CHAPTER II

REVIEW OF LITERATURE
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Milk claims a unique place in human diet worldwide. With all its valuable constituents like fat, protein (casein and lactalbumin) and lactose, in a balanced proportion, milk has special importance on nutritional standpoint. Therefore, the importance and utility of milk at different stages of human life (infants, adults, old age) is undebatable. The contamination of milk by OCPs is considered as one of the main dangerous aspects in the last few years. Thus, by determining their contents in milk, we can have an estimation of regional environmental contamination and this may be of great value for scientific and public health knowledge.

In this section an attempt has been made to present a short review of the available literature in India and abroad with respect to level of OCP residues detected in bovine and human milk, seasonal variation of OCP in milk, OCP residue level comparison with recommended MRLs and various health impacts of OCP contamination in human/infants.

OCP residue level in bovine milk

Kannan K et al. (1992) analyzed different foodstuffs collected from different regions in India for the presence of HCH (BHC), DDT, HCB, aldrin, dieldrin, heptachlor, and PCBs. They reported that dairy products and livestock meat are the prime sources of human dietary exposure to OCPs for the occurrence of significantly
high levels of food contamination with HCH, DDT, aldrin, and dieldrin throughout India.

Willett L B et al. (1993) found detectable residues of DDE [1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene] in milk fat and adipose tissues when cattle were allowed to graze land previously used as orchards. They reported that concentrations of DDE exceeded 0.3 mg/g at times and it’s concentration in adipose tissue were similar to those in milk fat at the beginning of lactation; residues in first lactation cows were approximately three times higher than in multiparous cows that were grazing similarly. Based on the equation [DDE, micrograms/g] milk fat = 0.28 (daily dose, mg) they found that, consumption of soil was likely not the sole source of residue when soil concentrations of DDT [1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane], DDE, and DDD [1,1-dichloro-2,2-bis(p-chlorophenyl)ethane] ranged from non-detected to 3.6, 2.1, and .655 mg/g, respectively. But grass appeared to be the likely source. The study was carried out in four plots located on three orchard locations with one control location and grasses in subplots were harvested at 2-, 4-, or 6-week intervals during the 18-week study. Grasses were also extracted differentially to determine DDT and DDE residues adhering to the plant surface and those associated with plant tissue and the DDE averaged between 0.01 and 0.11 mg/g in dry grass tissues. They reported that the differences between residues in grasses among plots were associated with soil residue concentrations and concentrations of DDE were not associated with air or soil temperature, relative humidity, solar radiation, or dry biomass harvested and also
precipitation increased the volatilization of residues from soil and deposition in 2 and 4 wk grass samples.

**Losada A et al. (1996)** determined the residue levels of the organochlorine pesticides (α HCH, lindane, heptachlorepoxide, aldrin, endrin, dieldrin, o,p'TDE, p,p'TDE, p,p'DDE and p,p'DDT) in raw bovine milk and compared it with the maximum levels allowed by the European Union (EU) in these foods. They reported highest incidence percentage of the ten insecticides measured was for lindane, followed by αHCH and aldrin and the highest mean residue level was for α HCH. But none of the samples analyzed exceeded the maximum levels allowed by the EU.

**Moran Z A (1996)** carried out a study in Nicaragua (December 1993 and March 1994) with 48 different milk samples collected from 48 different sites in the country to build a profile of the contamination of cow's milk with 10 organochlorine pesticides. The samples were analyzed for residues of hexachlorobenzene (HCB), alpha BHC, lindane, aldrin, dieldrin, oxychlordane, heptachlor epoxide, and the principal metabolites of DDT (p,p'TDE, p,p'DDE, and p,p'DDT) by means of solid phase extraction from milk fat, and the quantity of the residues was determined by gas chromatography with electron capture detection. Heptachlor epoxide was found in 1 milk sample, dieldrin in 1, lindane in 3, oxychlordane in 3, alpha BHC in 3, aldrin in 6, HCB in 9, and metabolites of DDT in 39 (81% of the samples). He reported that six samples which were most heavily contaminated with byproducts of DDT came from the departments of León and Chinandega, in the Pacific region, where there used to be intensive cotton production and the highest concentration was found in the sample from Malpaisillo, with 1105 mg
of pesticide per kg of milk fat. He recommended that studies should be done so that the risk of contamination of other food products can be estimated, and that the public's health should be protected through strict control of the production or importation, storage, sale, and use of organochlorine pesticides.

**Waliszewskia S M et al. (1996)** determined the contamination levels of OCPs of 192 samples of cow's milk collected from the central region of Veracruz State. They reported that mean DDT and HCH levels were 0.0057 and 0.0098 mg/ kg respectively expressed on fat basis and are within FAO tolerances and similar to those found in other tropical countries.

**Waliszewski S M et al. (1997)** studied 355 samples of cow's milk collected from the central region of Veracruz State and 448 samples of national butter brands to determine the contamination levels of organochlorine pesticides. They found that mean HCH levels were 0.094 and 0.093 mg/kg and mean DDT levels were 0.159 and 0.049 mg/kg, on fat basis in cow's milk and butter samples, respectively. In relation to cow's milk, the total HCH levels in Veracruz State were higher but total DDT levels were comparable to those reported in other countries. On the other hand, organochlorine levels detected in national brand butter samples were lower than those found in other countries, where these pesticides are still used in sanitary actions. Their results confirmed that dairy products in Mexico presented organochlorine pesticide residues (owing to their use in sanitary actions) indicating a human exposure through these food products.
Wong S K and Lee W O (1997) conducted a survey from 1993 through 1995 to monitor organochlorine pesticides and their metabolite residues in milk available in local Hong Kong markets. Of 252 samples analyzed, including pasteurized milk, fresh milk, and raw milk, they found 42 contained organochlorine pesticide residues at levels exceeding the Extraneous Maximum Residue Limits of the Codex Committee on Pesticide Residues. They reported that DDE and HCH isomer levels were substantially higher than those found in a 1984 to 1987 survey, probably because the source of cow's milk has shifted from local dairy industries to mainland China over the past decade and although organochlorine pesticides such as DDT and HCH have been banned in China since 1983, residues of such compounds may still persist in the environment and cause contamination through the food chain.

Cerkvenik V et al. (2000) examined 188 samples of raw cow milk from 19 dairy locations for residues of trace elements from 1994 to 1998. They found that residue levels of organochlorine pesticides in 174 samples were far below tolerance levels. In 90% of samples α HCH and in 86% of samples lindane was below the limit of detection (0.003 mg/kg of fat). The highest α HCH and lindane content reported was 0.008 and 0.023 mg/kg fat, respectively. The level of heptachlor was below the limit of detection (0.003 mg/kg fat). In 93.1% of samples, total DDT residues were between <0.005 and 0.02 mg/kg of fat, while the median and highest values were 0.007 and 0.091 mg/kg of fat, respectively. They also examined 108 samples of raw cow milk for PCB residues and found 0.14 mg total PCB/kg of fat content.
ICMR (2001) carried out a multi-centric study to assess the pesticide residues in selected food commodities collected from different states of the India. DDT residues were found in about 82% of the 2205 samples of bovine milk collected from 12 states. About 37% of the samples contained DDT residues above the tolerance limit of 0.05 mg/kg (whole milk basis). The highest level of DDT residues found was 2.2 mg/kg. The proportion of the samples with residues above the tolerance limit was maximum in Maharastra (74%) followed by Gujarat (70%), Andhra Pradesh (57%), Himachal Pradesh (56%) and Punjab (51%). In the remaining states, this proportion was less than 10%. Data on 186 samples of 20 commercial brands of infants formulae showed the presence of residues of DDT and HCH isomers in about 70 and 94% of the samples with their maximum level of 4.3 and 5.7 mg/kg (fat basis) respectively.

John P J et al. (2001) conducted a survey during 1993-1996 to investigate the magnitude of contamination of bovine milk with organochlorine pesticide (OCP) residues from Jaipur City, Rajasthan, India. Milk samples, i.e., dairy (toned and whole) and buffalo milk, were collected seasonally, and pesticide residues were assessed using a gas chromatograph (GC) with an electron capture detector (ECD). The found that milk samples were contaminated with dichlorodiphenyltrichloroethane (DDT) and its metabolites (DDE and p,p'-dichlorodiphenyldichloroethane [DDD]), isomers of hexachlorocyclohexane (HCH; alpha, beta, and gamma), heptachlor and its epoxide, and aldrin. Seasonal variations of these pesticide residue levels were also observed in all the milk samples. Samples collected during winter season were found to contain higher residue levels as compared to other seasons.
Ciscatoa C H P et al. (2002) surveyed residues of pesticides in 132 samples of cow milk collected from bulk transports (38 samples of raw milk) and market (94 samples of pasteurized milk). These samples were analysed by the multiresidue analytical method DFG S19 for pesticide contamination. They found that the 0.76% of samples was contaminated with HCH (alpha isomer) and 10.60% with endosulfan (alpha and beta isomers) and no organophosphorus, carbamates, pyrethroids, herbicides, and fungicides were detected in cow's milk samples. They also reported that both pesticides, endosulfan and HCH, found in milk samples, indicated their use in agriculture practices, although legislation in Brazil does not permit the use of HCH since 1985 and endosulfan can be used only in a few crops.

