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Article: **A Systematic Review of the Literature on the Toxicity Caused by Diapers and Pads**

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A Systematic Review of the Literature on the Toxicity Caused by Diapers and Pads

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Abstract

If the chemicals produced by organism due to metabolic activities is harmful to other organisms, then it is considered toxic and is generally known as a toxin. According to previously published studies, diapers and sanitary pads are a hotbed for chemical substances as well as toxins. For this reason, it is important to raise awareness about the negative impact of using hygiene products. This study determined that these products have lethal disease promoter components/harmful chemical substances and irritants, such as superabsorbents, leak-proof absorbents, and fragrances to enhance the quality of the product. It also overviewed the health issues, caused by careless use of diapers and pads, such as respiratory tract infections (RTIs), urinary tract infections (UTIs), infertility, testicular cancer, and chronic rash. The use of these products also results in environmental degradation due to the improper disposal and handling as well as the non-decomposable nature of the products. They are also known to release dangerous chemicals such as phthalates and volatile organic chemicals (VOCs). Hence, reusable cloth diapers and pads are the best options amongst feasible alternatives, since they have no harmful chemical or plastic materials. It is recommended that diapers and pads that are prepared from bamboo fibre, banana fibre, water hyacinth, or sea sponges should be promoted and commercialized since they are biodegradable.

1. Introduction

The term 'toxin' refers to a dangerous substance that is created by living organisms due to their metabolic activity. [1]. Toxins refer to a poison produced by animals, plants, microbes (including but not limited to protozoa, bacteria, viruses, rickettsia, or fungus), or infectious substances. It may also be a recombinant or synthetic molecule, regardless of its source or mode of manufacture [2]. Any benign substance is regarded as harmful when it starts to harm living beings at higher concentrations

. [3]. The toxicity of a chemical is determined by its structural integrity. If it is

identified as harmful, then it is detoxified (converted into less harmful substances), and eliminated from the body [4].

A sanitary pad, clean towel, clean pad, menstrual pad, or pad is an absorbent material worn inside the underwear by women and adolescent girls who are releasing blood subsequent to conceiving an offspring, during their periods, recovering from a gynecologic medical procedure, experiencing unexpected labour, or untimely birth [5]. A menstruation pad can be any absorbent material that is carried outside the vaginal canal, unlike tampons and menstrual cups, which are worn inside the vaginal canal. Menstrual pads are made of a variety of materials depending on the style, place of origin, and brand [6].Diapers are also meant to be worn as underwear, whereas sanitary pads are only meant to line the centre of underpants for more concentrated absorption. Diapers are meant to absorb urine in a higher amount in the front section. Conversely, sanitary pads are meant to absorb a much smaller amount of thick liquid, such as blood [7].

Disposable diapers are made from materials having a set safety profile, with no latex or scatter colours. Natural dormant polymers (cellulose, polyester, polypropylene, and polyethene), spandex, and colours are held together by weight and glue [8].

Among the item types, infant diapers have been considered [9] infant diapers are commonly worn by 0 to three years old children and are used to absorb their excretions. Disposable absorbent hygiene products comprise a variety of products, such as infant diapers, menstrual pads, and grown-up urinary incontinence diapers [10]. The purpose of this study is to spread awareness among the general populace about the injurious effects of diapers and pads, which are being carelessly used in every home worldwide, causing irreparable health and environmental damage. For this 21 reason, proper disposal of pads/diapers must be ensured and better alternatives must be promoted.

2. Methodology

This study overviews 40 previously published papers, out of which 35 were relevant and 5 papers were deemed to be irrelevant. Five out of 35 were used for abstract reading and rest are used for data extraction. The overviewed papers were selected based on their topic of discussion. Subsequently, the selected papers were used to gather pertinent information regarding the numerous harmful chemicals in sanitary pads and diapers, which exceeds the maximum permissible limits of EPA/WHO. The harmful impacts of these chemicals were also overviewed.

The following keywords were used to find these articles: toxicity caused by sanitary p ads and diapers, toxins detected in sanitary pads and diapers, detrimental effects of volatile organic chemicals (VOCs), disease caused by phthalates, effects on environment, and ways to dispose the waste and best alternate sources. The selected research articles were extracted from Springer.com, Research Gate, PubMed, Google Scholar and Science Direct from the year 1989 - 2020 (Figure 1).

