Breast Milk Analyses 1999-2003

Niedersächsisches Landesgesundheitsamt
(State Health Authorities of Lower Saxony)

5-year Breast Milk Monitoring Program of the State of Lower Saxony
Analyses from 1999 - 2003
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1 Introduction and Goals of this Study

With its composition of nutrients (fats, carbohydrates, vitamins, etc.), breast milk guarantees the optimal development of a breastfed infant. The numerous antibodies (immunoglobulins) contained in breast milk protect the infant from bacterial and viral disease. Breastfed children develop less allergies and allergy outbreaks tend to be less severe as a rule.

In the mid 70’s various foreign substances were detected in breast milk, which are also passed onto the infant. Chloroorganic compounds (e.g. DDT, dieldrin, hexachlorobenzene), which were used in the agricultural industry as insecticides or fungicides, were identified. Technical products such as polychlorinated biphenyls (PCB) were also found in breast milk. All substances have a high persistency (resistance) in the environment, as they decompose very slowly. They are lipophilic (fat-soluble) and are taken up again and again by human beings through food chains, stored in fatty tissue and concentrated.

These findings were an essential basis for the concern of potential long-term effects of these substances on the human body; above all, it was also the awareness that one could not wait for potential long-term adverse effects to crop up that led to an increase in bans on usage and even production of individual substances.

Despite these bans in the Federal Republic of Germany, these substances can still be traced in the environment, food chains and subsequently in the human organism. The concentrations of these foreign substances in breast milk, however, have dropped on average so noticeably that the “National Breastfeeding Commission”, which is currently situated at the Federal Institute for Risk Assessment “BfR” (1999), advocates exclusive breastfeeding until the sixth month. It also sees no health risk for infants who continue to nurse beyond this timeframe in addition to supplementary feeding [1].

In the 80s and early 90s, numerous attempts were made to attain more exact knowledge of the level of exposure of the human organism to environmental foreign substances through a greater number of breast milk analyses. However, the programs launched for this aim were usually impaired by the low participation rate of breastfeeding mothers so that the acquired values often had little implication.
When therefore the Lower Saxon Social Ministry commissioned the State Health Authorities of Lower Saxony (NLGA) in the year 1997 to re-establish a “Breast Milk Monitoring Program of the State of Lower Saxony”, from the very beginning, not only gynaecologists and paediatricians, but also and above all midwives were involved in propagating the breast milk analyses. This manner of proceeding brought about the desired success and thus since 1999 on an annual basis between 500 and 800 breast milk samples can be analysed. The results give mothers the assurance that their children can be breastfed without risk while giving health policy makers and government bodies the opportunity to recognise the long-term decline in environmental contaminants in the body. Moreover, these tests function as an indicator of potential acute contamination. The actual exposure to nitro-musk compounds as well as the non-exposure to nitrofen underpin the high value of breast milk analyses as a short and long-term bioindicator. This report now submitted summarizes the findings from the past 5 years. The analyses for the years 1999 until 2002 have already been reported [3, 11,16].
2 Brief Depiction of the Examined Foreign Substances

2.1 Organochlorine Compounds

2.1.1 Biocides

The pesticides examined in the breast milk from the group of organochlorine compounds are characterised by their extremely slow decomposition rate, which has led to a high-level accumulation in the environment and food chains down to the human organism. They are distributed in part throughout the entire surface of the globe and can even be traced in polar regions [13,14] where they were never released. Although production and usage of the substances has been banned for many years now in the Federal Republic of Germany, they can still be traced in breast milk. However, the concentration levels are much lower than those that could induce acute or chronic toxification in humans/infants.

a) Hexachlorobenzene (HCB)

was used in the Federal Republic of Germany until 1977 as a fungicide for agricultural seeds. There is no information available to substantiate acute toxification in the human organism. The consumption of HCB treated seeds for bread production in Turkey (1955-1959) led to epidemic, chronic toxification with severe photosensitivity of the skin (blistering), hyperpigmentation, increased hair growth, above all in the chin and extremity regions, and arthritic changes in the wrists. These symptoms could still be observed 20 – 25 years after the initial toxification symptoms within the course of control examinations.

b) Hexachlorinated cyclohexane (HCH)

was used in the agricultural and forestry industry as well as for wood preservation until it was banned in the Federal Republic of Germany in 1977. Among the various forms of HCH, the β-form (β-HCH) plays a particular role due to its distinctive longevity in the environment, food chains and in the human body.

Lindane, the purified form of HCH (γ-HCH) is still permitted for use today in veterinary and human medicine for combating lice and mites. Acute intoxication from accidental or intended intake of higher concentrations of lindane-containing preparations leads to hypersensibility of the central and peripheral motor nervous system up to occurrences of paralysis.
c) The use of **dichloro-diphenyl-trichloro-ethane (DDT)** as an insecticide has been banned in the Federal Republic of Germany since 1972. Nevertheless, in the former German Democratic Republic (GDR), DDT was still in use in the agricultural industry with certain usage restrictions until 1989. As a result of its excellent insecticide properties and cost-efficient production, DDT is finding an ever wider range of use for fighting the malaria carrier.

Acute DDT poisoning is characterised by a neurotoxin reaction with, for example, numbness to the tongue, skin dysesthesia up to seizures and paralysis. The targeted organ of chronic DDT poisoning is the liver. Higher doses of DDT can induce changes to the liver.

d) **Dieldrin**

was used as a contact insecticide against pests such as locusts and ants until its usage was banned in 1972 in the Federal Republic of Germany.

e) **Heptachloroepoxide (HCEO)**

was also used as a contact insecticide. Its production and usage were banned in the Federal Republic of Germany in 1980. The toxicity of dieldrin and heptachloroepoxide (both chlorinated cyclodienes) stems from its capacity as a neurotoxin. It triggers convulsions whereby its acute toxicity is usually severer than that of DDT.

f) **Nitrofen**

is a weed-killer (herbicide). A full ban on use for the ingredient nitrofen has been in effect in the Federal Republic since 1988. Intensive contact irritates eyes, skin and respiratory paths and can lead to skin disease. Tests on animals have shown that nitrofen in high doses can trigger cancer and impair reproductive ability. These findings have yet to be proven in humans.
2.1.2 Technical Products

Polychlorinated biphenyls (PCB) are marked by their high-level chemical and physical stability, their superior flame retardant properties and the capacity to suppress the conduction of electricity. For this reason, polychlorinated biphenyls were used widely in numerous closed (e.g. large and small condensators, insulation fluid and coolant for transformers) and open systems (e.g. plasticisers, lubricants in transmission oils). As a result of their distinctive persistence, they accumulate in the environment, food chains and finally in the human body. Thus, it is possible that the enrichment of PCB in tobacco might lead to PCB levels that are considerably higher in the blood of a neonate of a mother who is an active smoker than the levels in the neonate of a passive or non-smoking mother [12].