Pandit G G et al. (2002) examined milk and dairy product samples of various brands from different cities in Maharashtra, India, to determine if there is any contamination due to organochlorine pesticide residues. The measurements were made using a gas chromatograph electron capture detector system. Trace levels of DDT and HCH were detected in the samples. They reported that butter had higher levels of DDT than cheese and milk powder and total HCH levels in milk and milk product samples were lower than total DDT levels, which could be attributed to earlier extensive anti malaria sanitary activities. The levels of organochlorine pesticide residues in milk and milk products reported by them were well below the maximum permissible limits given by the FAO/WHO.

Pandit G G and Sahu S K (2002) estimated the risk posed by the presence of organochlorine pesticides in milk and milk products for the population of Mumbai and to
determine the levels of organochlorine pesticides in milk and milk products, 520 samples of milk and milk products of different brands were collected. The data about mean daily consumption of milk and milk products by different age groups was used to evaluate the daily exposure to the public. They evaluated non-cancer effects by comparing the predicted exposure distributions to the published guidance values. The majority of the chlorinated pesticides identified by them in the milk and milk product samples were found to be at levels which do not pose unacceptable risks to the public, with the exception of α HCH and the cancer risk estimated for this chemical slightly exceeds the US EPA guidance value.

**Sukla et al. (2002)** reported that the daily aldrin intake in average vegetarian diet exceeded ADI by 442 per cent; in average non-vegetarian diet, by 1,500 percent and the daily dieldrin intake in average vegetarian diet exceeded ADI by 514 per cent; in average non-vegetarian diet, by as much as 6,000 per cent.

**Waliszewski S M et al. (2003)** reported that organochlorine pesticides have been used in agriculture as a seed dresser, in sanitation, in malaria control programmes and in livestock to combat ectoparasites. Their residues accumulate in lipid rich tissues due to their chemical stability and persistence. In the body they circulate throughout all compartments, deposit themselves in adipose fat and can be excreted during lactation. These pesticides are applied in tropical zones and drift to areas where cattle graze. To determine the concentrations of HCB, beta HCH, p,p’ DDE, o,p’ DDT and p,p’ DDT they analyzed 150 milk samples each year from 1998 and 2001 to. Results obtained by them indicated that beta HCH is one of the main contaminants (0.106 and 0.087 mg x
kg(1) on fat basis) followed by p,p’ DDT (0.078 and 0.037 mg x kg(1) on fat basis) and p,p’ DDE (0.051 and 0.033 mg x kg(1) on fat basis). The HCB and o,p’ DDT were detected in lower quantities respectively (0.008 and 0.006 mg x kg(1), and 0.031 and 0.010 mg x kg(1) on fat basis).

Armendariza C et al. (2004) used a gas chromatographic method of to determining the OCPs like α HCH, β HCH, lindane, δ HCH, hexachlorobenzene, aldrin, heptachlor, heptachlor epoxide, mirex, 2,4-DDT, 4,4-DDT, 2,4-DDD, 4,4-DDD, 2,4-DDE and 4,4-DDE in cow milk. They found that correlation coefficients (r) of the calibration curves were greater than 0.996, the variation coefficients of the response factors were less than 4.90%, with the exception of aldrin (5.53%) and lindane (5.75%), the relative standard deviation of the slope being ≤1.52%. The recovery values of the pesticides analyzed by them were in the range of 81.92% (α HCH) to 105.49% (4,4 DDT), except in the case of aldrin and heptachlor epoxide, which yielded recovery values of under 40%.

Lehotay et al. (2005) analyzed fatty foods (e.g., milk, eggs, and avocado) to evaluate 32 pesticide residues using two methods. They reported QuEChERS method as quick, easy, cheap, effective, rugged, and safe method for pesticide residue analysis.

Battu R S et al. (2007) analyzed 92 samples of liquid milk from Ludhiana, India, during 1999–2001 and found DDT in 6 (7.4%) samples and of these 2 samples were found to be exceed the maximum residue limit (MRL) of DDT fixed at 0.05 mg/kg (on a whole milk basis). HCH residues were detected in 49 (53.3%) samples and constituted
only gamma-HCH (lindane). They found that all the 49 liquid milk samples exceeded the MRL of lindane. These results were indicative of contamination of bovine milk with pesticide residues as a result of the ban on the use of DDT and HCH in agriculture and public health programs. They again analyzed 40 samples of butter and reported the presence of DDT and HCH in 28 and 8 samples, respectively. However, none of the samples exceeded the MRL value of either DDT or any isomer of HCH. DDT residues comprised mainly p,p'-DDE and p,p'-TDE, whereas HCH residues were present as lindane in 6 samples, and 2 samples revealed the presence of b-HCH. They reported that the estimated daily intake of lindane through the consumption of contaminated liquid milk exceeded its acceptable daily intake value for children and interestingly, none of the liquid milk or butter samples revealed the presence of any commonly used organophosphorus or synthetic pyrethroid insecticides at their detection limit of 0.01mg/kg.

Santos J S et al. (2007) investigated the presence of organochlorine pesticides (α HCH, lindane, aldrin, HCB, p,p'DDE, o,p'DDD, p,p'DDD, and o,p'DDT) and PCBs (congeners 10, 28, 52, 138, and 180) in raw, pasteurized, and UHT milk from Rio Grande do Sul State (Brazil). They found HCB and p,p'DDE in all the samples. p,p'DDE (11.9 ng/g), o,p'DDD (7.38 ng/g), lindane (6.09 ng/g), and PCB 180 (5.31 ng/g) were the compounds found at the highest average concentrations. They reported that the EDIs for organochlorine pesticides were below the acceptable daily intakes established by FAO/WHO and few samples exceeded the maximum residue limits for the compounds evaluated.
Sharma H R et al. (2007) analyzed 147 samples of bovine milk collected from 14 districts of Haryana, India during December 1998–February 1999 for the presence of organochlorine pesticide (OCPs) residues. They detected ΣHCH, ΣDDT, Σendosulfan and aldrin in 100%, 97%, 43% and 12% samples and with mean values of 0.0292, 0.0367, 0.0022 and 0.0036 μg/ml, respectively and 8% samples exceeded the maximum residue limit (MRL) of 0.10 mg/kg as recommended by WHO for ΣHCH, 4% samples of 0.05 mg/kg for α-HCH, 5% samples of 0.01 mg/kg for γ-HCH, 26% samples of 0.02 mg/kg for β-HCH as recommended by PFAA and 24% samples of 0.05 mg/kg as recommended by FAO for ΣDDT. Concentrations of β HCH and p,p'-DDE were more as compared to other isomers and metabolites of HCH and DDT.

Nag S K and Raikwar M K (2008) monitored the bovine milk of different places in Bundelkhand region of India to evaluate the status of organochlorine pesticide (OCP) residues. Out of a total of 325 samples they found 206 samples (63.38%) were contaminated with residues of different OCPs. The average concentration of total HCH was 0.162 mg/kg. Among the different HCH isomers the frequency of occurrence of α-isomer was maximum followed by δ-, γ- and β endosulfan (α, β, sulfate) was detected in 89 samples with mean concentration of 0.0492 mg/kg while total DDT comprising of DDT, DDE and DDD was present in 114 samples having mean concentration of 0.1724 mg/kg. Dicofol was positive in 17 samples.

Ashnagar A et al. (2009) investigated residues of seven important OCPs in 35 milk samples collected from the city of Ahwaz, Iran. They reported that lindane (0.042
mg/Kg) and DDT [(1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane)] (0.28 mg/Kg) were exceeded the standard limits recommended by FAO/WHO.

**Bosnir J et al. (2010)** determined the residue levels of the organochlorine pesticides in 48 pooled cows’ milk samples: 40 pooled samples of non-processed (raw) milk and 8 pooled samples of processed milk collected in the Karlovac County from May 2003 until April 2004. They reported the presence of organochlorine pesticides like DDT and derivates, HCH, lindane, heptachlor and endosulfan using the GC-ECD method. The detection limit was 0.01 μg/kg. The determined amounts of organochlorine pesticides were predominantly and significantly below the Maximum Residue Limit (MRL) set by the European Union. They concluded that despite the fact that some of them have been banned some thirty years ago, pesticide persists in milk samples, which indicates a high degree of dispersion of this substances in the environment and also control of organochlorine pesticides in milk is therefore of great importance for public health.

**Donia A et al. (2010)** analyzed raw milk samples of buffaloes and cows for chemical composition and pesticide residues. They found that Buffalo's milk showed higher levels of fat, total protein (T.P), total solids (T. S) and ash than those detected in cow's milk. However, lactose content was higher in cow's milk than those detected in buffalo's milk. Interestingly, none of the raw milk revealed the presence of any OP pesticides (malathion, profenofos, pirimiphos-methyl and dimethoate). However, OC pesticides (HCB, lindane, aldrin, heptachlor epoxide, chlordane, endrin and DDT) were detected at a value exceeded the tolerance levels of FAO/WHO. Some residues of
pesticides were removed with skim milk and butter milk during the production of cream and butter. Samna and yoghurt were found to contain low levels of OCP pesticides due to the effect of heat treatment and the precipitate of residues with the by product (murta).

