Environmental Research 154 (2017) 425–434

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) in human breast milk and associated health risks to nursing infants in Northern Tanzania

M.H.B. Müller[a,*], A. Polder[a], O.B. Brynildsrud[b], M. Karimi[a], E. Lie[a,c], W.B. Manyilizu[d], R.H. Mdegela[d], F. Mokiti[e], M. Murtadha[e], H.E. Nonga[d], J.U. Skaare[f], J.L. Lyche[a]

[a] Norwegian University of Life Sciences, Campus Adamstuen, P.O. Box 8146 Dep, N- 0033, Oslo, Norway
[b] Norwegian Institute of Public Health, P.O. Box 4404 Nydalen, N-0403, Oslo, Norway
[c] Norwegian Institute for Water Research, Gaustadallèen 21, N-0349, Oslo, Norway
[d] Sokoine University of Agriculture, Department of Veterinary Medicine and Public Health, P.O. Box 3021, Morogoro, Tanzania
[e] Mount Meru Regional Referral Hospital, P.O. Box 3092, Arusha, Tanzania
[f] Norwegian Veterinary Institute, P.O. Box 750 Sentrum, N-0106, Oslo, Norway

ARTICLE INFO

Keywords:
Organochlorine pesticides
Polychlorinated biphenyls
Human breast milk
Estimated daily intake
Infant health risks

ABSTRACT

This is the first study to report organochlorines (OCs), including chlorinated pesticides (OCPs) and polychlorinated biphenyls (PCBs) in human milk from Tanzania. The main aims of this study were to assess the level of contamination and the possible health risks related to OC exposure in nursing infants from the Northern parts of Tanzania. Ninety-five healthy mother-infant couples attending Mount Meru Regional Referral Hospital (MMRRH), Arusha, Tanzania, were assessed for associations between maternal/infant characteristics, i.e. mother's age, BMI, gestational weight gain, occupation, residence and fetal growth parameters and breast milk levels of OCPs, such as dichlorodiphenyltrichloroethane (DDT) and its metabolites, dieldrin and PCBs. p,p′-DDE and p,p′-DDT were detected in 100% and 75% of the breast milk samples, respectively, and ranged between 24 and 2400 ng/g lipid weight (lw) and < LOD and 133 ng/g lw, respectively. Dieldrin was detected in 66% of the samples in levels up to 937 ng/g lw. ∑7PCBs ranged between < LOD and 157 ng/g lw. Other OCPs were detected in low levels. For assessment of health risks, the Hazard Quotient (HQ) was calculated by comparing estimated daily intakes of OCPs and PCBs with health based guidance values. The estimated daily intake (ng/kg body weight/day) of ∑DDTs, dieldrin and nondioxin-like PCBs (∑6PCBs) exceeded the provisional tolerable daily intake (PTDI) in two, six and forty-eight of the nursing infants, respectively, suggesting potential health risks. In addition, head circumference were negatively associated with p,p´-DDE in female infants, suggesting that OC exposure during pregnancy may influence fetal growth.

1. Introduction

Organochlorine pesticides (OCPs), like dichlorodiphenyltrichloroethane (DDT), dieldrin and hexachlorocyclohexane (HCH), have benefited humans in agriculture and vector control, and polychlorinated biphenyls (PCBs) have enhanced the productivity in industrial processes. Since the 1970s, an expanding number of organochlorine compounds (OCs), like OCPs and PCBs, have been restricted and banned due to their environmental persistence and possible toxic effects on domestic animals, wildlife and humans (The Stockholm Convention, 2016). OCs are lipophilic and persistent in nature, they bioaccumulate in organisms and increase in levels up in the food chain (biomagnify), and they may be transported over long distances in air and by sea currents (AMAP, 1997; Wania and Mackay, 1993).

Human exposure to OC chemicals are mainly through diet, like fish, meat and dairy products (EFSA, 2007, 2012). However, in Sub-Saharan countries other sources and exposure routes, such as exposure through vector control, occupation, and living close to old pesticide storages or waste dumping sites may be of significance (Asante et al., 2011; Ntow et al., 2008; Darnerud et al., 2006; Van Dyk et al., 2010). Thus, in contrast to developed countries, exposure sources in Sub-Saharan African countries may differ, both between countries but also between individuals within the same population.

Tanzania ratified The Stockholm Convention in 2004 (The

* Corresponding author.
E-mail address: mette.helen.bjorge.muller@nmbu.no (M.H.B. Müller).

http://dx.doi.org/10.1016/j.envres.2017.01.031
Received 21 September 2016; Received in revised form 15 January 2017; Accepted 25 January 2017
Available online 11 February 2017

Stockholm Convention, 2016). Nevertheless, recent use and discharge of banned and restricted OCPs are reported (Nonga et al., 2011; Lema et al., 2014; Polder et al., 2014, 2016). Although limited, the documentation of OCs in the African environment raise human health concern (Asante et al., 2011; Ntow et al., 2008; Bouwman et al., 2012). There are only two studies reporting the presence of OCs, i.e. DDTs, dieldrin and PCBs, in human samples, such as blood and adipose tissue, from Tanzania (van der Ven et al., 1992; Weiss et al., 2006), whereas there is no existing data reporting OCs in human milk and assessment of exposure to nursing infants from Tanzania.

