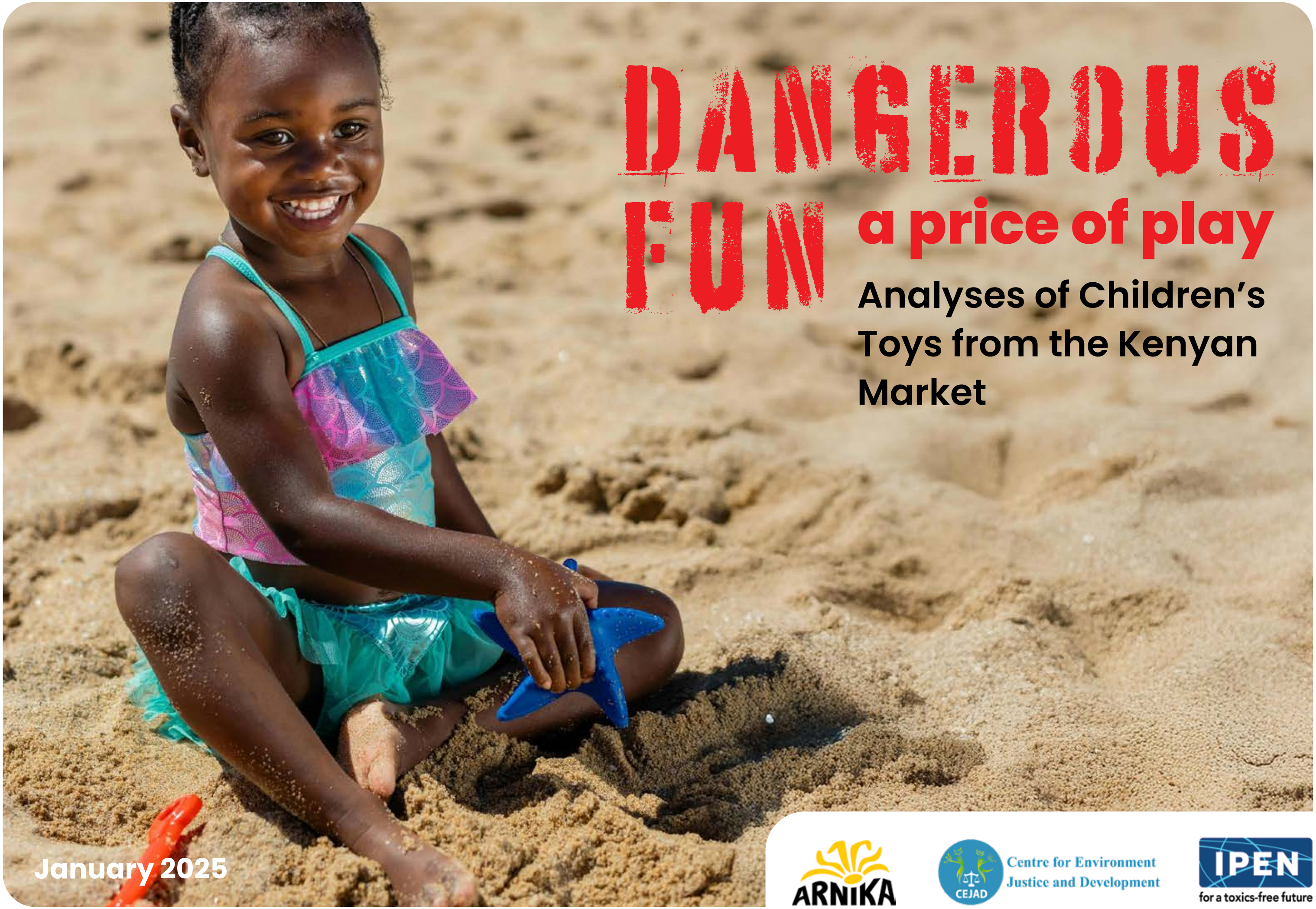

DANGEROUS FUN

a price of play

Analyses of Children’s Toys from the Kenyan Market

January 2025

ARNIKA

CEJAD Centre for Environment Justice and Development

IPEN for a toxics-free future

Arnika

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CEJAD

Centre for Environment Justice and Development (CEJAD), is a public interest Non-Governmental Organization in Kenya. CEJAD works to promote sound management of chemicals and waste in order to protect the environment and human health, especially vulnerable populations. CEJAD is an accredited NGO to UNEP and undertakes advocacy programs seeking to eliminate exposure to toxic chemicals by both humans and the environment. https://www.cejadkenya.org/

IPEN

International Pollutants Elimination Network (IPEN) is a global network forging a healthier world where people and the environment are no longer harmed by the production, use, and disposal of toxic chemicals. Over 600 public interest NGOs in more than 120 countries, largely low- and middle-income nations, comprise IPEN and work to strengthen global and national chemicals and waste policies, contribute to ground-breaking research, and build a global movement fora toxics-free future.
http://www.ipen.org

Acknowledgments

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Analyses of Children’s Toys from the Kenyan Market

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Abbreviations

BBP: Benzyl Butyl Phthalate
BPA: Bisphenol A

DBP: Dibutyl-Phthalate
DcHP: Dicyclohexyl Phthalate
DEHA: Di(2-ethylhexyl) Adipate
DEHP: Di(2-ethylhexyl) Phthalate
DEP: Diethyl Phthalate
DiBP: Diisobutyl Phthalate
DiDP: Diisodecyl Phthalate
DiNP: Diisononyl phthalate
DiPP: Diisopentyl Phthalate
DMEP: Bis(2-methoxyethyl) Phthalate
DMP: Dimethyl Phthalate
DnBP: Di-n-butyl Phthalate
DnHP: Di-n-hexyl Phthalate
DnPP: Di-n-pentyl Phthalate
DnPrP: Di-n-propyl Phthalate
DnOP: Di-n-octyl Phthalate
DPhP: Diphenyl Phthalate

EU: European Union

LCCPs: Long-Chain Chlorinated Paraffins

MCCPs: Medium-Chain Chlorinated Paraffins

NIAS: Non-Intentionally Added Substances
nPiPP: n-Pentyl Isopentyl Phthalate

POPs: Persistent Organic Pollutants
PVC: Polyvinyl Chloride

REACH: Registration, Evaluation, Authorisation, and Restriction of Chemicals

SCCPs: Short-Chain Chlorinated Paraffins
SVHC: Substances of Very High Concern

UNEP: United Nations Environment Programme
UV-P: Benzotriazole UV Stabilizer
UV-234, UV-320, UV-326, UV-327, UV-328, UV-329, UV-350: Specific UV stabilizers
UV: Ultraviolet Radiation

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Abstract

Plastics are made from polymers derived primarily from fossil fuels, combined with additives to impart specific properties such as flexibility or fire resistance. Over 16,000 chemicals are used in plastics, with more than 4,200 linked to health and environmental risks (Wagner et al., 2024). In addition to these intentionally added substances, plastics may also contain non-intentionally added substances (NIAS), such as manufacturing byproducts or contaminants from recycled materials, which can pose further risks.

This complexity becomes particularly concerning in products like children's toys, which rely on chemical additives for flexibility, durability, and UV protection. Phthalates, used as plasticizers, make plastics flexible but are known endocrine disruptors linked to reproductive and developmental health issues. UV stabilizers prevent degradation from sunlight exposure but are often persistent in the environment and potentially toxic to aquatic life and human health. Short-chain (SCCPs) and medium-chain chlorinated paraffins (MCCPs), used as flame retardants and plasticizers, are persistent organic pollutants that bioaccumulate and pose toxic risks to both humans and wildlife.

Our study evaluated toys, commonly available in Kenya, for the presence of phthalates, UV stabilizers, and chlorinated paraffins (MCCPs and SCCPs), focusing on their compliance with regulatory limits used in some developed countries but missing in Kenya and potential exposure risks to children.

