin > Mirbat as: 4.14, 3.88, 3.58, 2.69 µg/g dry weight, respectively. The maximum value of Cd concentration recorded, 7.08 µg/g dry weight, came from Hasik, while the lowest was from Mirbat (1.54 µg/g dry weight). Single factor ANOVA indicated significant differences between Cd concentrations in different sites at a P level of 0.05: F ratio was 5.317 and P value n of 0.002. Tukey post hoc tests for each of the combinations of groups showed significant differences in Cd concentration between Mirbat and other sites, but no significant results for Sadah, Hadbin and Hasik.

The Hg concentrations in the oyster samples from different sites appeared within a narrow range of 0.001–0.049 µg/g dry weight. Analysis of variance did not show a significant difference between sites (F=6.02, P=0.001). Tukey post hoc test revealed a significant difference only between Sadah and Hadbin.

The concentrations of Pb were very low, where it could only be estimated in several samples, the highest value was 0.156 µg/g dry weight at Mirbat. One-way ANOVA analysis did not show significant differences (reject the null hypothesis) between means of Pb concentration in different sites (F=0.857, P=0.468).

Therefore, low concentrations of studied heavy metals in the oyster flesh were obtained in Mirbat and Hadbin (2.72 and 3.59 µg/g dry weight), but higher concentrations in Sadah and Hasik (3.91 and 4.18 µg/g dry weight).

Studies of monthly changes in concentration of Hg, Cd and Pb in soft tissues of oysters from different sites did not reveal seasonal regularities (Figure 3 A,B,C). There were no significant differences between concentrations of Cd, Hg and Pb in different seasons. Cd concentration was higher from January to March and from May to June. The level of Hg concentration was slightly higher during August and September. In most months Pb concentrations were too low to be detected, increasing slightly in July, January and April.

Comparing our results with other regional data indicates that the heavy metals pollution along the Dhofar coast is still localized and low (Table 2). The present study indicated that the concentrations of the present toxic heavy metals in oysters correspond to natural background levels in the marine environment. Hg concentrations in the soft tissues of *S. cucullata* in the present study were close to previous studies of Fowler (1988) on the Oman coast and remain below 0.5 µg/g dry weight. The level of Pb concentration was significantly lower than polluted regions of Tanzania, Iran and India, and below concentrations recorded by Fowler (1988) anf Fowler *et al*. (1993) for the northern part of Oman. In the present study, Cd concentrations were significantly higher than Hg and Pb, and higher than the recommended range value of 1 µg/g dry weight. But it was markedly lesser than those reported from other regions of the Indian Ocean (Tanzania, Hong Kong) and to previous levels recorded in Oman (Fowler, 1993). Thus a more or less consistent decrease of some trace metals from north to south that can probably be related to higher anthropogenic input in the more industrialized north.

The present study showed very low levels of oyster contamination by Hg and Pb and some excess of the permissible level of their Cd contamination. Although the Cd concentration does not seem to be problematic in terms of human consumption, caution should be made about oyster consumption, since Cd level in their soft tissue can be considered high.

The concentrations of heavy metals in biota and sediments depend on many factors such as discharge of treated and untreated municipal, industrial and agricultural wastes, run-off and from atmospheric input, seasonal variations of suspended particulate matter and plankton, disruptions and precipitation factors. The principal source of Pb contaminants in the marine environment appears to be the exhaust of vehicles which run with leaded fuels, more concentrations of Pb and Cd were observed in petroleum rich areas. Relatively lower values of some heavy metal concentrations in oysters in the present study may be due to the limited human population density of the area, which is free from potential sources of heavy metals pollution. The data may be considered as a basic study in this region and it could serve as a baseline for further monitoring programmes.

