HAZARDOUS SUBSTANCES IN ARTICLES AND MATERIALS

ANALYSIS OF PHTHALATES AND ALTERNATIVE PLASTICISERS, FLAME RETARDANTS, CHLORINATED PARAFFINS, HIGHLY FLUORINATED SUBSTANCES AND FORMAMIDE IN OLD AND NEW PRESCHOOL ITEMS.

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NONHAZCITY

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CONTENTS

1 SUMMARY

The Interreg Baltic Sea Region Project NonHazCity ("Innovative management solutions for minimizing emissions of hazardous substances from urban areas in the Baltic Sea Region") aims to demonstrate possibilities for municipalities to reduce emissions of priority hazardous substances and other pollutants from small scale emitters in urban areas that cannot be reached by traditional enforcement techniques.

Tracking sources of hazardous substances is one part of the NonHazCity project. To learn more about the content of hazardous substances in articles and materials, a range of indoor items were analysed for a selection of chemicals, with a focus on items commonly found in preschools.

New and old toys, creative material, mattresses and other interior items from preschools were analysed for a selection of hazardous substances including phthalates and alternative plasticisers, brominated flame retardants (BFR), organophosphorous flame retardants (OFR), chlorinated paraffins (CP) and highly fluorinated substances (PFAS). Furthermore, formamide was also analysed for in certain types of material. The purpose was to:

- investigate to what extent hazardous substances are found in articles and materials used in preschools, and thereby
- motivate preschools to dispose of articles that may contain hazardous substances, and
- check compliance of contracted suppliers with set criteria and legislation.

A total of 51 newly purchased items and 128 old articles and materials from preschools in Stockholm were analysed. Many of the old items had previously been discarded from the preschools, as they have already started to work according to the guidance document for a "chemicals-smart preschool".

The results from the study provide support for the recommendations to discard certain articles and materials present in the guidance document for a "chemicals-smart preschool" since the concentration of hazardous substances in a considerable number of the old toys and articles greatly exceeded the current legislative limits. Furthermore, the study shows that non-toy material, i.e. items which are not intended for play, may contain hazardous substances. By discarding old, as well as high risk items as the preschools have done, the amount of hazardous substances present in the indoor environment has been reduced. In total, phthalates, chlorinated paraffins, organophosphorous flame retardants and formamide, were found in many old items and a few new, while neither the new nor the old articles and materials contained any detectable levels of brominated flame retardants. One class of highly fluorinated substances, fluortelomeric alcohols, were detected in some of the new materials.

On the other hand, the present survey indicates that newly purchased items from the procured assortment are, in most cases, free from the analysed substances or well below restricted levels. This shows that the legislation has had effect and that replacement of old material with new will effectively reduce the levels of hazardous substances in the preschool indoor environment. A few of the new items contained some of the analysed substances at levels above the restrictions, but, in three cases out of four, this was in very low concentrations compared to many of the old items. Nevertheless, this shows that it is important to include analyses in the follow up on both legacy substances as well as for substances for which there are criteria in the procurement documents and contracts.

2 INTRODUCTION

The assessment of the status of the Baltic Sea environment by HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission) has stated that the load of hazardous substances is an issue of major concern. Despite a number of legal regulatory acts and measures for emissions reduction, hazardous substances are still released from land-based sources to the aquatic environment. These releases occur through three main pathways: industrial and municipal wastewaters, and stormwater. Nowadays consumption-related diffuse sources are more important sources for hazardous substances than production-related point sources. Examples of consumption-related diffuse sources are emissions from articles and materials used indoors in for instance households, preschools and offices.

The Interreg Baltic Sea Region Project NonHazCity ("Innovative management solutions for minimizing emissions of hazardous substances from urban areas in the Baltic Sea Region") aims to demonstrate possibilities for municipalities to reduce emissions of priority hazardous substances and other pollutants from small scale emitters in urban areas that cannot be reached by traditional enforcement techniques.

Tracking sources of hazardous substances is one part of the NonHazCity project. To learn more about the content of hazardous substances in articles and materials, a range of indoor items were analysed for a selection of chemicals, with a focus on items commonly found in preschools. The study was included in the local project "chemicals-smart preschool" at the Chemicals Centre of the City of Stockholm.

Both the Swedish Government and the Swedish Chemicals Agency have stated that the focus on a toxic-free everyday environment for children is a national priority. This is due to the fact that unborn children, toddlers and even adolescents are more sensitive to chemicals than adults. Their brains, immune systems and hormone systems are not fully developed, and they breathe faster and eat and drink more in relation to their weight. Young children who explore their surroundings by feeling and tasting things are particularly vulnerable.

In a previous project, the Stockholm Chemicals Centre has determined the levels of a wide range of hazardous substances in dust and flooring materials, from preschools within the city. Many of the substances found in articles and materials (building materials, furniture, toys etc.) are also present in dust. The present study is a continuation of the aforementioned studies, but focusing on toys, creative material, mattresses and furniture with the aim of investigating how common the analysed hazardous substances are in items present in preschools.

Both old and new toys, creative material, mattresses and other interior items from preschools and preschool assortments were analysed for a number of substances within five substance groups: phthalates and alternative plasticisers, brominated flame retardants (BFR), organophosphorous flame retardants (OFR), chlorinated paraffins (CP) and highly fluorinated substances (PFAS). Furthermore, formamide was also analysed for in certain types of material.

The purpose was to:

- investigate to what extent hazardous substances are found in articles and materials used in preschools, and thereby
- motivate preschools to dispose of articles that may contain hazardous substances, and
- check compliance of contracted suppliers with set criteria and legislation.

The analysis comprised of 179 items, 51 newly purchased items from the city's contracted suppliers and 128 old items from preschools in Stockholm. Many of the old items had previously been discarded from the preschools, as they have already stared to work according to the guidance document for a "chemicals-smart preschool".

3 METHOD

The choice of articles and materials to sample and which substances to screen for was done in parallel. The final choice of samples to analyse was made by using knowledge concerning which materials that are likely to contain phthalates, flame retardants, chlorinated paraffins, highly fluorinated substances and formamide. The focus was on soft plastic material and the samples analysed are thus not representative of preschool material as a whole since, for example, kitchen utensils were not analysed in this project. Some articles were chosen which were expected to be free of the substances to be analysed for. Examples

of this include toys made of hard plastic or plastic types not known to contain hazardous substances.

The samples were sent to a contracted laboratory for chemical analyses. The results were evaluated and summarized by the Chemicals Centre, City of Stockholm.

The substance groups which were chosen for analysis are described below together with some information about the relevant legislation. Lists of all analysed substances within each substance group are presented in Appendix 1. The legislations related to the analysed substances are presented in a summarised way in Appendix 2.

