Bull. Environ. Contam. Toxicol. (1995) 54:584–590

Environmental Contamination and Toxicology

Arsenic in Shrimp from Kuwait

A.-H. Bou-Olayan,[1] S. Al-Yakoob,[2] M. Al-Hossaini[3]

[1]Chemistry Department, Faculty of Science, Kuwait University, PO Box 13060, State of Kuwait
[2]Environmental Sciences Department, and
[3]Mariculture and Fisheries Department, Kuwait Institute for Scientific Research, State of Kuwait

Received: 10 March 1994/Accepted: 1 August 1994

Arsenic is ubiquitous in the environment (NAS 1977) and can accumulate in food via contaminated soil, water or air (Navarro et al. 1993). It enters the food chain through dry and wet atmospheric deposition (Nurnberg 1977). Combustion of oil and coal, use of arsenical fertilizers and pesticides and smelting of ores contributes significantly to the natural background of arsenic in soils and sediments. The metal can be transferred from soil to man through plants (Marcus-Wyner and Rains 1982) and animals (Baxter et al. 1983).

In spite of variation in acute, subacute, and chronic toxic effects to plants and animals, evidence of nutritional essentiality of arsenic for rats, goats, and guinea pigs has been suggested, but has not been confirmed for humans (NAS 1977). Adverse toxic effects of arsenic as well as its widespread distribution in the environment raises concern about levels of arsenic in man's diet. Higher levels of arsenic in the diet can result in a higher accumulation rate.

Arsenic levels in marine organisms are influenced by species differences, size of organism, and human activities. Bottom dwellers such as shrimp, crab, and lobster accumulate more arsenic than fish due to their frequent contact with bottom sediments (Attar et al. 1992). Shrimp constitute approximately 30% of mean total seafood consumption in Kuwait (Khordagui and Al-Ajmi 1991). This study was designed to determine the accumulation of arsenic in the commercially important jinga shrimp (*Metapenaeus affinis*) and grooved tiger prawn (*Penaeus semisulcatus*).

Correspondence to: A.-H. Bou-Olayan

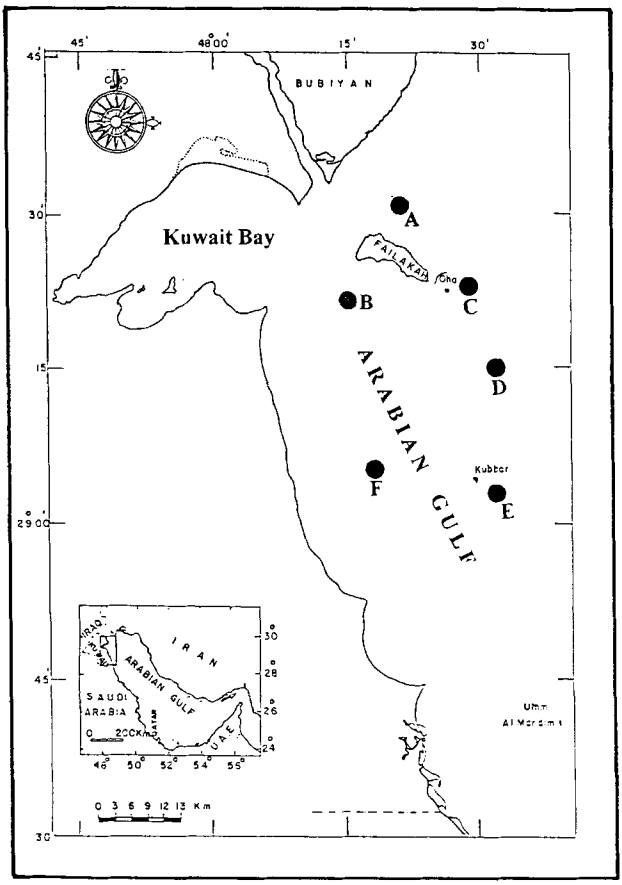

Figure 1. Shrimp sampling locations in Kuwait.

Materials and Methods

Shrimp were collected with a small trawl net at six stations in the Arabian Gulf (Fig. 1). The samples were washed with distilled water and carapace length and total weight measured. Approximately 3 g of homogenized tissue of each shrimp was weighed in tarred Vycor beaker and 10 ml of concentrated nitric acid (Aristar) were added. The contents were mixed thoroughly with a glass rod to wet the tissue sample and the glass rod rinsed with a minimum amount of distilled deionized water. The beaker was covered with a watch glass and left at room temperature for 1 hr followed by heating at 90°C for 2 hr. An additional 10 ml of concentrated nitric acid were added to the cool beaker and the contents were heated again at 90°C for 1 hr. The beaker was transferred to a muffle furnace at room temperature. The temperature of the furnace was set at 100°C for the first hour, then increased to 150°C for 3 hr,

muffle furnace at room temperature. The temperature of the furnace was set at 100°C for the first hour, then increased to 150°C for 3 hr, followed by an incremental increase of 100°C every hour to a temperature of 450°C. The sample was then ashed at 450°C for 12 hr, until a white residue was finally obtained. Ten ml of 25% hydrochromic acid (Aristar) were added to the cool residue, followed by warming on a hot plate until dissolution. The contents of the beaker were finally transferred into a 25-ml volummetric flask and diluted to the mark with distilled deionized water.

