VOLUME 9 ISSUE 2 2023

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 9, No. 2, 841-848 (2023)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Pesticide Residues in Human Milk: Health Impacts on Infants and Nursing Mothers

Prabhu Nilima S.[1]* and Meshram Leena N.[2]

[1]Department of Zoology, Chikitsak Samuha's S. S. and L. S. Patkar College of Arts and Science, and V. P. Varde College of Commerce and Economics,
Goregaon (West), Mumbai 400102, Maharashtra, India
[2]Department of Zoology, Mahatma Phule Arts, Science and Commerce College, Panvel, Raigad, Navi Mumbai 410 206, India

**Corresponding Author*

Received: 2nd August, 2023; **Accepted:** 22nd September, 2023; **Published online:** 9th October, 2023

https://doi.org/10.33745/ijzi.2023.v09i02.094

Abstract: Human breast milk is the only natural food of newly born infant as it provides essential nutrients and other supplementary requirements to support the growth and development of natural immunity during early infancy. Children provided with breast feeding up to 6 months after birth, show healthy growth with reduced chances of gastrointestinal diseases and other ailments. Presence of pesticide residues and other persistent organic pollutants in human breast milk posed a major and increasing threat to health of infants and also to the nursing mothers. This review aims to discuss the various aspects of pesticide residues in human milk and its adverse health impacts on infants and nursing mothers. It was noted that, various pesticides are still the major contaminants of human milk. Therefore, monitoring of human milk samples should be practised on a larger scale. General symptoms of pesticide residue toxicity of human milk include weakness, headache, backache, joint pain, fever, hepatitis, liver dysfunction, chest pain, respiratory discomfort, and hypertension. Safety measures recommended should include, dietary intake assessment of foods of different animal origin, monitoring of human milk samples, strict government guidelines for application of pesticides, and use of personal protection kits by women working in agriculture fields, and other areas where they are exposed to pesticides.

Keywords: Human milk, Bioactive factors, Colostrum, Infants, Organochlorines, Organophosphates, Pesticide residues, Pyrethroids, Nursing mothers

Citation: Prabhu Nilima S. and Meshram Leena N.: Pesticide residues in human milk: Health impacts on infants and nursing mothers. Intern. J. Zool. Invest. 9(2): 841-848, 2023.

https://doi.org/10.33745/ijzi.2023.v09i02.094

Introduction

Milk is the secretory fluid of the mammary glands of female mammals and contains nearly all the nutrients necessary to sustain life (Grosch, 2008). It is a whitish liquid containing milk proteins, fats,

lactose, and various vitamins and minerals, produced by the mammary glands of all adult female mammals after childbirth and serves as food for their young (Mourad *et al*., 2014). Milk has been known as nature's most complete food and play an important role in the diet of over 6 billion people in the world (Widyastuti and Febrisiantosa, 2021).

WHO (2003) noted that, human milk is the first food received by the baby since breast milk is well adapted to the needs of the infant and it was recommended universally to breast feed the baby at least for first 4-6 months of life (Mane *et al*., 2018). Human breast milk provides complete nutrition and many bioactive health factors. Breast feeding is associated with improved infant health and immune development, less incidences of gastrointestinal disease and lower mortality rates than formula fed infants (Lyons *et al*., 2020).

Human milk is uniquely suited to the human infant, both in its nutritional composition and in the non-nutritive bioactive factors that promote survival and healthy development. It contains many hundreds to thousands of distinct bioactive molecules that protect against infection and inflammation and contribute to immune maturation, organ development, and healthy microbial colonization (Ballard and Morrow, 2013).

Human milk not only provides the perfectly adapted nutritional supply for the infant but also plays a crucial role in promoting healthy growth and development (Mosca and Gianni, 2017). It is the best food for new-born nutrition and it provides protection for the health of the infant during the first weeks of life (Boquien, 2018). Human breast milk is essential for the infant's growth and development right after birth and is an irreplaceable source of nutrition for early human survival (Kim and Yi, 2020).