Phthalates are plasticisers present in different types of plastic material, most commonly as additives in polyvinyl chloride (PVC). It is fairly common for soft PVC plastic material to contain up to around 50% added plasticisers. Many phthalates are identified as Substances of Very High Concern (SVHC) in the European chemicals legislation REACH due to their classification as toxic for reproduction according to the regulation concerning classification, labelling and packaging of chemical substances and mixtures (CLP). Furthermore, six additional phthalates have specific restrictions for use in toys and child care articles, three of those only concern articles that can be put in the mouth, this stated in REACH, appendix XVII. The samples in this project were analysed for presence of the 15 REACH SVHC phthalates as well as the three unclassified phthalates that are present in the REACH appendix XVII restriction. This also reflects the criteria in the Toy Safety Directive and absence from those substances is thus the lowest standard used among European toy retailers nowadays. Furthermore, eleven of the phthalates on the candidate list are also present in appendix XIV, the authorization list. This means that authorization for use is needed for production within Europe while imported goods are not subject to this regulation (except for toys, in which all candidate list phthalates are regulated). Alternative plasticisers (non-phthalate plasticisers) were also tested for in some of the items, these are at present not subject to any regulation.

Organophosphorous flame retardants are used in furniture foam and textiles. This substance group also contains substances with other functions, for example pesticidal and plasticizing. Some of these have been found to be causative agents in cancer development as well as eliciting harm to the nervous system and brain development. Hence, a few of these substances are regulated via REACH while others have limit values in the Toy Safety Directive. Organophosphorous substances can be chlorinated or brominated, in this case they are grouped under the term ”halogenated flame retardants”.

Brominated flame retardants (other than the brominated organophosphorous flame retardants mentioned above) have been of wide use previously, for example in electronics and foam building materials. There are many varieties of these and there is still a lack of knowledge for some of them, while the presence and effects of others are well investigated and found to elicit long lasting effects in biological systems. HBCDD and many of the PBDEs and PBBs are identified as SVHC within REACH, many are also listed in the POPs Regulation.

Chlorinated paraffins (CP) are substances which occur in soft plastic or foam material as flame retardants and secondary plasticisers, in the latter case often together with a phthalate as primary plasticizer. Short chain chlorinated paraffins (SCCP) are regulated through the EU Regulation on Persistent Organic Pollutants (POPs regulation) and in the Stockholm Convention on POPs, SCCP are also present on the REACH SVHC list. Medium chain chlorinated paraffins (MCCP) are not regulated yet but they are classified as harmful to the nursing child and very toxic for aquatic organisms. Long chain chlorinated paraffins (LCCP) are neither regulated, nor classified. All three types were analysed.

Highly fluorinated substances (PFAS) are used as surface coatings on textiles, in kitchen utensils and lubricants of different kinds (the two latter uses were not analysed in this study). Many of these substances are highly persistent and bioaccumulative and are thus prone to have effects on health and environment, which is also indicated by many scientific studies. Some of these substances are regulated (for example PFOS), but not the fluorotelomer alcohols (FTOH).

Formamide is used when producing EVA-foam and TPR-rubber materials. The absolute concentration as well as emissions of formamide is regulated in the Toy Safety Directive if the contents in the article is above a certain level, since this substance is suspected to be a reproductive toxicant.

4 RESULTS AND DISCUSSION

4.1 New items

In total, 51 new samples of articles and materials were analysed. Of these, 22 were mattress material (covers and foam from mattresses for different types of use: nursing table, for rest during the day, small round pillows to sit on and one snow mattress), 11 were toys, and eight were creative materials. Eight textiles and two types of gloves for diaper exchange were also analysed. The items were not analysed for all substances, respectively, but for a choice of substance groups. Phthalates and chlorinated paraffins were analysed in 31 samples, alternative plasticizers were analysed in five samples, while flame retardants were analysed in 11 samples and formamide in only six. Highly fluorinated compounds were analysed in 11 samples. In 26 of the samples of new items, one or more of the substances analysed for were found, in 3 of them at levels above restricted level (0,1%), while 25 of the samples contained no detectable amounts of the analysed substances (Figure 1). Contents below the level of 0,1% is considered unintentional contamination during production.

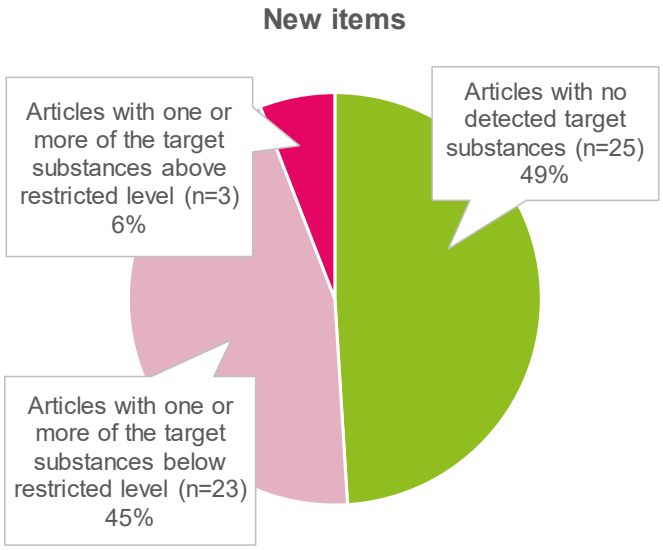


***Figure 1**: The distribution of new articles and materials containing quantifiable levels of any target substance above and below 1000 mg/kg (0.1% by weight), and no quantifiable levels, respectively.*

Phthalates were found in five out of 31 samples while chlorinated paraffins were found solely in two samples out of those 31. Organophosphorus flame retardants occurred in six samples out of eleven analysed samples and formamide in four out of six analysed samples. Brominated flame retardants were not found in any of the 11 analysed samples. In general, the detected substances were at low levels; well below or close to the regulated levels, except for one Öko-tex labelled sample which contained organophosphorus flame retardants at a total of 8.2%. LCCPs were analysed in four samples but not found. Out of alternative plasticisers (non-phthalate plasticisers), DINCH and DOTP were found in four of the five analysed new items, respectively, which indicates that these substances are replacing phthalates.

4.1.1 Matresses

One new mattress cover contained 0.3% of the phthalate DEHP as well as 0.7% SCCP, which makes it illegal to sell, both in relation to the regulation of phthalates in child care articles in REACH and the POPs Regulation where SCCP are regulated at 0.15%. One foam core of a mattress which was labelled with the Öko-tex ecolabel contained 8.2% of the organophosphorous flame retardants TDCPP and TCPP together, both restricted at 0.1% under the Öko-tex certificate. Another mattress, made for snow-play, contained 0.4% of the phthalate DINP in the cover. Although DINP is not regulated in this type of product (sports equipment) it is regulated in childcare articles which can be put in the mouth.

All the retailers have corrected the mistakes after receiving the results from the analyses, and taken the articles containing hazardous substances above restricted levels out of the market, changed contents in the article or replaced it with another material as well as making their own analyses of the material to verify the results of this study.