Key findings

Properties of the Substances Studied

All studied substances, including phthalates, SCCPs, MCCPs, and UV stabilizers, are toxic, bio accumulative, and environmentally persistent. They migrate from plastics, increasing exposure risks for humans, particularly children, who are more vulnerable due to frequent mouthing behaviors and prolonged contact with toys.

Presence of Substances in Analyzed Samples

The analysis detected at least two phthalates in all 11 tested toys, with DEHP, DnOP, and DiBP found in the highest concentrations. UV stabilizers were identified in all 11 samples, while SCCPs and MCCPs were found in 9 of 11 products. DEHA was identified in 7 of 11 samples.

Reasons for Banning

These chemicals pose serious health risks, such as endocrine disruption, reproductive toxicity, and developmental issues, which are especially concerning for children. Their environmental persistence threatens ecosystems and contributes to long-term pollution of the planet Earth.

Labeling

None of the analyzed toys carried labels indicating the presence of hazardous substances, preventing consumers from making informed choices.

Global Action Recommendations

To address these risks, international regulations should include a ban on toxic additives like phthalates, SCCPs, MCCPs, and UV stabilizers under the Global Plastics Treaty. The Stockholm Convention should expand to include MCCPs and specific UV stabilizers. Clear labeling of hazardous chemicals in products and prohibiting the recycling of contaminated plastics are crucial steps. Enhanced enforcement of the Basel, Rotterdam, and Stockholm Conventions can ensure safer trade and disposal of hazardous plastics globally.

Background

What is PVC?

Polyvinyl chloride (PVC) is one of the most widely used plastics, valued for its durability, versatility, and cost-effectiveness (Elgharbawy, 2022). Annually, approximately 40 million tons of PVC are produced worldwide with forecast to 60 million tons of PVC in 2025 (Elgharbawy, 2022; statista.com, 2024) making it a cornerstone material in the plastics industry. Naturally rigid, PVC is often made flexible and soft through the addition of chemical plasticizers. Among these, phthalates are the most commonly used, enhancing PVC's properties for a wide range of applications, including toys, medical equipment, cables, and flooring.

Softened PVC is commonly used to manufacture items like children's toys, including those analyzed in our study. These toys often rely on phthalates to achieve the desired flexibility, but their widespread use raises concerns due to potential health and environmental impacts, particularly in products designed for vulnerable populations such as children. Furthermore, the disposal of PVC products can lead to the formation of dioxins, highly toxic compounds that pose serious risks to human health and the environment (Jelinek et al., 2023; Stockholm Convention, 2008; Zhang et al., 2021).

What are phthalates?

Globally, over 8 million tons of phthalates are produced annually (Net et al., 2015), highlighting their significant role as additives. Beyond plastics, phthalates are also used in personal care products, coatings, and adhesives due to their ability to modify material properties efficiently and affordably.

Phthalates, known endocrine disruptors (X. Chen et al., 2014), interfere with hormone signaling and development, making children particularly vulnerable due to behaviors like hand-to-mouth contact and interaction with phthalate-containing items (Aurisano et al., 2021; Kay et al., 2014). Exposure occurs via ingestion, dermal absorption, and inhalation of off-gassing phthalates (Wang et al., 2019). Certain phthalates, such as DEHP and DINP, commonly used in toys, are linked to reproductive toxicity, developmental effects, and respiratory issues like asthma and allergies (Kay et al., 2014; Wang et al., 2019). Due to these risks, several phthalates are classified as SVHCs under REACH regulation and are restricted in products like toys (Tranfo et al., 2018).

What are adipates?

Adipates, such as DEHA, are plasticizers often used as alternatives to phthalates. DEHA, commonly found in flexible plastic products, has potential health concerns, including endocrine-disrupting effects and risks to the liver and reproductive system at high exposure levels, raising concerns about its use in children's toys (Sheikh & Beg, 2019).

What are short-chain chlorinated paraffins (SCCPs) and medium-chain chlorinated paraffins (MCCPs)?

Short-chain chlorinated paraffins (SCCPs) and medium-chain chlorinated paraffins (MCCPs) are synthetic chemicals used as flame retardants and plasticizers, particularly in polyvinyl chloride (PVC) products (J. Chen et al., 2024; van Mourik et al., 2020). SCCPs contain carbon chains with 10–13 atoms, while MCCPs have chains with 14–17 atoms (He et al., 2023). These substances are common in items like cables, flooring, and toys.

Global production of SCCPs and MCCPs including LCCPs is estimated to be one million of tons annually (Glüge et al., 2016), while 165 thousand of tons for SCPPs a year currently (Glüge et al., 2016). While no local production of SCCPs/MCCPs has been observed in some countries, such as Nigeria, large quantities of PVC and rubber products—known to contain SCCPs/MCCPs—are imported into the continent (Kutarna et al., 2023).

Both substances are persistent and bio accumulative, with SCCPs classified as persistent organic pollutants (POPs) under the Stockholm Convention. Due to regulatory restrictions on SCCPs, MCCPs have largely replaced them in many applications, but MCCPs are under review in the EU as Substances of Very High Concern (SVHC) for their potential toxicity and environmental risks.

In PVC toys, SCCPs and MCCPs are especially concerning because they can migrate from plastics into the environment (Babich et al., 2020). Children are more vulnerable to exposure through mouthing, skin contact, and inhalation of emissions. Studies associate chlorinated paraffins with developmental toxicity (Ali & Legler, 2010; Liu et al., 2016), endocrine disruption (Melchiors et al., 2024), and immune system impairment (Wang et al., 2019), raising significant health concerns for children exposed to these chemicals.

What are UV stabilizers?

UV Stabilizers are chemical additives used to protect plastics, including polyvinyl chloride (PVC), from degradation caused by ultraviolet (UV) radiation (El-Hiti et al., 2022). Exposure to sunlight can cause photodegradation, leading to discoloration, brittleness, and loss of mechanical properties. UV stabilizers prevent this damage, extending the lifespan and functionality of products like outdoor toys, cables, and construction materials.

Global production of UV stabilizers is estimated to exceed several hundred thousand tons annually. They are essential in a wide range of applications, including outdoor PVC products, automotive interiors and exteriors, coatings, and packaging. Certain UV stabilizers, such as benzotriazoles, are persistent and bio accumulative (Matouskova & Vandenberg, 2022; H. Zhou et al., 2023), raising concerns about their health and environmental impact (H. Chen et al., 2024; Khare et al., 2023). Studies, including UNEP (2023), highlight UV stabilizers' role in increasing the environmental burden of plastics, especially in poorly regulated recycling processes. Furthermore, UV stabilizers have been shown to migrate from polymer matrices under specific environmental conditions, as noted in Noguerol-Cal et al. (2011), indicating a risk of exposure through contact or mouthing behaviors in children.

While their health impacts are less studied compared to phthalates and chlorinated paraffins, Wu and Venier (2023) suggest that UV stabilizers could exhibit similar bio accumulative tendencies, with long-term risks to both children's health and ecosystems.

Notably, these stabilizers are often present in recycled materials, which raises concerns about the cumulative effects of repeated exposure. This is particularly relevant in the context of products intended for children, where exposure through dermal contact or ingestion could pose health risks.

Why are they problematic?

PVC toys rely on additives such as phthalates, SCCPs/MCCPs, and UV stabilizers to enhance flexibility, durability, and resistance to degradation. However, these chemicals pose significant risks to children due to their potential for migration from toys and exposure through mouthing, dermal contact, and inhalation. Phthalates are endocrine disruptors linked to developmental and reproductive toxicity, while SCCPs and MCCPs are associated with immune and hormonal effects, with SCCPs classified as persistent organic pollutants. UV stabilizers exhibit some similar properties (H. Zhou et al., 2023).