The concentration of arsenic was determined by Perkin Elmer AA-5100 using mercury hydrade system (MS-200). The recovery of arsenic was calculated on the basis of recovery of prepared arsenic standards. Recovery was 92% = 0.35% (n = 5). Arsenic concentrations are expressed in μg/g wet weight. The relationships between weight, length, and arsenic concentration were studied by linear regression analysis.

Results and Discussion

Table 1 presents the mean and range of arsenic concentrations in both species at different sampling stations. The mean arsenic concentration ranged from 0.45 (station F) to 1.11 (station D) μg/g wet wt for *Metapenaeus affinis* and from 0.59 (station C) to 1.90 (station B) μg/g wet wt for *Penaeus semisulcatus*. Differences between arsenic accumulation by *M. affinis* and *P. semisulcatus* (Table 1) indicate that these levels are not influenced by local inputs of arsenic (natural and/or anthropogenic). Factors influencing arsenic concentration in marine organisms include species differences and size (NAS 1977). The length of *M. affinis* ranged from 8.5 to 12.0 cm with a mean of 9.3 cm, whereas the length of *P. semisulcatus* ranged from 7.0 to 15.0 cm with a mean of 12.2 cm. The total weight of *M. affinis* ranged from 9.1 to 30.8 g with a mean of 15.4 g, while the total weight of *P. semisulcatus* ranged from 6.4 to 52.1 g with a mean of 32.2 g.

Significant linear relationships were observed between $\log_{10}$(total body weight) and $\log_{10}$(length) for *P. semisulcatus* ($R^2 = 0.95$, $p<0.01$) and *M. affinis* ($R^2 = 0.97$, $p<0.01$) (Fig. 2). These relationships are similar to that calculated for the opossum shrimp *Mysis relicta* by Lasenby and Van Duyn (1992).

Table 1. Arsenic concentrations (μg/g wet weight) in shrimp from several stations in the Arabian Gulf.

Station	*Metpenaeus affinis*			*Penaeus semisulcatus*		
	n	Mean	Range	n	Mean	Range
A	5	0.58	0.33-1.05	5	1.85	1.26-2.13
B	5	0.77	0.56-0.99	5	1.90	1.44-2.66
C	5	0.72	0.60-0.82	4	0.59	0.50-0.71
D	5	1.11	0.81-1.23	5	1.15	1.00-1.65
E				5	1.22	0.71-1.69
F	5	0.45	0.29-0.59			

Linear regressions describing the relationship between body weight and arsenic concentration in shrimp were calculated by the following equation [$\log_{10}$ (arsenic body burden, μg) = b . $\log_{10}$ (total body weight, g) + $\log_{10}$ a] (Fig. 3). The regression coefficient, b, was >1 for *P. semisulcatus* (R^2 = 0.8) indicating a concentration increase with increasing body weight and <1 for *M. affinis* (R^2 = 0.28) indicating a lower correlation concentration decrease with increasing body weight. Differences in these relationships can be observed from the results of other investigators. Smock (1983) found an inverse relationship between metal concentration and organism dry weight for a wide variety of metals and aquatic invertebrates, while Lasenby and Van Duyn (1992) found that smaller mysids had a lower percentage of total metal burden associated with their molts than larger mysids.

To assess public health impacts associated with arsenic in shrimp, it is important to estimate human exposure to the metal via shrimp consumption. In this study, the maximum concentration of arsenic was detected in a single *P. semisulcatus* from station B (2.66 μg/g wet wt.). This concentration exceeded the highest permissible concentration for seafood in Saudi Arabia (0.5 μg/g), but is below that of Hong Kong (10 μg/g) (Attar et al. 1992). Also, it is lower than the mean arsenic concentration in shrimp (*Penaeus semisulcatus*), lobster (*Thenus*

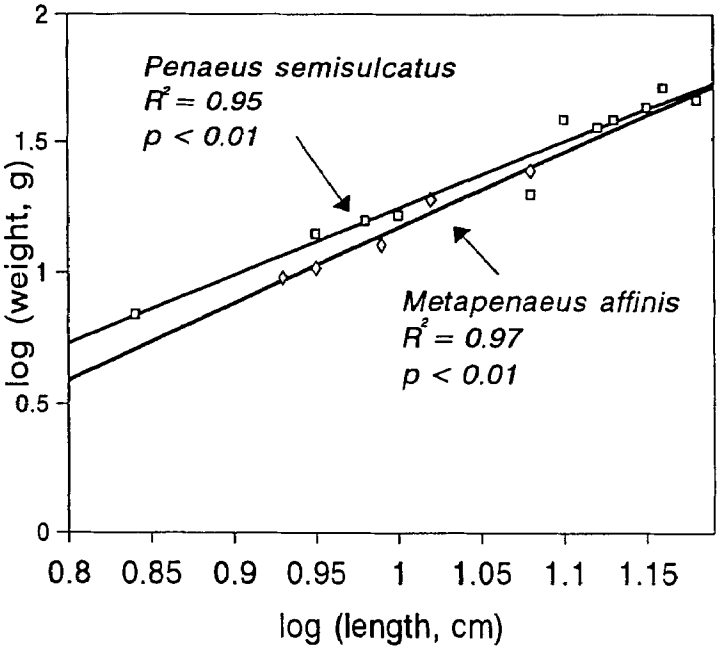

Figure 2. The relationship between length and body weight of shrimp.