Since 1978, the usage of PCB is prohibited in open systems. PCB-containing closed systems have not been in production in the Federal Republic of Germany since 1983. Chronic PCB toxication became known as “oil disease” (1968 in Japan, 1979 in Taiwan). Through the ingestion of PCB-contaminated rice oil, the affected persons suffered from chloracne and numbness in the extremities, amongst other ailments. Corresponding exposure at the workplace led to similar symptoms.

2.2 Nitro-Musk Compounds

Nitro-musk compounds have been used as odorants (scents) in cosmetics, detergent and body-care products for more than 100 years. Musk xylol and musk ketone are the most important and widely used compounds.

Musk xylol and musk-ketone display no genotoxic (gene-damaging) effects in various studies. The current safety assessment of both substances is not yet finished, however. On the basis of the previously available data, daily intake amounts were derived that should not present a health risk to humans. The little used musk ambrette, however, is characterised in toxicological examination on rats by its neurotoxic and reproductive toxic (testicular atrophy) effect. Therefore, the substance was banned in the European Union.

Polycyclic nitro-musk compounds in certain concentrations caused deformities in young fish in an ecotoxicological study. Again, further evaluation of these compounds has yet to be completed.
2.3 Polychlorinated Dibenzo-p-Dioxin (PCDD) and Dibenzofuran (PCDF)

PCDD and PCDF are formed as a by-product in practically all thermal processes (e.g. combustion). However, they also occur as impurities, for example, that are formed during the production of PCBs or during chlorine bleaching of cellulose. PCDD and PCDF degrade very slowly in the environment and accumulate via contaminated air, soil and nutrients in human fatty tissue. Upon the intake of very high concentrations, acute toxication occurrences may manifest themselves as chloracne, overpigmentation of the skin, and hepatosis (Seveso-catastrophe 1976). Data on the chronic toxicity of PCDD/PCDF is available from follow-up examinations of highly exposed children in Seveso/Italy. These children suffered years after being exposed from a stubborn chloracne.

2.4 Phthalic acid ester (phthalates)

The substances of the phthalic acid ester group are used as additives in numerous synthetic materials (e.g. nail polish (up to 15%), solvents for other cosmetics, for alcohol denaturing, etc.). From the large phthalate substance group with an annual global production rate of ca. 8 million tons, in terms of amount and toxicology, the di(2-ethylhexyl)phthalate (DEHP) is the most significant.

Phthalates are ubiquitously traceable in the environment. The significant impact of phthalates in a reproductive toxicology sense is based on the development of endocrine (hormone-like) effects on the body. The main agents di(2-ethylhexyl)phthalate (DEHP), di-n-butyl phthalate (DBP) and diisobutyl phthalate (DIBP) are analysed in the breast milk.
2.5 Selected Metals and Radioisotopes

a) Mercury and Mercury Compounds are used in the chloralkali and electronics industry, as a plant protectant (fungicide) but also as amalgam fillings in dentistry. In the environment, almost exclusively mercury of anthropogenic origin can be found. Organic mercury is ingested above all through food (in particular via fish and fish products) but also through amalgam fillings. Thereby, in the case of the latter, mercury intake is influenced by the number, composition and quality of the fillings as well as by the duration and intensity of the chewing stress (e.g. chewing gum). Acute intoxications with organic mercury cropped up after oral ingestion of contaminated fish (Minamata, Japan) and after the consumption of pita bread baked from seeds that were accidentally pickled with mercury (Iraq 1971/72). Predominant are symptoms of damage to the central nervous system: nausea, paresthesia (sensibility disorder), distorted vision, speech and hearing as well as impaired coordination of motions (ataxia). Severe intoxications lead to coma and death. The symptoms of chronic intoxication resemble that of an acute intoxication.

b) Lead and its compounds are used in a diverse number of technological fields. Nevertheless, foodstuffs present the main source of contamination for the general public. Lead pipes in house installations can lead to extensive lead ingestion via drinking water. Acute to sub-acute intoxication symptoms manifest themselves, for example, as stomach aches, constipation, kidney function disorders and anaemia. In serious cases, in particular in children, lead encephalopathy (brain damage) with headaches, apathy, vomiting, seizures, and coma may occur along with a weakening or paralysis of the extremities. Chronic lead poisoning affects above all the haematopoietic system (lead anaemia), the gastrointestinal tract (loss of appetite, colicky stomach cramps), and the central and peripheral nervous system (e.g. loss of memory, disability to concentrate, muscle weakness).
c) Cadmium compounds are used in the galvanising industry, as pigment in porcelain and ceramic painting, in the dyeing of plastic objects or in the production of nickel/cadmium batteries. The general public is mainly exposed to cadmium through food sources (vegetarian foodstuffs, pork and beef kidneys). Tobacco smoking leads to extensive inhalative intake of cadmium. Cadmium accumulates in the body (accumulative toxin). Acute intoxications have only been observed in workers in cadmium processing enterprises to date. The chronic intake of higher doses can lead to anaemia, osteomalacia (softening of the bone) and kidney damage.

d) Radionuclides
Radioiodine ($^{131}$Iodine) and caesium ($^{137}$Cs, $^{134}$Cs) were the main radionuclides released after the nuclear reactor catastrophe of Chernobyl in 1986. As a result of the fallout (dry deposit) and the washout (precipitation deposit), soil contamination occurred with follow-up radioactive contamination of foodstuffs (e.g. cow's milk, forest mushrooms, game, etc.). $^{137}$Cs and $^{134}$Cs can increase the general cancer risk, as can most radionuclides.
3 Methods

3.1 Analysis of the Breast Milk Samples

3.1.1 Demands on Analytics

Breast milk is made up naturally of a great number of chemical components: water, proteins, fats, sugar, vitamins, minerals and trace elements. The composition of breast milk is not constant and changes even during the act of breastfeeding. At the beginning of the breastfeeding act, the breast milk is rather watery in order to satisfy the infant’s thirst. Towards the end of nursing, the fat percentage in the milk increases in order to satiate the child.

In addition to water, the main chemical components are:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>ca. 1.2 %</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>ca. 7.0 %</td>
</tr>
<tr>
<td>Fats</td>
<td>ca. 4.1 %</td>
</tr>
</tbody>
</table>

The foregoing foreign substances are enriched in the milk fat of human milk samples. Consequently, from a chemical analytical point of view, the fat percentage in the sample in which the foreign substances occur is the subject of interest.

Currently, no analysis system is known that would be capable of determining organic trace components directly in a breast milk sample. Therefore it is necessary for technical reasons to separate the analytes in the sample to be examined from as many other (disturbing) components as possible in order to extract them within a range of concentration in which they can be evaluated. The analysis procedure to be used must be able to detect organochlorine and nitro-musk compounds of the size of a picogram (0.000.000.000.001 grams) as an absolute value.
3.1.2 Determination of the Fat Content in Breast Milk

The breast milk samples were first analysed in terms of their fat content [4]. In order to determine the fat content of the breast milk sample, the milk protein was dissolved by adding sulphuric acid. The milk fat released in this manner is then separated through centrifugation in a special measurement tool, the butyrometer (see Ill. 1), whereby the addition of isoamyl alcohol facilitates phase separation. The fat content of the breast milk can be read off on the scale on the butyrometer as a mass percentage.

