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Assessment of organochlorine pesticides in human milk and risk exposure to infants from North-East India

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ABSTRACT

Despite the worldwide ban on use of persistent organochlorine pesticides, their usage continued until recently in India, for vector-borne disease eradication programs and agricultural purposes. The concentrations of organochlorine contaminants, DDT and HCH, have been determined in human breast milk from Dibrugarh and Nagaon districts of Assam state, North-East India. The results demonstrated that the mean levels of total DDT were 3210 ng/g lipid wt. and 2870 ng/g lipid wt. and total HCH were 2720 ng/g lipid wt. and 2330 ng/g lipid wt. in Nagaon and Dibrugarh respectively. There was no significant difference in the levels of investigated pollutants between the two districts. Significant differences in ADI (Average daily intake) for total DDT were found between the two districts. In addition, a positive correlation was observed between OCP levels in breast milk and age of mothers. Based on OCP levels in human breast milk, the ADI by the infants has been estimated. It has been found that high daily intake of DDTs and HCHs by the infants exceeded the TDI (Tolerable daily intake) which implied that infants of the region are potentially at high risk by these contaminants.

1. Introduction

Longtime use of the organochlorine pesticides as well as their physical and chemical persistence in nature has resulted in their becoming ubiquitously occurring environmental contaminants (UNEP, 2003). In tropical countries, the OCPs have been extensively used in malaria control programs and to control pests and parasites in livestock/agricultural practices (Waliszewski et al., 1997). Dichlorodiphenyltrichloroethane (DDT) and Hexachlorocyclohexane (HCH) are the main organochlorine compounds, with different degrees and positions of chlorination, which determine their persistence and toxicity. The main reasons for environmental contamination by OCPs are their large production, uncontrolled use, inadequate discharge and persistence in the natural environment (Ross, 2004). Environmental exposure of living organisms to these OCPs results in their persistence and accumulation in fatty tissues (Falandysz et al., 2004) and cause health effects in wildlife and humans (Tanabe, 2002). In addition, organochlorine pesticides are lipophilic and thus undergo biomagnifications through successive trophic levels in the food chain (Angulo et al., 1999; Solomon and Weiss, 2002; Borga et al., 2001). As human is the last link in any food chain, it is likely to consume highest levels of these compounds.

Human milk, with a relatively high fat content, is perceived as a suitable matrix and best indicator to study long term exposure to OCPs (Brouwer et al., 1998; Schutz et al., 1998; Dekoning and Karmaus, 2000; Solomon and Weiss, 2002; Devanathan et al., 2009). It is easy to obtain, can be collected non-invasively and indicates the contaminant levels in maternal fat (Tanabe and Subramanian, 2006). In addition, monitoring of breast milk provides a means of estimating intake of OCPs by breast-fed infants.

India is the only country, other than United States, which has applied more than 100,000 t of DDTs, mainly for agricultural and malaria eradication programs, until it was banned for use in agriculture in 1989 (Kannan et al., 1995; Voldner and Li, 1995). Being a large agricultural country, India has been one of the major producers and consumers of OCPs. Moreover, DDT is still allowed to be used as pesticides for vector control in malaria, kala-azar, dengue etc. The usage of technical HCH in agriculture was also banned in 1997 in India (Mukherjee and Gopal, 2003). Government of India is encouraging its replacement with less persistent lindane (γ-HCH) which otherwise has all the harmful characteristics of HCHs. Now, India is one of the few remaining countries still engaged in the large scale manufacture, use and export of γ-HCH (Abhilash and Singh, 2009). Earlier studies on organochlorine pesticides in human breast milk, from India have shown concern that infants and children are more susceptible to the adverse effects than the adults are (Tanabe et al., 1990; Kalra et al., 1994; Minh et al., 2003; Sanghi et al., 2003; Devanathan et al., 2009).

Exposure to OCPs can cause disruption of endocrine system as they have capability to alter the hormonal imbalance (Colborn et al., 1993,

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1996; Kelce et al., 1994, 1997; Janssen et al., 1997; Beard et al., 2000). Accumulation of OCPs has been related to increased risk of various types of human cancer including breast, lung, cervix, prostate, endometriosis, hypospadias and cryptorchidias (Wolff et al., 1993, 2000; Birnbaum, 1994; Rier et al., 1995; Toppari et al., 1995; Hosie et al., 2000; Ahmed et al., 2002; Amaral Mendes, 2002) and genotoxic effects (Ennaceur et al., 2008a,b). Uncertain findings or associations have been reported about the effects of OCP exposure on human growth (Gladen et al., 2000, 2003; Longnecker et al., 2001; Nagayama et al., 2007; Alvarez-Pedrerol et al., 2008a; Schell et al., 2008), mental and psychomotor development (Dorner and Plagemann, 2002; BBC, 2006; Ribas-Fitó et al., 2006; Sagiv et al., 2008). Some other health problems, including neurological and immune system disorders and infection are also related with OCP exposure (Bernier et al., 1995; Karmaus et al., 2003; Ntow et al., 2008).

Although reports on high OCPs in breast milk from different parts of India are available, there is lack of data on contamination profile of HCH and DDT in Assam region. The area is characterized by intensive agriculture, including paddy and cash crop cultivation, and also infested by vector-borne malaria, a serious health problem in human beings. Therefore, OCPs are extensively applied in public health programs for malaria control and for pest control in agriculture. In the present study, DDTs and HCHs in human breast milk have been examined from two selected districts of Assam, North-east India. The large scale use of OCPs has provided a high exposure to local poor population of this area. The present study has generated useful data on contamination levels in local population and possible potential risk of the OC concentrations, particularly on infants in North-East region of India that has probably not been reported till now. Additionally, significant findings have been obtained by comparing the total DDT and HCH body burden with different HCH isomers and DDT metabolites, and also with different age groups, and parity in mothers.

