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Assessment of Dioxin-Like Compounds Released from Iranian Industries and Municipalities

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ABSTRACT

Background: *In the past 10-15 years, the world has encountered a new type of organic dioxin-like pollutant from products of combustion and byproducts of industrial processes and activities of the municipality. Dioxins are very toxic substances. According to various studies, it is believed that these compounds have devastating impacts on the environment and public health. Since these pollutants are persistent and can remain in the environment for several decades, they may have global implications.*

Materials and Methods: *Estimation of the amount of dioxin-like compounds has been done in 15 industrialized countries according to United Nations Environment Programme(UNEP).*

Results: *In this study, the amount of dioxin-like pollutants in Iran was estimated to be 1282gr TEQ/year compared with 100 to 4000gr TEQ/year in European countries, the USA and Japan. Iranian sources of dioxins are considerable comparing to that of industrialized countries. Therefore, a higher incidence of adverse health effects such as carcinogenesis and changes in liver function, thyroid hormone levels, immune cell levels, and decreased performance in learning and intelligence tests may be anticipated in polluted areas.*

Conclusion: *The result of this study necessitates a sound national strategy for monitoring the release of these pollutants in Iran. Further studies are recommended on Dioxin-like compounds in polluted areas.* ***(Tanaffos 2007; 6(3): 59-64)***

Key Words: *Dioxin-like compounds, UNEP, Persistent pollutants, Public health*

INTRODUCTION

Polychlorinated dibenzo-p-dioxins (PCDDs or CDDs), polybrominated dibenzofurans (PBDFs or BDFs), and polychlorinated biphenyls (PCBs) are in a class of chemical compounds widely recognized as some of the most toxic chemicals ever made by Man (1). The CDDs include 75 individual compounds, and BDFs include 135 different compounds. The most widely studied compound is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). This compound, often simply called dioxin, represents the

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reference compound for this class of compounds (2, 3). The structure of 2,3,7,8-TCDD and several related compounds is shown in Figure 1.

Dioxin-like compounds (PCDD/PBDF) are formed as a class of pollutants during combustion processes and are by-products of a wide range of chemical processes such as the manufacture of PVC, pesticides, incineration, pulp and paper bleaching, and the smelting and recycling of metals. These hazardous compounds have no useful purpose and are widely dispersed in the environment (4, 5, 6, 7, 8). Generation of dioxin is highly dependent on temperature, retention time, availability of catalytic metals and fly ash particles. It has been shown that high temperature combustion in the range of 200 to 400^{o}C produces the highest levels of dioxin in combustion chambers (9,10).

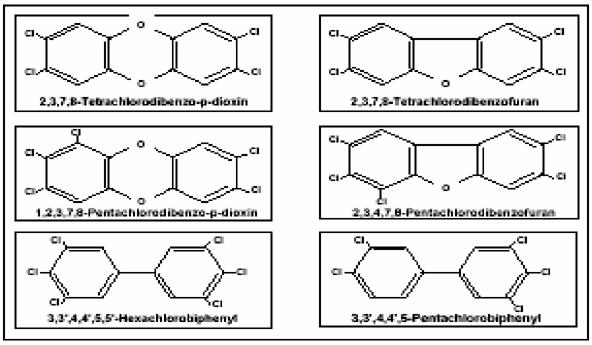

Figure 1. Structure of Dioxin-like compounds

Dioxin-like compounds are released directly into the environment (atmosphere, land, water) or indirectly (contaminated residues and products). Dioxins are deposited on plants, water, soil and sediments in the environment and are broken down very slowly. They undergo biomagnifications, that is, they are collected in plants, water, soil and sediments and are taken up by the animals and aquatic organisms where they tend to accumulate and become concentrated in the food chain (11, 12, 13, 14). Toxicity of dioxins has been magnified because of their longterm persistence in the environment (half-life of 11.6 years). Dioxins interfere with the basic and common Ah (aryl hydrocarbon) receptor involved in cellular regulatory processes. The Ah receptor is a member of a family of gene regulatory proteins. When dioxins interact with this receptor a chain of events begin which the body is unable to interrupt and correct. Occupational or accidental exposure to chemical mixtures containing dioxins have been associated with an increased prevalence of chloracne, hyperpigmentation of the skin, mild liver toxicity, and changes in male reproductive hormones. The health effects include changes in liver function, thyroid hormone levels, immune cell levels, and decreased performance in learning and intelligence tests**.** The International Agency for Cancer Research (IARC) has characterized 2,3,7,8-TCDD as a "human carcinogen" (15, 16, 17, 18, 19, 20).

