Bull. Chem. Soc. Ethiop. **2007**, 21(1), 145-149. ISSN 1011-3924
Printed in Ethiopia

SHORT COMMUNICATION

ORGANOCHLORINE RESIDUES IN TISSUES OF MARINE FAUNA ALONG THE COAST OF KENYA-MOMBASA ISLAND

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(Received January 8, 2006; revised March 22, 2006)

ABSTRACT. Soft tissues of species of marine fauna; crabs (*Crustacea*), oysters (*Pelecypoda, Bivalvia*), sea stars (*Asterroidea*), sea urchin (*Echinoidea*) and bony fishes (*Osteichtyes*) sampled along the Kenya-Mombasa coastal region were analyzed to determine the levels of organochlorine pesticides (OCPs). Analysis was done using gas chromatography with an electron capture detector. This study showed that marine fauna accumulated some OCPs in their tissues, 1,2,3,4,5,6-hexachlorocyclohexane (BHC) being the most common of the OCPs. These findings highlight evidence of pollution of marine fauna at the Kenyan coastal sites. It is necessary to have thorough waste management programs as a strategy to minimize marine pollution.

KEY WORDS: Environmental samples; Marine samples; Kenya-Mombasa coastline; Marine fauna, Organochlorine, Pesticides

INTRODUCTION

Pollution is an inevitable human activity whose growing evidence in severe environmental degradation prompts increased public environmental awareness and concern. The introduction of harmful substances into the marine ecosystem has many adverse harmful effects. It is therefore important to appreciate the pollution extent, causes, substances involved, their biological and environmental effects and methods of controlling and rectifying it. Pollution of the Kenyan marine ecosystem is of growing concern due to the impact of industrial growth, interference with natural processes and disposal of wastes.

The Kenyan coastline extends for about 480 km between 1°40'S and 4°40'S bordering Somalia in the North and Tanzania in the South and has five districts along its border. Mombasa is the largest urban centre, the principle seaport serving several land locked East and Central African countries. It experiences a bi-modal rainfall pattern and is quite warm throughout the year. The human population in Mombasa District is approximately 653,000, second largest in Kenya after Nairobi [1]. This results to the coastal area and resources being under pressure from the rapid population growth and increasing resource exploitation. Economic activities in the coastal area include tourism, industries and subsistence agriculture. These activities promote marine pollution and hence damage the tourism industry, which is among the leading foreign exchange earner in Kenya.

Organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) are biologically stable compounds that are hydrophobic and fat-soluble and therefore accumulate in aquatic biota at concentrations that exhibit ecotoxicological effects [2, 3]. Moreover, bacterial communities have been shown to bioconcentrate OCPs [4] and extracellular polymeric substances (EPS) that are secreted by the microorganisms in aquatic habitats act as a vector for

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contaminant uptake into aquatic food webs [5, 6]. The increasing usage of these hazardous man-made chemicals has become a matter of great concern. In the developed world restrictions have been placed on their usage [7] unlike in the developing countries such as Kenya. Concentrations from historical and current uses may still be sufficiently high as to pose problems to marine species. Pesticides enter into aquatic ecosystems by way of run-off from farmlands, while atmospheric transport, followed by precipitation in rainfall is another major route of entry [8, 9]. Ramesh *et al.* [9] report twenty five percent of the insecticides used for agriculture and vector control purposes being expected to find way into the coastal waters hence increasing the toxicity of OCPs to fish. This is supported by the following studies: lindane was acutely found to be toxic (EC_{50} and LC_{50} 24-96 h) in the range 9.6-7300 µg/L [10] in several aquatic macroinvertebrates while short-term exposure (48 h) to 500 µg/L lindane to 4th instar larvae of *Chironomus riparius* affected organisms not only during the exposure, but also after the exposure as adults [11]. In the 48 h acute toxicity tests *C. tentans* was found to be sensitive to chlordane with LC_{50} value of 5.8 µg/L [12]. Particle-associated fenvalerate caused sublethal responses at 1 µg/kg and lethal effects at 10 µg/kg, indicating that both sub-lethal acute effects and lethal chronic effects may be expected following short term exposure during runoff events [13]. Earlier, Woin [14] showed that fenvalerate had both direct and secondary effects on the structure of pond ecosystems when studying freshwater mesocosms, simulating natural fish-free eutrophic ponds. The direct effect of pesticide exposure was death of many invertebrate taxa, especially insects, while the secondary effects were altered interspecies relationships and life history cycles, leading to ecosystem breakdown.