Kampire E et al. (2011) examined fresh and pasteurized milk samples from Kampala markets for organochlorine pesticides using a gas chromatograph equipped with an electron capture detector and detected 5 organochlorine pesticides, namely; aldrin, dieldrin, endosulfan, lindane, DDT and its metabolites. The mean values were expressed in mg/kg milk fat (mf) basis. The mean concentration detected in the fresh milk (n=54) were: 0.026 ± 0.003 mg/kg mf; 0.002 ± 0.0003 mg/kg, below the detection limit; 0.007 ± 0.003 mg/kg, 0.009 ± 0.002 mg/kg milk fat for lindane, endosulfan dieldrin and aldrin, respectively. The mean concentrations of p,p'-DDE; p,p'-DDT and o,p'-DDT detected were 0.009 ± 0.002 mg/kg; 0.033 ± 0.007 mg/kg and 0.008 ± 0.001 mg/kg mf, respectively in the fresh milk samples. In the pasteurized milk samples (n=47), the mean concentrations recorded were: 0.008 ± 0.003 mg/kg, 0.025 ± 0.004 mg/kg, and 0.007 ± 0.001 mg/kg, respectively for p,p'-DDE; p,p'-DDT and o,p'-DDT. Alpha and beta endosulfan recorded the concentration below the detection limit and the mean of 0.022 ± 0.001 mg/kg mf, 0.005 ± 0.002 mg/kg mf, and 0.006 ± 0.0002 mg/kg mf, respectively for lindane, dieldrin and aldrin. They concluded that although, most of the residues detected were above the residue limits set by the FAO/WHO (2008), bioaccumulation of these residues is likely to pose health risks to the consumers of milk in Uganda.
Aslam M et al. (2013) analyzed the levels of organochlorine pesticide residues (namely hexachlorocyclohexane or HCH, dichlorodiphenyltrichloroethane or DDT and endosulfan) along with chemical composition in buffalo milk samples collected from different localities of Delhi. They detected p,p’DDT residues in 70% of the milk samples, p,p’DDE (dichlorodiphenyldichloroethylene) in 80% of the milk samples, DDD (dichlorodiphenyldichloroethane) another metabolite of p,p’DDT in 65% of the milk samples and α and β endosulfan in 35% and 40% of the milk samples respectively. Only the content of lindane exceeded the Maximum Residual Limit values in 50% of the samples. They found that DDT is the major contaminants in different parts of Delhi state and statistical correlation shows no significant correlation between chemical compositions of the samples.

Aziz U H et al. (2014) carried out a study to monitor the residue level of some selected pesticides (Dichloro diphenyl trichloro ethane, Dichloro diphenyl dichloroethylene, endosulfan, aldrin, cypermethrin, deltamethrin, permethrin, and bifenthrin) in milk samples collected from the cotton growing belt of the Punjab province. The residue level of these pesticides in dairy milk samples was analyzed on High Performance Liquid Chromatography (HPLC) system. They found about 70% of the collected samples were contaminated with either of the analyzed pesticides. Aldrin was detected in 35% samples with mean concentration level of 0.68 µg/ml, ranged between 0.32 µg/ml and 5.19 µg/ml. However, DDT, DDE, and endosulfan prevailed comparatively in lower percentage such as 10%, 9%, and 7%, respectively. DDT ranges between 0.003 µg/ml and 0.40 µg/ml, with mean concentration level of 0.01 µg/ml. Whereas DDE was present
with mean residue level of 0.04 µg/ml, ranging from 0.15 µg/ml to 1.23 µg/ml. They mentioned that lower level of DDT residues in milk was due to ban on the application of DDT. They also reported the mean concentration level of the endosulfan in milk was 0.13 µg/ml.

**Kaushik C P et al. (2014)** investigated seasonal trends in OC pesticides residues namely, 1,2,3,4,5,6-hexachlorocyclohexane (HCH) isomers, 1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane (DDT) and its metabolites and endosulfan stereo isomers in raw bovine milk samples from rural areas of Ambala, Gurgaon and Hisar districts of the state of Haryana for winter, summer, and post-monsoon seasons. Highest concentration of HCH and DDT was found in 43 % and 53 % milk samples, respectively in post-monsoon season whereas highest values of endosulfan was reported in 36 % samples during winter season. They reported that during the study period only 2 % milk samples exceeded the maximum residue limit recommended by WHO for ΣHCH, 1 % samples each for α-HCH and γ-HCH, 9 % samples for β-HCH as recommended by PFAA and 30 % samples for ΣDDT as prescribed by FAO. No statistical difference in the mean concentration of ΣHCH and ΣEndosulfan were observed by them in any of the three districts. However, ΣDDT concentration showed marked difference among the three districts.

**Zheng G et al. (2014)** developed a method for simultaneous determination of the 30 organochlorine pesticides (OCP) in milk and milk powder samples. Prior to the gas chromatography-tandem mass spectrometric analysis, the residual OCP in samples were extracted with n-hexane and acetone mixture (1/1, vol/vol) and cleaned up by gel
permeation chromatography and solid phase extraction. Selected reaction monitoring mode was used for gas chromatography-tandem mass spectrometric data acquisition to identify and quantify the OCP. Limits of quantification of all OCP were 0.8 μg/kg. With the exception of endrin, limits of quantification were significantly lower than maximum residue limits set by the European Union and China. They found that the average recoveries were in the range of 70.1 to 114.7% at 3 spiked concentration levels (0.8, 2.0, and 10.0 g/kg) with residual standard deviation lower than 12.9%.

Kuba J et al. (2015) evaluated the cow milk samples collected from agricultural and industrial areas from two regions of Poland for the content of dichlorodiphenyltrichloroethane (DDT) and its metabolites by gas chromatography. They found DDT residues in all the milk samples, mostly in the samples collected from the agricultural area, where a total DDT median concentration reached 0.336 mg/L. In the milk samples collected from the industrial area, the median concentration was lower, at 0.131 mg/L. p,p’-DDT was the main metabolite, constituting 83% of total DDT metabolites. They concluded that although none of the samples exceeded the level above which they should be considered dangerous, the results showed that the problem of DDT had not diminished and so should be constantly monitored.

Shaker E M and Elsharkawy E E (2015) detected five OC pesticides namely, alachlor, dieldrin, hexachlorobenzene, lindane and methoxychlor and three OP pesticides chlorpyrifos, malathion, and parathion-methyl during their analysis of raw buffalo milk samples collected from the agro industrial zone in upper Egypt. They reported that 44%, 33%, 66% and 88% of the samples, exceeded the 2008 European Commission (EC)
maximum residual limits (MRLs) for lindane and malathion, chlorpyrifos, methoxychlor and hexachlorobenzene, respectively. However, the levels of alachlor, dieldrin, and parathion-methyl residues were found below EC MRLs.

**OCP residue level in human Milk**

Hashemy-Tonkabony S E and Fateminassab F (1977) analyzed 131 samples of human milk from Tehran area for chlorinated pesticide residues analysis. They detected 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane (DDT) (with its metabolites), isomer of benzene hexachloride (γ BHC), and dieldrin in varying concentration in 101, 108, and 47 samples and mean ranged 0.024 (0.001 to 0.333) ppm, 0.008 (0.001 to 0.046) ppm, and 0.011 (0.001 to 0.028) ppm respectively. They reported that the mean dieldrin exceeded the World Health Organization limit and may pose a health hazard and there was no significant relationship between economic status of donors and pesticide in the milk; however, milk from the older nursing mothers contained more DDT than that from young mothers.

Savage E P et al. (1981) analyzed 1436 human milk samples from United States by gas-liquid chromatography for the chlorinated hydrocarbon insecticides dieldrin, chlordane, heptachlor, heptachlor epoxide, oxychlorodane and mirex. They found dieldrin was above the detection limit (1.0 ppb) in over 80% of all the samples collected. They reported that there was no chlordane in any of the 1436 milk samples but its metabolite, oxychlorodane, was found above the detection limit in 74% of the samples. Heptachlor was recovered in less than 2% of the samples, its metabolite, heptachlor epoxide, was
found above the detection limit in 63% of the samples. Mirex was not positively identified in any of the samples. They reported that the proportion of samples with values above the detection limit for dieldrin, heptachlor epoxide and oxychlordane varied significantly among the five geographic regions with the southeastern United States having the highest mean residue level for each of these three contaminants. They also reported detection limit for the mean fat adjusted residue levels for the United States which were 164.2 ppb for dieldrin, 91.4 ppb for heptachlor epoxide, and 95.8 ppb for oxychlordane.

Kanja L et al. (1986) determined the residue levels of the chlorinated hydrocarbons p,p'-DDT, p,p'-DDE, HCB, alpha-, beta-, and gamma-HCH, aldrin, dieldrin, and polychlorinated biphenyls (PCBs) in human milk of Kenyan mothers living in different areas of Kenya. The main organochlorine contaminants they found in all the milk samples were p,p'-DDT and p,p'-DDE. They found the mean levels of sum DDT and DDT/DDE ratio ranged from 1.1 to 18.7 mg/kg milk fat and from 0.7 to 5.7, respectively. Relatively low residue levels of HCB, alpha-HCH, beta-HCH, aldrin and dieldrin were detected in 59, 37, 27, 37, and 19%, respectively, of all the milk samples analyzed. Quantifiable residue levels of PCBs and alpha-HCH were not detected by them in the milk samples.