Composition of human milk:

Ballard and Morrow (2013) reported that composition of human milk is the biologic norm for infant nutrition. Composition of human milk is dynamic, and varies within a feeding, diurnally, over lactation, and between mothers and populations. Macronutrients present in 100 g of human milk consist of ash (0.2), energy (65 kcal), fat (3.2 g), lactose (7.2 g), protein (1.2 g) and water (87.5 g). Micronutrients present in human milk are vitamins (A, B1, B2, B6, B12, D) and minerals and trace elements (Ca, P, Mg, S, N, Na, K, Cl, Fe, Cu, Zn, Co, I) (FAO, 2013).

Major bioactive factors present in human milk consists of Cells (Macrophages, Stem cells); Immunoglobulin's (IgA, IgG, IgM); Cytokines (IL-6, IL-7, IL-8, IL-10); Chemokines (G-CSF, MIF); Cytokine Inhibitors (TNFR I and II); Growth factors (EGF, HB-EGF, VEGF); Hormones (Calcitonin, Somatostatin, Adiponectin, Leptin, Ghrelin); and Anti-microbial (Lactoferrin, Lactadherin) (Ballard and Morrow, 2013; Haschke *et al*., 2016; Salama, 2017).

Health benefits of human milk (*Yi and Kim, 2021*):

- Growth and development.
- Intestinal colonization.
- Immunity development.
- Host immunization.
- Prevention from diseases.
- Psychosocial development: Breastfeeding promotes the emotional relationship, or bonding, between mother and child (UNEP, 2017).

Therapeutic value of human milk (*Witkowska-Zimny et al., 2019*):

- Natural medicine and health impacts are life-long (Sheila and Bungum, 2003).
- Treatment for diaper rash, atopic eczema, diaper dermatitis, and umbilical cord separation (Allam *et al*., 2015).
- Protection against diabetes mellitus, obesity, hyperlipidemia, hypertension, cardiovascular diseases, autoimmunity, and asthma (Witkowska-Zimny *et al*., 2019).

- Fresh colostrum and human milk were used to treat conjunctivitis, chapped nipples, rhinitis, infections of the skin and soft tissues (Witkowska-Zimny *et al*., 2019).
- Support early human growth and development (Kim and Yi, 2020).
- Reduced risks of otitis media, acute diarrhoea, lower respiratory tract infections, sudden infant death syndrome, inflammatory bowel disease, juvenile leukemia, diabetes, obesity, asthma, and atopic dermatitis (Yi and Kim, 2021).
- Lowers mortality against infectious diseases (Yi and Kim, 2021).

Pesticides: *Definition, Types, Benefits and Adverse effects*:

Pesticide is defined as a chemical designed to combat the attacks of various pests and vectors on agricultural crops, domestic animals, and human beings (Şahin *et al*., 2017). Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, including insecticide, herbicide, fungicide, and various other substances used to control pests are called as, pesticides (EPA, 2009).

Pesticides are classified on the basis of mode of action and/or mode of entry or the approach by which a pesticide controls or kills the target pest, chemical structure, the features of pesticides, and the character of the target pests (Hassaan and Nemr, 2020). On the basis of chemical composition, pesticides are categorized into organochlorine, organophosphate, pyrethroids, carbamates and bio-pesticides (Nayak and Solanki, 2021).

Pesticides are also categorized into subtypes such as: acaricides (kill mites, ticks and spiders); fungicides (kill fungi and moulds); herbicides (kill weeds or prevent growth of weeds); insecticides (kill or repel insects and related species); molluscicides (kill snails, slugs, etc.); nematicides (kill nematodes); rodenticides (kill rats, mice, moles and other rodents); and miscellaneous pesticides (kill or repel pests of all types).

Pesticides have applications in agriculture (for control of weeds, pests, rodents etc.); domestic (household and garden spray, control of animals and birds); material building (incorporation of paints, glues, plastic protection sheeting, foundation of buildings etc); personal (for application of clothing and skin care); and public health (for control of malaria, dengue fever, cholera) (Gyawali, 2018). Environmental impacts of pesticides include contamination on natural environment (water, soil, air); impact on food safety, non-target organisms; and threats to aquatic and terrestrial biodiversity (Poudel *et al*., 2020). Impacts of pesticides on human health include neurotoxic, genotoxic, carcinogenic, and reproductive effects (Shah, 2020).