Fetuses and infants are exposed to chemicals, like OCs, through placental transmission and breast milk (Dewan et al., 2013; Skaare et al., 1988). The sensitive developmental processes that occur during pre- and postnatal life stages, are highly vulnerable to chemical exposure, even in low levels (Mostafalou and Abdollahi, 2013). Experimental and epidemiological studies suggest that early life exposure to OCs are associated with reduced fetal growth and adverse health effects, such as endocrine disruption, immunotoxicity, allergy, cancer, metabolic, reproductive and neurodevelopmental disorders (Casas et al., 2015; Cohn et al., 2007; Cooper et al., 2004; Dalvie et al., 2004; Dewan et al., 2013; Eskenazi et al., 2006; Langer, 2010; Sunyer et al., 2006). Additionally, recent data suggest gender differences in accumulation of OCs in breast milk as well as effects (Bouwman et al., 2012; Ribas-Fito et al., 2006).

The present study is part of a mother-infant project in Northern Tanzania (MORATANZ[1]), which aims to assess persistent, organic pollutants (POPs) exposure and related health risks to fetuses and nursing infants. In a previous study, surprisingly high levels of polybrominated diphenyl ethers (PBDEs) were detected in breast milk from the same 95 Tanzanian mothers as in this study, posing health risks to 20% of the nursing infants (Müller et al., 2016). In order to assess health risks related to OC exposure, this study evaluated breast milk levels of OCPs and PCBs, associations between OC levels and maternal/infant characteristics and individual estimated daily intakes of OCs towards health based guidance values.

2. Materials and methods

2.1. Study design and sampling

Study design and sampling procedures are described in Müller et al. (2016). In brief, 150 breast milk samples were collected from healthy, primiparous mothers attending Mount Meru Regional Referral Hospital (MMRRH), Arusha Tanzania (Fig. 1), during October and December 2012. Although WHO recommends sampling of breast milk between 3 and 8 weeks post-delivery (WHO, 2009), this study had to perform the breast milk sampling during the mothers´ hospital stay (0–2 days). Information about the mothers and infants was recorded using a questionnaire based on WHO guidelines (WHO, 2007). The desired amount of breast milk was at least 5 mL. If this amount was not possible to donate during hospitalization, the mothers were invited to donate a breast milk sample during their health check 7 days post-delivery. The samples were transported on dry ice to Norway by World Courier®, and kept frozen at −20 °C until analysis.

For analysis, breast milk from 95 mothers was selected. Seventy-nine were sampled within 0–2 days, 5 were sampled between 3 and 5 days and 11 were sampled between 6 and 10 days post-delivery.

2.2. Ethics and confidentiality

The mothers signed a consent for enrolment in the project after they were given information about the project aim. The mothers were free to withdraw from the project at any time and their identity are kept confidential. The project is approved by the Medical Research Coordinating Committee of the National Institute for Medical Research, Tanzania, and Regional Committee for Medical and Health Research Ethics, Section South East C, Norway.

Fig. 1. *Maps of Tanzania* (Maps of Tanzania, 2016)**.** The collection of breast milk samples was performed in Arusha, Northern Tanzania.

2.3. Chemical analyses

The chemical analyses were performed at the Laboratory of Environmental Toxicology, Norwegian University of Life Sciences (NMBU), Oslo, Norway. The chemical method used in the present study is accredited by the Norwegian Accreditation for analysing OCPs and PCBs in human milk according to the requirements of the NS-EN ISO/IEC 17025 (TEST 137).

The breast milk samples (n=95) were analysed for organochlorine pesticides (OCPs) group I and PCBs: hexachlorobenzene (HCB), β- and γ-hexachlorocyclohexanes (ΣHCHs), oxychlordane and trans-nonachlor (ΣCHLs), bis-2,2-(4-chlorophenyl)−1,1,1-trichloroethane (p,p′-DDT) and its metabolites p,p′-DDE, o,p′-DDD, p,p′-DDD, and o,p′-DDT (ΣDDTs), mirex, toxaphenes (ΣCHBs) Parlar nos.: CHB−26, −40, −41, −44, −50 and −62; PCBs (Σ7PCBs): IUPAC nos.: PCB−28, −52, −101, −118, −138, −153 and −180 (Σ6PCBs: PCB−28, −52, −101, −138, −153 and −180); OCPs group II: heptachlor, cis-heptachlor epoxide, trans-heptachlor epoxide, dieldrin, endrin, tecnazen, quintozen, pentachloranilin, α- and β-endosulfan and endosulfan sulphate.

2.3.1. Materials

Cyclohexane, acetone and dichloromethane of HPLC quality were supplied from VWR Chemicals, VWR International S.A.S, Radnor, Pennsylvania. Purified water was obtained from a Milli-Q Gradient A10 water system (Millipore, Bedford, MA, USA). Primary standards were supplied from Ultra Scientific, N. Kingstown, RI, USA (PCB−29, −112 and −207) and LGC Standards GmbH, Wesel, Germany (2-endo,3-exo,6-exo,8,9,10,10-heptachlorobornane (DE-TOX 409)). Bio-Beads S-

[1] Monitoring and Risk Assessment of Contaminants in Southern Africa: using Arusha in Tanzania as a model.