Due to the potential toxicity of dioxin-like compounds, great emphasis has been placed on policies to abate these compounds globally. The production of dioxins in industrialized countries has been ongoing since 1995. According to the Japan Offspring Fund (JOF), Japan and United States are the top producers of dioxin-like compounds. The Japanese Ministry of Environment has enforced an abatement policy for dioxin-like compounds since 1997. Release of dioxin-like compounds has been greatly reduced in incinerators which were the major sources (21). Specimens from the daily intake surveys in the Kansai region between 1977 and 1998, analyzed for dioxins, indicated that daily intake of dioxins has dropped to almost one third during this time period. Further decreases in the intake are expected since measures for reducing dioxin emissions are being undertaken. A concentration of

25.2 pg-TEQ/g of fat was found to be equal to the average concentration of dioxins in mother's milk from a 1998 nationwide survey, which analyzed breast milk from 415 Japanese mothers in 21 areas, 30 days after they gave birth (22).

The aims of this study were:

1- Estimation of dioxin-like compounds generated by various industrial, agricultural and civil activities in all provinces of Iran according to the UNEP standardized procedures
2- Identification of risk areas in Iran
3- Training health specialists, offering recommendations for the control of dioxin-like compounds and performing research studies in Iran concerning this issue

MATERIALS AND METHODS

The method for the estimation of dioxin-like compounds has been devised by UNEP and has been used by at least 15 industrialized countries (23). The basic aim of the UNEP toolkit is to enable an estimate of average annual release in each vector (air, water, and land, in products and residues) for each process identified. The method (toolkit) for estimation of dioxin-like compounds in µg TEQ/ ton per production or raw material consumed was applied. The toolkit is organized in eight categories regarding different activities such as waste incineration, ferrous and nonferrous metal production, power generation and heating, production of chemical and mineral products, transportation, uncontrolled combustion, consumer goods and miscellaneous activities.

The estimate of Dioxin-like compounds can be calculated by the following basic equation:

Source Strength (Dioxin emissions per year) = Emission Factor X Activity Rate

The PCDD/PBDF emission per year are calculated and presented in grams of toxic equivalents (TEQ) per year.

Data Collection: Information regarding the activity rate in accordance to criteria cited in the toolkit were obtained from the Ministries of the Interior, Industry, Agriculture, Energy, Petroleum and other governmental agencies.

RESULTS

Information regarding the activity rates of the industrial, agricultural and municipal operations, in accordance to criteria cited in the UNEP toolkit, was received from Iranian ministries through official requests from the Ministry of Health and Medical Education. After reviewing the data regarding the activity rates of industrial and civil activities with health professionals, the amounts of dioxin-like compounds from industrial and civilian activities in different provinces were calculated (Table1).

Table 1 shows the contribution of each province to the total amount of dioxin-like compounds generated in Iran. The most important provinces in this regard are: Yazd (85, 693, 532µg TEQ/ year), Isfahan (74, 982, 023µg TEQ/ year), Khorasan (67, 770, 345µg TEQ/ year), Semnan (57, 646, 054 µg TEQ/ year), Qazvin (45, 419, 818µg TEQ/ year), Qom (31, 674, 275µg TEQ/ year) and Zanjan (20, 889, 690µg TEQ/ year). In regard to production of dioxin-like compounds the most significant industries are: Copper production (615, 745, 120µg TEQ/ year), iron and steel production (458, 218, 750µg TEQ/ year), application of 2,4-D herbicide in agriculture(104,300,140µg TEQ/year) and power plants using heavy fuel (70, 433, 977µg TEQ/ year). These industries nearly comprise the total amount of dioxin-like compounds generated in Iran (Table 2).