Pesticide Residues:

Pesticide residues includes any derivative of a pesticide, such as conversion products, metabolites, reaction products and impurities considered to amounts of residues primarily depend on nature of pesticides, environmental conditions, good agricultural practices, waiting periods and storage conditions (Mondal *et al*., 2021).

Pesticides are commonly used in agriculture to enhance crop production and control pests. After application of pesticides to soil or used to treat crops, they are capable of migrating within various environments and, ultimately, accumulate in food chains or persist as degradation products (Pirsaheb *et al*., 2015; Silva *et al*., 2019). Pesticide residues can persist in the environment and agricultural crops. It can produce long-term negative effects on the health of humans and animals and stability of ecosystems by molecular mechanisms that mediate the start of a cascade of adverse effects (Valeriya *et al*., 2021).

To control the presence of pesticide residues in fresh milk and milk products is a big issue for producer, consumer and government due to the potential risk (Makadiya and Pandey, 2017).

Table 1: Pesticide residues detected in human milk samples

Pesticide residue detected	Area	Reference
3'BHC, Dieldrin, DDE, TDE, DDT, Total DDT	Iranian Nursing Mothers	Hashemy-Tonkabony and Fateminassab (1977)
Dieldrin, Heptachlor epoxide, PCBs, DDT (including metabolites)	United States and Canada	Calabrese (1982)
p,p'- DDE, p,p'-DDT and β-HCH	Middle and Upper Egypt	Salem and Ahmed (2002)
Endosulfan, Malathion, Chlorpyrifos, Methyl-parathion, R -HCH	Bhopal, Madhya Pradesh, India	Sanghi *et al*. (2003)
PCBs, DDT, hexachlorocyclohexanes (HCHs), hexachlorobenzene (HCB), chlordane compounds (CHLs), tris-4-chlorophenyl-methane (TCPMe)	Hanoi and Hochiminh city, Vietnam	Nguyen *et al*. (2004)
Chlorpyrifos	Tennessee, Knoxville	Casey (2005)
DDT and pyrethroid	Ubombo and Ngwavuma districts, KwaZulu-Natal Province, South Africa	Bouwman *et al*. (2006)
OCP Lindane (gamma HCH), DDT and it's metabolites (DDD and DDE)	Armenia	Artashes *et al*. (2007)
p,p'-DDT, p,p'-DDE, p,p'-DDD and o,p'-DDT	South African villages	Bouwman *et al*. (2012)
Cypermethrin, deltamethrin, malathion	Karachi-Pakistan	Uzma *et al*. (2012)
α-HCH, β-HCH, γ–HCH, Σ-HCHs, Aldrin, Dieldrin, Endrin, Σ-Cyclodienes, p,p'-DDT, p,p'-DDD, p,p'-DDE, Σ-p,p'-DDTs, Σ-OCPs	Rosetta region Northern of Delta in Egypt	Abbassy (2017)
Dichlorvos	Isparta province, Turkey	Şahin *et al*. (2017)
α-HCH, β-HCH, γ-HCH, ΣHCHs, HCB, o,ṕ -DDE, p, ṕ -DDE, p, ṕ -DDT, p, ṕ -DDD, ΣDDTs	Marivan, west of Iran	Shahmoradi *et al*. (2019)
Neonic Residues, Acetamiprid-N-desmethyl, imidacloprid	China	Chen *et al*. (2020)
Chlorpyrifos, p, ṕ -DDE, p, ṕ -DDT	North-western Himalayan region of India	Sharma *et al*. (2020)
Aldrin, dieldrin, endrin, hexachlorobenzene, α-, β-, and γ-hexachlorocycohexame, pp'-,op'-DDT, pp'-DDE, pp'-DDD, alpha and gamma chlordane, heptachlor, mirex and methoxychlor.	Riyadh, Al-Kharj, Al-Jobail and Al-Dammam cities in eastern and central Saudi Arabia.	EL-Saeid *et al*. (2021)
DDT and its metabolites; p,p′-DDE, p,p-DDD, and o,p-DDT	South-western Ethiopia	Mekonen *et al*. (2021)
Aldrin, Dieldrin, Endrin, Endrin Aldehyde, Endrin Ketone, Heptachlor, Heptachlor-Epoxide Isomer B, Methoxychlor, Alpha-Endosulfan, Beta-Endosulfan, Endosulfan Sulfate, HCH, DDE, DDD, DDT	North-western Poland	Witczak *et al*. (2021)
Glyphosate	Francisco Beltrao, Paraná state, Brazil	Camiccia *et al*. (2022)
Organochlorines (OCPs): (o,p?-DDE) and (p,p?-DDE)	Kalaburagi district, Karnataka, India.	Prashant and Vijaykumar (2022)