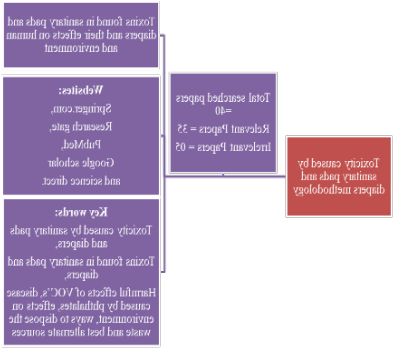

Figure 1. Flowchart depicting methodology of the review paper.

3. Results

3.1. Toxins Found in Pads and Diapers

In 2017, South Korean media revealed that a limited number of recently marketed brands of commercial sa nitary pads [11] were found to contain sig nificant levels of harmful chemicals (volatile organic chemicals - VOCs) that cause menstruation abnormalit ies. According to the users of these particular brands, these products caused menstruation abnormalities. Because of these concerns, researchers opt ed to evaluate the volatile organic chemicals (VOCs) and phthalates used in commercially available sanitary pads an d diapers from South Korea, Japan, Finlan d, France, Greece, and the United States o n a small scale.

Different categories of phthalates concentr ations in different brands of sanitary pads and diapers were found to contain methyle ne chloride, toluene, and xylene[12]. In recent research, analysts estimated three unpredictable naturally mixed volatile organic chemicals (VOCs) and four phthalates in sanitary pads and diapers. Phthalates are generally utilized as plasticizers to soften and build the adaptability/structural integrity of polyvinyl chloride plastics. Through experiments conducted on rodents, it was proven that phthalate introduction causes developmental and regenerative toxicity [13]. The air inside the bundling was additionally estimated and it enclosed up to 5.9 parts-per-billion (ppb) of volatile organic chemicals (VOCs). Two different types of diapers were found to have phthalates, while volatile organic chemicals (VOCs) toluene and Xylene were found in all four brands of diapers under observation [14].For this reason, it is pertinent to study the effect of volatile organic chemicals (VOCs) and phthalates on the genital area. Sanitary pads and diapers are manufactured by using synthetic plastics, such as phthalates. Furthermore, according to recent research, methylene chloride, a volatile organic chemical (VOC), is found in sanitary pad in a harmful amount. Fragrances, made from organic and artificial sources, are also added to feminine hygiene pads and diapers. These fragrances are made from chemicals that cause irritation.Generally, all aromas, including natural ones, must pass the criteria set by the International Fragrance Association (IFRA). They have to be evaluated to guarantee that they are non-sensitizing and non-allergenic. In some expendable diapers, the chemicals used to add fragrance are added in a very small quantity and situated underneath the absorbent material, away from the child's skin and thus are not harmful [15].The pigments added to the hygiene products are made up of large atoms, which do not retain dampness when wet.They can be found in materials, toys, colored pencils, beautifiers, nourishment bundling, and some therapeutic applications. Shade

hues have been considered fundamentally safe. Even if a limited quantity transfers to the skin, it can be effectively washed off (Table 1) (Figure 2) [16, 17].

Table: 1 Concentration of VOCs (volatile organic chemicals) noticed in sanitary pads.