Chikuni O et al. (1991) determined the residue levels of the chlorinated hydrocarbons p,p DDT, p,p DDE, p,p TDE, p,p DDT, alpha, beta, gamma HCH, heptachlor epoxide, dieldrin and polychlorinated biphenyls (PCBs) in human milk of 40 Zimbabwean mothers living in the greater Harare area. The main organochlorine
contaminants found in all the samples analyzed were p,p DDT and p,p DDE and the mean levels of sum DDT and DDT/DDE ratio were 6 mg/kg milk fat and 0.74 respectively. They detected relatively low residue levels of alpha, beta, gamma HCH, heptachlorepoxide and dieldrin in 58, 100, 63, 13 and 65%, respectively of all the milk samples analyzed.

Kalra R L et al. (1994) analyzed the human milk samples collected from areas having intensive cotton cultivation and sparse cotton cultivation in Punjab (India) for organochlorine insecticides. Both DDT and HCH were detected in almost all the samples analyzed. They found that the average levels of Σ DDT and Σ HCH residues in samples from cotton-growing areas were significantly higher than in those from areas where cotton was sparsely grown. Residues of Σ DDT mainly comprised p, p′-DDT and p, p′-DDE, while those of Σ HCH residues were mainly in the form of its β-isomer. They also found that the median values of 0.52 μg/g of Σ DDT and 0.19 μg/g of Σ HCH in samples of human milk from cotton-growing areas of Punjab (India) were higher than those reported from most other countries in the World.

Ejobi F et al. (1996) studied the levels of organochlorine pesticide residues in mother's milk and assessed the toxicological implications of it to health of the breast-fed infants in Uganda. They reported that the investigations on the levels of such residues in human milk can determine the potential risk of these contaminants to the health of breast-fed infants who could be regarded as the terminal link in the human food chain and suggested that the periodic biomonitoring of organochlorine residues is important to assess the trends of environmental contamination by these chemicals in Uganda.
**Hooper K et al. (1997)** measured the OC pesticides and PCBs in the breast milk samples taken from 92 donors representative of regional populations in southern Kazakhstan. They followed the World Health Organization protocol for assessing levels of chlorinated contaminants in breast milk and found that beta hexachlorocyclohexane (beta HCH), p,p'DDE, p,p'DDT, hexachlorobenzene, and alpha HCH were the most prevalent OC residues.

**Barkatina E N et al. (1998)** studied the breast milk samples from six regions of the Republic of Belarus for organochlorine pesticide (OCP) residues. DDE, DDT metabolite, was detected in all milk tests. They detected DDT in 1.2% test in Soligorsk and in 11.1% tests in Kopyl district. A beta isomer of hexachlorocyclohexane (HCH) was detected in 87.5 to 100% of almost all tests, alpha-HCH in 16.7% tests from Kopyl district and gamma- HCH in 18.8% tests from. They reported that Heptachlor, aldrin and dichlorodiphenyldichloroethane were not detected at all and out of 8 OCP, gamma-HCH, sometimes alpha and beta- HCH and p,p'DDE sometimes p,p'-DDT were detected in breast milk.

**Kinyamu J K et al. (1998)** examined the degrees of organochlorine pesticides in an urban area in human milk from Kenya. They found that mothers in Nairobi had low levels of organochlorines in their milk compared to those in the rural areas might be due to the restriction of the usage of pesticides.

**Harris C A et al. (1999)** determined the concentrations of OC pesticide residues in 168 samples of human milk collected between January 1997 and May 1998 in the UK.
They detected residues of p,p'-DDT, p,p'-DDE, dieldrin, HCB, b-HCH and g-HCH and also determined the correlations between the concentrations of p,p'-DDE, dieldrin, HCB, b-HCH and g-HCH and age.

**Smith D (1999)** reported the DDT levels and the apparent effect of restrictions on DDT use and concluded that the DDT concentrations in human milk have declined in most areas of the world, consistent with restrictions on its use. But levels were high in areas still using DDT, even higher than the World Health Organization’s recommended limit for infants and these needs a proper restrict or ban towards the use of DDT.

**Jaraczewska K et al. (2000)** measured the levels of organochlorinated pesticides (OCPs) like p,p'-DDT and its metabolites, HCB, hexachlorocyclohexane isomers (HCHs), chlordanes and their metabolites, and 18 polychlorinated biphenyl (PCB) congeners in maternal serum, umbilical cord serum and human milk collected from 22 mothers living in the Wielkopolska region, Poland. They found p,p'-DDT and its major metabolite, p,p'-DDE, together with HCB, in all milk and serum samples. Median concentrations of p,p'-DDE found in maternal milk was 634ng/g lipid weight. They got a good correlation (Spearman R(S)>0.75, p<0.001) for major PCBs, p,p'-DDT and p,p'-DDE, between maternal and umbilical cord serum, while the correlation was weaker between milk and serum.

**Schinas V et. al. (2000)** analyzed breast milk samples from 112 mothers from southwest Greece during 1995-1997 for the residues of lindane, beta-BHC, gamma-BHC, delta-BHC, p,p-DDE, p,p'-DDD, and p,p'-DDT. Concentrations of gamma-BHC
(i.e., lindane) were reported in 57.1% of the samples (mean concentration = 0.58 mg/L whole milk, range = nondetectable to 10.86 mg/L). Concentrations of alpha-BHC, beta-BHC, delta-BHC, p,p'-DDD, and p,p'-DDT were reported in 16%, 39.3%, 11.6%, 41%, and 55.3% of the samples, respectively. Hey reported that p,p'-DDE was detected in all samples which ranged from 0.33 to 278 mg/L and typically, the amounts of gamma-BHC and sigma-DDTs in breast milk were below the established acceptable daily intake value.

**Campoy C et al. (2001)** analyzed the milk samples obtained from healthy lactating women in the provinces of Granada and Almeria in Southern Spain to assess the contamination by organochlorine pesticides. The samples were obtained by the Neonate Section of the Department of Pediatrics of Granada University Hospital (Neonatology Division) and by the Neonatal Service of Poniente Hospital in El Ejido, Almeria and a liquid–liquid extraction procedure was performed. They identified aldrin, dieldrin, DDT and its metabolites, lindane, methoxychlor and endosulfan contamination in milk samples. The presence of these products was confirmed by mass spectrometry. They reported that the identification and quantification of these organochlorine molecules is important because they have estrogenic effects.

**Stuetz W et al. (2001)** analyzed the human milk for DDT, heptachlor, HCB and HCH residues (fat normalized data) from Chiang Mai City, Northern Thailand. They detected DDT in all samples with a median and maximum level of 209 and 2012 ng of total DDT isomers per ml of milk, respectively. The median and highest percentages of p,p’ DDT were 23.2 and 44.7%. In 15 samples heptachlor was detected in the
metabolized form of heptachlorepoxide with a median value of 4.4 ng/ml. They reported that the estimated daily intakes of DDT, heptachlor and heptachlorepoxide by the infants exceeded up to 20 times the acceptable daily intakes as recommended by the FAO and WHO. In nine samples HCB was detected with a median value of 5.4 ng/ml from which seven of the nine also had the highest values of DDT residues. The γ isomer of HCH was only found in one sample with 3.6 ng/ml. They found the mean sum DDT residues with 14.96 mg/kg milk fat and concluded that the mother breastfeeds her first child and that she originally comes from a region where DDT is still in use as a vector control agent, as well as the former use of organochlorine pesticides (OCPs) in agriculture which seem to be the main factors for high DDT and other OCP residues in the mothers’ milk.

Pandit G G and Sahu S K (2002) determined the levels of OC pesticides in milk and milk products in Mumbai City. 520 samples of milk and milk products of different brands were considered in their study. A survey was conducted by them to determine the mean daily consumption of milk and milk products by different age groups and this data was used to evaluate the daily exposure to the public. Non-cancer effects were evaluated by comparing the predicted exposure distributions to the published guidance values. They found that the majority of the chlorinated pesticides identified in the milk and milk product samples studied were found to be at levels which do not pose unacceptable risks to the public, with the exception of alpha HCH. The cancer risk estimated for this chemical slightly exceeds the US EPA guidance value.

Shukla M P et al. (2002) reported that 90% samples were found contaminated with pesticide residues, out of 20 samples of total-diet collected from in and around
Kanpur during July to Oct. 1999. Magnitude of contamination was more in non-vegetarian than vegetarian diet. They found that HCH, aldrin and dieldrin were the main contaminants and average daily intake of their residues were more than their acceptable daily intakes (ADI) accounting 1448.22, 32.52 and 36.86 µg/person/day through vegetarian and 1501.44, 95.93 and 367.02 µg/person/day through non vegetarian diet, respectively.

