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Phthalate Toxicity

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Abstract: Phthalates are esters of Pthalic acid, compounds mainly used as plasticisers. Phthalates are widely used chemicals which are of significant research interest as their exposure causes various consequences for human health. There are several categories of phthalates extensively used in many commercial productions with diverse uses, physicochemical properties and toxicological effects. This chapter discusses the toxicity of Phthalates and its potential risks to human health.

Keywords: Phthalate; toxicity; DEHP; health

1.1 Introduction

Some commonly used phthalates are DEHP used as sealants, solvent fragrance , detergents, pharmaceuticals, cosmetics, paints and Butyl Benzyl Phthalate (BBzP) used as adhesives in vinyl materials (K. M. Rodgers, 2014). The widespread use of phthalates leads to its distribution in general environment as well as in raw food materials, contamination can also occur during processing of food. Larger volume of phthalates are used in edible products (above 40%) in order to get high plasticizing effect. Some toxicologically relevant phthalates in food industry are DEHP, BBP, DnBP, DiBP etc. Another source of phthalates is paper and cardboard materials generated from recycled fibre (O. Kappenstein, 2012). The major cause of exposure of phthalates in human occurs through inhalation and ingestion, DEHP is the major phthalate that is present in hygienic materials such as shampoo, conditioners etc. Phthalates are cancerous for animals and can lead to fatal death and particularly reproductive toxicity in animals (G. Latini, 2005). In this chapter an effort has been made to analyse the phthalates toxicity in various sources.

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1.2 Toxicity of Phthalates

In recent decades, belief over the adverse impacts of phthalates on human beings has been taken into consideration by the researchers despite the fact phthalate toxicity is already acknowledged since 1950s. Studies performed on animals have revealed the fundamental side effects including reproductive system toxicity. The physical and chemical properties of phthalates differ with the molecular structure which may comprise of a vapour phase with a low vapour pressure. Phthalates are typically fat soluble, which affect their leaching and segmentation. The exposure of phthalate in human can also arise as a result of materials encompassing phthalates across one product to other as can happen with food packaging material or intra cutaneous fluids, or through surrounding environment. Phthalate assimilation can occur through food comprising pharmaceuticals and other nutritional supplement (Ted Schettler, 2005). DEHP is one of the most common plasticizers used to make plastic flexible. DEHP having chemical formula of $C_{24}H_{38}O_4$ and molecular weight equal to 390.56gmol^{-1} consists of a pair of eight carbon esters linked to a benzene carboxylic acid ring.

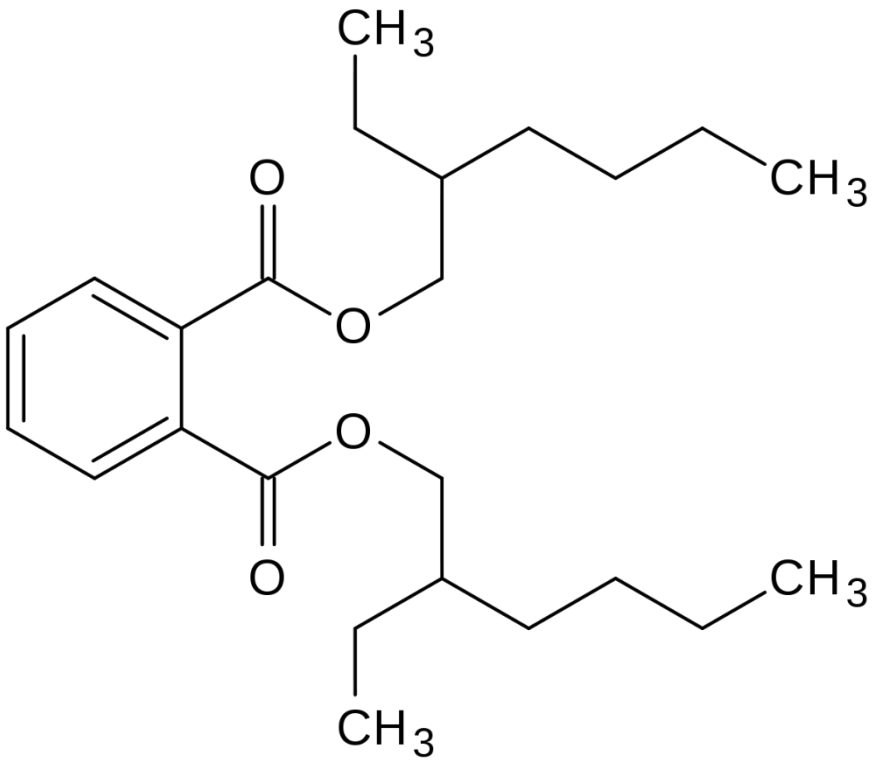

Figure1.1: Structure of DEHP.