Sr. No	Name of Chemical	µg per pad	References
1	Acetone	0.255 ~ 50.275	EPA, 2003a[24]
2	1-Butanol	0.12 ~ 24.556	EPA, 1989b[25]
3	2-Butanone	0.699 ~ 70.119	EPA, 2003b[26]
4	Bromo-dichloro-	0.125 ~ 0.365	DEQ, 2015a[27]
5	methane	0.032 ~ 6.48	WHO, 2005b[28]
6	Butyl acetate	0.035 ~ 4.705	EPA, 2010a[29]
7	n-Butylbenzene	1.379 ~ 1.379	EPA, 2012a [30]
8	sec-Butylbenzene	0.184 ~ 0.184	EPA, 2010b[31]
9	Carbon tetrachloride	0.123 ~ 0.811	EPA, 1989[32]
10	Chlorobenzene	0.163 ~ 2.941	EPA, 2009b[33]
11	Cumene	0.138 ~ 301.445	surrogate to cumen EPA,
12	p-Cymene	0.617 ~ 117.158	1997a[33]
13	Decanal	0.113 ~ 495.75	ECHA, 2019[34]
14	Decane	0.239 ~ 41.904	ACCVC, 2004[35]
15	2,4-Di-methylpentane	0.059 ~ 1.24	EPA, 1989b[25]
16	1,2-Di-chlorobenzene	0.03 ~ 0.223	EPA, 2010e[36]
17	1,2-Di-chloroethane	0.09 ~ 0.353	EPA, 2016a[37]
18	1,2-Di-chloropropane	0.834 ~ 3.364	EPA, 2006c[38]
19	1,3-Di-chloropropane	0.073 ~ 0.207	ATSDR, 2006[39]
20	1,4-Di-chlorobenzene	0.268 ~ 180.304	EPA, 2011[40]
21	Dodecane	0.225 ~ 38.851	EPA, 2013[41] NTP,
22	Ethyl acetate	0.142 ~ 5.682	2014[42]
23	2-Ethyltoluene	0.21 ~ 173.257	EPA, 2016b[43]
24	Heptane	0.492 ~ 2.445	EPA, 2016b[43]
25	Hexachlorobutadiene		EPA, 2007a[44]

Sr. No	Name of Chemical	µg per pad	References
26	Isooctane	0.053 ~ 5.481	EPA, 2007b[45]
27	4-Methyl-2-Pentanone	0.083 ~ 2.75	DEQ, 2015d[46]
28	Naphthalen	0.042 ~ 6.974	EPA, 1998[47]
29	Nonanal	0.474 ~ 147.949	surrogate to CH_2O EPA,
30	Nonane	0.093 ~ 19.149	1999[48]
31	Octane	0.026 ~ 4.261	EPA, 2009d[49]
32	n-Penta-decane	0.418 ~ 212.335	TCEQ, 2016[50]
33	Propyl benzene	0.136 ~ 0.769	EPA, 2009c[51]
34	1,2,4,5-	0.122 ~ 2.367	TCEQ, 2016
35	Tetramethylbenzene	0.26 ~ 221.328	EPA, 2009a
36	Tridecane	0.025 ~ 14.966	EPA, 2011[52]
37	1,1,2-Trichloroethane	0.036 ~ 1.435	Health Canada 1993[53]
38	1,2,3-Trichlorobenzene	0.148 ~ 12.256	EPA, 2016c[54]
	1,2,3-	0.307 ~ 65.48	ACCVC, 2004[35]
	Trimethylbenzene		EPA, 2009a[49]
	Undecane		TCEQ, 2012[55]

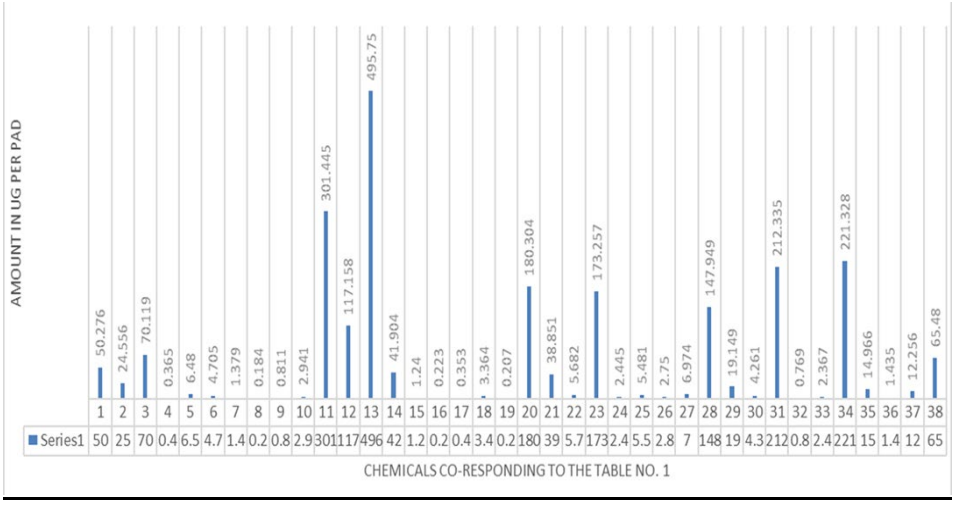

Figure: 2 Concentration of VOCs (volatile organic chemicals) detected in sanitary pads