**Burke E R et al. (2003)** developed a method to analyze OC pesticides in human milk using solvent extraction and analyzed milk samples obtained from women in a rural and an urban area of Indonesia. They found detectable residues of p,p'DDT (urban mean 0.11±0.18 mg/kg, rural mean 0.07±0.03 mg/kg) and p,p'DDE (urban mean 0.05±0.04 mg/kg, rural mean 0.76±1.46 mg/kg). Residues of HCB, βHCH, α-endosulfan and dieldrin were also detected in some samples. There was no significant difference (at the 95% confidence level) in levels of pesticides between urban and rural areas. They reported that the levels of organochlorine pesticides in milk from Indonesian women were lower than those reported from Indonesian women exposed to DDT through malaria eradication schemes and were similar to levels reported from UK and Japan.

**Kalra et al. (2003)** found that median values of DDT and HCH in samples of human milk from cotton-growing areas of Punjab (India) were higher than those reported from most other countries in the World.

**Sanghi R (2003)** monitored the HCH, endosulfan, malathion, chlorpyrifos, and methyl-parathion levels in human milk samples from Bhopal, Madhya Pradesh and
found endosulfan concentrations were highest and exceeded the α-HCH, chlorpyrifos, and malathion concentrations by 3.5-, 1.5-, and 8.4-fold, respectively. Correlation analysis between mothers' age and the content of the chemicals accumulated in breast milk indicated a substantial degree of correlation for malathion (r=0.5). But the other chemicals showed low to negligible correlation with donor age.

Yu, H et al. (2003) identified OCP and their metabolites in human milk in the Chinese capital of Beijing and found that the total DDT residues in human milk was 2.04 mg/kg and the total BHC residue in women's milk was 1.18 mg/kg.

Çok, I et al. (2004) detected organochlorine compounds in human breast milk from Ankara, Turkey and found that adipose tissue samples from the general population indicates widespread exposure to organochlorine pollutants from environmental sources.

Chao H R et al. (2006) determined the residues of organochlorine pesticides (OCPs) in human milk collected in central Taiwan between December 2000 and November 2001. They detected predominant OCPs like p,p′-DDE, p,p′-DDT, α-CHL, heptachlor epoxide, heptachlor, β-HCH, and γ-HCH, with median levels of 228, 19, 7.4, 4.0, 2.3, 1.2, and 0.8 ng/g lipid, respectively in the milk samples. A notable decrease in DDT levels (ΣDDT = 333 ng/g lipid) in human milk was found in their study compared to results from the previous two decades (ΣDDT = 3595 ng/g lipid).

Damgaard I N et al. (2006) investigated a possible human association between maternal exposure to 27 OCP compounds used as pesticides and cryptorchidism among male children. They found organochlorine pesticides in all samples (medians; nanograms
per gram lipid) for cases/controls namely p,p’-DDE: 97.3/83.8; β-HCH: 13.6/12.3; HCB: 10.6/8.8; α-endosulfan: 7.0/6.7; oxychlordane: p,p’-DDT: 4.6/4.0; dieldrin: 4.1/3.1; cis-heptachloroepoxide (cis-HE): 2.5/2.2. Five compounds [octachlorostyrene (OCS); pentachlorobenzene, p,p’-DDD; o,p’-DDT; mirex] they detected in most samples (detection rates 90.8–99.2%) but in lower concentrations. For methoxychlor, cis-chlordane, PCA, γ-HCH, 1,1-dichloro-2-(2-chlorophenyl)-2,2(4-chlorophenyl)ethane, transchlordane, α-HCH, and o,p’-DDE, both concentrations and detection rates were low (26.5–71.5%). Heptachlor, HCH (δ, ), aldrin and β-endosulfan were detected at negligible concentrations and low detection rate. They found that the seventeen of 21 organochlorine pesticides [p,p’-DDT, p,p’-DDE, p,p’-DDD, o,p’-DDT, HCH (α, β, γ ), HCB, PCA, α -endosulfan, chlordane (cis-, trans-) oxychlordane, methoxychlor, OCS, and dieldrin] detected were in higher median concentrations in case milk than in control milk.

Kumar A et al. (2006) collected the blood and milk samples from lactating women who were divided into four groups on the basis of different living standards viz residence area, dietary habits, working conditions and addiction to tobacco from Anupgarh area of Rajasthan. They found that the level of total organochlorine pesticides in blood samples ranged from 3.319mg/L to 6.253mg/L while in milk samples it ranged from 3.209Mdash;4.608 mg/l.

Kumar A et al. (2006) analyzed the levels of the DDT and HCH residues in human milk collected from remote rural part of Agra. β and γ isomers of HCH accounted for the major residue of total HCH excreted in breast milk. δ HCH was not detected in
the samples. They found that 95% and 88% of the samples were contaminated with DDT and DDD respectively and total concentration of total DDT was higher than total HCH.

**Kumar A et al. (2006)** reported the level of total organochlorine pesticides in blood ranged from 3.319 mg/l to 6.253 mg/l while in milk samples it ranged from 3.209 mg/l;4.608 mg/l from Anupgarh, Rajasthan.

**Subramaniam K and Solomon J (2006)** investigated the blood of the patients with minimum health complaints and skin diseases for the residue of the banned organochlorine pesticides DDE and BHC using gas chromatography. They found high concentrations of both BHC and DDE in the serum samples of the people who had direct exposure to the pesticides, namely agriculturalists and public health workers with few exceptions. The pesticide residue concentration in serum ranged from 0.006 to 0.130 ppm for BHC and 0.002 to 0.033 ppm for DDE.

**Ennaceur S et al. (2008)** determined the concentrations of DDT and its metabolites, HCB, HCHs, dieldrin, and 20 polychlorinated biphenyls (PCBs) in 237 human breast milk samples collected from 12 locations in Tunisia. The predominant OCs found in human breast milk were PCBs, p,p'DDE, p,p'DDT, HCHs and HCB. They observed that the concentrations of DDTs in human breast milk from rural areas were significantly higher than those from urban locations (p<0.05) and there was positive correlations between concentrations of OCs in human breast milk and age of mothers and number of parities. The comparison of daily intakes of PCBs, DDTs, HCHs, and HCB to infants through human breast milk with guidelines proposed by WHO and
Health Canada showed that the some individuals accumulated OCs in breast milk close to or higher than these guidelines.

**Mathur V et al. (2008)** assessed the influence of organochlorine pesticides upon the occurrence of reproductive tract cancers in women from Jaipur, India. Blood samples were collected from 150 females were subjected to pesticide extraction and analyzed with the help of gas chromatography. The pesticides detected were benzene hexachloride and its isomers, dieldrin, heptachlor, dichloro diphenyl trichloro ethane and its metabolites. The data obtained by them indicated that the organochlorine pesticide residue levels were significantly higher in all the cancer patients as compared with the control group.

**Pathak R et al. (2008)** analyzed the levels of organochlorine pesticide residues in maternal and cord blood samples of normal healthy women with full term pregnancy to gain insight into the current status of pesticide burden in newborns from North India. Hexachlorocyclohexane (HCH) contributed maximum towards the total organochlorine residues present in maternal and cord blood followed by endosulfan, p,p’ DDE and p,p’ DDT being the least. Their data indicated a transfer rate of 60–70% of these pesticides from mothers to newborns and this high rate of transfer of pesticides is of great concern as it may adversely affect the growth and development of newborn.

**Devanathan G et al. (2009)** carried out a study to understand the current contamination status of organochlorine compounds (OCs) in human breast milk from three metropolitan cities in India (New Delhi, Mumbai and Kolkata). Among the OCs
analyzed by them, DDTs were predominant followed by HCHs and PCBs. CHLs and HCB levels were much lower. As per the estimated daily intake they reported that some infants were exposed to OCs to a greater extent, particularly HCHs than the guideline standard and there was no association between concentrations of OCs and demographic characteristics such as parity and age of mothers which might be due to narrow range of mother’s age.

Hedley A J et al. (2010) reported the concentrations of 24 persistent organic pollutants (POPs), in 10 pools of human milk samples, collected at 2–6 weeks postpartum from 238 primiparous women living in Hong Kong and south China, who participated in the 2002–2003 WHO exposure study. Residues were determined by gas chromatography with electron capture detector and confirmed by gas chromatography with mass spectrometry. They found that the mean levels of alpha-HCH (mean 0.6 ng/g fat), beta-HCH (940 ng/g fat), gamma-HCH (1.8 ng/g fat), dieldrin (1.0 ng/g fat) and HCB (21.8 ng/g fat) were much lower than the 1985 estimates. Mean levels of alpha-HCH, gamma-HCH, dieldrin and cis-heptachlor-epoxide were comparable to the international median levels of the 15 other countries participating in the 2002–03 WHO exposure study. They found that Hong Kong had the highest level of beta-HCH, possibly a residual effect of previous high exposures in the 1970s. Body loads of beta-HCH and chlordane were lower among mothers with younger age while mothers born in mainland China had lower levels of beta-HCH, cis-heptachlor-epoxide, oxy-chlordane and trans-nonachlor. Levels of toxaphene, endrin, endosulfan, bromcyclene and nitrofen were not detected in all or almost all of the milk pools. They concluded that continuous
monitoring of persistent organic pollutants in human milk, especially beta-HCH, is needed for surveillance and interpretation of time trends, and for linkage to strict enforcement of agricultural regulations.