Research on children's exposure to toxic chemicals from toys in Africa highlights significant health risks due to phthalates, toxic metals, and other harmful chemicals. In Nigeria, low-cost toys sold in Ibadan, showed contamination levels with toxic metals like lead, posing serious health hazards based on calculated hazard indices (Kamara et al., 2023). In Zambia, imported plastic toys were found to exceed global safety standards for lead, reflecting regulatory gaps and insufficient monitoring (Sakala, 2017). Additionally, in South Africa, research revealed that phthalates from PVC-based products, including toys, leach into freshwater systems, contributing to indirect human exposure with measurable health risks (Fatoki et al., 2010). These findings underscore the urgent need for stricter regulation and improved chemical safety standards in African markets.

These risks are further exacerbated by the triple planetary crisis—climate change, biodiversity loss, and chemical pollution. The production and disposal of PVC toys contribute to greenhouse gas emissions, intensifying climate change. Persistent pollutants like SCCPs and MCCPs accumulate in ecosystems, disrupting biodiversity and threatening wildlife health. Pollution from these chemicals, including their migration into air, water, and soil, perpetuates toxic contamination, impacting both the environment and human health. Addressing the risks of these substances in toys is essential not only to protect children but also to mitigate their role in this interconnected global crisis.

Where are these substances found?

Substances such as SCCPs, MCCPs, and UV stabilizers have been detected in environments where they do not belong, raising significant concerns (Apel et al., 2018; Granados-Galvan et al., 2024; Lu et al., 2019; Vorkamp et al., 2019), including food sources (Adu-Kumi et al., 2019; EFSA CONTAM et al., 2020; Saetang et al., 2024; Zhou et al., 2024).

Research on environmental pollution in Africa highlights chemical contamination from plastic waste, including children's toys. In Kenya, di-butyl phthalates were found in water, soil, and sediment near coastal areas, suggesting discarded plastic products, including toys, as a source of pollution (Fatoki et al., 2010). Recent studies by Karanja (2022), along the Kenya coast have found high concentration of BPA and DBP in soils, water and seaweed in public beaches of Mombasa and pirates possibly attributed to plastic pollution. Studies in wastewater treatment plants in Lake Victoria regions have also recorded high levels of DMP, BEHP, and BBP, attributed to use of products suspected to contain phthalates such as soft squeeze toys, food containers and teething rings (Onchiri et al. 2021). Similarly, studies across African countries show that phthalates, commonly used as plasticizers in PVC toys, leach into the environment, posing risks to ecosystems and public health (Adewuyi & Olowu, 2012).

These findings highlight the environmental mobility and persistence of hazardous substances and emphasize the need for stricter regulation to prevent widespread contamination. Despite their ban under the Stockholm Convention, SCCPs have been detected in new plastics, including PVC consumer products and toys (Kutarna et al., 2023; Vorkamp et al., 2019). However, data on SCCP concentrations in consumer products, especially toys, remain scarce in Africa, highlighting the need for further research in this region (Nevondo & Okonkwo, 2021). MCCPs have similarly been identified in a wide range of products (Lu et al., 2019). These chemicals are particularly concerning because they can be unintentionally incorporated into products during manufacturing or recycling, resulting in contamination of consumer goods (Allinson et al., 2018; Lahl & Zeschmar-Lahl, 2024; Vorkamp et al., 2019).

Aim of this study

Our study focused on PVC toys from Kenya's market to assess the presence and concentrations of these substances and their risks to vulnerable populations like children. It also addresses the lack of data in African consumer products, especially toys, which are often imported and may contain restricted substances.

Methodology

Samples

Eleven samples of PVC toys, labeled KE-PVC-toy-01 through KE-PVC-toy-11, were sourced from various retailers in Kenya. The selection included a variety of toy types, such as plastic dolls, inflatable play items (e.g., balls and floaters), teething toys, bath toys, squishy toys, and wearable items like an inflatable Spiderman suit. These toys were selected based on their composition and likelihood of containing phthalates and other substances studied.

Analyses

In this study, we analyzed a comprehensive range of chemical substances commonly used in polyvinyl chloride (PVC) products to assess their presence and potential risks. The analysis focused on phthalates, which are widely used as plasticizers to enhance flexibility and included substances such as dimethyl phthalate (DMP), diethyl phthalate (DEP), diisobutyl phthalate (DiBP), and di(2-ethylhexyl) phthalate (DEHP). Additionally, alternative plasticizer di(2-ethylhexyl) adipate (DEHA) was assessed. The study also included

***Photo 1** Doll labelled as KE-PVC-toy-01.*

an evaluation of chlorinated paraffins, specifically short-chain (SCCPs) and medium-chain (MCCPs) chlorinated paraffins, which are commonly employed as flame retardants and plasticizers. Furthermore, we examined UV stabilizers, including benzotriazole UV stabilizers (e.g., UV-P) and others like UV-234, UV-320, and UV-328, which are used to protect plastics from photodegradation. By analyzing these chemical groups, the study aimed to identify their presence in PVC-based children's toys and assess their concentrations to evaluate potential exposure risks, particularly for vulnerable populations such as children.

All samples were screened using a handheld NITON XL3t 800XRF analyzer to provide an indicative assessment of metal levels and to guide the selection of samples for further laboratory analysis. All the substances mentioned above were analyzed by a Czech certified laboratory at the Department of Food Chemistry and Analysis of the University of Chemistry and Technology in Prague, Czech Republic.