Table 2: Health effects of pesticide residues in human milk on infants and nursing mothers

Health Concerns	References
• Carcinogenic (breast cancer). • Deleterious effects on the immune system. • Hyporeflexia, convulsions, EEG abnormalities, hepatic disorders and blood dyscrasias.	Krieger *et al*. (1994)
• Weakness, Headache, Backache, Joint pain, Fever. • Hepatitis, liver dysfunction, chest pain, Respiratory discomfort, Hypertension,	Kackar *et al*. (1999)
• Cancer and in extreme cases, death. • Aberrations in cognitive, behavioural, sensory, and motor development in children.	Rauh *et al*.,(2011)
• Altered reproductive function in males and females. • Increased incidence of breast cancer. • Abnormal growth patterns. • Neurodevelopmental delays in children. • Changes in immune function.	WHO/UNEP (2012)
• Exposure may result in either acute or chronic effects. • Acute effects: Irritation, dermatitis, and death. • Chronic exposure: Cancer, birth defects, neurotoxicity, neurobehavioral disorders, neurophysiological changes, and adverse effects on reproduction and fertility.	WHO/UNEP (2014)
• Adverse effect on the lactation process and content of nutrients in the milk. • Oxidative damage, biochemical and histopathological alterations.	Pirsaheb *et al*. (2015)
• Neurotoxicity. • Deleterious impacts on the neurodevelopment of infants.	Han *et al*. (2018)
• Can cause a variety of diseases. • Carcinogenic risks, neurotoxicity, and genotoxicity. • Destructive effects on the endocrine, reproductive and immune systems.	Kuang *et al*. (2020)
• Endocrine disruption and reproductive toxicity. • Gonadal changes, changes in reproductive behavior, an increase in organ malformations (e.g., hypospadias), fetal defects, thyroid dysfunction, etc.	Witczak *et al*. (2021)

Human milk is contaminated through the contaminated food. These residues are too much persistent. They accumulate in body fat even in breast milk. Therefore, the objective of present study was to review the concentration of pesticide residues in human milk and to generate awareness about the lethal effects of these pesticides on infants and nursing mothers.

Pesticide residues recorded in human breast milk:

Table 1 illustrates the detected pesticide residues in samples of human milk.

Adverse Health Effects on Infants and Nursing mothers:

Table 2 illustrates the various health effects of pesticide residues in human milk in infants and nursing mothers.

Safety measures for pesticide residues in human milk:

- Monitoring of foods of animal origin, fishes, vegetables, fruits and grains for pesticide residues.
- Frequent monitoring of human milk samples for pesticide residues.
- Dietary intake assessment.

- To create awareness among pregnant and nursing mothers regarding health hazards by pesticide residues from food.
- Strict government guidelines regarding application of pesticides in agriculture and public places.
- Regular monitoring of drinking water and other water resources for pesticide residues.
- Use of personal protection kits by women working in agriculture fields, grain storage houses, handling of fruits and vegetables, etc.