4.1.2 Toys and creative material

The toys tested were all within legal limits of chemical content. When phthalates were detected, it was always below 0,1%, while there were higher levels of alternative plasticisers but these are not restricted or classified. Formamide was detected in four out of six toy samples and the levels were all below the legislated level of content at 0.3% as well as the level where emission tests need to be undertaken (0.02%), the highest level was found in a toy made from TPU rubber (0.017%).

One creative material, a magnetic tape used for making of fridge magnets, contained 0.12% SCCP which is just above the limit for information according to the SVHC regulation in REACH. Since such information was not given when the article was sold to preschools, this was also not in accordance with the legislation. This article was exchanged by the supplier to one without content of SCCP.

4.1.3 Textiles

A number of different types of highly fluorinated substances were analysed including perfluorooctane sulfonate (e.g. PFOS), perfluoro carboxylic acids (PFCAs, e.g. PFOA) and fluorotelomer alcohols (FTOHs). Out of 25 types of highly fluorinated substances, the only substances found were FTOHs, in two different chain lengths of the carbon backbone (8:2 FTOH and 10:2 FTOH). One or both of these were detected in all three types of new mattress covers and in all three types of preschool furniture textiles as well as in one table cloth with an acrylic surface (Figure 2). The use of these substances is intended to give good stain repellent properties for articles used in preschools. The four analysed furniture textiles from the office assortment did not contain any detectable levels of highly fluorinated substances. The suppliers of office furniture might also deliver to pre-schools. After gaining knowledge of the results, the suppliers and manufacturers have taken action. Repeat analysis of one mattress indicated contamination in the first sample. For another mattress, FTOH is now removed from the production. Repeat analysis of these two mattresses have now shown no detection of any highly fluorinated substances.

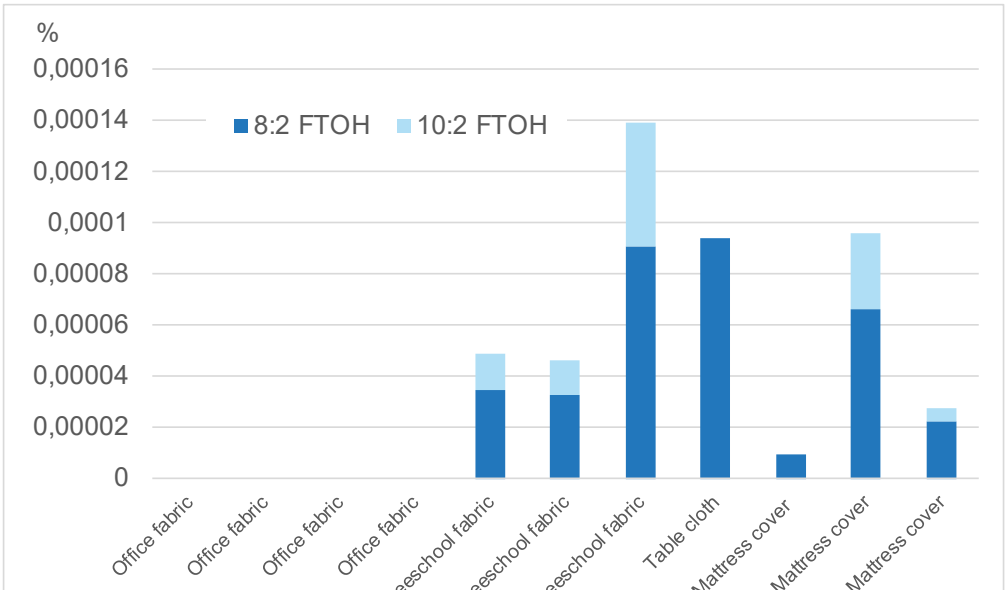


***Figure 2**: The amount of fluorotelomer alcohols (FTOH) found in different types of textiles (office furniture fabrics, preschool furniture fabrics, a table cloth and mattress covers).*

4.2 Old items

In total, 128 old items from preschools were analysed. All samples were not analysed for all substances, but for a selection of substance groups or formamide. Out of the old articles and materials, only 21 out of 128 had no detected levels of the analysed substances (Figure 3).

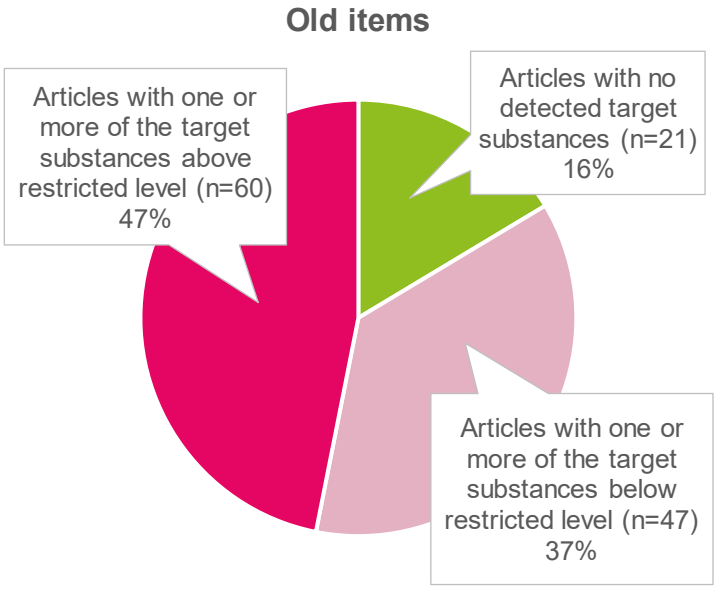


Figure 3: *The distribution of old articles and materials containing quantifiable levels of any target substance above and below 1000 mg/kg (0.1% by weight), and no quantifiable levels, respectively.*

Phthalates were detected in 80 out of 94 samples, SCCP in nine out of 79 samples and MCCP in 13 out of 79 samples. LCCP was not found in any of the five analysed samples. Organophosphorous substances were found in 23 out of 27 samples and formamide in eight out of nine samples. The levels were more frequently found to be far above legislated levels in the old material compared to the new items where levels, if detected, usually were low. Brominated flame retardants were not found in any of the 27 samples which were analysed for this substance group. Alternative plasticizers (DINCH, DEHT and ATBC) were found in four out of eight old plastic toys analysed for such substances. The results for the old samples are divided into different categories; mattresses and plastic toys, other toy types and interior items.

4.2.1 Mattresses

Mattresses of different kinds were sampled, both the covers and foam cores were analysed.

Mattress covers

Covers from 12 mattresses to be used for resting during the day, three nursing table mattresses and two mattresses for sports were analysed. Only one out of all the mattress covers did not contain any of the analysed substances. Figure 4 illustrates the occurrence of the three most commonly detected phthalates, DEHP, DINP and DIDP, in the mattress covers. Some other phthalates were also found in a few of the samples (Appendix 3). Chlorinated paraffins were detected in four of the 17 samples.