3.2. Disease/Health-risk Caused by Pads

VOCs (volatile organic chemicals) comprise a range of chemicals that can cause eye, throat and nose irritation, headaches, shortness of breath, fatigue, dizziness, nausea, and skin issues. Higher concentrations might cause lung irritation, as well as damage to the kidney, liver, or the central nervous system. According to research, long-term exposure to mild volatile organic chemicals (VOCs) may also cause damage to the liver, kidneys, or the central nervous system [13].Disposable diapers are made up of sealed polymers, spongy polymers, and scented synthetic compounds, which cause diaper rash, respiratory issues (such as asthma), and male infertility. A majority of parents are not aware of the long-term harmful effects of disposable diapers and use them on their infants on regular basis [18].Poor menstrual hygienic management (MHM) also makes women more susceptible to reproductive tract infection (RTI). A restricted group of proof backings might be the reason that bacterial vaginosis (BV) might be progressively normal in ladies with unhygienic menstrual management practices [19, 20]. Urinary tract infections (UTIs) are common among young ladies that are menstruating due to unhygienic menstrual practices [21].

Wearing dry and wet fabric and expendable diaper materials affects the skin wetness. These influence the coefficient of skin rubbing, the skin's weakness to scraped area, its penetrability, and its help of microbial development. Hence, it was deduced that fabric diaper material makes the skin wetter than disposable diaper material [22] (Table: 2).

Table: 2 Disease caused by VOC (Volatile Organic Compounds)

Sr. No	Name of Chemical	Endpoints/ Disease	References
1	Acetone	Nephrotoxicity	EPA, 2003a[24]
2	1-Butanol	Neurotoxicity	EPA, 1989b[25]
3	2-Butanone	Reproductive toxicity	EPA, 2003b[26]
4	Bromodichloromethane	Reproductive toxicity	DEQ, 2015a[27]
5	Butyl acetate	Hepato, Nephro toxicity	WHO, 2005b[28]
6	n-Butylbenzene	Hepatotoxicity	EPA, 2010a[29]
7	sec-Butylbenzene	Nephrotoxicity	EPA, 2009d [30]
8	Carbon tetrachloride	Hepatotoxicity	EPA, 2010b[31]
9	Chlorobenzene	Hepatotoxicity	EPA, 1989[32]
10	Cumene	Nephrotoxicity	EPA, 1997a[33]
11	p-Cymene	Nephrotoxicity	surrogate to cumen
12	Decanal	No adverse effect	EPA, 1997a[33]
13	Decane	No toxicity observed	ECHA, 2019[34]

Sr. No	Name of Chemical	Endpoints/ Disease	References
14	2,4-Di-methylpentane	“	ACCVC, 2004[35]
15	1,2-Di-chlorobenzene	Nephrotoxicit	EPA, 1989b[25]
16	1,2-Di-chloroethane	Reproductive toxicity	EPA, 2010e[36]
17	1,2-Di-chloropropane	Hepato,Nephro toxicity	EPA, 2016a[37]
18	1,3-Di-chloropropane	Hepatotoxicity	EPA, 2006c[38]
19	1,4-Di-chlorobenzene	-	ATSDR, 2006[39]
20	Dodecane	Hepatotoxicity	EPA, 2011[40]
21	Ethanol, absolute	Body weight decrease	EPA, 2013[41]
22	Ethyl acetate	Testicular atrophy	Fioruci, 2015[42]
23	2-Ethyltoluene	Neurotoxicity	EPA, 2016b[43]
24	Heptane	-	EPA, 2016b[43]
25	n-Hexadecane	Nephrotoxicity	_
26	Hexachlorobutadiene	Nephrotoxicity	EPA, 2007a[44]
27	Isooctane	Nephrotoxicity	EPA, 2007b[45]
28	4-Methyl-2-Pentanone	Body weight decrease	DEQ, 2015d[46]
29	Naphthalen	Weight gain reduction	EPA, 1998[47]
30	Nonanal	Body weight decrease	surrogate to CH2O
31	Nonane	No toxicity observed	EPA, 1999[48]
32	Octane	-	EPA, 2009d[49]
33	n-Penta-decane	Hepato,Nephro toxicity	TCEQ, 2016[50]
34	Propylbenzene	-	EPA, 2009c[51]
35	Tetra-decane	-	_
36	1,2,4,5-	-	_
37	Tetramethylbenzene	Hepato-Immunotoxicity	_
38	Tri-decane	Neurotoxicity	EPA, 2011[52]
39	1,1,2-Trichloroethane	Salivation	Health Canada
40	1,2,3-Trichlorobenzene	Hepatotoxicity	1993[53]
41	1,2,3-Trimethylbenzene	Hepatotoxicity	EPA , 2016c[54]

