Available online at www.sciencedirect.com
SCIENCE DIRECT®
Science of the Total Environment 348 (2005) 102–114
Science of the Total Environment
An International Journal for Scientific Research into the Environment and its Relationship with Humankind
www.elsevier.com/locate/scitotenv

# Organochlorines (PCBs and pesticides) in the bivalves *Anadara (Senilis) senilis*, *Crassostrea tulipa* and *Perna perna* from the lagoons of Ghana

Fred A. Otchere*

*Azimuth Consulting Group, 218-2902 West Broadway, Vancouver, British Columbia, Canada V6K 2G8*

Received 20 July 2004; accepted 22 December 2004
Available online 19 March 2005

**Abstract**

The bivalves, *Anadara (Senilia) senilis* (*n*=95), *Crassostrea tulipa* (*n*=75) and *Perna perna* (*n*=30) from Ghana, were analyzed for their organochlorines (pesticides and PCBs) concentrations and the body burden. A comparison was done based on two different standard PCB mixtures (Aroclor 1254 and 1260) with the percentage individual congener contribution and that of the sample. From these comparisons, it appeared that the pattern of PCB residues in the samples was neither Aroclor 1254 nor 1260. On the other hand, there was seasonal qualitative difference in the pattern that is purely marine (in the dry season) versus terrestrial input (in the wet season). ∑PCB was 0.10 μg/g dw or 2.2 μg/g lw (median values). There was no correlation between PCB concentration and lipid content reflecting the importance of indirect contamination of the bivalves. The pesticides, aldrin, dieldrin, endrin, lindane, DDTs, HCH, HCB, endosulfan, heptachlor epoxide and heptachlor, were detected. The most abundant pesticides were the ∑DDT: 73 and ∑HCH: 29 ng/g dw. DDT/DDE and hept./heptachlor epoxide ratios reflect their recent applications, while the ratio for aldrin/dieldrin suggests that the use of aldrin has been discontinued, at least on the coast of Ghana.


*Keywords:* Organochlorines; Pesticides; PCBs; Bivalves; Lagoons; Marine; Ghana; West Africa

## 1. Introduction

Apart from biocides and various metals, many new compounds have been extensively used for various industrial purposes. For instance, the polychlorinated biphenyls (PCBs), which were used principally as dielectric (insulating) fluids in the electrical industries, were first introduced in 1929. It was only many years after its introduction that environmental problems caused by their use and careless disposal were first recognized. Concern about exposure to organochlorines among humans has arisen chiefly because of the carcinogenicity of these chemicals in animals and their ubiquity, bioconcentration and persistence in human tissues (Silberhorn et al., 1990; IARC, 1991).

* Tel.: +1 604 608 4283.
*E-mail address:* atotchere@yahoo.co.uk.

0048-9697/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.scitotenv.2004.12.069

Despite its ban in Western countries, a large proportion of PCBs remain in transformers and capacitors in most developing countries (Zhou et al., 2001; Nakata et al., 2002). Presently, there is much emphasis on the development of simple models to describe the behavior of organic contaminants in aquatic environments. These are in general based on physical properties of compounds such as water solubility and *n*-octanol/water partition coefficient.

Studies suggest that part of the toxic nature of technical PCB mixtures may be associated with the presence of trace levels of particular coplanars having four or more chlorine atoms at both *para* and *meta* positions such as 3,3′,4,4′-tetrachlorobiphenyl (TCB), 3,3′,4,4′,5-pentachloro-biphenyl ($P_5CB$) and 3,3′,4,4′,5,5′-hexachlorobiphenyl ($H_6CB$) (Yoshimura et al., 1978; Domingo et al., 2002). Biota could potentially acquire PCBs from three sectors in the environment: atmosphere, water and food. Because of their lipophilicity, changes in PCB concentration might also be related to changes in lipid content (Boon and Duinker, 1986; Nakata et al., 2002). For example in aquatic organisms, uptake involves: adsorption/absorption/partitioning of PCBs in water through gills and epidermis and consumption of contaminated food. PCB levels in marine invertebrates are best explained by equilibrium partitioning between body lipids and ambient water. So PCBs in tissues of bivalves such as *Mytilus edulis* should reflect the PCB concentration in its environment. Bivalves are widely used as bioindicators of organic pollution in coastal areas because they are known to concentrate these compounds, providing a time integrated indication of environmental contamination. In comparison to fish and crustaceans, bivalves have a very low level of activity of enzyme systems capable of metabolizing persistent organic pollutants (POPs), such as aromatic hydrocarbons and PCBs. Therefore, contaminants concentrations in the tissues of bivalves more accurately reflect the magnitude of environmental contamination (Phillips, 1980, 1990).

Recently, a number of investigators have reported the association between breast cancer and other neoplastic diseases in humans and long-term exposure to organochlorines (OC) (Woodruff et al., 1994; Ahlborg et al., 1995). In addition, studies have shown that OC such as DDT, dieldrin and PCBs have endocrine disrupting capacities (McKinney and Waller, 1994). Similarly, epidemiological studies have suggested an etiological relationship between exposure to OC and Parkinson's disease (Fleming et al., 1994). Carlsen et al. (1992) working on human sperm count found an association between a decrease in count and OC concentration. Other workers also found an increase in breast cancer incidence among women at the rate of 1% per year for more than 50 years, which have been postulated to be associated with elevated exposure to environmental estrogens such as OC (Feuer and Wun, 1992). These studies, in addition to several others, have provided new dimensions on the importance of evaluating human exposure to OC contaminants. In developing countries, incidence of cancer has doubled during the past 10 years (Kannan et al., 1997; Nakata et al., 2002), which suggests the need to assess the relationship between exposure to chemical contaminants and epidemics.

The aims of the study were to investigate and assess the level of contamination in lagoons along the coast of Ghana and to establish a baseline for organochlorine residues, and to determine spatio-temporal variations in the concentration levels in these mollusks (only detailed discussion on cockles).

## 2. Materials and methods

Three species of bivalves were collected from the lagoons of Ghana (which lies between latitude 4°N and 115°N) with approximately 590 km long coastline, stretches from 3°W to 1°10′E and lies between 4°5′N and 6°6′N. About 50 lagoons occur on the coast (Otchere et al., 2003). The lagoons are of two main types: 'open' and 'closed' lagoons. The open lagoons are in contact with the sea throughout the year and therefore partly under tidal influence. Temperature and salinity ranges are 24 to 32 °C and 10 to 40 psu, respectively. The closed lagoons are cut off from the adjacent sea by a sand bar (about 40 m wide) for the greater part of the year. Temperature and salinity ranges are: 27 to 34 °C and 27 to 70 psu, respectively. Hyperhaline condition results from evaporation during the dry season (Otchere, 2003; Otchere et al., 2003).

Oysters *Crassostrea tulipa* (*n*=75) and cockles *Anadara (Senilia) senilis* (*n*=95) were collected from