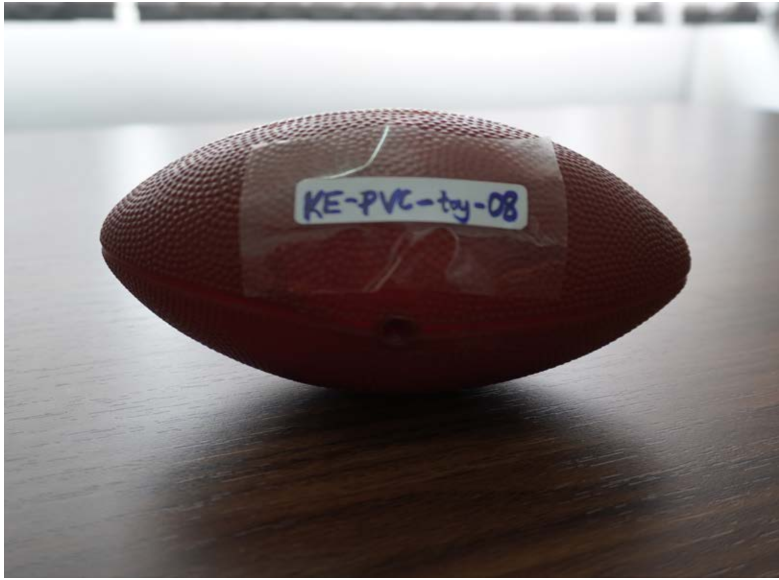


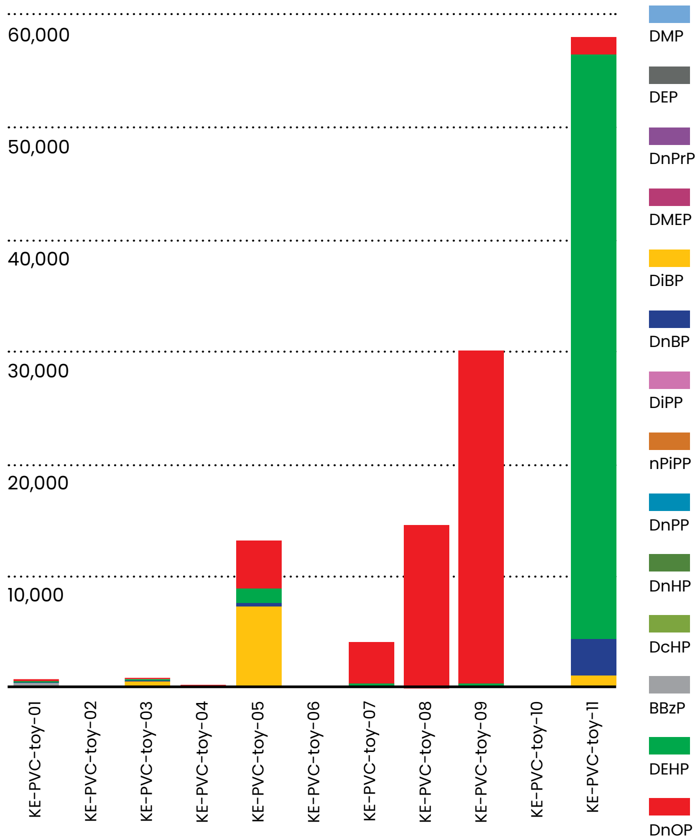
Photo 2 *All samples were labelled.*

Results

Phthalates and adipate

The analysis revealed significant concentrations of phthalates in several toy samples. DEHP (Bis(2-ethylhexyl) phthalate) was detected at extremely high levels, with the maximum concentration of 52,270 mg/kg found in sample KE-PVC-toy-11. Other notable findings include DnBP (Di-n-butyl phthalate) at 3,410 mg/kg in sample KE-PVC-toy-11, and DnOP (Di-n-octyl phthalate) at 29,981 mg/kg in sample KE-PVC-toy-09, at 14,511 mg/kg in sample KE-PVC-toy-08 and at similar levels at KE-PVC-toy-07 (3,837 mg/kg) and KE-PVC-toy-05 (4,191 mg/kg). DIBP was found in all of the samples, highest in KE-PVC-toy-05 and KE-PVC-toy-11, with concentrations of 7,248 mg/kg and 1,010 mg/kg, respectively. The second-highest concentration of DEHP was found in sample KE-PVC-toy-05. DnOP was found in samples KE-PVC-toy-05 (4,191 mg/kg), KE-PVC-toy-07 (3,837 mg/kg), KE-PVC-toy-08 (14,511 mg/kg), and KE-PVC-toy-11 (1,380 mg/kg), as well as DMP, DEP, DiBP, DNBP, DEHP. Several phthalates, including DiPP, nPiPP, and DcHP, were consistently below detection limits across all samples. DEHA was found in 7 of 11 samples. Maximum concentration of DEHA was found in KE-PVC-toy-07 (93.8 mg/kg). You can see the results in Figure 1.

Figure 1 *Sum of phthalates in analyzed samples in mg/kg.*



In Figure 2, the mixture of phthalates analyzed and detected in the samples is shown.