Sr. No	Name of Chemical	Endpoints/ Disease	References
42	Undecane	Hepatotoxicity	ACCVC, 2004[35]
43	Bromobenzene	Hepatotoxicity,	EPA, 2009a[49]
	Bromochloromethane	Nephrotoxicity	TCEQ, 2012[55]
			EPA, 2005[56]
			EPA, 2009b[57]

Table: 3 Average pathogen survivals time period in feces at specific temperature

Pathogen	Moderate environment (10 -15◦C)	Warm environment (20 - 30◦C)
Trematodes	<30	<30
Cholera	<30	<5
Amoebic eggs	<30	<15
Viruses	<100	<20
Salmonella	<100	<30
Fecal coliforms	<150	<50

3.3. Harmful impacts of diapers that are affecting our Environment

As per WHO (2014), dioxins are industrious ecological poisons that can cause a variety of medical issues including, skin infections, and particular sorts of malignant growth. The internal spongy layer of a diaper is treated with synthetic substances and can cause hypersensitivity in children. At the point when discharged into the earth, the dioxins can aggregate [23]. he excretions absorbed by diapers contains pathogenic microorganisms, which may cause untreatable diseases in people. As per a WHO report (2014), human excreta have been known to cause numerous untreatable ailments including cholera, typhoid, hepatitis, polio, cryptosporidiosis, ascariasis, and schistosomiasis. Some of the pathogens caused by faecal matter have the ability to survive for months. Individuals typically dump soiled disposable diapers at dumping sites near residential areas, which may be harmful to the nearby population [58]. Due to the increased use of disposable diapers, the environmental well-being is at risk. These diapers are generally disposed at two spaces, either at landfills and disposable facilities, or they are thrown as waste in public space.

Unlike developed countries, underdeveloped countries,. such as Zimbabwe continue to employ outdated techniques of disposing waste in landfills. It also exposes individuals who work with solid waste management, such as municipal staff and waste pickers, to pollutants that can cause grave infections since they can come into contact with soiled disposable diapers. Due to an underdeveloped trash disposable system, solid waste, containing diapers and pads, is often mixed with organic waste.

For this reason, waste workers may be exposed to around 120 distinct types of viruses including enteroviruses, rotaviruses, enteric adenoviruses, and human caliciviruses (noroviruses) [58].

According to Peterson (1974), newborns are the most notable carriers of enteroviruses. Due to lack of proper waste management by local authorities, this issue is steadily increasing and causing more harm. [16]. According to Ramaswamy and Sharma (2011), residents in places where garbage collection is low improvise by throwing away their waste in plastic bags, which they subsequently dump in exposed spaces near their homes and municipal solid waste stream. According to Tsiko (2011), toxic waste, such as used diapers, is also thrown near riverbanks, destroying the local environment and polluting the riverbank. Plastic and disposable diapers are not bio-degradable and will damage the ecosystem since it takes around 400 to 1000 years for them to decompose [59, 60,61].Unsafe substances are discharged in the air and further harm the ozone during waste disposal of diapers, causing atmospheric degradation and contamination. The soiled diapers also release ozone-depleting chlorofluorocarbons when they are laid out open in the landfills. Furthermore, disposal of solid waste creates several greenhouse gases (GHGs), which significantly contributes to global climate change. According to some research, clothed diapers are less harmful to the environment than disposable diapers, since they can be washed and sterilized [62].Additionally, open waste dumps cause environmental health problems since it can be easily affected by weather. Weather may increase the decomposition rate of the waste and attract flies, which may transfer communicable diseases to local communities. Untreated human waste is a breeding ground for diseases, such as cholera, dysentery, and diarrhoea. Despite these health risks, findings of various studies revealed that soiled diapers are still being disposed of in open spaces in the city's disposal site, unauthorized dumping sites, becoming a feeding ground for diseases vectors such as flies [63]. When incinerated, the disposable waste released harmful chemicals that can endanger human health. At times, the soil was used to cover the waste, including the diapers. However, when such waste is buried in the ground, they have the potential to pollute groundwater [64 , 65]