The determination of fat content is required in order to be able to depict the residue in breast milk as a quantitative reference value, thus enabling comparison of results.

Ill. 1. Butyrometer

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1 Examination procedure pursuant to § 35 LMGB [German Food and Utility Articles Act]: Determination of the Fat Content of Milk According to the Gerber Process
3.1.3 Determination of Organochlorine Compounds and Nitro-Musk Compounds

Further qualitative and quantitative determination of breast milk in terms of organochlorine and nitro-musk compound contents is effected according to the H. Steinwandter method [5] by means of a gas-chromatographic measurement of the samples (GC-ECD).

III. 2. Chemical Structural Formulas of Some Analysed Compounds

![Chemical structures of some compounds](image)

- PCB 138
- PCB 180
- pp-DDE
- Nitrofen
- Musk xylol
- pp-DDE

To determine the polychlorinated biphenyl (PCB), organochlorine pesticide and nitro-musk compounds in breast milk, capillary gas chromatography is the method of choice (see III. 3). After the analyte mixture has been separated, detection is carried out using an electron capture detector (ECD) or mass spectrometer (MS), whereby the detection sensitivity of the ECD is better than that of the mass selective detector.

III. 3. Gas Chromatograph
Apart from the residual material one looks for, the breast milk samples that are the subject of analysis contain a considerable portion of interfering secondary substances. A very efficient extraction method is required for separating the residual matter from the secondary substances. Depending on the fat content in a sample, as a rule, 10 grams of breast milk were used for analysis.

In these 10 g samples, for the most part less than 1 nanogram of the sought after residual matter was found; i.e. the percentage of analysed foreign substances falls under one millionth (1/1,000,000). In order to fulfil this analytical demand, adsorption chromatography was implemented. Thereby, first of all the breast milk sample is levigated with silica gel. Subsequently the prepared sample is filled into a chromatography column (see Ill. 4) in which the silica gel needed for extraction purposes was already placed. Extraction is effected using a petrol ether/dichloromethane mixture, whereby interfering components (e.g. fat) remain in the column for the most part.

**III. 4. Chromatography Columns for Extraction**

Along with further fat soluble (nonpolar) substances, the eluate contains the desired analytes. In order to enrich the eluate, it is gently concentrated in the rotation damper until almost dry. The eluate is then filled up with n-hexane until it reaches a defined volume and can then be injected into the gas chromatograph (see Ill. 3). The analysis findings are depicted and analysed in chromatograms (see Ill. 5.).
This determination method was backed up by using gas chromatography – mass spectrometry coupling (GC-MS). The measured foreign substance concentrations were placed in reference to the relevant fat content of the breast milk sample and indicated in mg/kg milk fat.

The Lower Saxon State Office for Consumer Protection and Food Safety (LAVES), Foodstuff Institute Oldenburg, examined a portion of the breast milk samples in terms of their dioxin and furan (PCDD/PCDF), phthalic acid ester and heavy metal contents as well as radioactivity. LAVES reports on the detailed findings according to agreement.
3.2 Breast Milk Analysis Flowchart

The following chart clarifies the breast milk analysis procedure:

Ill. 6. Flowchart

1. Declaration of participation
2. Sample pack is sent to participant
   - Sample pack without sample: No further processing
   - Sample pack with sample: Recording in the lab information management system (LIMS)
3. Fat content determination according to the Gerber Procedure
4. Extraction/enrichment
5. Measurement in gas chromatographs
6. Evaluation
7. Findings
3.3 Analytic Quality Assurance

Along with the development and optimisation of analytic methods, quality assurance received its due diligence before the Breast milk Monitoring Program commenced at the NLGA in the year 1999 with the first samples from Lower Saxon mothers. Due to a lack of norms and certified reference materials on the breast milk matrix, the following measures were implemented:

3.3.1 Internal Laboratory Checks

- The batches of the chemicals used were checked for purity by means of chromatographic measurements.
- The devices were tested at close-meshed intervals for correct functionality, constancy and non-contamination.
- In order to check the extraction success of each sample, internal standards were implemented.
- Deployment of cow’s milk samples (checking for fat content)
- Deployment of pooled samples (breast milk)

3.3.2 External Laboratory Checks

Regular participation in external interlaboratory tests was limited to the determination of the fat content in cow’s milk. Interlaboratory tests for the qualitative and quantitative determination of organohalogenic and nitro-musk compounds in the milk matrix are not offered (commercially). Nonetheless, the environmental medicine laboratory endeavoured to provide efficient external controlling mechanisms. For this, comparative measurements of real breast milk samples were conducted by other laboratories, which for the most part determine the same parameters in human milk. The following laboratories participated in this sample exchange and comparative measurements:

- The Lower Saxon State Office for Consumer Protection and Food Safety (LAVES), Foodstuff Institute Oldenburg
- The State Office for Natural and Environmental Affairs of the State of Schleswig Holstein, Kiel
- Institute for Hygiene of the University of Magdeburg
3.3.3 Documentation

Documentation was devised in such a way so that the pathway of the sample from sample entry until the final findings can be completely retraced. The laboratory received accreditation in the year 2002.

III. 7. Accreditation Document
3.4 Questionnaire for Data Collection Pertaining to Influencing Factors

In order to collect data pertaining to influencing factors that could have an impact on the content of foreign substances in the breast milk, the participating mothers filled out a standardised questionnaire.

3.5 Statistical Assessment

The foreign substance concentrations of the examined breast milk samples were depicted in the following assessments as medians (“middle values”), as these are least of all subject to influence by extreme values, inter alia. The mean (“average value”) was only given for reasons of facilitating comparison with the foreign substance concentrations determined in the years 1987 until 1994 by the former Chemical Foodstuffs Analysis Office (presently LAVES).

For the specific question of whether the concentrations of foreign substances have changed in the years 1999 until 2003 so-called linear models were used, whereby the effect of various influencing factors can be controlled for simultaneously. Samples with a concentration below the threshold of measurement were set at a value between zero and the respective threshold of measurement.
4 Findings

It should always be kept in mind in terms of the further assessment of the submitted data that they are not representative of all breastfeeding mothers in Lower Saxony. The participants registered for the analysis of their breast milk on their own initiative after being provided with information by midwives, gynaecologists or articles in the press and have thus not been selected at random from the overall population of breastfeeding mothers in Lower Saxony. Due to the large number of examinations that were conducted, however, a certain generalisation is possible. Nevertheless, such a statistical assessment is expedient against the background of being able to identify possible trends or noticeable problems in certain population segments that can be followed up with representative analyses.