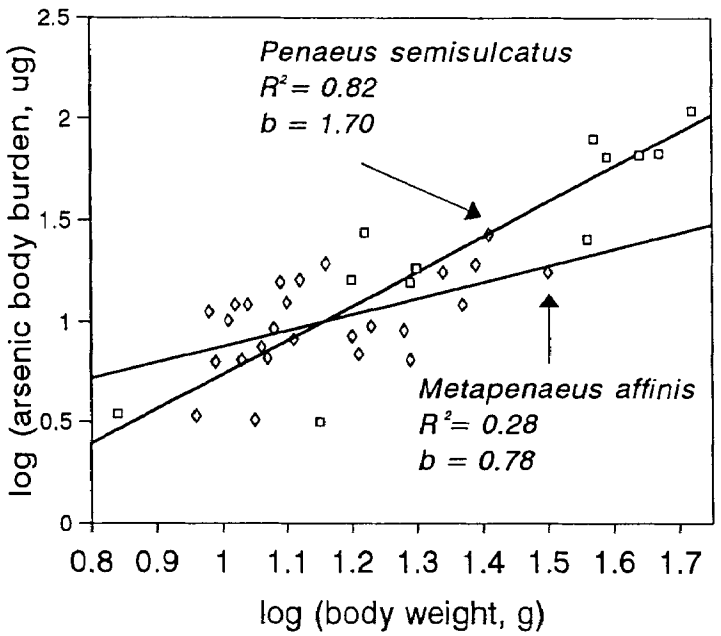

Figure 3. The influence of shrimp body weight on arsenic body burden.

orientalis) and crab (*Lupa pelagica*) from the Saudi Arabian marine environment (Attar et al, 1992).

Based on shrimp consumption in Kuwait (86.0 g wet wt/ person month) estimated by Khordagui and Al-Ajmi (1991), and considering the likely preference of consumption of highly contaminated shrimp, the daily intake of arsenic through the ingestion of shrimp may be calculated assuming the maximum detected arsenic concentration as a potential extreme in exposure [2.66 μg/g wet wt x 86.0 g/ month x 1 month/ 30 day = 7.63 μg/person day]. This estimate does not exceed the WHO provisional tolerable daily intake of 100 μg (WHO 1983). In addition, it is lower than the daily intake rate of arsenic in Japan (70-170 μg/person day) (Nakao 1960; Ishizaki 1979) and within the range observed in Canada, UK, USA, and France (7-60 μg/person day) (WHO 1973).

REFERENCES

Attar MA, El-faer MZ, Rawadah TN, Twabini BS (1992) Levels of arsenic in fish from the Arabian Gulf. Mar Pollut Bull 24: 94 - 97

Baxter JC, Johnson De, Kienholz EW (1983) Heavy metals and persistent organics content in cattle exposed to sewage sludge. J Environ Qual 12: 316 -319

Ishizaki M (1979) Arsenic contents in foods on the market and its average daily intake. Nippon Eiseigaki Zasshi 34: 605 - 611

Khordagui H, Al-Ajmi D (1991) Mercury in seafood: A preliminary risk assessment for Kuwaiti consumers. Environ Intl 17: 429 - 435

Lasenby DC, Van Duyn J (1992) Zinc and cadmium accumulation by the Opossum shrimp *Mysis relicta.* Arch Environ Contam Toxicol 23: 179-183

Marcus-Wyner L, Rains DW (1982) Uptake, accumulation, and translocation of arsenical compounds by cotton. J Environ Qual 11: 715 - 719

Nakao M (1960) A study of the arsenic content in daily food consumption in Japan. J Osaka City Med Center (Osaka Shiritsu Daigaku Igakubu Zasshi) 9: 541 - 557

NAS (1977) Medical and biological effects of pollutants. Arsenic. National Research Council. National Academy of Sciences,

Washington DC
Navarro M, Sanchez M, Lopez H, Lopez MC (1993) Arsenic contamination levels in waters, soils, and sludges in southeast Spain. Bull Environ Contam Toxicol 50: 356 - 362
Nurnberg HW (1977) Potentialities and applications of advanced polarographic and voltammetric methods in environmental research and surveillance of toxic metals. Electrochim Acta 22: 935 - 949
Smock LA (1983) Relationships between metal concentrations and organism size in aquatic insects. Freshwater Biol 13: 313 -321
World Health Organization (1973) Trace elements in human nutrition. WHO Technical Reports Series 532. World Health Organization, Geneva
World Health Organization (1983) 27th Report of the joint FAO/WHO Expert Committee on Food Additives. Technical Reports Series 696. World Health Organization, Geneva, Switzerland