Many researchers have emphasized the importance of coastal environment as a reservoir of persistent OCPs and advocate the need for introducing excellent monitoring strategies employing bio-indicators [15-17]. There have been several reported research works and data on the state of marine pollution from various parts of the world like Australia [18], Pacific ocean [19] and India [20] to name but a few. This kind of finding, however, is at its initial stages for the Kenyan coastal ecosystem. A recent study by Oyugi *et al.* [21] detected OCPs in marine sediments and seaplants at the Kenyan coast.

Organochlorine pesticides are toxic and can be incorporated into biological processes in the ocean [22]. It is therefore essential to have knowledge of their contamination levels, which also imply the associated levels of risk to man and to the marine ecosystem. These findings will pave for finding the possible remedies for pollution control. The objective of the present work was to determine the concentration levels of OCPs in soft tissues of marine fauna. In the study, samples of selected marine fauna; crabs (*Crustacea*), oysters (*Pelecypoda*, *Bivalvia*), sea stars (*Asterroidea*), sea urchin (*Echinoidea*) and bony fishes (*Osteichtyes*) were used as fauna bio-indicators and analysed to assess the current status of contamination along the coast of Mombasa Island by persistent OCPs. The technique used for the analysis was Gas Chromatography with an electron capture detector (GC-ECD).

EXPERIMENTAL

Sampling and sample preparation

Marine fauna; crabs (*Crustacea*), oysters (*Pelecypoda*, *Bivalvia*), sea stars (*Asterroidea*), sea urchin (*Echinoidea*) and bony fishes (*Osteichtyes*) were sampled during low tide ocean currents by hand nylon-lined gloves from eight sites along the coast of Mombasa Island. The sites were at the English Point, Nyali Bridge, Kenya Meat Commission (KMC), Makupa Creek, Port Reitz, Vanga, Marine Park and Mbaraki Creek. Different species were obtained from different sites, this being attributed to their breeding habits and the nature of the ecosystem. The samples were packed into sterilized plastic containers and transported to the laboratory at a temperature of 4 °C. The species were identified at Kenya Marine and Fisheries Research Institute, Mombasa.

Soft tissues of the sampled fauna species were teared off the skeletons and thoroughly homogenized with a high-speed tissue blender and sub-sampled for analysis. Fresh homogenized tissue (5 g) was dried with anhydrous sodium sulphate (15 g) and then extracted with n-hexane (150 mL) in a Soxhlet apparatus for 8 h at 70 ^{o}C. The extract was concentrated to 10 mL at 30 ºC under reduced pressure before analysis [23].

5 mL of the extract was passed through a microscale florosil and eluted first with 6 % n-hexane in diethyl ether (2 mL) followed by 15 % n-hexane in diethyl ether (2 mL). 2 µL of each fraction was then injected into the GC.

Instrumentation and analysis

The GC-ECD model used was of Varian 3400 with an integrator Model Varian 4400. The operating parameters for analysis of OCPs by GC-ECD included initial column temperature (100 °C), final column temperature (220 °C), injector temperature (230 °C), detector temperature (300 °C), detector type (electron capture), column type (capillary mega bore), carrier gas (nitrogen), carrier gas flow rate (5 mL/min), make-up gas flow rate (25 mL/min), run time (15 min), chart speed (1 cm/min), detection limit (0.01), sample size (2 µL) and mixed standard conc. (0.01 µg/g). The validation of recovery, precision and accuracy were done and concentration of the triplicate measurements was calculated according to UNEP/IOC/IAEA [2].

RESULTS AND DISCUSSION

Samples were analysed in triplicates for organochlorine pesticides, aldrin, dieldrin, endosulfan, lindane, 1,2,3,4,5,6-hexachlorocyclohexane (BHC), pp'-DDE and pp'-DDT with the results obtained given in Table 1. It was observed that different pesticides were detected in different marine fauna. The results generally indicate low pesticide accumulation by most of the fauna species. A swimming crab from Nyali Beach and an oyster shell from Port Rietz were found to have accumulated the largest number of different OCPs thus 71 % and 57 %, respectively. This is expected since the swimming crab is a marine "scavanger" and the oyster shell is a filter feeder.