4.1 Participation in the Years 1999 to 2003

Participation in the Breast Milk Monitoring Program is not consistent for the whole of Lower Saxony. In terms of figures, most samples came from the Hannover Region.

In order to get an approximate estimation of the participation rate in the individual rural districts and independent urban districts, the annual sample volume was based on the live births in the year 2000. The summarized “participation rates” of the five years under concern (information in %) are depicted in the following map:

**Ill. 8. Depiction of Participation Rates**

The distribution of the sample volume according to the four district regions fluctuated considerably: For example, in the year 2002 more than 40% of the samples came from the administrative district of Hannover whereas in the year 2003 it was just under 30%.
4.2 Basic Data

For the years 1999 – 2003, 2873 questionnaires accompanying the milk samples were incorporated into the following assessment, whereby questionnaires in which basic information – such as the native country of birth of the mother or the breastfeeding duration – was lacking could not be taken into consideration.

Table 1. Breakdown according to Nation of Birth of the Mother, Absolute Frequency

<table>
<thead>
<tr>
<th>Country</th>
<th>Years 1999-2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2873</td>
</tr>
<tr>
<td>West German Federal States, in particular Lower Saxony ,</td>
<td>2569</td>
</tr>
<tr>
<td>Former German Democratic Republic</td>
<td>62</td>
</tr>
<tr>
<td>Australia</td>
<td>2</td>
</tr>
<tr>
<td>Bosnia-Herzegovina</td>
<td>2</td>
</tr>
<tr>
<td>Brazil</td>
<td>3</td>
</tr>
<tr>
<td>Canada</td>
<td>2</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
</tr>
<tr>
<td>Greece</td>
<td>3</td>
</tr>
<tr>
<td>Iran</td>
<td>3</td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>24</td>
</tr>
<tr>
<td>Netherlands</td>
<td>9</td>
</tr>
<tr>
<td>Peru</td>
<td>2</td>
</tr>
<tr>
<td>Poland</td>
<td>35</td>
</tr>
<tr>
<td>Rumania</td>
<td>6</td>
</tr>
<tr>
<td>Russia / former USSR</td>
<td>28</td>
</tr>
<tr>
<td>Spain</td>
<td>3</td>
</tr>
<tr>
<td>Sudan</td>
<td>57</td>
</tr>
<tr>
<td>Turkey</td>
<td>16</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>2</td>
</tr>
<tr>
<td>Ukraine</td>
<td>2</td>
</tr>
<tr>
<td>USA</td>
<td>5</td>
</tr>
<tr>
<td>Further countries – total²</td>
<td>28</td>
</tr>
</tbody>
</table>

² For a list of further countries, see appendix 1
Table 1 displays the itemization of the data records according to the nation of birth of the mother. Thereby, 10.58% of the participating mothers stem from the former GDR or from abroad.

In Table 2 the participating mothers are broken down according to their age, country of origin, whether they are “first-time breastfeeders” or “repeat breastfeeders”. The greatest percentage of participating mothers is between the age of 25 and 35. The percentage of mothers who were nursing their first child was 53.4%, i.e. just over half of all participating women. The group of first-time breastfeeding mothers of Western-German origin aged between 25-34 was highlighted in Table 2, as the analysis of the concentration of foreign substances over the past years was carried out for this restricted group (approximately 37.2% of all participants) in Chapter 4.5.

### Table 2. Age of the Mothers – According to Region of Origin (100% = 2865)

<table>
<thead>
<tr>
<th></th>
<th>&lt; 25</th>
<th>25 - 29</th>
<th>30 - 34</th>
<th>35-39</th>
<th>40 +</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS.³ First-time</td>
<td>2.8%</td>
<td>15.3%</td>
<td>21.9%</td>
<td>6.8%</td>
<td>0.9%</td>
<td>47.7%</td>
</tr>
<tr>
<td>West German FS³ Repeat</td>
<td>0.6%</td>
<td>6.7%</td>
<td>20.8%</td>
<td>11.8%</td>
<td>1.9%</td>
<td>41.8%</td>
</tr>
<tr>
<td>Former East Germany</td>
<td>1.5%</td>
<td>2.1%</td>
<td>1.6%</td>
<td>0.5%</td>
<td>0.0%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Other nations Repeat</td>
<td>0.6%</td>
<td>1.7%</td>
<td>1.2%</td>
<td>1.1%</td>
<td>0.2%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Total</td>
<td>5.5%</td>
<td>25.7%</td>
<td>45.5%</td>
<td>20.2%</td>
<td>3.1%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Country of origin of the mother and total number of breastfed children are important influencing factors affecting the foreign substance concentrations in the breast milk, as is described in the following:

---

³ LS.: Lower Saxony, FS: Federal States
4.3 Age Distribution of Participating Mothers

Illustration 9 depicts the age distribution of the mothers participating in the Breast Milk Monitoring Program from the years 1999 until 2003 in comparison with the age distribution of the paras in Lower Saxony during the same timeframe.

**III. 9. Age Distribution**

The participation rate of mothers aged between 16 and 27 is rather low. In contrast, active participation was noted amongst mothers between age 30 and 35.
4.4 Foreign Substance Concentrations in the Analysed Breast Milk Samples

In Table 3, the median, minimum and maximum concentrations of foreign substances of the breast milk samples analysed in the years 1999 until 2003 are listed. Neither the minimal nor the median concentrations of foreign substances thereby exceed the current reference values [6] recommended by the Federal Institute for Risk Analysis (BfR). Overstepping was as a rule detected in the breast milk of mothers from Eastern Europe or other continents.

Table 3 also shows that the foreign substances HCB, DDT and PCB in every and β-HCH in nearly all analysed breast milk samples were detectable. In contrast, the concentrations of γ-HCH, HCEO or musk compounds were only determined in isolated cases, as they fell below the threshold of measurement in most breast milk samples. For this reason, in the following chapters (4.5ff) only the assessments of the foreign substances PCB, DDT, HCB and β-HCH will be depicted.