***Figure 2** Ratio of phthalates in analyzed samples in %.*

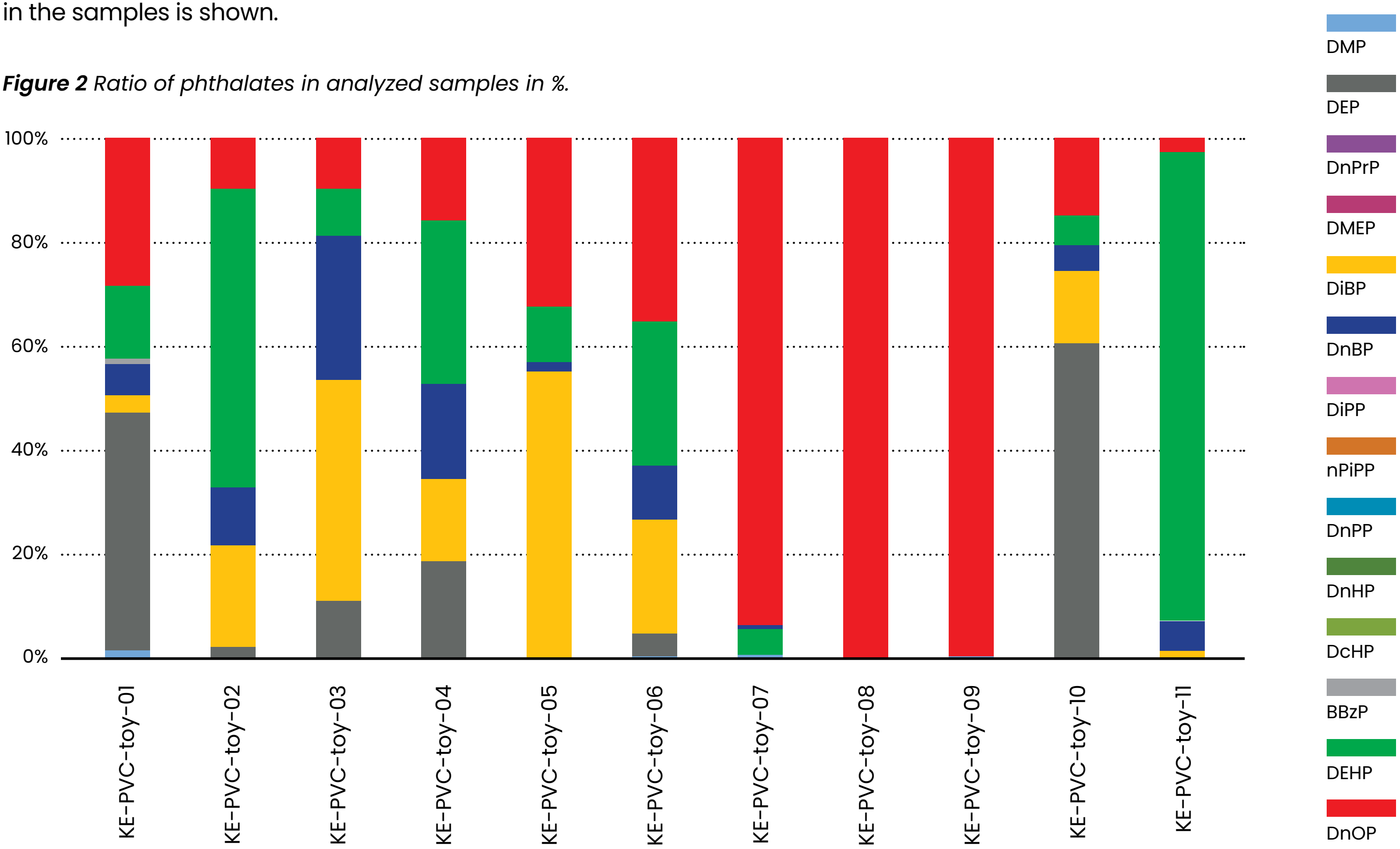


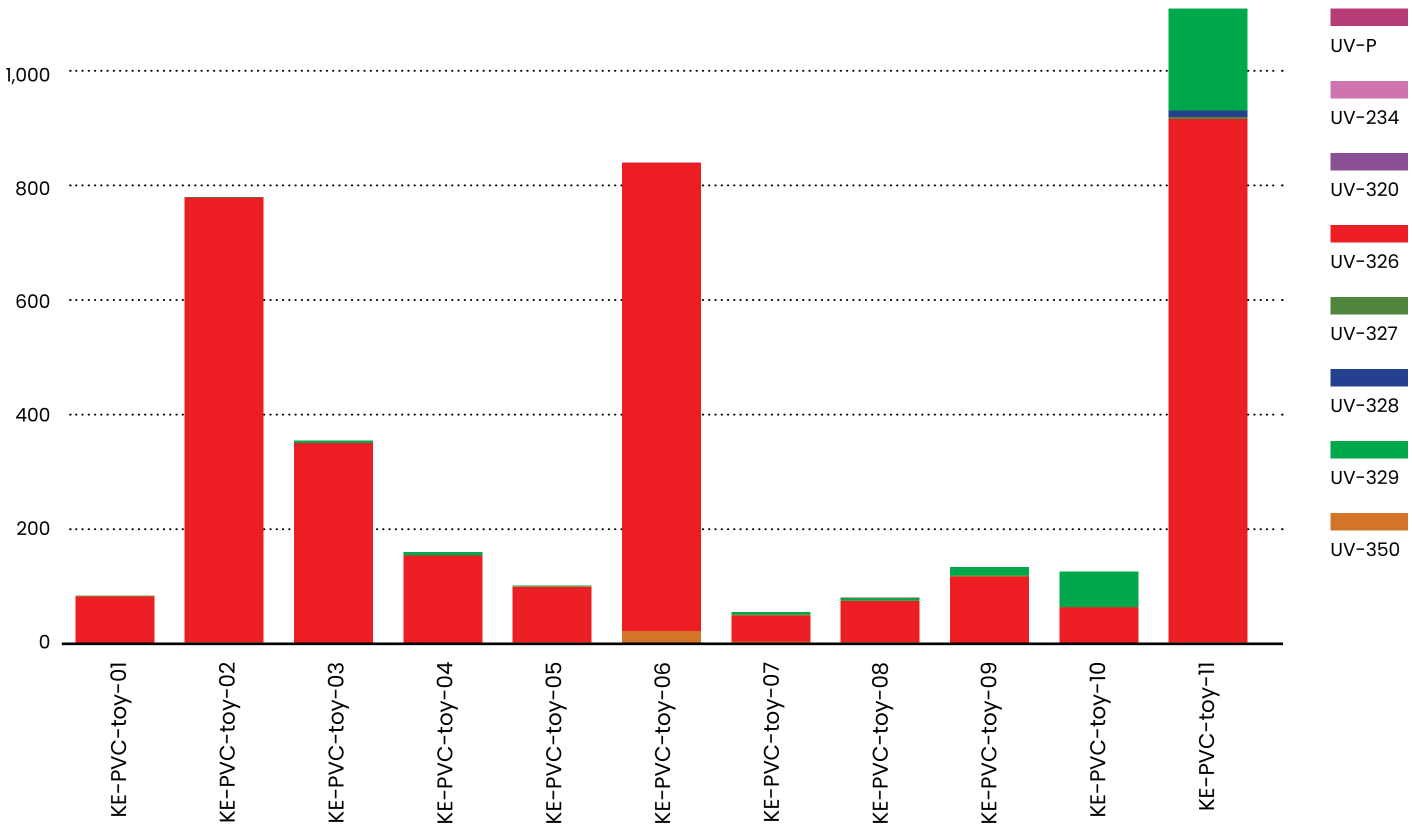
***Photo 3** KE-PVC-toy-09 with highest level of DnOP (Di-n-octyl phthalate).*

UV stabilizers

The highest concentrations of UV-326 were recorded in KE-PVC-toy-11, KE-PVC-toy-06, and KE-PVC-toy-02, with concentrations of 912 ng/g, 815 ng/g, and 774 ng/g, respectively. UV-234 was present in all samples except two, whereas UV-320 and UV-350 were below limit of detection in any sample. Other UV stabilizers, including UV-234, UV-326, UV-328, and UV-329, were found in multiple samples. UV-P was detected in only one sample, KE-PVC-toy-06, at a concentration of 20.8 ng/g, while UV-327 was found in just two samples (KE-PVC-toy-10 and KE-PVC-toy-11).

***Photo 4** The KE-PVC-toy-06 teething toy is of concern, as it contains the second-highest level of UV-326.*

Figure 3 *Sum of UV stabilizers in analyzed samples in ng/g.*

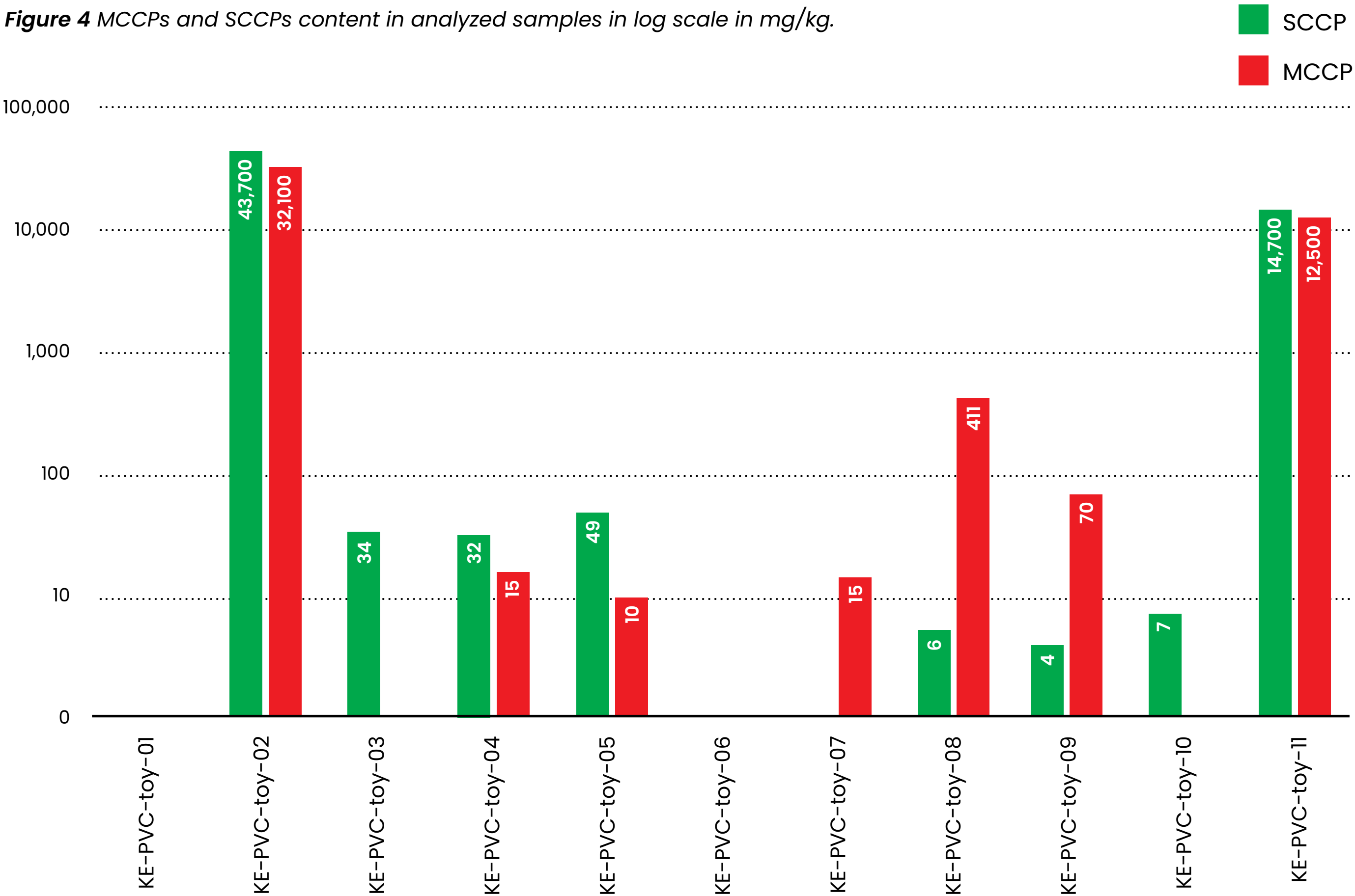


Chlorinated paraffins

SCCPs and MCCPs were detected in the majority of samples, with only two samples, KE-PVC-toy-01 and KE-PVC-toy-06, having both groups below the detection limit. The highest concentrations of SCCPs and MCCPs were found in sample KE-PVC-toy-02, with levels of 43,700 mg/kg and 32,100 mg/kg, respectively, followed by sample KE-PVC-toy-11, with concentrations of 14,700 mg/kg and 12,500 mg/kg.