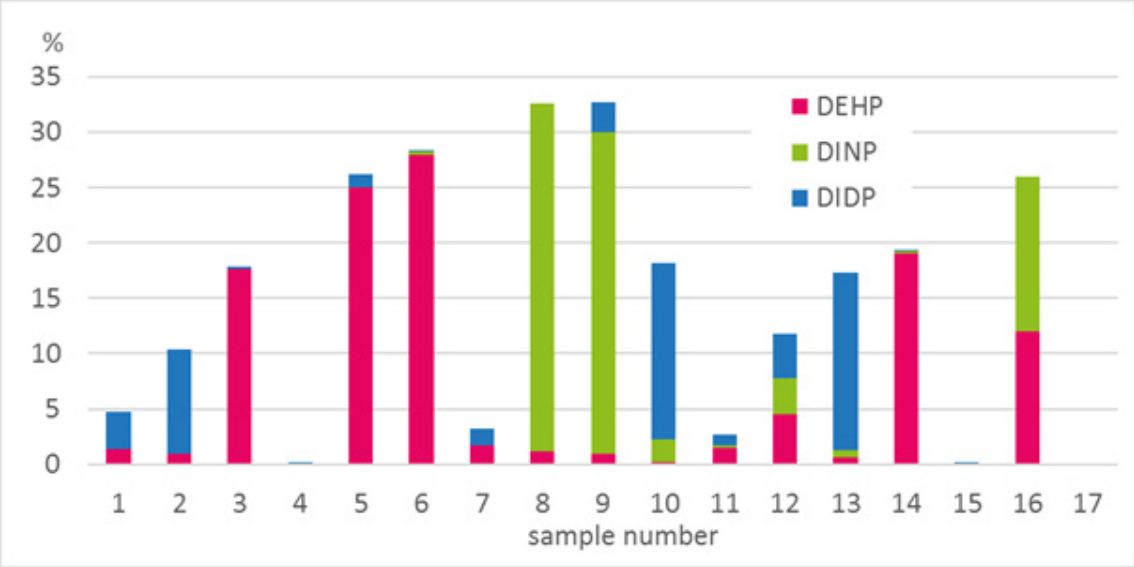


Figure 4: *Total levels of occurrence (%) per sample of the most commonly detected phthalates (DEHP, DINP and DIDP) in mattress covers.*

Foam filling

Foam filling from 12 mattresses for rest, two nursing table mattresses and two mattresses for sports were analysed for flame retardants. Among the mattresses for rest, organophosphorous flame retardants were found in ten out of twelve samples. The substances which were found in the highest levels were TDCPP (at 6.1%) and TCEP (at 3.5%). Eight out of the twelve samples from mattresses were, in addition to analysis for flame retardants, also analysed for presence of phthalates, and in seven out of those eight, phthalates were detected with the highest level being DEHP at 11% in one sample.

4.2.2 Plastic toys, other toy types and interior items

Most of the analysed plastic toys were made from soft plastic materials. Other toy types include other materials, for example plush material and puzzle-mats as well as non-toy materials which are used for play. The latter group includes, for example gardening hoses as well as handbags and other items used for dress-up. Interior items include table cloths, rugs, pillows, furniture fabric and furniture foam filling etc.

The plastic toys were analysed for phthalates and chlorinated paraffins while other toy material and interior items were analysed for different substance groups depending on the category of the material. The plush animals were analysed for flame retardants while the puzzle-mats were analysed for formamide since they are made from EVA foam.

Plastic toys

In total, 52 old plastic toys were analysed for presence of phthalates and chlorinated paraffins. The plastic toys are categorized into four groups: dolls, balls, animals and other. Phthalates were detected in 39 out of 52 plastic toys and in 14 out of those 39, the levels were very high (Figure 5). The three most commonly detected phthalates were DEHP, DINP and DBP, while four other phthalates were occasionally found in the plastic toys (DIBP, BBP, DNOP and DIDP). In the 14 plastic toys with very high levels (up to 40% of the toy material), the levels are up to 400 times above the current legislated level in this type of material. These toys were, for example, soft plastic thorny balls and plastic farm animals.

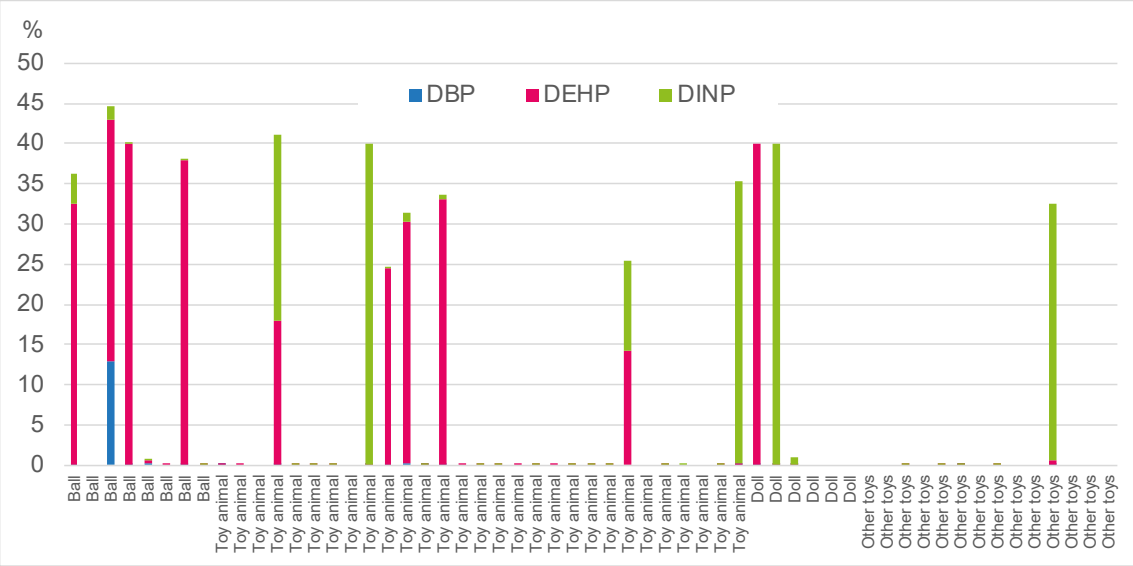


***Figure 5**: Total levels of occurrence (%) of the three most commonly detected phthalates (DBP, DEHP and DINP) in different categories of plastic toys.*

In three out of the 52 analysed plastic toys chlorinated paraffins were detected, at levels between lower than 0.1% to 0.7% for SCCP and below 0.1% to 2.9% for MCCP. No LCCPs were found in the one sample analysed.

Other toy types and interior items

The legislation on chemicals in articles differs between areas of use of articles, toys are subject to more stringent legislation since children are more susceptible to toxic effects and have another type of behaviour than adults, for example frequent mouthing of items. Articles intended to come into contact with food are also subject to specific legislation. Meanwhile, other articles are subject to much less stringent legislation concerning chemical content. One example of this is gardening hoses which are intended to use for watering of plants and not as a food contact material or a toy.