Table 3. Median, Minimum and Maximum Foreign Substance Concentrations in the Analysed Breast Milk Samples (mg/kg fat)

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Median</td>
<td>Minimum</td>
</tr>
<tr>
<td>HCB</td>
<td>0.006</td>
<td>0.253</td>
<td>0.040</td>
<td>0.007</td>
</tr>
<tr>
<td>β - HCH</td>
<td>n.d.</td>
<td>1.459</td>
<td>0.022</td>
<td>0.002</td>
</tr>
<tr>
<td>Σ DDT</td>
<td>0.016</td>
<td>2.258</td>
<td>0.138</td>
<td>0.020</td>
</tr>
<tr>
<td>Σ PCB x 1.64</td>
<td>0.044</td>
<td>1.292</td>
<td>0.321</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>0.006</td>
<td>0.205</td>
<td>0.034</td>
<td>0.006</td>
</tr>
<tr>
<td>β - HCH</td>
<td>n.d.</td>
<td>0.869</td>
<td>0.019</td>
<td>n.d.</td>
</tr>
<tr>
<td>Σ DDT</td>
<td>0.023</td>
<td>3.138</td>
<td>0.115</td>
<td>0.017</td>
</tr>
<tr>
<td>Σ PCB x 1.64</td>
<td>0.031</td>
<td>1.089</td>
<td>0.294</td>
<td>0.064</td>
</tr>
</tbody>
</table>

n.d. = not determinable, i.e. below the threshold of measurement

---

4 On the 1st of November 2002, the Federal Institute for Health and Consumer Protection and Veterinary Medicine (BgVV) was restructured to become the BfR.
4.5 Contamination of Breast milk with Pollutants in the Course of Time

Illustration 10 depicts the temporal progression of the concentration of foreign substances in the breast milk of Lower Saxon mothers from the year 1987 (without taking influencing factors such as the age of the mother, number of breastfed children, etc., into consideration). For all measured foreign substances, a clear decline in concentration figures could be noted, whereby this was not always consistent. Determination of the foreign substance concentrations in the breast milk was conducted by the Lower Saxon State Office for Consumer Protection and Food Safety (LAVES), Foodstuff Institute Oldenburg from 1987 to 1997 [7,8]. Thereby the measurements from the years 1995 to 1998 are not regarded in Illustration 10 due to the low number of participants (n = 60, twice n = 41).


Since 1999 the State Health Authorities of Lower Saxony (NLGA) have been conducting the breast milk analyses [3, 11,16].

\[\text{Konzentration in mg/kg Fett}\]

[formerly: State Chemical Foodstuff Examination Office (CLUA)]
4.6 Nitrofen

In the year 2002, a food contamination incident with the banned plant treatment agent nitrofen unsettled the German public. Its classification as a possible birth defect causing substance led to concerns and questions amongst pregnant women and nursing mothers. Due to its material properties, nitrofen can also pass into the breast milk of nursing mothers. Within the framework of this Breast milk Monitoring Program, the State Health Authorities of Lower Saxony were able to immediately develop a method for detecting nitrofen in breast milk so that the breast milk of all women could be analysed for this substance. At the same time, breast milk samples from the time before knowledge of this contamination were analysed. No nitrofen was detected in the breast milk samples from the year 2002 as well as in the samples from the year 2001, i.e. 1 ½ years before notification. In addition, random samples from the years 1999 and 2000 were examined and since establishment of the analytical process, every breast milk sample to date is analysed for nitrofen. Nitrofen was found in no samples. This example illustrates how the breast milk analysis acts not only as an excellent instrument for depicting long-term contamination with pollutants, but how it can also be implemented quickly to deal with current problems.

Ill. 11. Structural Formula of Nitrofen

Chemical designation: 2,4-Dichlorophenyl-4'-nitrophenyl ether

![Structural formula of nitrofen](image-url)
4.7 Dioxins and Furans (PCDD/PCDF)

The LAVES Foodstuffs Institute in Oldenburg examined breast milk samples for traces of dioxins and furans (PCDD/PCDF) from 1986-2002 [15]. These findings are depicted in the following Illustration 12.

III. 12. PCDD/F-Contamination of Breast Milk in the Course of Time (1986-2002)

The PCDD/PCDF concentrations of the breast milk dropped by a third from 1986 to 2001. This continuous downward trend was set forth in the year 2003.
4.8 Phthalates

Within the course of the Phthalate Ester Analysis Program, the LAVES Foodstuffs Institute in Oldenburg examined ten breast milk samples. Due to suspicion of a potential health risk (e.g. hormone-like effect on the body) as well as its ubiquitous distribution (e.g. in food packaging), breast milk samples were analysed for phthalates. In four of the ten examined samples, the content of di(2-ethylhexyl)phthalate (DEHP) amounted to 0.01mg/kg. In the six other samples, it fell under the measurement threshold of 0.01mg/kg. The concentration of di-n-butyl phthalate (DBP) and diisobutyl phthalate (DIBP) fell under 0.01mg/kg in all cases. Thus, the findings are tendentially somewhat lower than in earlier analyses [17,18].

Table 4. Phthalic Acid Ester in Breast Milk (each listed in mg/kg)

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Age of the mother</th>
<th>Number of children</th>
<th>DIBP</th>
<th>DBP</th>
<th>DEHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36</td>
<td>1</td>
<td>n. d.</td>
<td>n. d.</td>
<td>n. d.</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>2</td>
<td>n. d.</td>
<td>n. d.</td>
<td>0.01</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>1</td>
<td>n. d.</td>
<td>n. d.</td>
<td>n. d.</td>
</tr>
<tr>
<td>4</td>
<td>31</td>
<td>1</td>
<td>n. d.</td>
<td>n. d.</td>
<td>0.01</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>2</td>
<td>n. d.</td>
<td>n. d.</td>
<td>n. d.</td>
</tr>
<tr>
<td>6</td>
<td>33</td>
<td>1</td>
<td>n. d.</td>
<td>n. d.</td>
<td>n. d.</td>
</tr>
<tr>
<td>7</td>
<td>32</td>
<td>1</td>
<td>n. d.</td>
<td>n. d.</td>
<td>0.01</td>
</tr>
<tr>
<td>8</td>
<td>35</td>
<td>2</td>
<td>n. d.</td>
<td>n. d.</td>
<td>0.01</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>1</td>
<td>n. d.</td>
<td>n. d.</td>
<td>n. d.</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
<td>2</td>
<td>n. d.</td>
<td>n. d.</td>
<td>n. d.</td>
</tr>
</tbody>
</table>

(n. d. = not determinable, value below the threshold of measurement of 0.01 mg/kg)
4.9 Metals

In cooperation with the LAVES Foodstuffs Institute in Oldenburg, breast milk samples were randomly tested for the heavy metals \textit{mercury}, lead, cadmium as well as \textit{caesium isotopes}.

No elevated concentrations were detected in any samples. Of the 237 analysed samples, cadmium above the analytical detection limit was found in only one sample. Unfortunately, this finding could not be verified by means of a follow-up sample, as the participant did not supply any further samples.

Amalgam

Due to various queries, 18 breast milk samples from dentists and dental assistants, who work or worked in the past with the mercury-containing \textit{amalgam}, were specially tested for \textit{mercury}. \textit{Mercury} was not detected in any of the samples, whereby the measurement threshold lies at 0.003 mg/kg per sample.
4.10 Influencing Factors on the Foreign Substance Content of the Breast Milk

4.10.1 Number of Breastfed Children

The concentration of foreign substances in breast milk decreases with each additionally breastfed child, as is empirically verified by the following Illustration 13. Hence, nursing functions as an elimination mechanism (expulsion mechanism) for certain foreign substances in the body, albeit to the disadvantage of the nursed infant.

