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Assessment of arsenic and heavy metal contents in cockles (*Anadara granosa*) using multivariate statistical techniques

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Abstract

Cockles (*Anadara granosa*) sample obtained from two rivers in the Penang State of Malaysia were analyzed for the content of arsenic (As) and heavy metals (Cr, Cd, Zn, Cu, Pb, and Hg) using a graphite flame atomic absorption spectrometer (GF-AAS) for Cr, Cd, Zn, Cu, Pb, As and cold vapor atomic absorption spectrometer (CV-AAS) for Hg. The two locations of interest with 20 sampling points of each location were Kuala Juru (Juru River) and Bukit Tambun (Jejawi River). Multivariate statistical techniques such as multivariate analysis of variance (MANOVA) and discriminant analysis (DA) were applied for analyzing the data. MANOVA showed a strong significant difference between the two rivers in term of As and heavy metals contents in cockles. DA gave the best result to identify the relative contribution for all parameters in discriminating (distinguishing) the two rivers. It provided an important data reduction as it used only two parameters (Zn and Cd) affording more than 72% correct assignations. Results indicated that the two rivers were different in terms of As and heavy metal contents in cockle, and the major difference was due to the contribution of Zn and Cd. A positive correlation was found between discriminate functions (DF) and Zn, Cd and Cr, whereas negative correlation was exhibited with other heavy metals. Therefore, DA allowed a reduction in the dimensionality of the data set, delineating a few indicator parameters responsible for large variations in heavy metals and arsenic content. Taking into account of these results, it can be suggested that a continuous monitoring of As and heavy metals in cockles be performed in these two rivers.

Keywords: Cockles; MANOVA; Discriminant analysis; Arsenic; Heavy metals; GF-AAS; CV-AAS

1. Introduction

Malaysia is presently undergoing rapid industrial development and there have been incidences of toxic pollution from industry. Solid and liquid wastes emanating from the industrial activities are the inevitable by products of manufacturing process. These wastes contain toxic chemicals such as chromium salts, sulfides and other substances including heavy toxic trace metals [1]. A number of natural and anthropogenic sources produce heavy metals. People are becoming more aware of the complexity of the nature and the delicate balance that exist within the global ecosystem [2]. The discharge of effluents and associated toxic compounds into aquatic systems represents an ongoing environmental problem due to their possible impact on communities in the receiving aquatic water and a potential effect on human health [3]. Especially in highly polluted and industrial areas, point and non-point sources of anthropogenic chemicals and metals have polluted rivers with highly complex mixtures of chemicals and other anthropogenic perturbations to degree where life in rivers is severely impacted [4]. Urbanization, increases in population density and the intensification of agricultural activities in certain area are among the main causes of water pollution [5].

The blood cockle *Anadara granosa* is a bivalve mollusc in the family Arcidae, subfamily Anadarinae. The bivalves in this family are of considerable importance as a source of cheap protein in tropical areas, especially in the Indo-Pacific region [6]. Therefore, semi-culture of marine bivalves particularly *A. granosa* is of considerable economic importance in Malaysia. For the past 19 years up to 5000 ha of mudflats along the west coast of Malaysia have been utilized for this purpose [7]. Since *A. granosa* is a filter feeding organisms contamination of the highly productive mudflats with heavy metals tend to be accumulated

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in their whole body tissue. This could serve as an important environmental sinks of heavy metals [8] and provide an indication of river pollution.

The application of multivariate methods has increased tremendously in recent years for analyzing environmental data [7,8]. These methods are useful where several dependant variables are measured on each sampling unit. Multivariate analysis of variance (MANOVA) can be used to test the significant differences, while discriminant function (DF) has been used to identify the relative contribution of all variables to the separation of the groups [9,10].

The objectives of this study have been to determine whether the concentrations of arsenic and heavy metals in cockles sampled from two different rivers are different based on the concentrations of arsenic and six heavy metals (Cu, Pb, Cd, Cr, Zn, and Hg). In addition, it is important to identify the relative contribution for all parameters in distinguishing the cockles according to the above selected parameters contribution. This study may assist the evaluation of the impact of industry and agricultural discharge on aquaculture products of the two areas of choice.