Table 1. Production level of dioxins and furans in Iranian provinces (µgTEQ/Yr)

Provinces	Dioxins&Furans released in environment (µg TEQ /Yr)				
	Air	Land	Water	Product	Residue
Ardebil	274888.5			4200	
Western Azarbaijan	2766048.5			3566500	
Eastern Azarbaijan	4579900			29400	960750
Bushehr	504182.5			6300	
Chahar mahal va Bakhtiary	3245650			14700	4725000
Fars	1252785			6564600	34000
Gilan	1143195			350	691350
Golestan	33750			32200	
Hormozgan	2015895			3850	
Hamedan	1353500			36400	
Ilam	183340			396200	
Isfahan	74982023			1563800	26758440
Kerman	13460327			7000	15098000
Kermanshah	1405548.5			19219900	
Khorasan	67770345			9856700	55019700
Khuzestan	12283670			4797100	15030000
Kohkiloyeh va Boyer Ahmad	41847.5			35700	
Kordestan	3536959			25200	2661000
Lorestan	4095463				1890000
Mazandaran	351584			4251100	
Markazi	2193234.5			4445350	826300
Qom	31674275			126700	24831450
Qazvin	45419818			8182300	33785640
Semnan	57646054			13305250	47179000
Sistan and Baluchestan	2179517.5			2801050	
Tehran	11859111			7868000	7375960
Yazd	85693532			8403990	149076000
Zanjan	20889690			9100	11935980

Table 2. Production level of dioxins and furans in Iranian provinces in industry (µgTEQ/Yr)

Industrial Operations	Total production µg TEQ /Yr	Dioxins&Furans released in environment (µg TEQ /Yr)				
		Air	Land	Water	Product	Residue
2,4-D herbicide	104300140				104300140	
Brass Simple Furnace	53266.5	53266.5				
Chlorinated pesticide 2,4-D	700000	700000				
Copper Production (basic technology)	615745120	344467200				271277920
Iron&steel production (dirty scrap)	485218750	165467500				319751250
Lead production (scrap)	4844400	4844400				
Lime production (no dust control)	121000	121000				
Power plant (Heavy fuel)	70433977	70433977				
Power plant (Light fuel oil)	5426.5	5426.5				
Power plant (Natural gas)	71448	71448				
Production of cement (wet kilns)	78000	65000				13000
Zinc production melting (only)	156993.9	156993.9				
Total	1281728521.9	586386211.9			104300140	591042170

DISCUSSION

As seen in Table 1, the major producers of dioxin-like compounds in Iran are the industrialized provinces of Yazd, Isfahan, Khorasan, Semnan, Qazvin, Qom and Zanjan. The Iranian share of Dioxin generation is beyond the calculated amounts of 1, 281, 728, 522µg TEQ/year (Table 2). Unfortunately, the statistics regarding incineration or burning of municipal and industrial wastes are not available in Iran, which undermines the present amount of dioxin-like compounds.

It is interesting that small provinces such as Yazd, Semnan, Qazvin, Qom and Zanjan rather than Tehran, are the major sources of dioxin-like compounds in Iran. Generally, comparing Iranian levels of dioxin-like compounds (1.3 Kg TEQ/ year) with fifteen industrialized countries in range of 0.1-4.0 Kg TEQ/year, showed Iran to be a significant producer of these toxic compounds. Therefore, Iranians could also suffer symptoms of dioxin-like compounds. Therefore, further research is required in this respect. As indicated by assessment of fifteen industrialized countries, production of copper, steel and electrical power are the main industrial causes of dioxin-like compounds. They are also the major sources of dioxins in Iran (21). Therefore, a clear mitigation strategy in copper, steel and energy production is needed and alternative herbicides should be sought for agricultural practices.

Hot spots in Iranian provinces, in terms of dioxin-like compounds are chemical plants formulating 2,4-D herbicide in industrial zones of Saveh and industrial provinces such as Yazd, Isfahan, Khorasan, Semnan, Qazvin, Qom and Zanjan. In the noted provinces, areas around copper, steel and power plants are prime areas of dioxin-like compounds. Generally, bioaccumulation of dioxins through the food chain in polluted areas is possible, which, in turn could lead to exposure of the general population (22). Occupational exposure of workers in chemical factories manufacturing 2,4-D herbicide and other workers in secondary furnaces recovering scrap metals (copper and iron) may be very significant; thus, proper monitoring of these workers should be performed.

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