Photo 5
KE-PVC-toy-02 with highest level of both SCCPs and MCCPs.

Figure 4 *MCCPs and SCCPs content in analyzed samples in log scale in mg/kg.*



Heavy metals

Table 1 highlights the concentrations of selected metals in PVC and non-PVC toys. Barium reached the highest concentration (1,491 mg/kg) in sample KE_PVC_TOY_06, while zinc peaked in KE_PVC_TOY_09 (438 mg/kg). Heavy metals like lead or cadmium were not detected, suggesting compliance with regulatory standards.

Table 1 *Concentrations in ppm (=mg/kg) of heavy metals in samples.*

Sample	PVC	Ba	Ti	Zn	Cu	Cr, Sb, Sn, Cd, Bi, Pb, Hg, Ni, Fe, V
KE_PVC_TOY_01	YES	<LOD	<LOD	173	<LOD	<LOD
KE_PVC_TOY_02	YES	<LOD	<LOD	379	153	<LOD
KE_PVC_TOY_03	YES	801	<LOD	294	<LOD	<LOD
KE_PVC_TOY_04	NO	<LOD	1,782	<LOD	<LOD	<LOD
KE_PVC_TOY_05	YES	119	<LOD	346	<LOD	<LOD
KE_PVC_TOY_06	NO	1,491	<LOD	<LOD	<LOD	<LOD
KE_PVC_TOY_07	YES	239	<LOD	362	<LOD	<LOD
KE_PVC_TOY_08	YES	<LOD	<LOD	148	<LOD	<LOD
KE_PVC_TOY_09	YES	70	<LOD	438	<LOD	<LOD
KE_PVC_TOY_10	NO	<LOD	2,470	<LOD	<LOD	<LOD
KE_PVC_TOY_11	YES	455	<LOD	401	134	<LOD

Summary of concentrations

Concentrations of phthalates ranged from LOQ to 52,270 mg/kg. Highest concentrations of specific phthalates were 52,270 mg/kg for DEHP; 29,981 mg/kg for DnOP and 7,248 mg/kg for DiBP. None of the samples contained zero concentrations of phthalates. DEHA levels ranged from LOQ mg/kg to 93.8 mg/kg.

SCCPs ranged from LOQ to 43,700 mg/kg and MCCPs from LOQ to 32,100 mg/kg. Only 2 out of 11 samples did not contain chlorinated paraffins (or were below the LOQ).

Highest level of different UV stabilizers was 912 ng/g for UV-326, followed by 177 ng/g (UV-329) and 20.8 ng/g (UV-P), lowest were under LOQ. None of the samples contained zero concentrations of UV-stabilizers.

PVC toys exhibited notable concentrations of barium (up to 801 mg/kg) and zinc (438 mg/kg), while a higher barium concentration (1,491 mg/kg) in the non-PVC sample suggests that significant barium content may also stem from non-PVC materials, potentially indicating diverse sources of stabilizers and additives.

Photo 6 *KE-PVC-toy-03 with second highest level of barium (801 ppm).*

Discussion

The analysis of PVC toys in this study highlights critical concerns regarding hazardous chemical additives, including phthalates, chlorinated paraffins (SCCPs and MCCPs), and UV stabilizers. These findings align with global research underscoring the risks posed by such substances in children's products.

The detection of phthalates, including those banned outright in the EU (e.g., DEHP, DBP, BBP, DiBP), in children's toys from the Kenyan market underscores significant health risks, even though these products are not subject to EU regulations. Under EU REACH Regulation 1907/2006 (European Parliament and Council, 2006) and the Toy Safety Directive 2009/48/EC (European Parliament and Council, 2009), these phthalates are prohibited due to their well-documented health effects, including endocrine disruption and reproductive toxicity. While these regulations do not apply to toys sold in Kenya, the toxicological effects of phthalates are universal, posing similar health risks regardless of the region.

All samples were compared against the Stockholm Convention on Persistent Organic Pollutants and its associated EU Regulation (EU) 2019/1021 on Persistent Organic Pollutants, which addresses low POPs content levels, to evaluate their compliance with established thresholds for persistent organic pollutants.

Heavy metals

Safety of Toys in Kenya is regulated through ISO standard 8124-5 that deals with safety of toys in relation to mechanical and physical properties, flammability, and migration of certain elements. Elements provided for under migration are mainly heavy metals, with the following maximum allowable limits: Sb (6 mg/kg), As (2 mg/kg), Ba (100 mg/kg), Cd (7 mg/kg), Cr (6 mg/kg), Pb (9 mg/kg), Hg (6 mg/kg), and Se (50 mg/kg). Part 6 of the standards deals with certain phthalate esters in toys and children's products. However, no elements or their thresholds have been given on the same.

In five out of eleven samples, an exceeded concentration of barium was detected. No exceedance was found for any other measured element.

Phthalates and adipate

In this study, several phthalates exceeded the EU's maximum allowable concentration of 0.1% (1,000 mg/kg) by substantial margins, as specified in Regulation (EC) No 1907/2006 in Annex XVII. For example, DEHP was detected at levels exceeding the EU limit by more than 52 times in one sample and 1.5 times in another. DiBP was found at concentrations 7.4 times higher than allowed, while DnBP surpassed the limit by 3.4 times. The most frequent exceedance was observed for DnOP, with significant levels in multiple samples. Of particular concern are two samples suitable for mouthing (KE-PVC-toy-05 and KE-PVC-toy-09) with detected concentration of DnOP – in KE-PVC-toy-09, the DnOP concentration was nearly 30 times the EU's allowable limit.

Phthalates such as DEHP, DnOP, DiBP, and DnBP, detected in alarming concentrations—particularly in KE-PVC-toy-11—pose significant health risks, consistent with findings from previous studies. Similarly, in a study by (Møller et al., 2020) were phthalates found in 60% of tested PVC toys at concentrations ranging from 261,200 mg/kg to 435,400 mg/kg. A similar study conducted in Serbia in 2020 revealed DEHP concentrations ranging from 1,600 to 181,500 mg/kg in ten toys out of the 36 analyzed (Mart et al., 2020). In the study by Adewuyi & Olowu (2012) conducted in Nigeria, the highest concentrations of phthalates were found in the following toys: DMP in truck toys (278.81 mg/kg), DEP in Barbie-type girl doll toys (387.50 mg/kg), DPhP in baby suction toys (225.73 mg/kg), and DBP in soft rabbit with carrot toys (1625.25 mg/kg). A study by Carney Almroth & Slunge (2022) investigating toys and childcare products in Europe revealed that older items were more likely to exceed EU legal limits for phthalates (0.1%). DEHP and DINP concentrations in some old toys, such as balls, exceeded 400,000 mg/kg, highlighting significant risks associated with legacy compounds in older products.

In 2014, Arnika and the Center for Environmental Solutions (CES) conducted a survey of PVC toys and childcare products in Belarus. All 21 tested samples contained at least one of the examined plasticizers (DEHP, DINP, DBP, DOIP, or DEHA), with concentrations ranging from 161,000 to 562,000 mg/kg. The highest phthalate content was found in a squeaky pink pig toy, where DEHP exceeded half the sample's weight. DEHA was detected in one sample at a concentration of 111,000 mg/kg (Petrlík et al., 2014).

While EU legislation provides a benchmark for safe levels, the lack of equivalent regulations or enforcement in Kenya increases the potential exposure risk for children.