**Cok I et al. (2011)** determined the organochlorine pesticides (OCPs) and PCB residue levels in 100 human milk samples from the city of Antalya. They determined the levels of seven major PCB congeners; 28, 52, 101, 118, 138, 153, 180 and nine OCPs, α-HCH, β-HCH, γ-HCH, HCB, heptachlor epoxide, p,p′-DDT, p,p′-DDE, endosulfan-α and endosulfan-β and found their levels as follows: ΣPCBs 27.46 ± 11.58, ΣDDT 1,407 ± 123, and ΣBHC 160 ± 490 ng/g lipid wt.basis.

**Mishra K and Sharma R C (2011)** determined the concentrations of OC contaminants, DDT and HCH in human breast milk from Dibrugarh and Nagaon districts of Assam, North-East India. They 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 but significant differences in ADI (Average daily intake) for total DDT were found between the two districts. They found high daily intake of DDTs and HCHs by the infants exceeded the TDI (Tolerable daily intake) and a positive correlation between OCP levels in breast milk and age of mothers.

**Tutu A O et al. (2011)** conducted a study to determine the types and levels of organochlorine pesticide residues in the breast milk of 21 primiparae mothers in La, a
suburb of Accra an urban community in the Greater Accra region of Ghana. They identified 14 different organochlorine pesticides residues namely p,p’-DDT, p,p’-DDE, gamma-HCH, delta-HCH, heptachlor, aldrin, endrin, endrin-aldehyde, endrin-ketone, alpha-endosulfan, endosulfan-sulphate, gamma-chlordane, dieldrin, and methoxychlor in the individual breast milk samples using a Gas Chromatograph (GC) with an Electron Capture detector. They recorded p,p’- DDE, p,p’-DDT, delta-HCH, gamma-HCH, and endosulfan sulfate incidence ratios of 100, 76.79, 95.25, 80.95 and 85.71%, respectively for the breast milk samples. They found concentrations of organochlorine pesticide residues in the human breast milk samples ranged from 1.839 to 99.05 g/kg fats, with the exception of endosulfan sulphate whose mean concentration (99.052 g/kg) was above the Australian Maximum Residue Limit (MRL) of 20 g/kg for milk. The mean concentrations for all the other organochlorines detected by them were below their respective limits.

Zeinab H M et al. (2011) determined the residues of organochlorine pesticides (OCPs) in 40 samples of human milk collected from eight rural and urban regions in El-Gabal Al-Akhdar region –Libya, between March to December 2007. They had detected 7 pesticides from the dirty dozen (Stockholm Convention on Persistent Organic Pollutants, 2001) from all breast milk samples, including dieldrin, aldrin, endrin, chlordane, heptachlor, DDT, and BHC and found their mean concentrations were higher than the Maximum Residue Limit (MRL). They further reported that the mean concentration of OCPs residues was higher in rural than urban regions and low DDE/DDT ratio (1.026) in this area indicated recent exposure to DDT.
Dhananjayan V et al. (2012) estimated the exposure level of organochlorine pesticides (OCP) among workers occupationally engaged in agriculture and sheep wool associated jobs in rural neighborhood of Bangalore city, India. Thirty participants were interviewed and obtained informed consent before blood sample collection. The maximum concentrations of OCP were detected in blood samples of agriculture workers than sheep wool workers. Among the metabolites of HCH and DDT, lindane (γ-HCH) and p,p'-DDE were the most contributed to the total OCP. They found no differences in pesticide residues found between sex and work groups and observed that about 30% of samples exceeded the tolerance limits of 10 µg/l prescribed for HCH under the prevention of food adulteration act.

Mehboob U et al. (2012) investigated the presence of pesticide residues in human milk and their effects on the enzyme levels (cholinesterase and lactate dehydrogenase) as well as the health status of the pesticide exposed women of Karachi, Pakistan and identified cypermethrin, deltamethrin, malathion and match as main residues in the milk samples. The highest concentration of 34.86 µg/L of delta methrin and the lowest concentration of 0.336 µg/L of cypermethrin was found in the milk sample. They concluded that exposed women showed significant increased and decreased enzyme levels at different division and also complained about the disturbance in the normal functioning of different organ system and possibly produced various ailments and clinically suffered with skin diseases, backache, and disturbance in micturition, difficulty in breathing, asthma and hepatitis.
Muddasir B et al. (2012) estimated the pesticide residual levels in 600 human blood samples (three groups) taken randomly from the inhabitants of Dal Lake hamlets of Kashmir from 2008–2010 for seven commonly used pesticides viz. butachlor, α-HCH, chlorpyrifos, hexaconazole, endosulfan 1, endosulfan 2 and dichlorovos. Out of seven pesticides analysed only chlorpyrifos was detected in all the three population groups. Mean concentration of chlorpyrifos in study groups (PG-1 & PG-2) was $0.5194 \pm 0.6456$ ng/μl and in control group (PG-3) was $0.0008 \pm 0.0009$ ng/μl which was found highly significant in all three groups. They suggested that chronic low dose exposure to pesticides either directly or indirectly can be a major contributor for presence of pesticide residual levels in human blood.

Canbay H S et al. (2013) reported 15 pesticides levels in human breast milk in Isparta, Turkey. Human milk samples were collected in Isparta between October 2009 and May 2010. Human milk samples were taken from 101 healthy women. They found the detection limits between 0.04-0.027 ng/g lipid for the studied pesticides, recoveries ranged from 89.26 to 101.10% in samples and the relative standard deviations were in the range 1 to 10%. They detected Endosulfan only in 3 samples and mean concentration of endosulfan was 0.190 ng/g lipid and also dichlorvos was measured only in 5 samples and mean concentration of dichlorvos was 0.188 ng/g lipid.

Shi R et al. (2013) investigated the accumulative levels of DDTs and HCHs in human breast milk of primipara in Shenzhen area. Among the several groups of DDTs and HCHs metabolites, they detected p,p'-DDE in total 85 samples and beta-HCH in 58 samples, which accounted for 68.2% of the breast milk. The median levels of sigma
HCHs and sigma DDTs were 2.980 ng/g whole weight (80.200 ng/g fat) and 9.610 ng/g whole weight (268.390 ng/g fat). They found that both levels of sigma HCHs and sigma DDTs in the human milk had a positive association with maternal age among the demographic characteristics of primiparas.

**Sharma A et al. (2014)** carried out a study to determine the present status of pesticide residues in breast milk from Punjab. A total of 127 breast milk samples were analyzed and pesticide residues were detected in 25% of the milk samples. Residues of cyfluthrin, fenvalerate, cypermethrin, profenophos, γ-HCH, β-HCH, chlorpyriphos, monocrotophos, p,p’ DDE and phosalone were detected with mean levels of 63.04, 11.69, 3.63, 2.66, 2.64, 2.29, 1.91, 1.63, 0.56 and 0.29 ng g$^{-1}$, respectively. Cyfluthrin was leading pesticide detected in breast milk contributing 31.28% to the total residue load. They also observed that the residue levels were decreasing with increase in parity and age of mother and cyfluthrin had highest mean concentration of 90.63 ng g$^{-1}$ in the first parity and 21.11 ng/g in youngest age group. They also found that residue levels were higher in urban population than the rural population although, this difference was found statistically non-significant (p>0.05).

**Vall O et al. (2014)** studied the potential population risk factors of exposure to DDT on 72 consecutive lactating women from Tenerife, Canary Islands (Spain). They reported detectable levels of DDT (mean: 0.92 ng/g), ranging between 0.08 to 16.96 ng/g in 34 milk samples out of 72 (47.2%) and found positive association between DDT levels and vegetables (OR (95%CI): 1.23 (1.01–1.50)) and poultry meat (OR (95%CI):
2.05 (1.16–3.60)) consumption, and also between the presence of DDT in breast milk and gestational age (OR (95%CI):0.59 (0.40–0.90)).

**Bedi J S et al. (2015)** estimated the current status of residues of organochlorine pesticides (OCPs), organophosphates (OPs) and synthetic pyrethroids (SPs) pesticides in human blood. They found that the gas chromatographic analysis of human blood samples collected from Punjab revealed the presence of p,p’-dichlorodiphenyl dichloroethylene (DDE), p,p’ dichlorodiphenyl dichloroethane (DDD), o,p’ DDE and β-endosulfan at mean levels of 15.26, 2.71, 5.62 and 4.02 ng/ml respectively. p,p’ DDE residue was observed in 18.0% blood samples, and it contributes 55% of the total pesticide burden in human blood. They reported that the difference of total dichlorodiphenyl trichloroethane (DDT) between different age groups of humans was found to be statistically significant (p<0.05) and the difference of DDT and endosulfan between dietary habits, gender and spraying of pesticides was found statistically non-significant.

**Pirsaheb M et al. (2015)** extracted 710 national and international articles and texts to survey the organochlorine pesticides residue in breast milk. They reported that the majority of the reviewed articles indicated the presence of two or more organochlorine pesticides in the collected samples of breast milk. Based on the reviewed studies, they found that dichlorodiphenyltrichloroethane (DDT) had the highest level of concentration in the collected samples of breast milk. Moreover, there was a statistically significant positive correlation between mother’s age, her multiparty and concentration of chlorinated pesticides in breast milk. They concluded that the organochlorine
pesticides are still applied in some developing countries including some regions of Iran. Thus, it seems essential to inform the community about the adverse effects of this class of pesticides; and most importantly the governments should also ban the use of such compounds.