Conclusion

Results of this study clearly indicate that various pesticides are the major contaminants of human milk. Therefore, monitoring of human milk samples should not be neglected and can be practised on a larger scale. Breast-feeding is recommended despite the presence of chemical residues (Rogan, 1996). Present study reveals that the benefits of breastfeeding outweigh its disadvantages. Dietary intake assessment of foods of animal origin, fishes, vegetables, fruits and grains for the presence of pesticide residues is recommended. The preventive measures suggested are monitoring of human milk samples for pesticide residues and to create awareness among pregnant and nursing mothers regarding health hazards by pesticide residues. Strict government guidelines should be imposed for application of pesticides in agriculture and public places. Use of personal protection kits by women working in agriculture fields, grain storage houses, handling of fruits and vegetables, will also mitigate the hazards of pesticide residues from human milk up to a greater extent.

References

Abbassy MMS. (2017) Pesticide residues in buffalo and human breast milk of vegetables and fruits farming community at Northern of Delta in Egypt. J Environ Anal Toxicol., 7: 432.

Allam N, Megrin W and Talat A. (2015) The effect of topical application of mother milk on separation of umbilical cord for newborn babies. Am J Nurs Sci. 4: 288-296.

Artashes T, Stephen JR, Kevin MK, Laurence F, Albert M, Natalya T, Margarita P and Suren B. (2007) Organochlorine pesticide residues in breast milk in Armenia. J Pre-Clin Clin Res. 1(1): 084-088.

Ballard O and Ardythe LM. (2013) Human milk composition: nutrients and bioactive factors. Pediatr Clin North Am. 60(1): 49-74.

Boquien CY. (2018) Human milk: An ideal food for nutrition of preterm new-born. Front Pediatr. 6: 295.

Bouwman H, Henrik K, Barbara S and Riana B. (2012) High levels of DDT in breast milk: Intake, risk, lactation duration, and involvement of gender. Environ Pollut. 170: 63-70.

Bouwman H, Sereda B and Meinhardt HM. (2006) Simultaneous presence of DDT and pyrethroid residues in human breast milk from a malaria endemic area in South Africa. Environ Pollut. 144: 902e917.

Calabrese, Edward J., 1982. Human Breast Milk Contamination in the United States and Canada by Chlorinated Hydrocarbon Insecticides and Industrial Pollutants: Current Status. Journal of the American College of Toxicology, 1(3): 91-98.

Camiccia M, Candiotto LZP, Gaboardi SC, Panis C and Kottiwitz LBM. (2022) Determination of glyphosate in breast milk of lactating women in a rural area from Paraná state, Brazil. Braz J Med Biol Res. 55: e12194,

Casey KA. (2005) Chlorpyrifos in Human Breast Milk?. Ph.D. Thesis, University of Tennessee. https://trace.tennessee.edu/utk_graddiss/672.

Chen D, Zhibin L Holly B, Jiajun H, Bing L, Yan Li, Jingguang L, Yunfeng Z and Yongning W. (2020) Nationwide biomonitoring of neonicotinoid insecticides in breast milk and health risk assessment to nursing infants in the Chinese population. J Agric Food Chem. 68(47): 13906-13915.

El-Saeid, Mohamed H, Ashraf SH and Abdulqader YB. (2021) Levels of pesticide residues in breast milk and the associated risk assessment. Saudi J Biol Sci. 28: 3741-3744.

EPA. (2009) What is a pesticide? http://www.epa.gov/opp00001/about/.

FAO (Food and Agriculture Organization of The United Nations) (2013) Milk and dairy products in human nutrition. ISBN 978-92-5-107863-1.

Grosch W. (2008) Milk and Dairy Products. In: Food Chemistry,(eds.) Belitz H.D., Grosch W. and Schieberle P., Springer, pp. 498-521.

Gyawali K. (2018) Pesticide uses and its effects on public health and environment. J Hlth Promotion 6: 28-36.

Han W, Tian Y and Shen X. (2018) Human exposure to neonicotinoid insecticides and the evaluation of their potential toxicity: An overview. Chemosphere 192: 59-65.

Haschke F, Nadja H and Sagar KT. (2016) Breast milk: Nutritive and bioactive proteins. Ann Nutr Metab. 69 (suppl 2): 17-26.

Hashemy-Tonkabony SE and Fateminassab F. (1977) Chlorinated pesticide residues in milk of Iranian nursing mothers. J Dairy Sci. 60: 1858-1862.