**Ill. 13. Median Foreign Substance Concentrations in Breast Milk According to the Number of Children Breastfed in Total (only mothers born in FRG)**
4.10.2 Country of Origin of the Mother - Foreign Substance Concentrations in the Breast milk of Foreign Mothers

The region of origin of the mother can have a considerable impact on the foreign substance concentration. Even though the majority of the participating mothers were born in West German Federal States, and the number of participating foreign mothers is still too low to render a meaningful descriptive statistics, clear and also explainable differences arise when it comes to gross classification according to region of origin.

In the following Illustration 14, the foreign mothers from Western or Eastern Europe are divided up (cf. also Table 1). The single results of mothers from other continents are not statistically and graphically presented due to the low number of case\(^6\).

Nevertheless, peculiarities were observed in the breast milk of these participants. Therefore, these individual findings will be reported separately, as they can be valued merely as indicative information.

III. 14. Median Concentrations of Foreign Substances in the Breast Milk of First-Time Breastfeeders according to Region of Origin of the Mothers; Year 2003

---

\(^6\) First-time breastfeeding mothers outside of Europe n=2.
Higher PCB concentrations were detected in the breast milk of women from West German Federal States than in the milk of mothers from the former East German Federal States and Eastern Europe. PCB was not used much in the former GDR and this is reflected in the PCB concentrations of the breast milk. In contrast, higher DDT concentrations can be found in the milk of women from the former GDR and Eastern Europe when compared to women from Western Europe, or respectively the West German Federal States. In particular in the former GDR, DDT was still in use in the agricultural industry until 1989 whereas it had been banned in the FRG (West Germany) since 1972. Higher concentrations of β-HCH are found in the breast milk of mothers from Eastern Europe than in the milk of other women.

4.10.3 Age of the Mother

The foreign substance concentrations in the breast milk of mothers who are breastfeeding their first child displays a clear age dependency. With an increase in the age of the mothers, increasing concentrations of foreign substances can be traced in the breast milk. Thus is in comparison to younger mothers, the longer intake period of foreign substances and the associated enrichment in the fatty tissue of the older mothers is expressed. During breastfeeding, foreign substances are mobilised from the fatty tissue and passed into the breast milk.

Illustration 15 reflects this process. As the age of the mother and the number of breastfed children are statistically interdependent anyway, only the group of first-time breastfeeders will be regarded. We have foregone depicting the group of over 40-year-olds due to of the low number case. Likewise, mothers from the former GDR as well as mothers of foreign origin were not incorporated in the depiction.

---

7 In 2003 nine breastfeeding mothers over the age of 40 (median values: PCB 0.625; DDT 0.227; HCB 0.065; β-HCH 0.030.)
III. 15. Median Foreign Substance Contamination of the Breast Milk According to the Age of the Mothers who are Breastfeeding their First Child and were Born in the FRG. Year 2003

4.10.4 Further Influencing Factors

In the following several factors are listed which might have an influence on the concentrations of foreign substances in the breast milk.

- Place of residency, geographic particularities (contaminated sites, former production sites, trips abroad)
- Handling chemicals (private/professional)
- Nutrition (mixed diet, vegetarian diet, one-sided nutrition)
- High relative body weight (high body-mass-index, BMI = weight in kg/(height in metres)$^2$)
- Relative weight fluctuation due to birth and breastfeeding
- Total previous breastfeeding duration
- Individual risk behaviour (e.g. smoking)
4.10.5 Changes in the Concentration of Foreign Substances from 1999 to 2003

Simple depiction, not controlled by any influencing factors, of the progression of the average contamination with pollutants from the past years (see Illustration 10) suggests that contamination – although it is already at a very low level anyway – is continuing to decline over time.

However, this reduction may also be caused by other influencing factors which likewise change over the years. Hence, it remains to be examined whether this reduction is maintained if various influencing factors are regarded simultaneously in the assessments. To this end, we proceeded as follows:

Along with the year of sample-taking, the following (possible) individual influencing factors were regarded in view of the concentration of foreign substances:

- Age of the mother
- Relative weight (BMI)
- Smoking status (currently, formerly, never)
- Breastfeeding duration
- Change in weight during breastfeeding. Relation of the current weight to weight at birth.

In order to be able to investigate the significance of the individual influencing factors, data of a collective that is as homogenous as possible must be analysed. Only the data of mothers were incorporated that fulfilled the following criteria:

- First-time breastfeeder
- Between the age of 25 and 34
- German origin

For the four considered foreign substances or respectively foreign substance groups, Table 5 renders the relative significance of the considered influencing factors. Hereby the significance indicates with which amount of assurance a direct correlation between the influencing factor (e.g. age) and the material concentration (e.g. DDT) can be presumed without other factors (e.g. nation of origin) distorting the outcome. A correlation is called “significant” when the probability of error, expressed as the p value, is very low. The lower the probability of error is (about 5 %, 1 % or even 0.1 %), the surer the verified correlation is from a statistical point of view.
Influence factors on the foreign substance content in breast milk (multivariate regression model for foreign substances (original scaling), only mothers from Lower Saxony between the age of 25-34), “all” = all participants, relative effect in terms of p-values: ***: p < 0.1% (highly probable correlation), **: p < 1% (very probable correlation), *: p < 5% (probable correlation), +: p < 10% (borderline correlation), n. s.: p > 10% (correlation not significant)

The sample-taking year entails a considerable influence on the concentration of foreign substances for each individual foreign substance; i.e. the five years vary in terms of their average concentrations. A clear trend is depicted for all four examined materials; i.e. year by year the controlled average foreign substance content in first-time breastfeeders drops by a minimum. These reductions are listed in Table 6.

The age of the mother as well as the relative weight (BMI) were also determined to be significant influencing factors on the concentration of foreign substances in breast milk. The older a mother is, the higher the concentration of foreign substances in her breast milk is due to the longer period of foreign substance intake on the average. In light of relative weight, for PCB and DDT it was established that the higher the percentage of fatty tissue in which foreign substances can be stored, the lower the output of the foreign substances via breast milk will be. In the case of HCB, the opposite was verified. For these two influencing factors as well, the estimated effects – reductive or increasing - are listed in Table 6 for first-time breastfeeders.
The two individual factors “smoking” and “weight reduction” are of less importance when compared to the other factors. In addition, in the case of smoking, there is no increase in the amount of pollutants in the breast milk. Instead, the higher values were detected in the breast milk of non-smokers. Thence, an elevation in the concentration of foreign substance in the breast milk directly due to smoking was not observed. In another study [12], the opposite was reported in reference to the correlation between smoking and PCB contents.

The number of breastfed children has a clear influence on the concentration of foreign substances. The more children are breastfed, the lower the concentration of foreign substances in the breast milk is.

Table 6. Estimated Absolute Effects on the Average Foreign Substance Content of the Identified Influencing Factors (Multivariate Regression Model for Foreign Substances (original scaling), Only Lower Saxon First-Time Breastfeeding Mothers Aged between 25 and 34.)

