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The distribution of organochlorine pesticides in sediments from iSimangaliso Wetland Park: Ecological risks and implications for conservation in a biodiversity hotspot☆

Archibold Buah-Kwofie*, Marc S. Humphries

Molecular Sciences Institute, School of Chemistry, University of the Witwatersrand, Private Bag 3, WITS, Johannesburg, 2050, South Africa

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ABSTRACT

The iSimangaliso Wetland Park World Heritage site, located on the east coast of South Africa, spans ~3300 km^2 and constitutes the largest protected estuarine environment for hippopotami, crocodiles and aquatic birds in Africa. Given the ecological importance of this site and continued use of organochlorine pesticides (OCPs) in the region, this study focused on the nature, distribution and potential sources of organochlorine contamination within iSimangaliso Wetland Park. OCPs were widely distributed in surface sediment samples obtained from the four main Ramsar wetland systems within the park (Lake St Lucia, Mkhuze, Lake Sibaya and Kosi Bay). ∑HCH and ∑DDT were the dominant contaminants detected with concentrations in the range of 26.29–282.5 ng/g and 34.49–262.4 ng/g, respectively. ∑DDT concentrations revealed a distinctive gradient, with significantly higher concentrations at Kosi Bay and Lake Sibaya attributed to the application of DDT for malaria control. p,p'-DDE and p,p'-DDD were the dominant isomers detected, but the detection of p,p'-DDT in a number of samples reflects recent inputs of technical DDT. Highest concentrations of HCH, endosulfan and heptachlor were detected in sediments from Mkhuze and reflect the substantial residue load these wetlands receive from agricultural activities within the catchment area. Isomeric compositions indicate that endosulfan and heptachlor residues are derived mainly from historical application, while inputs of HCH, aldrin and endrin could be attributed to more recent usage at several sites. OCP sediment concentrations from iSimangaliso represent the highest yet recorded in South Africa and some of the highest reported globally this century. Sediments found within the lakes and wetlands of iSimangaliso represent large reservoirs of contaminants that pose ecotoxicological threats to this globally important biodiversity hotspot. Detailed investigation into the bioaccumulation and toxicological risks of OCPs within the wetland park is urgently required.

1. Introduction

Pesticides have contributed enormously to increases in world agricultural production and improved human health. Despite these achievements, inherent human health and environmental challenges are associated with the use of these compounds because of their toxicity and ability to accumulate in the environment (UNEP, 2001). Of particular concern are organochlorine pesticides (OCPs), which have been linked to a range of physiological disruptions in both humans and wildlife (Conis, 2010; Porter and Wiemeyer, 1969). Despite restrictions on their use, OCP residues continue to be detected in various environmental matrices on a global scale, including water, sediments and aquatic organisms (Fillmann et al., 2002; Iwata et al., 1994; Veljanoska-Sarafiloska et al., 2013). OCPs are toxic, environmentally persistent and able to undergo long-range environmental transport (Dalla Valle et al., 2007; Ritter et al., 1995; Solomon and Schettler, 2000). As a result, their impact on non-target organisms and bioaccumulation potential in the environment are well established (e.g., Barlas, 2002; Davies and Randall, 1989; Gerber et al., 2016). Due to their high hydrophobicity, OCPs tend to adsorb to sedimentary surfaces and often eventually accumulate in estuaries and lakes (Zhou et al., 2006), where they may be transferred through the food chain.

The impact of pesticide residues is of great concern when applied near ecologically sensitive areas. Although banned in many

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* Corresponding author.
E-mail addresses: archiekwofie@yahoo.co.uk, 832243@students.wits.ac.za (A. Buah-Kwofie).

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countries, OCPs continue to be used in South Africa, particularly in the north-eastern parts of the country where DDT is applied for malaria control. Other OCPs including hexachlorocyclohexanes (HCHs), aldrin, heptachlor, and endosulfan have a long history of usage for agricultural purposes. The continued use of OCPs in South Africa is of particular environmental concern as the north-eastern malaria endemic regions of the country are host to a number of globally important conservation areas, including Kruger National Park and iSimangaliso Wetland Park (Fig. 1). The detection of significant OCP levels in different environmental matrices from the region, including human breast milk (Bouwman et al., 2006), surface sediment (Gerber et al., 2015; Sereda and Meinhardt, 2005; Van Dyk et al., 2010), fish tissue (Gerber et al., 2016; Wepener et al., 2012), bird eggs (Bouwman et al., 2008, 2013) and crocodile eggs (Bouwman et al., 2014), presents serious implications for both biodiversity conservation and human health.