Phthalates and chlorinated paraffins were detected in old articles in this category. Seventeen items in the category other toy types and interior items were analysed for phthalates. The results for the three most commonly detected phthalates DBP, DEHP and DINP are shown in Figure 6. Five other phthalates (DIBP, BBP, DNOP, DIDP and DnHP) were also found in some of the items. Chlorinated paraffins were found in six of the items.

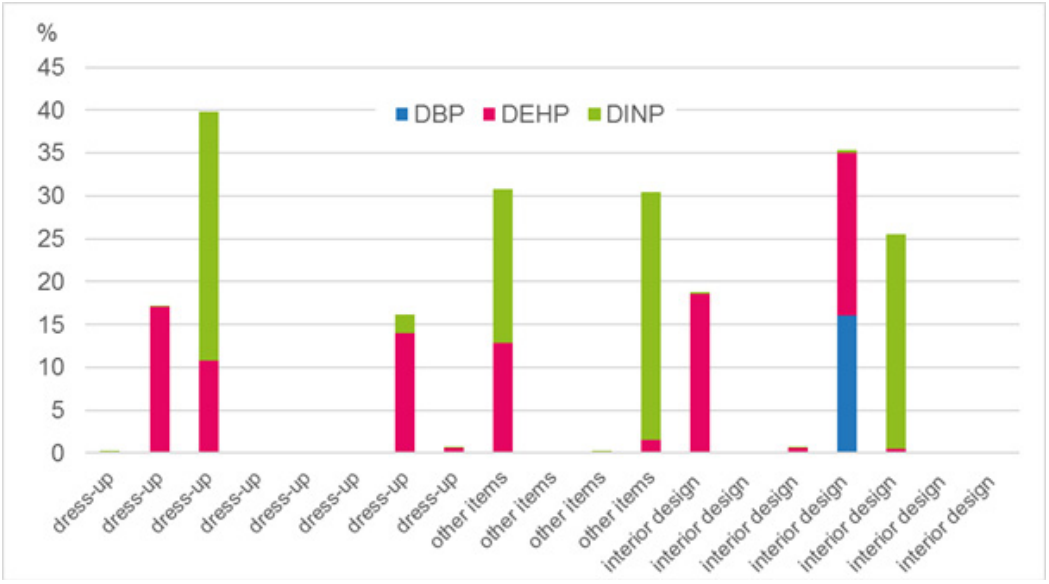


***Figure 6**: Total levels of occurrence (%) of the three most commonly detected phthalates (DEHP, DINP and DBP) in items used for dress-up, interior design and other items.*

Brominated and organophosphorous flame retardants were analysed in eleven old samples where six were toys and the remaining five were categorized as interior items. Brominated flame retardants were not detected in any of the samples while organophosphorous flame retardants were found in nine out of eleven samples. The two samples which were free from flame retardants were toys. In the nine samples where organophosphorous flame retardants occurred, it was common that more than one of the substances in this group were detected, especially when high levels were detected (up to 3.5%).

Formamide was analysed in seven old samples (including puzzle-mats, toy building blocks etc.) and was detected in all samples but at relatively low levels (0.0037-0.042%). The level of 0.042% formamide detected in one sample exceeds the level of 0.02% for test of emissions according to the Toy Safety Directive. The detected levels indicate that formamide is present in the production process of EVA foam, or, that formamide is a breakdown product from another additive used in the production of these materials.

Rugs and other floor coverings can be treated with flame retardants and may contain phthalates in a non-slip surface on the back side of the rug. In this survey, samples from two large rugs, one smaller entrance rug with rubber backing, one thin yoga-mat and one slip proofing-mat were analysed. The two large rugs were analysed for flame retardants and no brominate flame retardants were detected while low levels (0.012-0.023%) of organophosphorous flame retardants were found. The small entrance rug was analysed for phthalates and chlorinated paraffins as well. No chlorinated paraffins were found, but DEHP and DINP were found at levels slightly above 0.1% and DIDP and DIBP were found in lower levels. The yoga-mat contained DBP and DEHP at levels ranging from 16-19% with lower levels of DINP (0.3%). The slip-proof mat contained 25% DINP and 4.4% DEHP together with 7% MCCP and 0.4% SCCP. The level of SCCP makes this item illegal to sell according to the current legislation where the level of restriction is 0.15% for SCCP.

A number of different types of highly fluorinated substances were analysed in one old textile carpet. Out of 25 types of highly fluorinated substances, the only substances found were FTOHs, in three different chain lengths of the carbon backbone (6:2 FTOH, 8:2 FTOH and 10:2 FTOH).

5 CONCLUSIONS

The results from the study provide support for the recommendations to discard certain articles and materials, present in the guidance document for a “chemicals-smart preschool” since the concentration of hazardous substances in a considerable part of the old material largely exceeded the current legislative limits. Furthermore, the study shows that both toy and non-toy (i.e. items which are not intended for play) articles may contain hazardous substances. By discarding old as well as high risk items, the amount of hazardous substances present in the indoor environment can be reduced, thus lowering the risk of diffuse distribution and exposure of these substances from toys and other items to humans and environment.

In total, phthalates, chlorinated paraffins, organophosphorous flame retardants and formamide, were found in many old items and a few new, while neither the new, nor the old articles and materials contained any detectable levels of brominated flame retardants. Highly fluorinated substances of the type fluortelomeric alcohols were detected in some of the new materials.

The survey shows that new items purchased from the municipality’s procured product range are in most cases free from the harmful substances included in the survey or the substances are detected well below restricted levels. This shows that the legislation has had effect and that replacement of old material with new will effectively reduce the levels of harmful substances in the preschool indoor environment. Prohibited substances were, however, found in some of the new samples, which demonstrates the need for chemical analyses, both of legally regulated substances and substances included in the criteria for the procurement, to be included in the follow up dialogue with the contracted suppliers.

The risks associated with the analysed substances are not acute at the moment of exposure which can be predicted to occur from interior articles and materials such as toys, furniture, dust etc. but, the constant and long term exposure to low doses from various sources give health effects in the population as a whole. This implies that it is important to ensure that children’s everyday environment is as free as possible from these substances. To ensure this, it is imperative that items which are intended for children’s play are chosen as toys since these are regulated by much stronger legislation than articles which are not for that purpose.

5.1 The presented analytical results in relation to current legislation

The regulation of chemicals in articles and materials differs depending on the intended purpose of the item. If it is produced to be a toy or in contact with food, more stringent legislation applies than if it is a gardening tool or clothes and accessories, to state some examples. Children use articles and material in different ways compared to adults, i.e. they put things in the mouth. This together with the fact that children are more sensitive to chemical exposure than adults justify the more stringent legislation for toy and childcare items. As an example, wallets and handbags are most often produced for use by adults and gardening hoses are intended for use to water plants and not to hold drinking water or be used as a toy, hence, the content of these items are not as well scrutinized by the suppliers as are toy materials. New toys, which are subject to the chemical restrictions in the Toy Safety Directive in force since 2013 are, due to the above mentioned facts, the safest items to use for play.