**Sharma A et al. (2015)** investigated the current levels of pesticide residues in the human populace of Punjab state. A total of 111 human blood samples were analyzed by gas chromatography and pesticide residues were detected in 35% of the blood sample(s). They detected residues of alpha-hexachlorocyclohexane (α-HCH), beta-hexachlorocyclohexane (β-HCH), p,p’-dichlorodiphenyldichloroethane (p,p’ DDD), p,p’ dichlorodiphenyldichloroethylene (p,p’ DDE), p,p’ dichlorodiphenyldichloroethane (p,p’ DDT), β-endosulfan, monocrotophos, profenophos and phosalone in human blood samples with mean levels of 1.11, 5.89, 0.51, 3.88, 0.39, 34.90, 0.79, 0.39 and 6.76 ng ml⁻¹, respectively, with β-endosulfan as a leading pesticide residue. They observed a paradigm shift in the pattern of the pesticide usage with a shift from organochlorine pesticides to organophosphates.
OCP contamination and its health impact

Hayo (1996) reported that pesticide use in agriculture can cause undesirable effects on humans and the natural environment. One of the objectives of integrated agriculture is the elimination or reduction of possible sources of environmental pollution such as pesticides. To achieve this objective, farmers need a method to assist them in estimating the environmental impact of pesticide use. He also stated that as the environmental impact of a pesticide depends on its dispersion in the environment and on its toxicological properties and also discussed the use of simulation models to assess environmental impact of pesticide.

Longnecker M P et al. (1997) stated that organochlorines are a diverse group of persistent synthetic compounds and many organochlorines are endocrine disruptors or carcinogens in experimental assays and also p,p'-DDE and PCBs (polychlorinated biphenyls) comprised the bulk of organochlorine residues in human tissues. They reviewed the relevant human data cited in the 1991-1995. Medline database and elsewhere and reported that high-level exposure to selected organochlorines appears to cause abnormalities of liver function, skin (chlorane), and the nervous system.

Hoyer P A et al. (1998) assessed prospectively the risk of breast cancer in relation to serum concentrations of several organochlorine compounds in 1976 in 7712 women serum samples from Copenhagen City. Some organochlorine compounds may have weak oestrogenic effects and are, therefore, suspected of increasing the risk of breast cancer. They reported that Dieldrin was associated with a significantly increased
doserelated risk of breast cancer (adjusted odds ratio 2.05 [95% CI 1.17–3.57], p for trend 0.01). B hexachlorocyclohexane increased risk slightly but not significantly (p for trend 0.24). There was no overall association between risk of breast cancer and p, p’-dichlorodiphenyltrichloroethane or metabolites or for polychlorinated biphenyls. Exclusion of women with breast cancer diagnosed within 5 years of blood sampling strengthened the result for dieldrin, but did not affect the other results.

Gina M Solomon and Pilar M Weiss (2002) reviewed the available data on levels of organochlorine pesticides, polychlorinated biphenyls (PCBs), polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polybrominated diphenyl ethers (PBDEs), metals, and solvents in breast milk. Examples drawn from around the world illustrate the available data and the patterns that have appeared in various areas over time. Over the past few decades, levels of the organochlorine pesticides, PCBs, and dioxins have declined in breast milk in countries where these chemicals have been banned or otherwise regulated. Regional differences in levels of xenobiotics in breast milk are related to historical and current local use patterns. Diet is a major factor that influences breast milk levels of persistent organic pollutants, with patterns in fish consumption playing a particularly significant role. Improved global breast milk monitoring programs would allow for more consistent data on trends over time, detection of new xenobiotics in breast milk, and identification of disproportionately exposed populations.

Gupta P K (2004) reported that the use of pesticides in India began in 1948 when DDT was imported for malaria control and BHC for locust control. India started pesticide production with manufacturing plant for DDT and benzene hexachloride
(BHC) (HCH) in the year 1952. In 1958, India was produced over 5000 metric tonnes of pesticides and there were approximately 145 pesticides registered for use, and production had increased to approximately 85,000 metric tonnes. Rampant use of these chemicals had given rise to several short-term and long-term adverse effects of these chemicals. He stated that the first report of poisoning due to pesticides in India came from Kerala in 1958 where, over 100 people died after consuming wheat flour contaminated with parathion. Subsequently several cases of pesticide-poisoning including the Bhopal disaster had been reported. Despite the fact that the consumption of pesticides in India is still very low, about 0.5 kg/ha of pesticides against 6.60 and 12.0 kg/ha in Korea and Japan, respectively, there had been a widespread contamination of food commodities with pesticide residues, basically due to non-judicious use of pesticides. In India, 51% of food commodities were contaminated with pesticide residues and out of these, 20% had pesticides residues above the maximum residue level values on a worldwide basis. He observed that their long-term, low-dose exposure were increasingly linked to human health effects such as immune-suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer.

Subramanian A et al. (2007) from their study observed that the mothers’ milk from Chennai (formerly Madras), India and three other places adjoining to Chennai were found to be contaminated with measurable concentrations of HCHs, DDTs, PCBs, CHLs and HCB. They found that Chennai mothers have higher levels of HCHs in their milk and hence may transfer considerably higher amounts of the chemical than the mothers from all the other three places of study indicating a higher health risk to Chennai’s
children. The levels of the two organochlorine pesticides (HCHs and DDTs) increased in Chennai mothers’ milk in the last decade. They reported that the food items collected from Chennai markets did not show any remarkably higher levels of any of the chemicals measured and the levels of the two classical organochlorines (DDTs and HCHs) had declined in many of the food items, showing the effectiveness of the recent ban on both these chemicals in the country.

Abhilash P C and Singh N (2009) described that in the process of development of agriculture, pesticides have become an important tool as a plant protection agent for boosting food production. Further, pesticides play a significant role by keeping many dreadful diseases. However, exposure to pesticides both occupationally and environmentally causes a range of human health problems. They observed that the pesticides exposures were increasingly linked to immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer. He also reported that currently, India is the largest producer of pesticides in Asia and ranks twelfth in the world for the use of pesticides. A vast majority of these had been compiled for the India For Safe Food campaign (2012). Although Indian average consumption of pesticide is far lower than many other developed economies, the problem of pesticide residue is very high in India. Pesticide residue in several crops has also affected the export of agricultural commodities in the last few years. They concluded that in this context, pesticide safety, regulation of pesticide use, proper application technologies, and integrated pest management are some of the key strategies for minimizing human exposure to pesticides.
**Eskenazi, B et al. (2009)** reported that the dichlorodiphenyltrichloroethane (DDT) was used worldwide until the 1970s, when concerns about its toxic effects, its environmental persistence, and its concentration in the food supply led to use restrictions and prohibitions. In 2001, more than 100 countries signed the Stockholm Convention on Persistent Organic Pollutants (POPs), committing to eliminate the use of 12 POPs of greatest concern. However, DDT use was allowed for disease vector control. In 2006, the World Health Organization and the U.S. Agency for International Development endorsed indoor DDT spraying to control malaria. To better inform current policy, they investigated the human health consequences of DDT and/or DDE exposure. They observed that the recent literature shows a growing body of evidence that exposure to DDT and its breakdown product DDE may be associated with adverse health outcomes such as breast cancer, diabetes, decreased semen quality, spontaneous abortion, and impaired neurodevelopment in children. They also reported that DDT and DDE may pose a risk to human health and observed that the lack of knowledge about human exposure and health effects in communities where DDT is currently being sprayed for malaria control.

**Katarina L (2011)** reported that the pesticide exposure can cause a range of neurological health effects such as memory loss, loss of coordination, reduced speed of response to stimuli, reduced visual ability, altered or uncontrollable mood and general behavior, and reduced motor skills. These symptoms are often very subtle and may not be recognized by the medical community as a clinical effect. Other possible health effects include asthma, allergies, and hypersensitivity, and pesticide exposure is also
linked with cancer, hormone disruption, and problems with reproduction and fetal development. Children are at greater risk from exposure to pesticides because of their small size: relative to their size, children eat, drink, and breathe more than adults. Their bodies and organs are growing rapidly, which also makes them more susceptible; in fact, children may be exposed to pesticides even while in the womb.

**Devi N L and Raha P (2012)** reviewed the use and contamination of selected organochlorine pesticides (DDT, HCH, endosulfan, Aldrin, Dieldrin, and Heptachlor) in India. They reported that to meet the food demand of increasing population, the modern agriculture practices involve an increase usage of pesticides which results in OCPs contamination of the environment. Organochlorine pesticides (OCPs) were found to be residue in different foods and also detected in human fats, due to their bioaccumulating and persisting nature and has a great impact on human health.