The iSimangaliso Wetland Park World Heritage site, located on the east coast of South Africa, spans ~280 km of pristine coastline (Fig. 1) and encompasses four major Ramsar wetlands of international importance (Lake St Lucia, Mkhuze wetlands, Lake Sibaya, and Kosi Bay). iSimangaliso forms part of the Maputaland-Pondoland-Albany biodiversity hotspot and includes some of the most important habitats for hippos, crocodiles, and aquatic birds on the continent. The lakes and wetlands also support neighboring

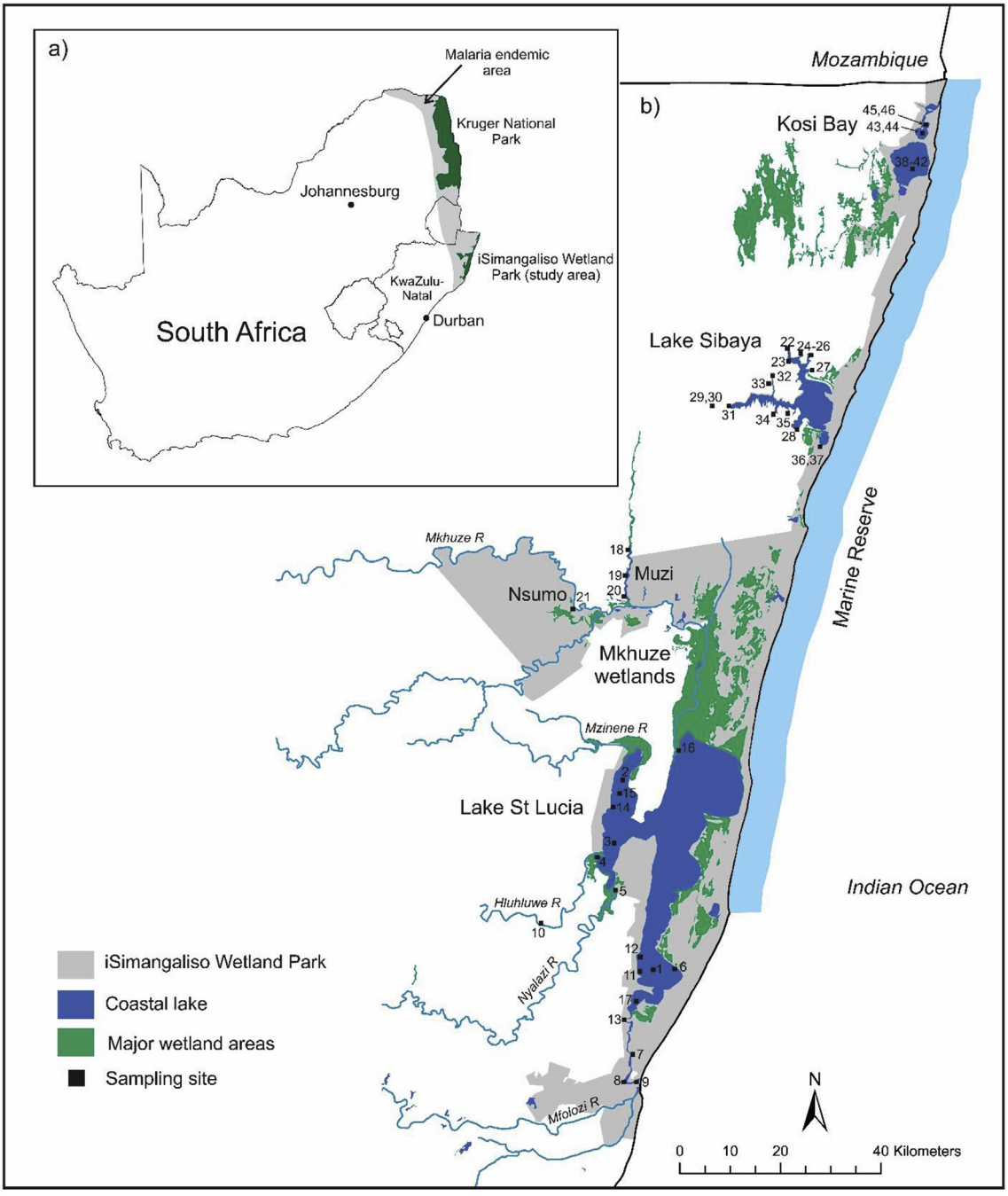

Fig. 1. Map showing the location of a) major conservation areas within the malaria endemic region of South Africa, and b) the location of sediment sampling sites (1–46) within iSimangaliso Wetland Park. Sampling focused on the four main Ramsar wetland sites (Lake St Lucia, Mkhuze wetlands, Lake Sibaya and Kosi Bay).