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Table 1. Number of samples (N), mean, range and standard deviation (SD) of Cd, Pb and Hg concentrations in the soft tissue of *S. cucullata* (µg/g dry weight).

| Site | Cd | | | Pb | | | Hg | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | mean/range | ± SD | N | mean/range | ± SD | N | mean/range | ± SD |
| Mirbat | 25 | 2.69<br>1.54–5.97 | 1.275 | 26 | 0.015<br>0.0–0.156 | 0.039 | 30 | 0.015<br>0.007–0.037 | 0.006 |
| Sadah | 19 | 3.88<br>2.41–6.20 | 1.153 | 19 | 0.013<br>0.0–0.124 | 0.032 | 24 | 0.020<br>0.007–0.049 | 0.009 |
| Hadbin | 18 | 3.58<br>1.80–5.62 | 1.089 | 15 | 0.003<br>0.0–0.045 | 0.012 | 25 | 0.011<br>0.001–0.027 | 0.006 |
| Hasik | 9 | 4.14<br>3.34–7.08 | 1.181 | 8 | 0.026<br>0.0–0.129 | 0.051 | 14 | 0.016<br>0.007–0.034 | 0.009 |
| Pooled data | 71 | 3.41<br>1.54–7.08 | 0.150 | 68 | 0.013<br>0.0-0.156 | 0.004 | 93 | 0.015<br>0.001–0.049 | 0.001 |

Note: over the line is on average, under the line is minimum and maximum.

 

Table 2. Comparison of heavy metal concentrations (μg/g dry weight) in *S. cucullata* in different locations

| Location | Cd | Pb | Hg | Reference |
|---|---|---|---|---|
| China | – | 11.6 | – | Wang and Wong (2006) |
| Honk Kong | 8.29–16.2 | – | – | Blackmore (2001) |
| Honk Kong | – | 3.8 | – | Chu *et al*. (2007) |
| India | – | 5.1–30.6 | – | Barua *et al*. (2011) |
| Iran | – | 3.83–5.26 | – | Peer *et al*. (2010) |
| Qatar | – | 0.25 | – | De Mora *et al*. (2004) |
| Oman | – | 0.67 | – | De Mora *et al*. (2004) |
| Oman | 2.8–34.8 | 0.06–2.2 | – | Fowler *et al*. (1993) |
| Oman | 6.2–25.5 | 0.3–3.5 | 0.023–0.226 | Fowler (1988) |
| Oman | 1.54–7.08 | 0.0–0.156 | 0.001–0.049 | Our data |
| Tanzania | 33.9–85.5 | 56.5–114.0 | – | Mtanga and Machiwa (2007) |

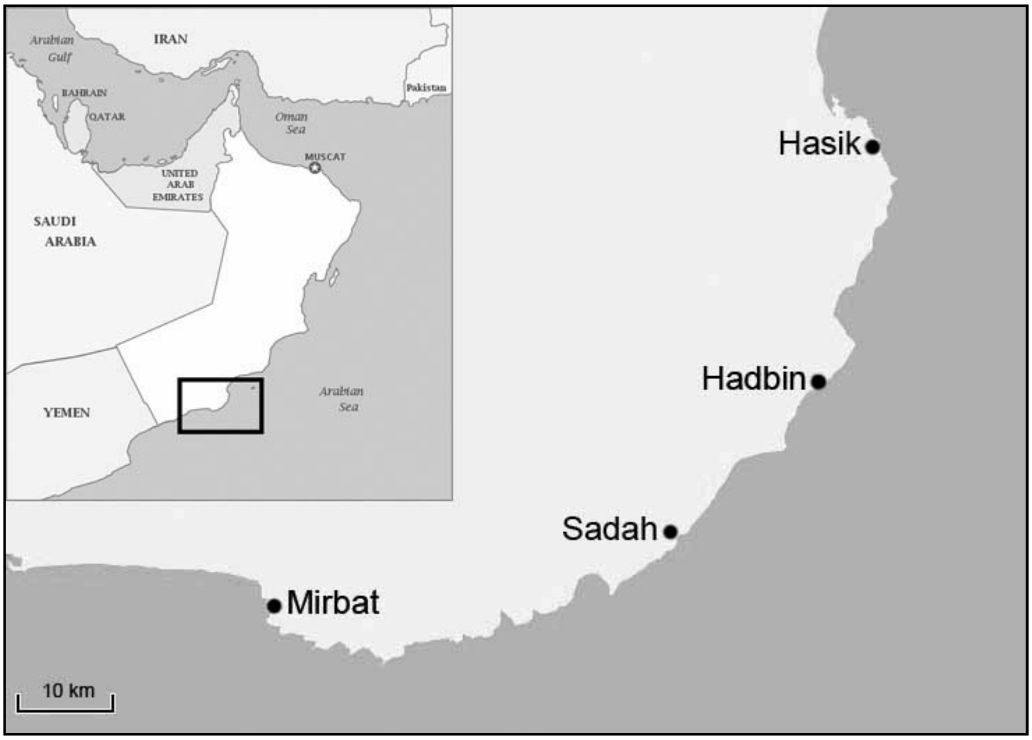


Figure 1: Map showing the location of the sampling sites in Dhofar region of Oman.