Chlorinated paraffins

In this study, SCCPs ranged from LOQ to 43,700 mg/kg and MCCPs from LOQ to 32,100 mg/kg, with only 2 out of 11 samples below the LOQ. Similarly, Karlsson (2023) found SCCPs ranging from 1 mg/kg to 60,400 mg/kg and MCCPs from 1 mg/kg to 73,800 mg/kg, with all samples containing detectable levels. Maximum concentrations were higher in Karlsson (2023), but the general pattern of contamination is consistent. Children's products and toys available on the Japanese market were found to contain SCCPs at concentrations ranging from 1.3 to 120,000 mg/kg, making them more impacted by these chemicals compared to other PVC consumer goods (Guida et al., 2023). In a study published in 2017, laboratory analyses of 60 toys and other children's products from 10 countries (Brazil, Canada, China, the Czech Republic, India, Japan, Kenya, the Netherlands, Russia, and the United States) revealed that 45% (27 samples) contained SCCPs, with concentrations ranging from 8,4 to 19,808 mg/kg (Miller et al., 2017). Four toys from Kenya included in the study contained SCCPs at concentrations ranging from 678 to 6,918 mg/kg (Miller & DiGangi, 2017).

A study by Carney Almroth & Slunge (2022) investigating toys and childcare products in Europe revealed that older items were more likely to exceed EU legal limits for SCCPs (0.15%) compared to newer items, highlighting significant risks associated with legacy compounds in older products.

A recent study (Mu et al., 2023) found potential organ damage even at low concentrations, highlighting the need for stricter regulation. The low POPs content for SCCPs is still under negotiation, with environmental advocates proposing a limit of 100 mg/kg, while industry supports a much higher 10,000 mg/kg (Karlsson, 2023), even though 2 out of 11 samples analyzed exceeded both the proposed lower limit. Both studies identified the highest concentrations in inflatable toys, suggesting that this category may be particularly prone to the use of chlorinated paraffins, potentially due to material properties or manufacturing practices.

UV stabilizers

UV stabilizers, such as UV-326 and UV-329, were detected in notable concentrations in KE-PVC-toy-11, raising concerns about their persistence and potential for leaching. UV-328, a substance under consideration for inclusion in the Stockholm Convention due to its persistent and bio accumulative properties, was detected in 7 out of 11 samples analyzed in this study. The highest levels of UV stabilizers were 912 ng/g for UV-326, followed by 177 ng/g for UV-329 and 20.8 ng/g for UV-P, while the lowest levels were below the limit of quantification (LOQ). Notably, none of the samples contained zero concentrations of UV stabilizers, indicating their widespread presence in the analyzed toys.

These findings align with previous research, such as (Noguerol-Cal et al., 2011), which demonstrated the migration of UV stabilizers from polymer matrices under specific environmental conditions, posing risks of exposure through contact or mouthing behaviors in children. While UV stabilizers are generally found in lower concentrations compared to phthalates and chlorinated paraffins, their persistence and potential for bioaccumulation (Wu & Venier, 2023) underscore their long-term risks to both children's health and ecosystems. Additionally, studies have highlighted the prevalence of UV stabilizers in recycled materials (UNEP, 2023), raising concerns about cumulative exposure, particularly in regions with limited regulatory oversight. The detection of UV-328 in multiple samples reinforces the importance of monitoring such additives in toys, where safety standards must prioritize the prevention of unnecessary exposure to potentially harmful substances. Although the concentrations of UV stabilizers in this study are lower than those of other hazardous additives, their environmental persistence and potential endocrine-disrupting properties (Kirchnawy et al., 2020) suggest that stricter enforcement of safety standards is critical for protecting children from exposure to these compounds.

The most toxic toy identified in this study

The toy sample KE-PVC-toy-11, a Spiderman suit, was the most toxic in the study due to its extremely high levels of hazardous substances. It contained DEHP at 52,270 mg/kg, alongside other phthalates like DnBP (3,410 mg/kg) and DiBP (1,010 mg/kg), as well as MCCPs (12,500 mg/kg) and SCCPs (14.7 mg/kg). UV stabilizers, including UV-326 (912 ng/g), further added to its toxic profile. These substances, known for their endocrine-disrupting and bio accumulative properties, pose significant risks to children through mouthing, skin contact, and inhalation, raising serious concerns about the safety of this toy and emphasizing the need for stricter regulation.

Notably, the SCCP concentration in this sample exceeds the low POPs content limit proposed by environmental advocates (100 mg/kg) and remains far below the much higher 10,000 mg/kg threshold supported by industry (Karlsson, 2023).

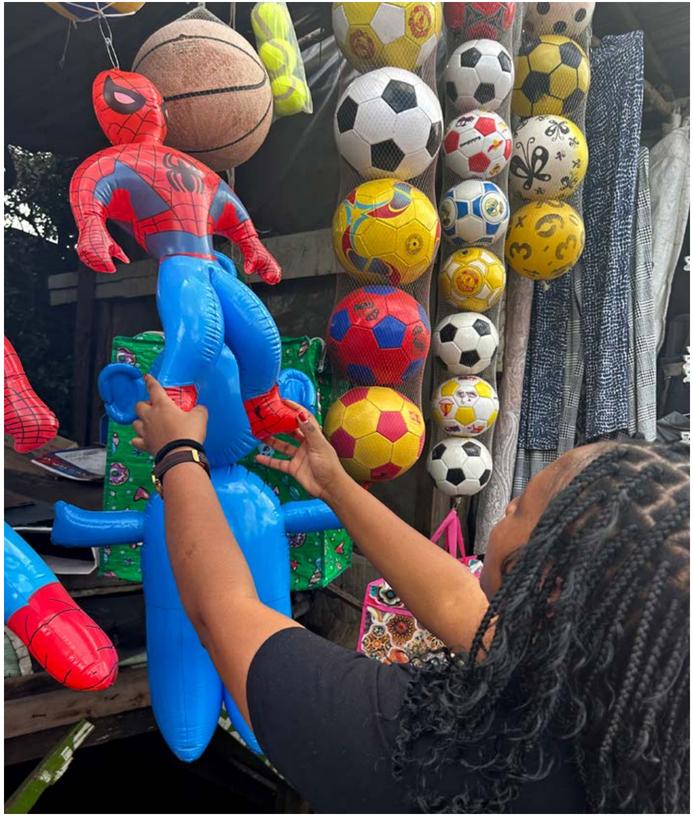


Photo 7 *KE-PVC-toy-11 as probably the most toxic toy in this study due to content of DEHP, DnBP, DiBP, MCCPs, SCCPs and UV-326.*

Conclusion and recommendations

The detection of hazardous additives, including phthalates, chlorinated paraffins, and UV stabilizers, in PVC toys highlights significant health and environmental risks. These findings emphasize the urgent need for Kenya to address toxic chemical use through existing and emerging global frameworks like the **Basel and Stockholm Conventions**, negotiated **Global Plastics Treaty**. New Plastics treaty presents a critical opportunity to advocate for binding international commitments to phase out hazardous additives in plastics and establish universal safety standards for consumer products, particularly children's toys. Active participation in the Plastics Treaty will enable Kenya to safeguard its population from toxic exposure and align its national efforts with global initiatives to reduce chemical pollution.

National recommendations:

- Introduce mandatory restrictions in standards or regulations on the use of PVC in consumer products intended for sensitive applications, such as toys, childcare products, clothing, etc.
- Develop national standards for hazardous additives in toys.
- Enhance the monitoring of POPs in products and waste by implementing Unintentional Trace Contamination (UTC) limits and strict Low POP Content Levels. UTC limits for SCCPs and MCCPs should prohibit their presence in consumer products intended for sensitive applications and prevent harmful recycling practices.
- Establish clear labeling of chemical additives in plastic products, such as toys, to empower consumers to make informed choices.
- Raise public and industry awareness about the presence of hazardous additives, such as phthalates, chlorinated paraffins, UV stabilizers, and persistent organic pollutants (POPs), in PVC toys and other plastics, highlighting their adverse environmental and health impacts to encourage informed consumer choices and demand for safer alternatives.
- Sensitize government regulators and customs officials to the presence of toxic chemicals in plastics, and strengthen the monitoring and control of such products, particularly at border points.