4. Cause for Concern

4.1. Phthalates: They are a group of chemicals used to moderate and increase the adaptability of plastic and vinyl. [66]. Disperse dyes (scatter colours) are a class of marginally water-solvent colours scattered in fluid answer to colour engineered material strands. Scatter colours are viewed as key allergens in material dermatitis/ and cause contact allergy [67].

4.2. Heavy Metals: Any moderately thick metal or metalloid with potential toxicity or ability to cause an unfavourable response is a heavy metal. In huge sums, dangerous heavy metals, such as mercury and lead, may affect human anatomy and cause formative handicaps [68].

4.3. Organotin: Chemical mixes dependent on tin with hydrocarbon substituents utilized as stabilizers in the assembling of plastics just as for use as biocides in mechanical applications. Some organotin mixes have an assortment of danger, including to the marine condition, immune-toxicity, and consequences for the anxious system [69].

4.4. Polyvinyl Chloride (PVC): It is a strong unscented plastic that contains significant levels of chlorine. It is used to make restorative gadgets, garden hoses, and toys. Continuous contact with PVC may cause health issues, such as conceptive and formative issues Moreover, certain cancer-

causing dioxins might be released when PVC is disposed of through incineration [70, 71].

4.5. Bisphenol A (BPA): Bisphenol A (BPA) is a modern compound used to make certain plastics or epoxy gums including water bottles, athletic gear, CDs, and DVDs. BPA displays hormone-like properties [72].

4.6. Formaldehyde Releasers: It is an additive and is used in paper items, paints, prescriptions, family cleaners, restorative items, and texture wraps up. These substances are associated with malignant growth, skin irritation, and skin allergies [73, 74]. This type of chemical is mostly used in cosmetics as preservatives.

4.7. Recommendations for Effective Disposal of Menstrual Waste

If fireboxes are used in accordance to eco-friendly procedures, then fewer contaminants might be generated. They must be used at a definite temperature of around 800 degrees Celsius to discharge less smoke. They must be built in schools, organizations, and slum spaces, as well as in communal spaces. Appropriate chemicals should be added to the chute of latrines to increase the decomposition rate of menstrual waste. Reusable cloth pads have no harmful chemicals or plastic materials and hence are better than commercially produced pads. For this reason, pads that are prepared from bamboo fibre, banana fibre, water hyacinth, and sea sponges should be commercialized and sold. Unique bins ought to be introduced to deal with menstrual waste effectively. Furthermore, disposal bags should be distributed in schools and female organizations for effective disposal of soled waste, including pads and diapers. By following these procedures, solid waste can be effectively disposed and controlled, preventing the spread of toxic pathogens.

5. Cloth Versus Sanitary Pads

Cloth pads are eco-friendlier and more cost-effective than sanitary pads, but they must be washed properly in order to maintain hygiene. The sun's heat is a natural sterilizer and cloths/cloth pads dried under direct sunlight make them germ-free for future use [76].

Conclusion

This overview concluded that sanitary pads and diapers have volatile organic chemicals (VOCs) and phthalates. The amount of these chemicals used in these products differs substantially from brand to brand and area to area. It was determined that there is a need to raise concern about the safety measures associated with the use of products having high concentrations of volatile organic chemicals (VOC) and phthalate. The physical position of the disclosure site, the high immersion level of chemicals in the genitals, and the long-term exposure period all necessitate a thorough examination of the prospective impact of the disclosure on VOCs and phthalates. For this reason, further research must be conducted to properly examine the potential health risks of using VOC or phthalate-containing diapers and sanitary pads. It is suggested that pads such as bamboo fiber, banana fiber, and water hyacinth manufactured sanitary pads should be promoted and commercialized among the masses.

Conflict of Interest

The author affirms no conflict of interest.

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