<table>
<thead>
<tr>
<th>Factor</th>
<th>PCB</th>
<th>DDT</th>
<th>HCB</th>
<th>β-HCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample age (per day)</td>
<td>-0.00012</td>
<td>(-0.00010)</td>
<td>(-0.000028)</td>
<td>-0.000018</td>
</tr>
<tr>
<td>Age of the mother (per annum)</td>
<td>+0.023</td>
<td>+0.0068</td>
<td>+0.0035</td>
<td>+0.0010</td>
</tr>
<tr>
<td>Relative weight (in BMI)</td>
<td>-0.0096</td>
<td>-0.0033</td>
<td>+0.0013</td>
<td>(+0.00012)</td>
</tr>
<tr>
<td>Sample year</td>
<td>-0.016</td>
<td>-0.0085</td>
<td>-0.0035</td>
<td>-0.0020</td>
</tr>
</tbody>
</table>

For first-time breastfeeders, that would mean, for example (see grey shaded figure), that per year of life the PCB content increases by 0.023 mg/kg fat provided that all other examined influencing factors have been taken into consideration.

With the aid of these linear models, it was also investigated if there were differences in the foreign substance concentrations between the Lower Saxon rural districts and independent urban districts, provided that the other analysed influencing factors had been incorporated. To this end, along with the 47 rural districts and independent urban districts, the year of sample-taking (general time trend), the relative weight and the age of the mother as well as the breastfeeding duration were incorporated into the models. Here as well, only first-time breastfeeders aged between 25 and 34 were taken into consideration.
Only in the case of HCB was a “regional effect” determined (for first-time breastfeeders). As the samples were not randomly “drawn”, this verified differentiation should by all means not be over-interpreted as regards content.

Above all the administrative district proved to have a strong influence: In the Weser-Ems region, the values were considerably lower in comparison to the other three districts. In contrast, the urban district effect can be disregarded. All other analysis approaches yielded no clear results.

### 4.11 Findings from Mothers from other Nations (1999-2003)

Since project begin in the year 1999, mothers from over 40 nations who are living in Lower Saxony have participated. Due to the low number of cases, they mostly cannot be represented statistically meaningful way. However, for some nations of origin, an initial assessment can be made.

**III. 16. Foreign Substance Contents (Medians) according to Region of Origin of the Mothers from 1999-2003**

![Bar chart showing foreign substance contents (medians) according to region of origin of the mothers from 1999-2003.](chart)

As Illustration 16 shows, no essential differences were recognisable for HCB levels between the various regions. In terms of β-HCH, values that were approximately 5 times higher were determined for mothers from the former USSR. Similar β-HCH-concentrations in breast milk were found in the workgroup of Polder et al [2].

The highest DDT-contamination levels were found in mothers from Sudan. The lowest concentrations were found in mothers from the West German Federal States. The latter are
an expression of the output ban on DDT in the agricultural industry, which is in effect since 1972.

An opposite situation was found for PCB contamination, as this substance group was primarily used in industrial nations.

4.12 Individual Findings

In this chapter, exclusively individual cases are the subject of analysis that were particularly conspicuous in view of their concentrations of foreign substances in breast milk.

DDT

The highest DDT concentrations were determined in the milk of two participants from Chile and Ecuador. According to the information they provided, both participants did not work in the agricultural industry. The age of the mothers at the time of sample-taking was 26 (Ecuador) and 38 (Chile).

In the case of one participant each from the countries Indonesia, Turkey and Kazakhstan, noticeably higher levels of DDT contents were found in the breast milk samples.

A mother from former East Germany had a DDT value that was elevated in comparison to the other mothers from the former GDR:

For one Lower Saxon mother, a 13 x higher DDT concentration as compared to the Lower Saxon median (0.120 mg/kg milk fat) was determined. This 32-year old participant had lived all her life exclusively in the Weser Ems administrative district from which her parents and even grandparents also stem.

A possible explanation for the high DDT value in her breast milk might be the large number of tropical fruits (e.g. kiwi fruit) she consumed almost on a daily basis as a child. As DDT was in widespread use on a global basis in the early 70s, this path (of contamination) appears to be possible.
Table 7. Maximum DDT Contents of Individual Breast Milk Samples from Various Nations

<table>
<thead>
<tr>
<th>Country of origin</th>
<th>Total-DDT-content (in mg/kg milk fat)</th>
<th>Multiple as compared to the Lower Saxony median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecuador</td>
<td>18.662</td>
<td>156</td>
</tr>
<tr>
<td>Chile</td>
<td>15.443</td>
<td>129</td>
</tr>
<tr>
<td>Indonesia</td>
<td>3.138</td>
<td>26</td>
</tr>
<tr>
<td>Turkey</td>
<td>2.258</td>
<td>19</td>
</tr>
<tr>
<td>Former UDSSR</td>
<td>1.692</td>
<td>14</td>
</tr>
<tr>
<td>Former GDR</td>
<td>1.828</td>
<td>15</td>
</tr>
<tr>
<td>Lower Saxony</td>
<td>1.509</td>
<td>13</td>
</tr>
</tbody>
</table>

**PCB, HCB and β-HCH**

Within the other three foreign substance groups (PCB, HCB and β-HCH) no values as elevated as those of DDT were observed.
4.13 Samples from Sudanese Mothers

At the State Health Authorities of Lower Saxony, 57 samples from nursing mothers from Sudan were examined. The findings were surprising and were confirmed by means of random testing done by the LAVES Institute in Oldenburg.

Table 8. Foreign Substance Contents in Breast Milk Samples

<table>
<thead>
<tr>
<th></th>
<th>HCB</th>
<th>β-HCH</th>
<th>Lindane</th>
<th>Total DDT</th>
<th>Total PCB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.003</td>
<td>0.021</td>
<td>0.013</td>
<td>0.752</td>
<td>0.156</td>
</tr>
<tr>
<td>Median</td>
<td>0.002</td>
<td>0.013</td>
<td>0.008</td>
<td>0.399</td>
<td>0.016</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.009</td>
<td>0.123</td>
<td>0.205</td>
<td>6.775</td>
<td>1.283</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>M. ambrette</th>
<th>M. ketone</th>
<th>M. xylol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.818</td>
<td>0.021</td>
<td>0.013</td>
</tr>
<tr>
<td>Median</td>
<td>0.573</td>
<td>0.013</td>
<td>0.008</td>
</tr>
<tr>
<td>Maximum</td>
<td>49.549</td>
<td>0.123</td>
<td>0.205</td>
</tr>
</tbody>
</table>

The contents of synthetic nitro-musk compounds (musk ambrette, musk ketone and musk xylol) are rather conspicuous. No musk ambrette or musk ketone was detected in any samples from Lower Saxon mothers and musk xylol was only found in minute traces.