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1.2.1 Reproductive and Developmental Toxicity of Phthalates

Phthalates acquires endocrine-disrupting properties and their exposure to high concentrations will lead to fatal death, cancer, deformations, liver and kidney damage and reproductive toxicity in animals. In human beings, major problem have been arisen related to detrimental effects. Consequent exposure to phthalates during their development, phthalates can be transferred from maternal blood to developing foetus and into infants through breast milk and these exposures may impact the endocrine system which is critical for various biological functions involving reproductive functions. In addition phthalates were also found in breast milk, seminal fluid and placenta. Phthalates may also unfavourably affect other functions such as metabolic processes, thyroid signalling and immune system. (Jan L. Lyche et al, 2016)

1.2.2 Phthalate Toxicity in Food

Food is the major source of exposure of phthalates in humans, European Food Safety Authority (EFSA) through speculations of scientists on food preservatives, additives and materials has determined the tolerable daily doses (TDI) for some major phthalates and evaluated that exposure of phthalates in human through dietary products is within the estimated TDI set between 0.03 to 0.2 mg/kg of body weight. Generally phthalates used in food material such as tubes, conveyer belt and disposable material have been found as a major source of phthalate contamination. (European Food Safety Authority; 2005, Pasquale Ventrice, 2013)

1.2.3 Phthalate Toxicity in Water

The aquatic environment is a significant reservoir of phthalates receiving the waste water discharge, landfill leachate and rainfall. There has not been any estimation available regarding the presence of Phthalates at a national scale for recognizing their hazardous risk levels. In China the Environmental Quality Standards for Surface Water and Standards for Drinking Water Quality have regulated the limit values for phthalates (Xiaowie Lie, 2013).

Plastic bottles manufactured from Poly Vinyl Chloride (PVC) containing Phthalates used as plasticisers are used globally for packing drinking water; the usage of water bottles has been constantly rising worldwide over the recent few years (Imran Al-saleh, 2011).

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1.2.4 Phthalate Toxicity in Cosmetics

Phthalates are widely used in many applications such as skin care products (skin moisturizer, skin softeners), nail polish and sealants. There are number of phthalates reported to be found in cosmetics for example, DEHP, DEP(diethyl phthalate), DBP and DBB (dibutylbenzyl phthalate). Diethyl phthalate was noted to be present in 67 skin care products. 309 patents have been held including 120 nail polishes and enamels and 27 manicuring formations. These products may have adverse health impacts on human body through direct contact with skin, hair, nails and mucous membrane (Hyun Jung Koo, 2004).

1.2.5 Phthalate Toxicity in Soil

The main sources of phthalates in soil are waste water irrigation, pesticides, insecticides and other industrial productions. There are many pathways where phthalates are distributed in soil. The retention and transport of phthalates in soil is dependent upon the type of soil, anthropogenic actions and land usage whereas other weather factors (temperature, humidity) are also likely to affect the soil by the degradation and percolation of phthalates through soil profile. Phthalates contamination in soil also impact microbial population which is crucial for nutrient recycling, controlling pests and preservation of soil structure(Lizhi He, 2014).The lysimeter studies showed the presence of DEHP in both soil and leachate samples indicating that it could migrate to deeper soil layers causing groundwater contamination (Suresh, 2019).

1.2.6 Phthalates Toxicity in Indoor Air and Dust

People used to spend long time indoors and indoor source of contamination associated with constrained ventilation and slower contaminant degradation process leads to high pollutant levels. Polluted Indoor Air is found to be the most consequential environmental hazard to human health. Many endocrine-disrupting compounds (EDCs) such as plastics, detergents and other domestic products are reported as critically indoor contaminants (less studies has been done). Various researches have been done on many phthalates and are found to dominate indoor air. Diethyl phthalate (DEP) and di-n-butyl phthalate were reported at a high concentration in both air and dust.

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Table 1.1 *Concentrations of phthalates in Environment and their toxic effects on human health.*

SN	Sources	Phthalate Compounds	Observed Concentration	Toxic Effects	References
1	River Water	DEP, DMP, BBP, DEHP	313-4640 ng/l	Impacts aquatic organisms (Increased mortality, decreased body weight and distortion of sex ratio in embryos)	B R Ramaswamy et al, (2014)
2	Indoor Air	DEP, DBP, DEHP	Less than 10 ppb	Upper airway irritation and Asthma	Karen Chou et al, (2006)
3	Soil	DMP, DEP, DnBP, DnOP, DEHP and BBP	0.032-6.29 mg Kg-1	Carcinogenic risk in humans through dietary pathways	L Niu et al, (2014)
4.	Foodstuff (Grain, bread and cereal products)	DEHP	300ug/kg	Reproductive toxicity in adults, insulin resistance and type II diabetes, obesity, allergy, asthma, cancer	Serrano et al, (2014)
5.	Personal care products (perfumes shampoo, skin moisturizers) Adhesives	MMP,DEHP,DEP, DBP,DBB	4.6 ug/l	Dermal toxicity, skin inflammation, allergic dermatitis	M. Mariama et al, (2016)

1.3. Conclusion

Presence of phthalates in the environment is hazardous for human health and ecosystem. Over the past decades, researches have indicated that phthalates can leach into the ecosystem from varying sources and affect human health and environment. Measures of phthalate toxicity vary widely according to phthalate type and its molecular structure. Leaching of Phthalate can lead to contamination of food, air, soil and water etc. which ultimately disturbs human health and environment. Various studies available on human health impact of phthalate are showing evidence of a wide range of adverse effects in the urinary tract, semen, pregnancy, reproductive tract, kidneys, lungs, foetus, and heart. Further studies have to be carried to understand the detailed pathway of Pthalate degradation to develop regulatory measures.

1.4. References

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Abbreviations

Benzylbutyl phthalate	BzBP
Dimethyl phthalate	DMP
Di-n-butyl phthalate	DnBP
Diethyl phthalate	DEP
Di-2-ethylhexyl phthalate	DEHP
Di-isononyl phthalate	DnOP
Di-n-butyl phthalate	DnBP
Benzyl butyl phthalate	BBP