- Development of plastic recycling standards to prevent intentionally and NIAS (of hazardous chemicals) to consumer plastic products

Recommendations for the Plastics Treaty:

- **Eliminate Production of Most Harmful Plastics:**
  Advocate for halting or reducing PVC production, as it is one of the most harmful plastics used in consumer products.

- **Eliminate Toxic Additives:**
  Advocate for a global ban on harmful chemicals, including phthalates, MCCPs, SCCPs, and UV stabilizers, in plastics production and use.

- **Regulate Recycling Practices:**
  Prohibit the recycling of plastics containing hazardous additives to prevent their reintroduction into consumer markets.

- **Ensure Transparency and Traceability:**
  Mandate clear labeling and disclosure of chemical content in all plastic products, with a focus on children's toys, to protect public health and empower informed consumer choices.

- **Promote Global Standards:**
  Push for universal regulations on hazardous chemicals in plastics, ensuring consistent safety standards across all markets.

The Basel, Rotterdam, and Stockholm Conventions (BRS) provide critical frameworks for regulating hazardous chemicals and waste. Kenya can strengthen its engagement with these conventions to address the risks posed by toxic additives in plastics.

Recommendations for Basel, Rotterdam and Stockholm Conventions:

- **Expand Stockholm Convention:**
  Advocate for adding MCCPs to the list of persistent organic pollutants (POPs) to prevent their use and environmental buildup.

- **Strengthen Basel Convention**
  Enforce stricter controls on the import of hazardous plastics and ensure proper disposal of products containing phthalates, chlorinated paraffins, and UV stabilizers.

- **Leverage Rotterdam Convention**
  Use prior informed consent (PIC) to regulate the import of hazardous additives in plastics.

- **Enhance Implementation**
  Build capacity for monitoring and enforcing BRS obligations, with a focus on hazardous plastics.

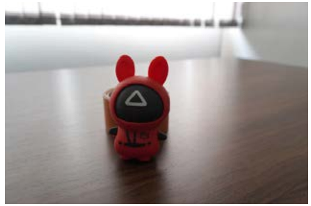
- **Foster Regional Collaboration**
  Work with neighboring countries to harmonize policies and improve cross-border enforcement against hazardous waste and products.

Annex

List of items

DESCRIPTION OF THE TOY	PHOTO OF THE TOY
KE-PVC-toy-01 **Name**: Plastic Doll **Vendor**: Toi Market, Ngong Road, Nairobi **Type**: Plastic toy for children **Material**: Not labeled	
KE-PVC-toy-02 **Name**: Watermelon Inflatable Ball **Vendor**: Biashara Selections Limited, Biashara Street, Nairobi **Type**: Inflatable toy for children **Material**: Not labeled, likely PVC	
KE-PVC-toy-03 **Name**: Inflatable Tiger Floater **Vendor**: Biashara Selections Limited, Biashara Street, Nairobi **Type**: Inflatable pool toy for children **Material:** PVC	

DESCRIPTION OF THE TOY	PHOTO OF THE TOY
KE-PVC-toy-04 **Name**: Squeaky Rabbit Rattle **Vendor**: Biashara Selections Limited, Biashara Street, Nai-robi **Type**: Squeaky toy for infants **Material**: Not labeled	
KE-PVC-toy-05 **Name**: Yellow Rubber Duck **Vendor**: Totos N Toys, Biashara Street, Nairobi **Type**: Bath toy for children **Material**: Not labeled	
KE-PVC-toy-06 **Name**: Teether **Vendor**: ToyZoona, Junction Mall, Nairobi **Type**: Teething toy for infants **Material:** PVC	

DESCRIPTION OF THE TOY	PHOTO OF THE TOY
KE-PVC-toy-07 **Name**: Tiger Figurine **Vendor**: Miniso, Junction Mall, Nairobi **Type**: Plastic figurine for children **Material**: Not labeled	
KE-PVC-toy-08 **Name**: Inflated Rugby Ball **Vendor**: Miniso, Junction Mall, Nairobi **Type**: Inflatable ball for children **Material**: PVC	
KE-PVC-toy-09 **Name**: Bath Toy (Chick) **Vendor**: Kiddy Garden, Watersys Plaza, Biashara Street, Nairobi **Type**: Bath toy for children **Material**: Not labeled	
KE-PVC-toy-10 **Name**: Among Us Squishy Toy **Vendor**: China Square, The Waterfront Mall, Nairobi **Type**: Squishy toy for children **Material**: Not labeled	
KE-PVC-toy-11 **Name**: Spiderman Inflatable **Vendor**: Toi Market, Ngong Road, Nairobi **Type**: Wearable inflatable suit for children **Material**: Not labeled	

Complete results

Table 3 *Complete results for phthalates, chlorinated paraffins, UV stabilizers and DEHA.*

		KE-PVC-toy-01	KE-PVC-toy-02	KE-PVC-toy-03	KE-PVC-toy-04	KE-PVC-toy-05	KE-PVC-toy-06	KE-PVC-toy-07	KE-PVC-toy-08	KE-PVC-toy-09	KE-PVC-toy-10	KE-PVC-toy-11
	Units	toy	toy	toy	toy	toy	toy	toy	toy	toy	toy	toy
DMP		15.2	0.178	3.45	0.194	2.40	0.205	1.23	0.638	1.77	0.053	6.59
DEP		302	2.03	101	43.4	90.2	0.854	2.82	2.23	1.94	56.2	47.1
DnPrP		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
DMEP		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
DiBP		19.4	12.9	370	36.9	7,248	4.09	26.0	3.35	8.98	12.5	1,010
DnBP		46.5	7.45	243	41.5	129	2.00	21.5	1.86	12.9	4.44	3,410
DiPP		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
nPiPP		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
DnPP	mg/kg	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
DnHP		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
DcHP		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
BBzP		1.57	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
DEHP		91.3	38.5	107	70.9	1,459	5.35	195	2.56	158	4.93	52,270
DnOP		186	6.23	56.8	35.3	4,191	6.60	3,837	14,511	29,981	13.4	1,380
DEHA		10.5	0.190	1.89	<0.005	<0.005	<0.005	93.8	1.23	0.610	<0.005	5.07
SCCP		<0.30	43,700	34.4	32.4	48.5	<0.30	<0.30	5.59	3.88	7.44	14,700
MCCP		<0.75	32,100	<0.75	15.4	10.0	<0.75	14.5	411	70.4	<0.75	12,500

		KE-PVC-toy-01	KE-PVC-toy-02	KE-PVC-toy-03	KE-PVC-toy-04	KE-PVC-toy-05	KE-PVC-toy-06	KE-PVC-toy-07	KE-PVC-toy-08	KE-PVC-toy-09	KE-PVC-toy-10	KE-PVC-toy-11
	Units	toy	toy	toy	toy	toy	toy	toy	toy	toy	toy	toy
UV-P	ng/g	<5.0	<5.0	<5.0	<5.0	<5.0	20.8	<5.0	<5.0	<5.0	<5.0	<5.0
UV-234		<0.25	1.88	0.618	1.02	1.53	0.296	2.50	1.52	0.666	<0.25	1.44
UV-320		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
UV-326		80.8	774	348	151	96.0	815	45.4	71.6	115	61.9	912
UV-327		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.76	2.90
UV-328		1.95	0.715	<0.5	<0.5	1.45	<0.5	1.44	0.891	1.88	<0.5	11.9
UV-329		<0.25	0.260	3.74	6.37	1.16	0.842	4.51	4.77	14.6	61.1	177
UV-350		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

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