In a sample from a Sudanese mother with nearly 50 mg musk ambrette/kg milk fat, the highest level of foreign substance content was determined that was measured at all within the framework of the Breast milk Monitoring Program. In addition, the distribution of the contents was surprising. Musk ketone and musk xylol usage was widespread in industrial fields. In contrast, production of musk ambrette was low in comparison to the other nitro-musk compounds. As these synthetic scents are found in cosmetics, detergents and body care products, the nitro-musk compounds enter the human body and are passed on to the breast milk most likely via the skin. It cannot be explained how these synthetic scents could pass into the milk of Sudanese mothers who demonstrably do not use such products.

It would be interesting to research to what degree environmental pollution (drinking water, surface water) could come into question.
The content of DDT and PCB fall on the whole within the expected range. Nevertheless, in one sample a high PCB contamination level was detected, which is rather characteristic of mothers from western industrial nations.

This example as well illustrates the significance of breast milk biomonitoring.

**Ill. 17. Musk Ambrette Concentrations in Breast Milk**

![Graph showing Musk Ambrette Concentrations in Breast Milk]

**Ill. 18. Musk Xylol Concentrations in Breast Milk**

![Graph showing Musk Xylol Concentrations in Breast Milk]
5 Environmental Medicine Assessment

For years now it has been customary to assess the contamination of foodstuffs with foreign substances using the term TDI (Tolerable Daily Intake). This TDI value is calculated proceeding from the assumption of the lifelong daily intake of a foodstuff that is contaminated with a certain foreign substance. If accordingly a foreign substance in a foodstuff falls below or within the TDI value range, it can thus be assumed that the present foreign substance concentrations would cause no health damage in the event of daily and lifelong intake. This TDI value is referred to again and again in relation to the foreign substances contained in breast milk and the related health assessment, although the breastfed infant only receives breast milk for four to six months as a rule and for more than 12 months in only the rarest cases. Hence, higher values of a foreign substance can be tolerated in breast milk. Especially in light of this aspect, the presence of a foreign substance in breast milk in a concentration that falls under or within the TDI value range means that this foreign substance concentration does not present any health risks to the breastfed infants according to current scientific findings. Whereas in the late 70s and early 80s, comparably high foreign substance concentrations were found in breast milk, through the relevant bans on usage within the past 20 years, the concentrations of the main environmental foreign substances of those days have decreased considerably. However, there are still individual substances that have newly appeared in breast milk or which have not yet decreased considerably in concentration. Despite the relatively high concentrations of foreign substances in breast milk in the 80s, the Commission “Examination of Residues in Foodstuffs” of the German Research Community (DFG) undertook a health assessment of the residues in the year 1984 and developed reference values for the various foreign substances in breast milk. Already back then, this Commission established that the advantages of breastfeeding by far outweigh any possibly hazard presented by the existent foreign substances. As the concentrations of the foreign substances – as indicated above – have massively declined in the meantime, it can be generally assumed that the concentration of the previously known environmental pollutants in breast milk no longer plays such a relevant role in terms of neonatal health.
However, there are still individual mothers who had unexpectedly high concentrations of individual foreign substances due to their different nutritional habits or due to their origin from an emerging or developing nation. Along with providing assurance to the majority of mothers that their breast milk is well suited to nourish their infants, the monitoring of exactly these individual women with high concentrations of a foreign substance is particularly vital. Principally speaking, all foreign substances are undesired in breast milk and therefore, the minimisation precept should continue to be held upright. This is particularly true for new environmental foreign substances that are identified in breast milk and about whose health impairment potential still little is known.
6 Uses of Breast Milk Monitoring Programs

Individual Findings for the Participating Mothers
The Lower Saxon Breast Milk Monitoring Program is offered to mothers free of charge so that mothers receive the assurance through the analysis that their breast milk does not display any critical concentrations of foreign substances and that they can breastfeed their child without cause for concern. In the events of rare cases of occurring increases in the foreign substance concentrations in breast milk, the reasons for such can be individually researched together with the mother in question and individual breastfeeding recommendations can be vocalised, if necessary. For this aim, environmental medicine experts, paediatricians and toxicologists are available at the State Health Authorities of Lower Saxony.

Population Medicine Findings for Lower Saxon Health Policies
Using the breast milk monitoring programs as an “early warning system” for the exposure of the human organism to environmental foreign substances has been propagated by German as well as international experts in their publications [9].
With its “Breast Milk Monitoring Program of the State of Lower Saxony”, the Lower Saxon Ministry for Social, Women’s, Family and Health Affairs has intensified its efforts not only to provide individual protection to breastfeeding mothers, but also to obtain information on the exposure of women to contaminants in general.
In terms of health policy, such a programme, when conducted for a sufficient amount of time, provides vital information on the exposure of the human body to environmental foreign substances. Therefore, the Breast milk Monitoring Program can also be used in a population medicine context.

Breast milk as an Indicator of Environmental Pollution
The concentration of foreign substances in breast milk has been sinking continuously for years not least of all due to the ban on the production and use of numerous substances. It is necessary to further monitor this retrogressive overall trend, as for example improperly stored pesticides in the developing nations and the current usage of certain substances (e.g. DDT to combat malaria) may reverse this trend at any time. By entry into the environment, the pesticides are circulated globally and lead to an increased uptake by humans through the food chains, which is measurable by the elevation of the content of foreign substances in breast milk.
That the monitoring of foreign substances in breast milk, for which bans on production and usage have been in effect for years now in western nations, should continue to receive high priority is demonstrated by the latest examples from the year 2001 of an extensive food and animal feed contamination with the pesticide nitrofen. Via contaminated storage facilities, the substance which was taken out of circulation in the 80s was again found in foodstuffs. The State Health Authorities of Lower Saxony have therefore been analysing breast milk for nitrofen ever since notification of this case was issued. To date, nitrofen has not been found in any breast milk samples. As no nitrofen was found even in earlier - retroactively analysed - breast milk samples, it can be assumed that principally speaking the Lower Saxon population was not heavily exposed to this contaminant.

**Breast milk is an Excellent Bioindicator for Health Protection**

As the foreign substance concentrations largely corresponds to the concentration in the fatty tissue of the relevant mother’s organism, the foreign substance contamination of comparable population groups can be approximated. Hence, the analysis of breast milk can be seen as an indicator for initiation environmental policy measures to protect the health of the population.

On the basis of representative breast milk data, reference values for foreign substances can be derived. These reference values reflect the general background contamination ("current condition") of a "normally" exposed population group [6]. Reference value elevations, e.g. in breast milk, indicate an increase in foreign substance contamination. If reference value increases are detected not only in individual mothers, but in a larger group of breastfeeding women with mutual group characteristics, this points at a particular source of contamination, the cause of which can then be specifically investigated. The analysis of breast milk for foreign substances thus not only benefits the nursed infant, but the general public of the State of Lower Saxony as well.

In addition, the pollution of the environment with new foreign substances can be traced by relevant measurements of the breast milk. Thus, UV filter substances and polybrominated diphenyl ethers, which are used as a flame retardant agent in the electronics and textile industry, have now been identified to a large degree in breast milk.
7 References


## Appendix 1

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<th>Quantity</th>
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