Hassaan MA and Ahmed EN. (2020) Pesticides pollution: Classifications, human health impact, extraction and treatment techniques. Egyptian J Aquat Res. 46: 207-220.

Kackar R, Srivastava MK and Raizada RB. (1999) Assessment of toxicological effects of mancozels in male rats after chronic exposure. Indian J Exp Biol. 37: 553-559.

Kim SY and Dae YY. (2020) Components of human breast milk: from macronutrient to microbiome and microRNA. Clin Exp Pediatr. 63(8): 301-309. https://doi.org/10.3345/cep.2020.00059.

Krieger N, Wolff MS, Haitt RA, Rivera M, Vogelman J and Orentreich N. (1994) Breast cancer and serum organochlorines: a prospective study among white, black and Asian women. J Nat Cancer Inst. 86: 589-599.

Kuang L, Yizhong H, Fangqu H, Huachang H, Hongjie S, Wenjing D and Hongjun L. (2020) Pesticide residues in breast milk and the associated risk assessment: A review focused on China. Sci Total Environ. 727: 138412.

Lyons KE, Anthony CR, Eugene MD, Paul RR and Catherine S. (2020) Breast milk, a source of beneficial microbes and associated benefits for infant health. Nutrients 12: 1039.

Makadiya J and Pandey A. (2017) Detection of pesticides in buffalo milk collected from different areas of Gandhinagar and Ahmedabad by Thin Layer Chromatography. Int J ChemTech Res. 10(1): 231-238.

Mane SM, Patil NJ, Alka, Nerurkar V and Patharkar S. (2018) The study of biochemical composition of breast milk in malnourished mothers versus well-nourished mothers. Int J Recent Trends Sci Technol. 8(2): 13-16.

Mekonen S, Argaw A, Mekitie W, Patrick K and Pieter S. (2021) Exposure of infants to organochlorine pesticides from breast milk consumption in southwestern Ethiopia. Sci Rep. 11: 22053.

Mondal P, Vishwanath HA, Mukherjee K, Ghosh SK and Karmakar R. (2021) Pesticide residues: Analysis, impact and mitigation. In: Handbook of Agriculture, Environment and Biotechnology, (eds.) Rakshit A., Singh H.B., Singh A. K., Abhilash P. C., Sarma B. K., Tripathi V. K.and Parewa H. P., Assoc Agricult Environ Biotechnol., New Delhi, India, pp. 425-449.

Mosca F and Gianni ML. (2017) Human milk: composition and health benefits. La Pediatria Medica e Chirurgica 39: 155.

Mourad G, Guessas B and Medjekal S. (2014) Composition and nutritional value of raw milk. Issues Biol Sci Pharmaceut Res. 2(10): 115-122.

Nayak P and Solanki H. (2021) Pesticides and Indian agriculture- a review. Int J Res Granthaalayah 9(5): 250-263.

Nguyen HM, Masayuki S, Tu BM, Tatsuya K, Hisato I, Mafumi W, Shinsuke T, Pham HV and Bui CT. (2004) Persistent organochlorine residues in human breast milk from Hanoi and Hochiminh city, Vietnam: contamination, accumulation kinetics and risk assessment for infants. Environ Pollut. 129: 431-441.

Pirsaheb M, Limoee M, Namdari F and Khamutian R. (2015) The association between air pollution and weather conditions with increase in the number of admissions of asthmatic patients in emergency wards: a case study in Kermanshah. Med J Islam Repub Iran 29: 228.

Poudel S, Bikash P, Birochan A and Puspa P. (2020) Pesticide use and its impacts on human health and environment. Environ Ecosystem Sci. 4(1): 47-51.

Prashant V and Vijaykumar K. (2022) Analysis of organochlorine pollutants in mother's milk from Kalaburagi district, Karnataka, India. Int J Food Nutr Sci. 11: 1-6.

Rauh V, Arunajadai S, Horton M, Perera F, Hoepner L, Barr DB and Whyatt R. (2011) Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide. Environ Health Perspect. 119(8): 1196-1201.