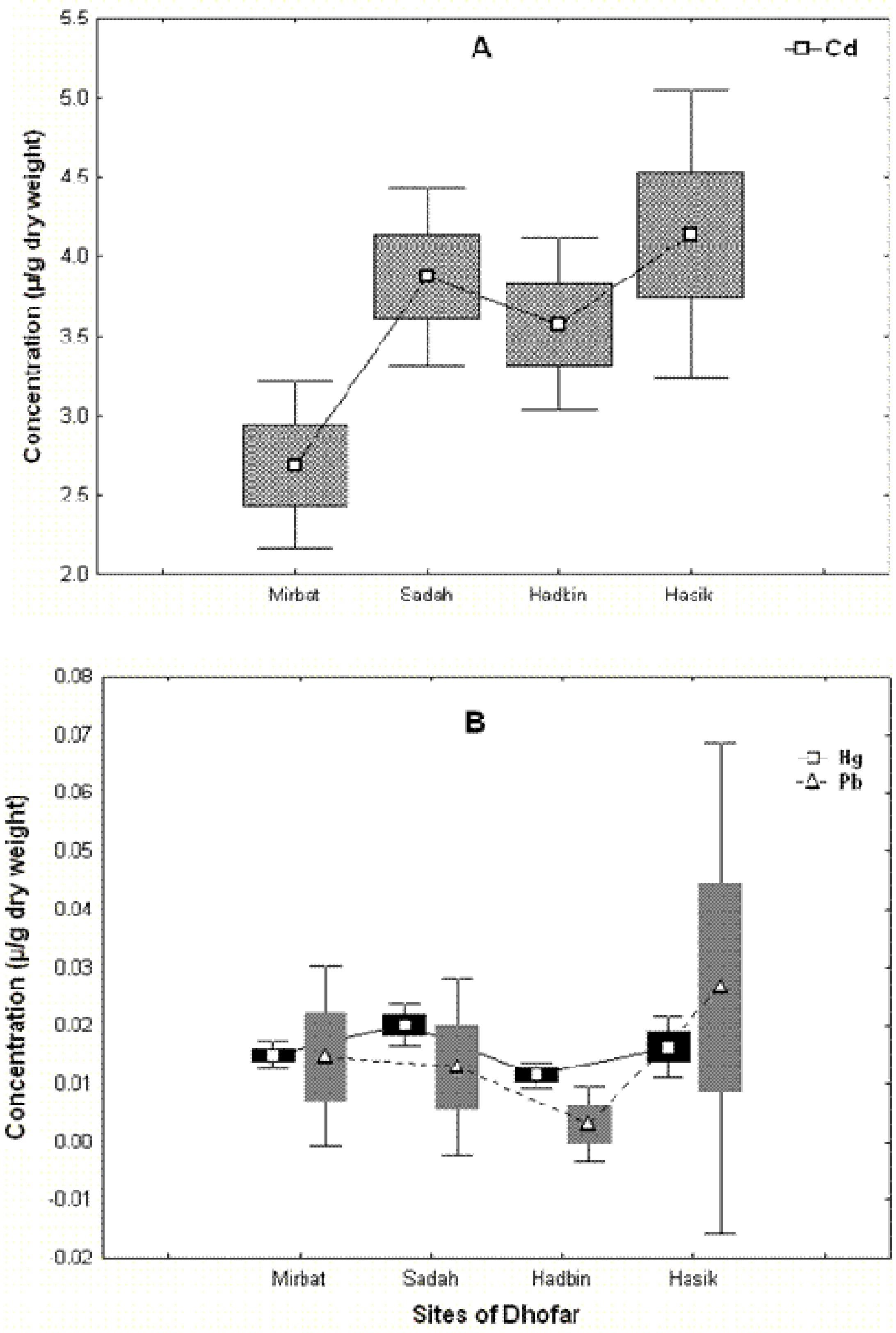


Figure 2. Concentrations of cadmium (Cd) (A), lead (Pb) and mercury (Hg) (B) in soft tissue of *S. cucullata* from studied sites: mean; box: mean ± SE; whisker: mean ± confidence interval.