**Man Y B et al. (2014)** investigated the DDTs (summation of o,p'-DDE, p,p'-DDE, o,p'-DDD, p,p'-DDD, o,p'-DDT, and p,p'-DDT) in multiple human matrices in mothers' milk, placenta and hair collected from residents from two coastal cities: Guiyu (GY) and Taizhou (TZ) and one inland city: Linan (LA). TZ (milk: 360 ± 319 ng/g lipid wt.) showed significantly higher concentrations of DDTs than those from LA (milk: 190 ± 131 ng/g lipid wt.), whereas, concentrations of DDTs in GY (milk: 305 ± 109 ng/g lipid wt.) were in between TZ and LA. In addition, levels of DDTs in the human tissues from TZ (placenta: 122 ± 109 ng/g lipid wt.; hair: 79.9 ± 215 ng/g dry wt.) were significantly higher than those from Linan (placenta: 49.2 ± 30.2 ng/g lipid wt.; hair: 10.8 ± 7.09 ng/g dry wt.). The above concentrations of DDTs in milk exceeded the
Codex Maximum Residue Limits/Extraneous Maximum Residue Limits for milk (20 ng/g lipid wt. whole milk), indicating that the human milk samples were grossly polluted. They reported that the human specimens collected from the coastal city (TZ) were more contaminated with inland one (LA), based on the levels of DDTs contained in samples which may be due to the higher dietary exposure to DDTs via consumption of contaminated seafood. The estimated daily intakes of DDTs by GY, TZ and LA infants were 1.69 ± 1.86, 1.48 ± 0.79, and 0.95 ± 0.73 g/kg body wt./day, respectively which did not exceed 10 g/kg body wt./day, the provisional tolerable daily intake proposed by the Food and Agriculture Organization/World Health Organization.

Iftikhar B et al. (2014) assessed 80 milk and 30 diet samples to analyze the transfer of organophosphate and pyrethroid pesticides in dairy cattle’s milk when fed on agro-industrial by-product diet. The transfer and accumulation of such pesticide in cattle fat tissue and milk was also assessed and the adverse effect on cattle’s and human health was also studied by them. All the samples were extracted with acids using "quick, easy, cheap, effective, rugged, and safe" (QuEChERS) method and analyzed through gas chromatography-mass spectrometry (GC-MS). They found that about 40 and 20% of milk samples had greater content of cypermethrin, chlorpyrifos and profenofos than their maximum residue limits as suggested by World Health Organisation (WHO). Cypermethrin, chlorpyrifos and profenofos were present at concentration greater than their maximum residue limits in mixed diet whereas profenofos was completely absent in sugarcane khal and was present in traces in cotton khal but remained within the maximum residue limit. Nonetheless, transfer of residue of parent cypermethrin,
chloropyrifos and profenofos to milk was not consistent with diet in all dairy milk samples. This revealed the contention that some other sources such as drinking or inhaling contaminated water or dust were also contributing to pesticide contamination in milk. They reported that cancer potency factor for cypermethrine in children and adults remained within the recommended value and although pesticides residue in milk was not high enough to cause cancer risk in human, they might cause adverse health effect and delayed toxicity due to their long term accumulation and persistence within cattle’s body.

**Bedi J S et al. (2015)** analyzed the pesticide residues in bovine milk ($n = 312$) from Punjab, India and found chlorpyrifos, DDT, and γ-HCH as the predominant contaminants. They also found β-endosulfan, endosulfan sulphate, cypermethrin, cyhalothrin, fenvalerate, deltamethrin, malathion, profenofos, and ethion residues. From the study it was observed that 12 milk samples exceeded the maximum residue limits (MRLs) for γ-HCH (lindane), 18 for DDT and chlorpyrifos, and 1 sample each for endosulfan, cypermethrin, and profenophos. They reported that in India, DDT is still permitted for a malaria control program, which may be the plausible reason for its occurrence in milk samples and the spatial variation for presence of pesticide residues in milk indicated greater levels in cotton-growing areas of Punjab. Based on both lower-bound [LB (mean residue levels)] and upper-bound [UP (95th percentile level)] limits they assessed the human health risk in terms of non cancer and cancer hazard and noticed that cancer and non cancer risk were within United States Environmental
Protection Agency prescribed limits for both adults and children at the LB, but children were being exposed to greater risk for DDT and HCH at the 95th-percentile UB level.

Dos Santos J S et al. (2015) investigated the estimated daily intake (EDI) of organochlorine (OC) pesticides (HCB, a-HCH, lindane, aldrin, p,p- DDE, p,p-DDD, and o,p-DDT) through consumption of dairy products from Rio Grande do Sul State, Brazil. They found that fluid milk and cheese had similar SOC levels (26.04 and 26.14 ng/g fat, respectively), whereas milk powder had lower levels (2.23 ng/g fat). OC levels in UHT milk exhibited a declining trend over time (SOC ¼ 27.70 ng/g fat in 2000 vs. 1.50 ng/g fat in 2009/2010). The EDI of OC pesticides was remarkably higher for children (8.266 ng/kg/day) than for adolescents, adults, and the elderly (ranging from 0.393 ng/kg/day to 0.614 ng/kg/day). They concluded that the average EDIs for OC pesticides were below the acceptable daily intakes (ADI), with the exception of aldrin, which greatly exceeded the ADI for children.

Lu D et al. (2015) analyzed 27 OCPs in breast samples collected from 142 pregnant mothers during lactation in 2011–2012 in Shanghai, China. Detection rates were in a range of 65.5 to 100 %. In particular, metabolites of 2,2-bis(chlorophenyl)-1,1,1-trichloroethane (DDT) such as 2-chloro-1,1-bis(4-chlorophenyl)ethylene (DDMU), 2,2-bis(4-chlorophenyl)ethanol (DDOH), bis(4-chlorophenyl)ketone (DBP), and 4,4’-dichlorodiphenylmethane (DDM) were detected in most milk samples. DDTs, hexachlorobenzene (HCB), and hexachlorocyclohexane (HCH) were dominant OCPs with mean levels of 316, 49.8, and 41.5 ng/g lipid content, respectively, whereas levels of methoxychlor, ∑Drins, ∑Heptachlor, ∑Chlordane, and ∑Endosulfan were fairly low.
(0.87–5.6 ng/g lipid content). They reported that consumption of higher amounts of fish was associated with higher milk levels of OCPs. The probabilistic exposure assessment model revealed that Shanghai infants were exposed to low levels of OCPs through breast milk consumption. However, infants as the vulnerable group might be subject to the potential additive and/or synergistic health effects from complex OCP exposure and could cause deleterious effects.

Kalla et al. (2015) carried out a research work to isolation and identification of specific pathogens, presence of antibiotics, aflatoxins, pesticide residues and industrial contaminants in supply chain of milk in selected coastal districts of Andhra Pradesh. The raw milk is usually colonized by pathogens like Campylobacter jejuni, enterohemorrhagic Escherichia coli, Salmonella typhimurium, Listeria monocytogenes, Staphylococcus aureus and Yersinia enterocolitica. The milk samples were found to be positive for Tetracycline and Beta lactam antibiotics. The Aspergillus flavus was identified and the colonies producing aflatoxin M1 appeared in yellow color on the Aspergillus agar (M1127). They detected pesticides residues like Lindane, Endosulfan, Chlorane, Heptachlor and Methoxchlor and heavy metals like lead, arsenic, zinc and mercury in raw and chilled milk samples by atomic absorption spectrophotometer. They concluded that the hygienic quality of the milk was found to be poor due to exceeding the standard limits in number of specific pathogens, antibiotic, aflatoxin M1, pesticide and heavy metal residues and immediate measures are needed to be taken to ensure safety of raw milk in public point of view in Visakhapatnam, East & West Godavari regions.
Miao X et al. (2015) established a rapid, environment friendly and sensitive method for the extraction and analysis of five organophosphorus pesticides (OPPs) (chlorpyrifos, chlorpyrifos-methyl, isocarbophos, malathion and phorate) in milk samples by means of gas chromatography-flame photometric detection. They first extracted pesticides with acetonitrile from milk samples by using the modified “quick, easy, cheap, effective, rugged, and safe” (QuEChERS) method. No other clean-up was required after extraction. They found that the limits of detection of the five OPPs were ranged in 0.1–0.3 μg/l, and the limits of quantification were at the range of 0.3–1.0 μg/l. They also detected the recoveries of the target analytes from milk samples at spiking levels of 0.01, 0.05 and 0.1 mg/l which were between 80.5 and 106.5% with the relative standard deviations varied from 3.6 to 6.3%.

Tsakiris I N et al. (2015) monitored the occurrence of residues of DDT and its metabolites in 196 cow milk samples of various pasteurized commercial types collected from the Greek market. Residue levels were determined by GC-MS analysis. In 97.4% of the samples at least one DDT isomer or one of the DDT metabolites was detected, in levels not exceeding the maximum permitted residue level by the EU. Hazard Index for both carcinogenic and non-carcinogenic effects was estimated by them under two assumptions: a) using DDT concentrations from positive samples and b) imputing LOD/2 as an arbitrary concentration for negative samples. They got non-significant differences in detected or summed residue (p > 0.05) concentrations between different milk types were observed, with the exception of specific metabolites of DDT in some milk types. They assessed the exposure scenarios for children aged 1, 3, 5, 7 and 12
years old based on estimated body weights and daily milk consumption. They observed that the hazard Indices for non-carcinogenic effects were below 0.109 covering also carcinogenic effects according to WHO approach and the cancer risk values for carcinogenic effects according to the US EPA Cancer Benchmark Concentration approach, ranged from 0.4 to 18.