Rogan WJ. (1996) Pollutants in breast milk. Arch Pediatr Adolesc Med. 150(9): 981-990.

Şahin G, Ersin U, Recep A and Tufan N. (2017) Determination of the residue levels of some commonly used organophosphorus pesticides in breast milk. Ankara Med J. 17(1): 9-20.

Salama AK. (2017) Lactational exposure to pesticides: A review. Toxicol Open Access 3(1): 1000123.

Salem DA and Maher MA. (2002) Evaluation of some organochlorine pesticides in human breast milk and infants' dietary intake in middle and upper Egypt. Alexandria J Pediatr. 16(2): 259-265.

Sanghi R, Pillai MKK, Jayalekshmi TR and Nair A. (2003) Organochlorine and organophosphorus pesticide

residues in breast milk from Bhopal, Madhya Pradesh, India. Human Exp Toxicol. 22: 73-76.

Shah R. (2020) Pesticides and human health. In: Emerging Contaminants, (ed.) Nuro A., IntechOpen; 2021. http://dx.doi.org/10.5772/intechopen.93806.

Shahmoradi B, Maleki A, Kohzadi S, Khoubi J and Zandi S. (2019) Levels of organochlorine pesticides in human breast milk in Marivan, west of Iran. J Adv Environ Health Res. 7(1): 32-37.

Sharma ND, Chandel RS, Sharma ID, Sharma PL and Gurung B. (2020) Pesticides contamination of lactating mothers in the North-western Himalayan region of India. J Environ Biol. 41: 23-28.

Sheila GJC and Bungum TJ. (2003) The benefits of breastfeeding: An introduction for health educators. Californian J Health Promotion 1(3): 158-163.

Silva LCC, Vanerli B, Ronaldo T and Daisy PN. (2014) Milk contamination by organophosphorus and carbamate residues present in water and animal feedstuff. Semina Ciências Agrárias Londrina 35(5): 2485-2494

UNEP. (United Nations Environment Programme) (2017) Global Monitoring Plan on Persistent Organic Pollutants Guidelines for Organization, Sampling and Analysis of Human Milk on Persistent Organic Pollutants.Chemicals Branch, Division of Technology, Industry and Economics (DTIE), United Nations Environment Programme (UNEP), pp. 39.

Uzma M, Mohammad AA, Mohammad AA and Syed NHN. (2012) Effect of pesticide residues on health and different enzyme levels in the milk of women from Karachi-Pakistan. J Basic Appl Sci. 8: 444-450.

Valeriya PK, Elena NE, Kseniya VK and Valentina A. (2021) Pesticides: formulants, distribution pathways and effects on human health – a review. Toxicol Rep. 8: 1179-1192.

WHO (World Health Organization) (2003) United Nations Children's Fund. Global strategy for infant and young child feeding, Geneva.

WHO/UNEP (World Health Organization/United Nations Environment Programme) (2014) Toxic Hazard. Geneva: World Health Organization (WHO); 2014.

WHO/UNEP. (2012) State of the science of endocrine disrupting chemicals – 2012 An assessment of the state of the science of endocrine disruptors prepared by a group of experts for the World Health Organization and the United Nations Environment Programme, Geneva. http://www.who.int/ceh/publications/endocrine/en/.

Widyastuti Y and Febrisiantosa A. (2021) Milk and different types of milk products. In: Advances in Food Science and Nutrition, (eds.) Visakh P.M, Laura B. Iturriaga and Pablo Daniel Ribotta, Scrivener Publishing LLC., pp. 49-68.

Witczak A, Pohoryło A and Abdel-Gawad H. (2021) Endocrine-disrupting organochlorine pesticides in human breast milk: changes during lactation. Nutrients 13: 229.

Witkowska-Zimny M, Kaminska-El-Hassan Ewa and Wróbel E. (2019) Milk therapy: Unexpected uses for human breast milk. Nutrients 11: 944.

Yi DY and Kim SY. (2021) Human breast milk composition and function in human health: From nutritional components to microbiome and micrornas. Nutrients 13: 3094.