BHC was the OCP detected in most marine fauna species. These results compare well with the study by Oyugi *et al.* whose results showed a similar trend in marine flora [21]. A comparison of the OCPs levels in this study with those obtained by Oyugi *et al*. indicate that marine flora had lower OCPs than the fauna. This can be explained by the natural bioaccumulation trend where the marine fauna feed on the flora and hence this trend may be accounted for. Quantitatively, the highest concentration was that from a sea cucumber sampled from the English Point, a site in the vicinity of the coastal agricultural show ground. The levels therefore could be attributed to the agricultural land runoffs [8].

Table 2 compares the concentration levels of BHC, aldrin, pp'-DDE and pp'-DDT for the phyla Crustacea, Echinodermata and Mollusca. Except for pp'-DDE in the phyla Echinodermata, BHC was quantitatively highest for the various OCPs in the three phyla. In the marine fauna, Crustaceans were detected to accumulate the highest levels of BHC while Echinodermata were detected to have on average the highest levels of pp'-DDE.

Table 1. Mean concentration of organochlorine pesticides (μg/g) in marine fauna.

Site	Pesticide concentration (μg/g)						
Sample	BHC	Aldrin	pp'-DDE	pp'-DDT	Endosulfan	Lindane	Dieldrin
English Point							
Sea cucumber	0.05±0.01	nd	0.95±0.02	0.15±0.01	nd	nd	nd
Nyali Bridge							
Swimming crab	0.20±0.02	0.16±0.01	0.19±0.01	nd	0.05±0.01	nd	0.06±0.01
Fish	0.12±0.01	0.04±0.01	nd	nd	nd	nd	nd
KMC							
Oyster shell	0.19±0.01	nd	nd	nd	0.06±0.01	nd	0.46±0.01
Sea cucumber	0.04±0.01	nd	nd	nd	nd	nd	nd
Makupa Creek							
Gerres oyearia	nd	nd	nd	nd	nd	nd	nd
Port Reitz							
Fiddler crab	0.42±0.02	nd	nd	nd	nd	0.09±0.02	nd
Oyster shell	0.41±0.03	0.02±0.01	0.12±0.01	0.27±0.02	nd	nd	nd
Vanga							
Angroove crab	nd	nd	nd	0.35±0.02	nd	nd	nd
Oyster shell	nd	0.13±0.01	nd	nd	nd	nd	nd
Mbaraki							
Fiddler crab	0.56±0.03	0.41±0.02	nd	nd	nd	0.50±0.02	nd
Marine park							
Sea cucumber	0.20±0.03	0.02±0.00	nd	nd	nd	nd	nd
Starfish	nd	nd	nd	nd	nd	nd	nd
Sea urchin	nd	0.12±0.01	nd	nd	nd	nd	nd

nd = not detected.

Table 2. Comparison of concentration levels (μg/g) of OCPs for various phyla.

Phyla/Pesticide	BHC	Aldrin	pp'-DDE	pp'-DDT
Crustacea	0.30	0.14	0.05	0.09
Mollusca	0.20	0.05	0.04	0.09
Echinodermata	0.06	0.01	0.24	nd

nd = not detected.

CONCLUSIONS

In conclusion it is evident from this study that certain marine organisms have indeed accumulated some OCPs in their soft tissues. This highlights evidence of pollution of marine fauna by organochlorine pesticides. The management of ocean and coastal environment may not be an easy matter, due to contaminants from multiple sources. The investigators recommend a thorough waste management programs as a strategy to minimize marine pollution. Further research is also required as a mode to trace the sources of these OCPs pollutants.

Industries do have a moral, legal and economic responsibility to consider waste treatment as an integral part of their production expense and may, therefore, assist in reducing marine pollution. This may be achieved, for example, by giving permission before wastes are discharged to the sea and by implementing techniques that reduce toxic levels of pollutants to non-toxic levels. The results of this work generate a need to investigate heavy metal pollution in fauna for marine pollution monitoring and other forms of pesticides such as the organophosphates so as to fully establish extend of marine pollution at the Kenyan coast.

ACKNOWLEDGEMENTS

The authors are grateful to Kenyatta University for the Vice-Chancellor's Research Grant, which financially supported this study, to Kenya Marine and Fisheries Research Institute, Mombasa where identification and laboratory procedures were done and to Kenya Agricultural Research Institute, Nairobi for the GC analysis.

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