The high content of phthalates in many of the old items would, by today's standards, make them illegal for sale. Out of all analysed toys and childcare articles, 62% contain at least one of the legacy phthalates at levels above 0.1% (Figure 7). A similar pattern was observed for the categories dress-up, interior items and other, where 71% of the analyses showed levels exceeding 0.1% for at least one phthalate which is restricted for use in toys and childcare articles (Figure 7).

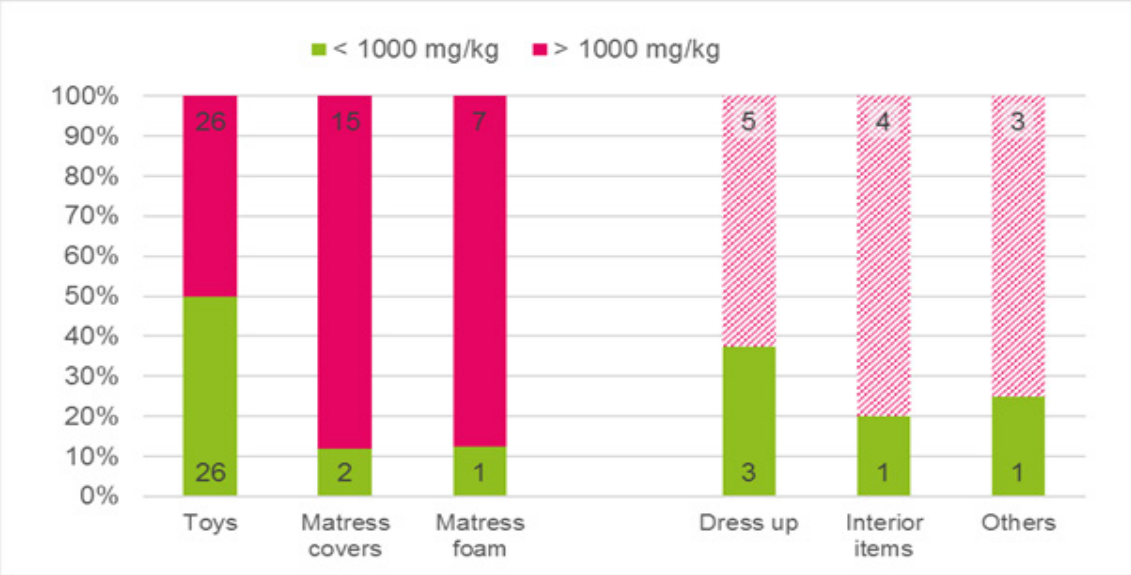


***Figure 7**: The proportion of old items (%) with detected levels above (pink) and below (green) the limit of 0.1% of at least one legacy phthalate. The hatched bars show the distribution for items which are not included in the legislation but are anyway used as toys in preschools. The numbers stated in the bars indicate the number of items.*

The items in the categories dress-up, interior items and other are not categorized as toys which means that those items, despite the high levels of hazardous substances, they would not be subject to the restrictions for toys and childcare articles within the current legislation. This shows that these types of articles are not suitable for use as toys. But, more stringent legislation for articles other than toys and childcare articles, food contact material etc. are being developed. An example is that eleven phthalates are now on the authorization list in REACH making them prohibited for use in production of articles within the European union, another example is the general restriction for lead in consumer products at 0.05%.

Out of the 17 phthalates which were included in the analyses, a total of eight were found in the analysed items of which the most commonly detected were DEHP and DINP. Concerning the other legislated substances, SCCPs were found in three articles, one soft plastic toy, one mattress cover and one slip protection carpet, in levels above the legislated 0.15%, making them unfit for sale. There were four toys containing chlorinated organophosphorous substances at levels above restriction (5mg/kg) in the Toy Safety Directive (up to 1.2% of the material). The organophosphorous substances TCEP, TCPP and TDCPP were found both in mattress foam core, toys and other interior items. Those three substances are restricted in toys through an addition to the Toy Safety Directive in 2015.

Concerning formamide, one analysis of a toy indicated levels above the limit of 0.02% where a migration test has to be performed to ensure that the leakage of formamide will not exceed the limit of 20µg/m3, the level detected was at 0.04% and the limit of restriction for total content is at 0.3%.

Neither of the brominated flame retardants from the groups PBDE, PBB, HBCDD or the substance TTBPA were found in any of the old or new samples tested for these which is positive (n=40). One possible explanation for this is that these groups of brominated flame retardants are more commonly used in electronics instead of the sampled materials which were more of textile, soft plastics and furniture foam types.

The only type of highly fluorinated substance found in this study was FTOH of different carbon chain lengths, and these substances were only found in preschool articles, not in office furniture textiles. This may be due to a goal of providing good stain repellent properties of furniture with textile surfaces used in preschools. The levels measured in this study are residual monomers since these FTOHs are used to produce a polymer in/on the textile. The real added amount is therefore not known and these results can only serve as an indication of intentional addition of polymeric PFAS, which according to the limited number of analyses conducted within this study are when the levels are above 0.1 mg/kg.

Medium chained chlorinated paraffins (MCCP) were found in some of the tested items while long chained chlorinated paraffins (LCCP) were not found above reporting limits in any of the tested items (nine items).

5.2 Newly purchased articles and materials

The results from the analyses indicate that articles and material from the city's procured assortments are, in most cases, free from the hazardous substances which were screened for, or contain very low amounts, below the limits in the restrictions. Even though it was uncommon to find levels of hazardous substances exceeding the levels of restriction, a few articles showed such content which highlights the importance of following up on chemical content in articles and materials according to limits set in both legislation and procurement criteria. The results were shared with the respective contracted companies as soon as they were available to the city and had been compiled into a presentable format. Following this, the suppliers took action. If there was an article which was not in accordance with the legislation or procurement criteria, the article was either removed from the market or the production procedure updated to remove the presence of the hazardous substance(s) found. Some of the suppliers also made their own follow-up on the analysis to verify the result, this yielded results at the same range as the initial result, which also proves the correctness of the analytical methods.

In total, the results from the analyses of the new material show that chemical analyses as a means of follow-up on criteria set in both legislation and contracts with procured suppliers has a positive effect on the presence of hazardous substances in articles and materials. This, together with development of more stringent legislation will make everyday articles and materials safer to use, both in terms of human exposure and emissions of hazardous substances to the environment as well as providing a step on the way to fulfil the vision of a Stockholm devoid of hazardous chemicals.