2. Material and methods

2.1. Study area

The investigation area was located in districts Nagaon and Dibrugarh of Assam state (latitude 24° 44′ to 27° 45′ N and longitude 89° 41′ to 96° 02′ E), North-East India. (Fig. 1). The State is bounded by the hill states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura, and shares an international border with Bhutan on the north and Bangladesh on the south. Assam is the most populous (30.24 million in year 2010) and second largest state (78,523 km^2) in north-eastern India.

Assam alone, with only 2.6% of the country's population, contributes more than 5% of the total malaria cases in the country (Prasad, 2009). The region is highly prone to malaria transmission due to high and prolonged rainfall (2000–3000 mm), high humidity (60–90%) and warmer climates (22–33 °C) for most part of the year, promoting vector breeding and longevity.

Anapheles minimus, *A. dirus* and *A. fluviatilis* are the main vectors responsible for malaria transmission in the State. All these vectors are found to be highly susceptible to DDT, thus, residual spraying with two rounds of DDT (1 g/m^2) is the main force for vector control. Due to lack of other suitable alternative methods for malaria eradication in the northeastern India, DDT and related organochlorines are being used in this region for more than 20 years (Dev et al., 2001), despite the global treaty to ban these compounds. Annual consumption of DDT in the years 2001, 2002, 2003, 2004 and 2005 were 940, 1102, 1102, 1060, 1500 MT respectively in Assam state. The studied area is rich in forests and water and has vast tracts of fertile land. More than 77% of the population in this region is engaged in agriculture and allied activities. Around 40% of the total area is cultivated and cereals like paddy and wheat and plantation crops like tea are grown extensively. Therefore,

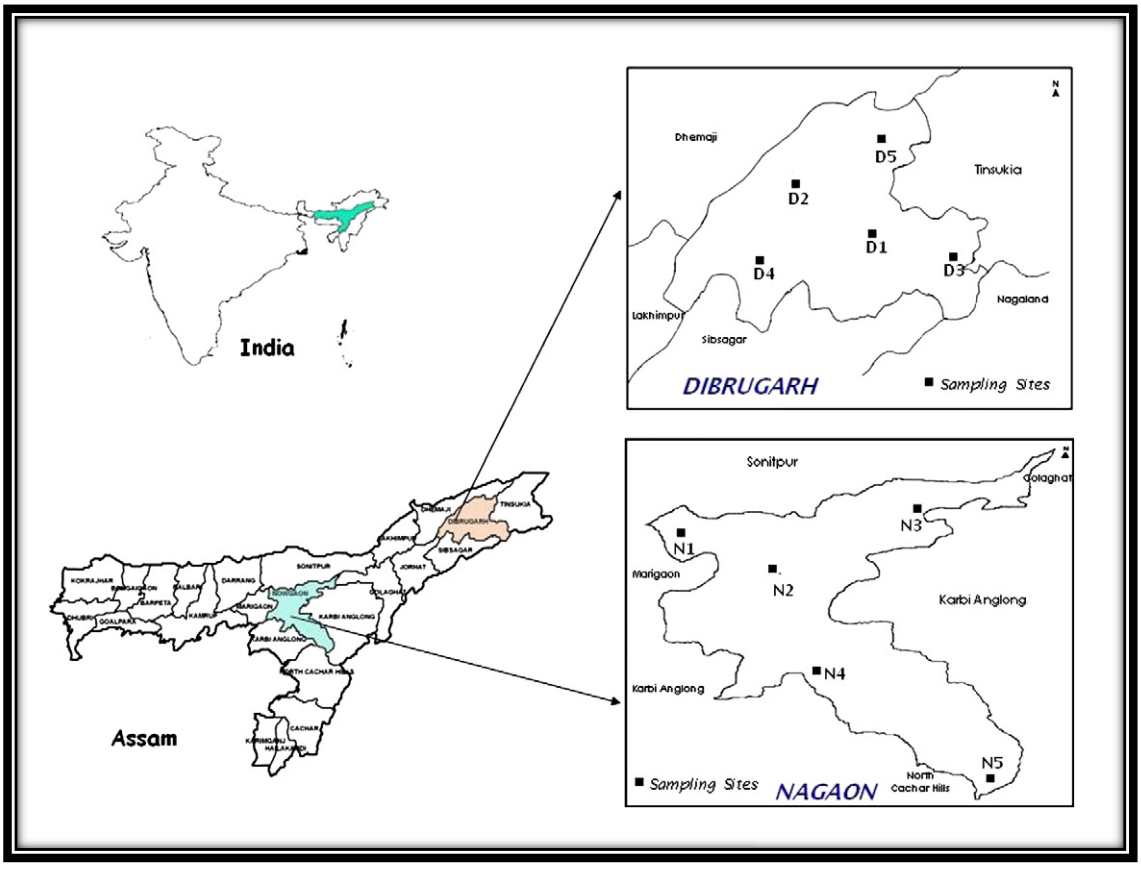

Fig. 1. Study area showing sampling locations in Dibrugarh and Nagaon districts (D2 and N2 are urban areas and D1, D3, D4, D5, N1, N3, N4, N5 are rural areas).