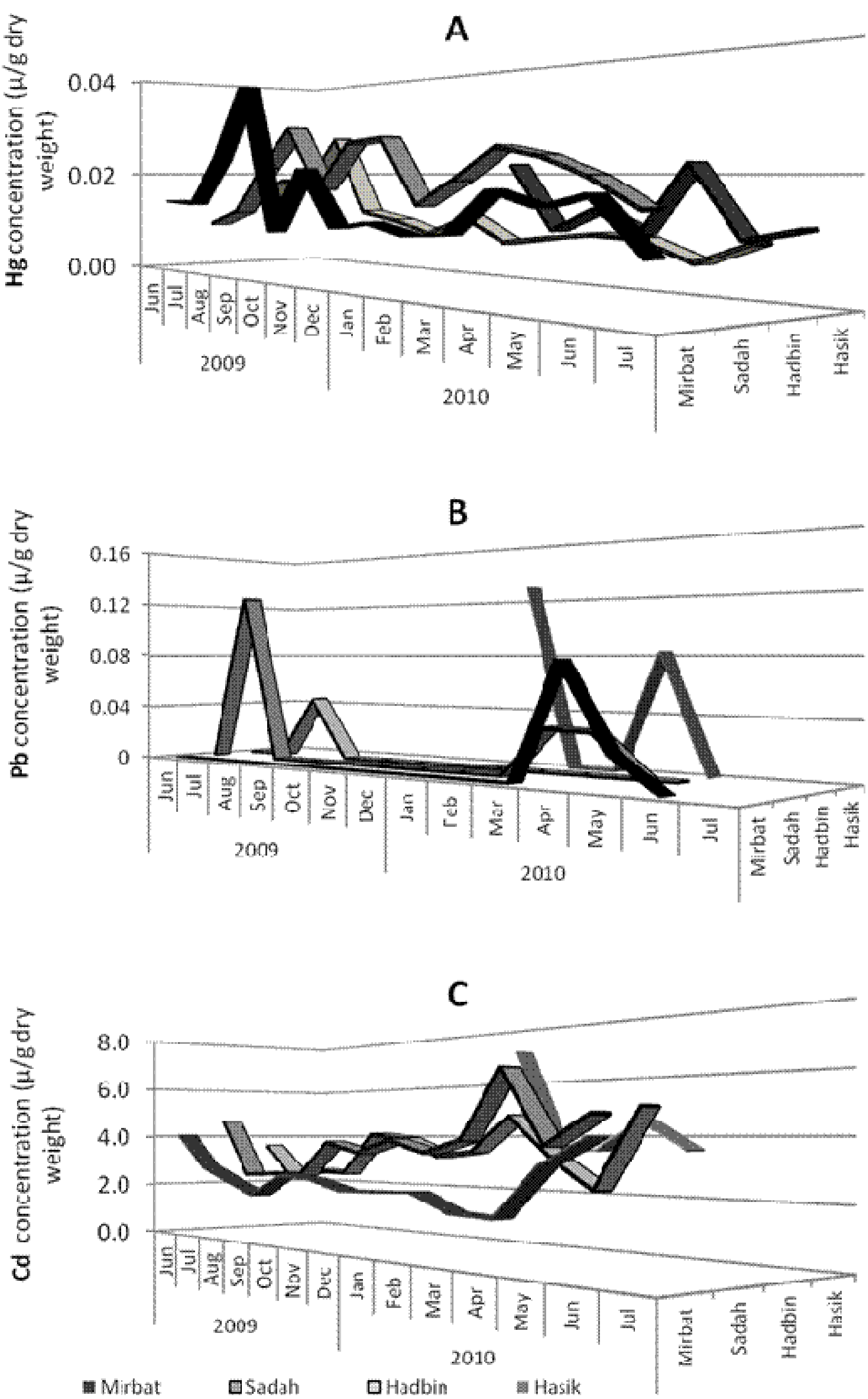


Figure 3. Monthly variation of heavy metal concentration in soft tissue of hooded oyster *S. cucullata* in studied sites: A – Hg, B – Pb; C – Cd.