5.3 Future prospects

Future prospects include continuation of chemical analyses of articles and materials as a means in the procedure to follow up on compliance with both legislation and criteria in contracts, as well as investigating the presence of other hazardous substance groups in the preschool environment. This includes analyses of other types of articles such as kitchen utensils as well as other substance groups for example, polycyclic aromatic hydrocarbons (PAH) and nitrosamines in rubber materials and metals (lead, cadmium, chrome, mercury and tin, the latter as an indicator of organotin presence in plastics). Furthermore, it would be useful to assess emissions from articles and materials, i.e. the amount of hazardous substances that are emitted to the surrounding environment from specific items during a set timeframe. Since these substances are also found in dust, another aspect is to evaluate the effects of the guidance document by conducting dust sampling before and after disposal of old toys and furniture etc. to see if this can be linked to reduced levels of hazardous substances in the dust. This will be done within another part of the NonHazCity project during 2018.

APPENDIX 1: ANALYSED SUBSTANCES

Tables with substances analysed, analytical methods used and limits of quantification (LOQ).

Table 1. Analysed substances within the substance group Phthalates and the Limits of quantification (LOQ).

Substance	Abbreviation	Cas.No	LOQ (mg/kg)
Di(2-etylhexyl)phthalate	DEHP	117-81-7	50
Dibutylphthalate	DBP	84-74-2	50
Bensylbutylphthalate	BBP	85-68-7	50
Diisobutylphthalate	DIBP	84-69-5	50
Di(branched C6-C8) alkylphthalates	DIHP	71888-89-6	200
Di(branched C7-C11) alkylphthalates	DHNUP	68515-42-4	200
1,2-Benzendicarboxylacid-dihexylester, branched and linear	-	68515-50-4	200
1,2-Benzendicar- boxylacid-dipentylester, branched and linear, n-Pentylisopentyl-phthalate, Dipentylphthalate	-	84777-06-0	200
Di-C6-C10- alkylphthalate and di- C6,C8,C10- alkylphthalate, containing ≥ 0.3% dihexyl phthalate (EC-nr 201-559-5)	-	68515-51-5 68648-93-1	200
Dihexylphthalate	DNHP	84-75-3	200
Diisopentylphthalate, Diamylphthalate	DIPP	605-50-5	200
Di(2-metoxi- etyl)phthalate	DMEP	117-82-8	200
Dipentylphthalate	PIPP	131-18-0	200
Diisononylphthalate	DINP	28553-12-0	50
Diisodecylphthalate	DIDP	26761-40-0	50
Di-n-oktylphthalate	DNOP	117-84-0	50
N-pentylisopentylphthalate	-	776297-69-9	200

Table 2. Analysed substances within the substance group Brominated flame retardants and the Limits of quantification (LOQ).

Substance	Cas.No	LOQ (mg/kg)
Hexabromcyklododekan HBCDD	3194-55-6	10
Bromobiphenyl	different	10
Dibromobiphenyl	different	10
Tribromobiphenyl	different	10
Tetrabromobiphenyl	different	10
Pentabromobiphenyl	different	10
Hexabromobiphenyl	different	10
Heptabormobiphenyl	different	10
Octabromobiphenyl	different	10
Nonabromobiphenyl	different	10
Decabromobiphenyl	13654-09-6	10
Bromodiphenyl ether	different	10
Dibromodiphenyl ether	different	10

Substance	Cas.No	LOQ (mg/kg)
Tribromodiphenyl ether	different	10
Tetrabromodiphenyl ether	different	10
Pentabromodiphenyl ether	different	10
HexabromoDPE	different	10
HeptabromoDPE	different	10
OctabromoDPE	different	10
NonabromoDPE	different	25
Decabromodiphenyl ether	1163-19-5	25

Table 3. Analysed substances within the substance group Highly fluorinated substances and the limits of quantification (LOQ).

Substance	Cas.No	LOQ (mg/kg)
PFOA (perfluorooctanoic acid)	33-67-1	0,05
PFUdA (henicosafluoroundecanoic acid)	2058-94-8	0,05
PFTeDA (heptacosafluorotetradecanoic acid)	376-06-7	0,05
PFTrDA (pentacosafluorotridecanoic acid)	72629-94-8	0,05
PFDoA (tricosafluorododecanoic acid)	307-55-1	0,05
PFOS (perfluorooctane sulfonic acid)	1763-23-1	0,05
Perfluorohexylethanol (6:2 FTOH)		0,05
Perfluorooctylethanol (8:2 FTOH)	678-39-7	0,05
Perfluoropentylethanol (10:2 FTOH)	865-86-1	0,05
Perfluorononane Acid (PFNA)	375-95-1	0,05
Perfluorodecane Acid (PFDA)	335-76-2	0,05
Perfluoroundecanoic Acid (PFUnA)	4234-23-5	0,05
2-(N-methylperfluoro-FASE1-octanesulfonamido)-ethanol (MeFOSE)	2448-09-07	0,05
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol (EtFOSE	1691-99-2	0,05
N-methylperfluoro-1-octanesulfonamide (MeFOSA)	31506-32-8	0,05
N-ethylperfluoro-1-octanesulfonamide (EtFOSA)	4151-50-2	0,05
1H,1H,2H,2H-Perfluorodecylacrylate (8:2 FTA)	27905-45-9	0,05
1H,1H,2H,2H-Perfluorododecylacrylate (10:2 FTA)	17741-60-5	0,05
(PFBS) Perfluorbutansulfonate	375-73-5	0,05
(PFHxS) Perfluorhexansulfonate		0,05
(6:2 FTS) Fluortelomersulfonate		0,05
(PFBA) Perfluorbutanoate		0,05
(PFPeA) Perfluorpentanoate		0,05
(PFHxA) Perfluorhexanoate		0,05
PFHpA Perfluorheptanoate		0,05

Table 4. Analysed substances within the substance group Organophosphorus flame retardants and the limits of quantification (LOQ).

Substance	Abbreviation	Cas.No	LOQ (mg/kg)
Tris-(aziridinyl)phosphinoxide	TEPA	545-55-1	10
Tris(2-chloroethyl)phosphate	TCEP	115-96-8	10
Tris(1,3-dichloroisopropyl) phosphate	TDCPP	13674-87-8	10
Trixylylphosphate	-	25155-23-1	10
Tris(2-chloro-iso-propyl)phosphate	TCPP	13674-84-5	10
Tri-n-butyl-phosphate	TNBP	126-73-8	10
Triphenylphosphate	TPP	115-86-6	10
Tris(2-ethylhexyl)phosphate	TEHP	78-42-2	10
Tris(2-butoxyethyl)phosphate	TBEP	78-51-3	10
Tris-iso-butylphosphate	TIBP	126-71-6	10
Bis-(2,3-dibromopropyl)phosphate	-	5412-25-9	10
Tri-o-cresylphosphate	TOCP	78-30-8	10
Tri-(2,3- dibromopropyl)phosphate	TRIS	126-72-7	10

Table 5. Other substances and substance groups and the Limits of quantification (LOQ).