2. Materials and methods

2.1. Description of study sites

The study site is located on the North West coast of Peninsular Malaysia, in the state of Penang and within a coastal mudflat in the Juru and Bukit Tambun district (Fig. 1). The sites are located adjacent to industrial areas which were reclaimed from mangrove. The types of industry presently in operation include: electronics; textiles; basic and fabricated metal products; food

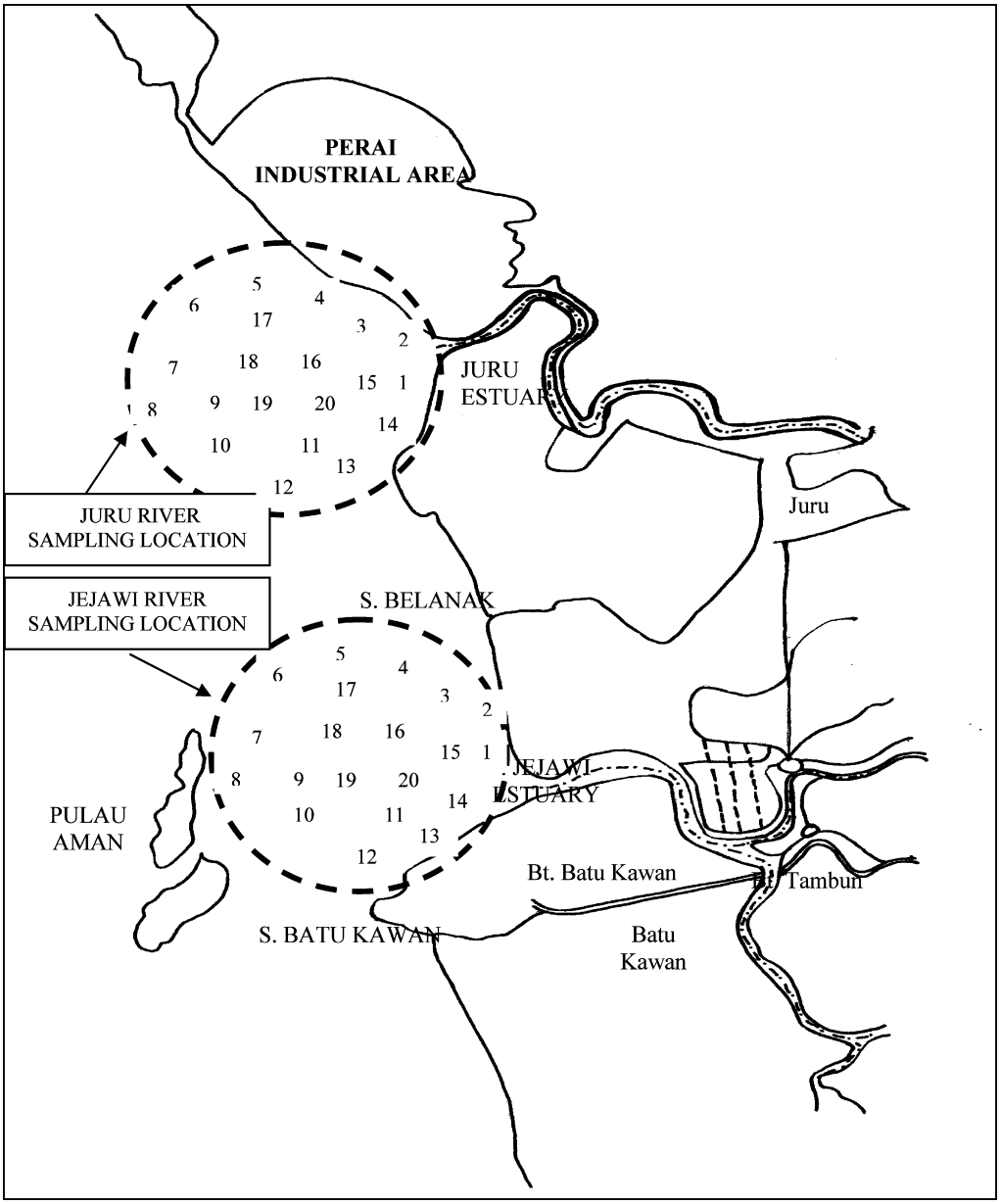

Fig. 1. Map of sampling locations for study areas.