Substance	Cas.No	LOQ (mg/kg)
Formamide	75-12-7	50
SCCP Sum short chain chlorinated paraffins (C10-C13)	85535-84-8	100
MCCP Sum medium chain chlorinated paraffins (C14-C17)	85535-85-9	100
LCCP Sum long chain chlorinated paraffins (C18-C35)		300

APPENDIX 2: LEGISLATION APPLICABLE TO THE SUBSTANCES SCREENED FOR IN THIS REPORT

Registration, Evaluation, Authorization and restriction of Chemicals (**REACH**, 1907/2006/EG) is the European chemicals legislation, Appendix XVII (restriction on substances in specific applications) of REACH regulates the presence of some phthalates in toys and childcare articles, listed below (this also includes nursing table and resting mattresses).

Furthermore, eleven phthalates are subject to authorization for use in all types of articles present on the European market, these overlap with three of the previously regulated in toys and childcare articles.

Substances of very high concern (SVHC) are listed in the Candidate List which is published by The European Chemical Agency (ECHA) in accordance with Article 59(10) of the REACH Regulation. This list includes PBT and vPvB substances as well as substances meeting the criteria for classification as carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with the CLP Regulation, and which candidate for further regulation. Substances with other adverse effects on humans and the environment, like endocrine disrupting compounds (EDC) can also be included in the Candidate List. The list is by no means exhaustive, the process to include substances on the list is lengthy and costly, which makes the progress on including substances on the list slow. As of February 2018, the list contains 181 entries. Professional customers should receive information on candidate list substance content in purchased articles while private customers need to request such information, according to Article 33 of REACH.

Fifteen phthalates, short chain chlorinated paraffins (SCCP) and some PFAS substances, among others, are present on the candidate list (2018).

To summarize:

- BBP, DBP, DEHP – regulated at 0.1% for all toys and childcare articles. These are also subject to authorization as well as present on the candidate list.
- DIDP, DINP and DNOP – regulated at 0.1% for toys and childcare articles which can be put in the mouth. These three phthalates are not present on the candidate list.
- Eleven phthalates are subject to authorization according to Appendix XIV, among these are, BBP, DBP, DEHP, DIBP, DIPP, DPP, together with five more, all of these are also present on the candidate list.
- Fifteen phthalates in total are present on the candidate list and thus subject to content information in articles sold to professional customers and private customers on demand.
- Short chain chlorinated paraffins (SCCP) but not medium- or long chained (MCCP and LCCP) are present on the candidate list.
- PFOS, PFOA, PFDA and PFHxS and a few more PFAS are present on the candidate list, PFOS is already subject to restrictions concerning contents in articles (see below) while PFOA is subject to increased restriction in the coming years.

The regulation on classification, labelling and packaging of substances and mixtures (CLP, 2008/1272/EC) regulates the classification of substances into, among others, CMR and PBT substances. The CLP regulation abides to the globally harmonized system (GHS) for classification and labelling of chemicals.

The regulation on Persistent Organic Pollutants (POPs regulation, EC 850/2004) regulates presence, in articles, for some of the analysed substance groups:

Chlorinated paraffins

- Short chain chlorinated paraffins (SCCP) are restricted in the POPs regulation at 0.15 % per weight in articles.

Brominated flame retardants

- Certain brominated flame retardants are restricted in the POPs regulation.

Highly fluorinated substances (PFAS)

- Certain PFAS are restricted in the POPs Regulation, for example PFOS and its salts and related compounds.

The Toy Safety Directive (TSD, 2009/48/EG) lays down the safety criteria that toys must meet before they can be marketed in the EU. Toys must also comply with any other EU legislation applicable to them.

The general safety requirements cover:

- general risks: the health and safety of children, as well as other people such as parents or caregivers
- particular risks: physical and mechanical, flammability, chemical, electrical, hygiene and radioactivity risks

More specific regulations include:

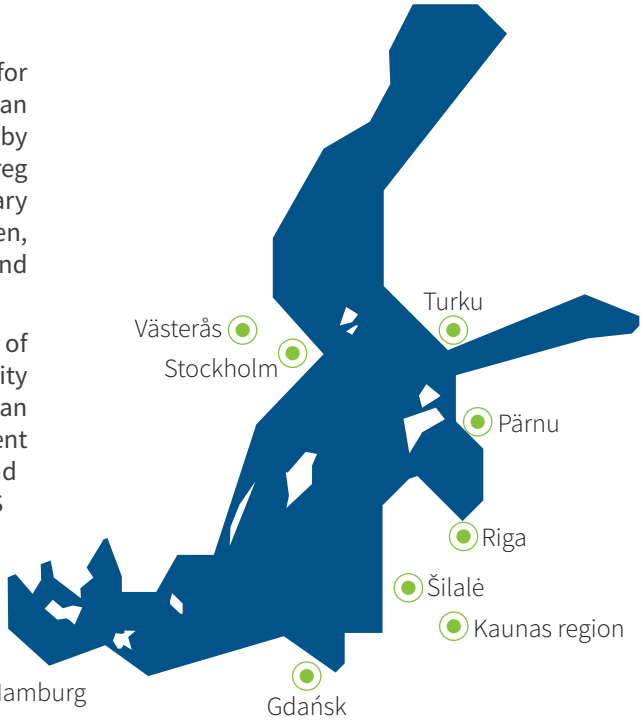
- Organophosphorous flame retardants; TCEP, TCPP och TDCPP are regulated at 5 mg/kg per substance. These three organophosphorous substances are regulated due to their carcinogenic and reprotoxic properties.
- Formamide emissions are regulated at 20 µg/m3 for toys made from Ethyl-Vinyl-Acetate (EVA) foam if the material contains 200mg/kg or more of formamide, up to 3000mg/kg where there is a limit for total content. Formamide is classified as a reproductive toxicant, hence the regulation.
- There is a general limit of 0.1-1% by weight of toy materials for all substances classified as carcinogenic, mutagenic or reproductive toxicants (CMR substances) depending on level of classification; for carcinogenic or mutagenic category 1A and 1B: 0.1%, and category 2: 1%, for toxic for reproduction category 1A and 1B: 0.3%, and category 2: 3%. This automatically regulates all phthalates present on the candidate list in REACH as they are all classified as reproductive toxicants in category 1.

ABOUT THE PROJECT

The project “Innovative Management Solutions for Minimizing emissions of hazardous substances from urban areas in the Baltic Sea Region” (NonHazCity) is financed by the European regional development fund within the Interreg Baltic Sea Region program, from March 2016 to February 2019. The project involves 18 partners from Sweden, Finland, Estonia, Latvia, Lithuania, Poland and Germany and 23 associated partners.

NonHazCity wants to demonstrate possibilities of municipalities and WWTPs to reduce emissions of priority hazardous substances (HS) from small scale emitters in urban areas that cannot be reached by traditional enforcement techniques. Substances of concern will be identified and prioritised, sources tracked and ranked, individual HS Source Maps and Chemicals Action Plans developed by each partner municipality.

Municipal entities will implement own substance reduction measures at their premises. Private small scale businesses will pilot substitution actions and improve their assortment. Inhabitants will be shown their HS emission share and test the use of less HS in every-days household management to help to protect the Baltic Sea environment but also their own health.



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