BPA and BPS in Thermal Paper: Results of Testing in Minnesota Hospitality Industry

Produced with funding from the U.S. Environmental Protection Agency
and the Minnesota Pollution Control Agency

Minnesota Pollution Control Agency

March 2014

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Contributors/acknowledgements

The authors thank Ben Rabe and Al Innes for their contributions to this report and the participating businesses for their partnership in this project.

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Estimated cost of preparing this report *(as required by Minn. Stat. § 3.197)*

Total staff time: 25 hrs.	$782
Consultant	$6,480
Total	$7,262

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Document number: p-p2s10-13

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Executive summary

Over the past two decades, there has been rising concern about the use of Bisphenol A (BPA), a chemical commonly found in plastic and food packaging products, and its impact on humans and the environment. Independent studies on BPA's effects on the human endocrine (or hormone) system have prompted questions about its safety. Consequently, the State of Minnesota and the U.S. Food and Drug Association (FDA) have both banned BPA's use in baby bottles and children's cups. Numerous manufacturers have begun voluntarily removing BPA from other products.

BPA is also in the 640,000 tons of thermal receipt paper the U.S. uses each year. Although BPA leaching into food from containers made with the chemical is a concern, thermal receipt paper from common retailers was found to have 250 to 1,000 times more BPA than typically found in food from a BPA-laden can (Lunder, Andrews, and Houlihan, 2010). It is important for government, the public and businesses to recognize the possible health and environmental impacts of BPA in thermal receipt paper.

In 2011, the Minnesota Department of Health listed Bisphenol A as one of nine priority chemicals of concern, due to its widespread presence in humans and high production volumes. In response, the Minnesota Pollution Control Agency (MPCA) retained the Stratford Companies to help assess the prevalence of BPA-laden receipt paper in one set of Minnesota businesses. Because the hospitality industry—which includes restaurants, theme parks, lodging, event planning and other tourism-related businesses—is a Pollution Prevention Grant priority sector for the US Environmental Protection Agency (EPA) Region 5, the MPCA chose to study hospitality companies for this project.

An additional project goal was to analyze how businesses can reduce their use of thermal paper receipts and move to paperless Point of Sale (POS) systems or to paper use and handling reduction strategies, such as not issuing receipts for low-dollar-amount transactions. The intent of this work is to minimize human exposure to BPA and the release of BPA to the environment.

Moving away from receipts containing BPA is not simple for businesses. Typically, the chemical content of the paper is not disclosed to end users and may vary from shipment to shipment. There are currently no clearly safe alternatives to BPA for use in thermal receipt paper. The most common alternative is Bisphenol S (BPS), and BPS paper manufacturers and resellers *can* call their products "BPA-free." But research has shown that BPS can exhibit endocrine disruptive characteristics similar to BPA (Viñas and Watson, 2013). The best alternative at present is to encourage businesses to offer digital receipts or to take other steps to minimize use and handling of thermal paper. It is possible for businesses to use non-thermal paper if they change receipt-printing systems, but paper receipts generate waste. The MPCA is primarily promoting paperless alternatives.

For this study, the receipt paper from 19 hospitality businesses was analyzed for BPA and BPS content by the Minnesota Department of Health. Only one of the businesses didn't use thermal paper. Samples were also taken at a paper recycler, and from domestically manufactured Boise Cascade's Aspen 30% and Aspen 100% recycled copy paper; the MPCA is concerned about the potential contamination of recycled paper stocks by BPA and BPS-laden thermal papers in the recycling stream.

All the thermal receipt paper tested in this study contained either BPA or BPS in various quantities. In the recycled-content paperboard, testing detected BPA and BPS at levels 2 and 3 orders of magnitude (respectively) less than in thermal papers. No BPA or BPS was detected in the recycled content copy papers tested.

The purpose of this white paper is to summarize the MPCA's interest in reducing BPA, detail the scope and limitations of this overall project including paper testing, and to report the test results. A second white paper will describe how a few businesses made changes to their POS systems or in the way their employees handle receipts.

What is BPA and why is it a concern?

BPA is an industrial chemical compound that has been used to make plastics and resins since the mid-1900s. Each year, more than 13 billion pounds of BPA is produced and used in polycarbonate plastics and epoxy resins in such products as baby bottles, plastic food and drink containers and the lining of food cans (Transparency market Research, 2014). BPA is also used as a developer in inkless thermal receipt paper. To produce a receipt, the paper is coated with a dye and a developer (BPA or another chemical). Heat from the thermal printing head triggers a reaction between the dye and developer, allowing the black print to appear (Lunder, Andrews and Houlihan, 2010). BPA can enter the bloodstream of people handling receipt paper by being absorbed directly into the skin, or when they touch their food or their mouths after touching BPA paper and ingest the chemical (Biedermann, et al., 2010).

The National Toxicology Program (NTP) Center for the Evaluation of Risks to Human Reproduction has stated "The NTP has *some concern* for effects of BPA on the brain, behavior and prostate gland in fetuses, infants and children at current human exposures to BPA" (National Toxicology Program [NTP] (original emphasis), 2008; EPA, 2010a). Because of the widespread presence of BPA in humans and because it is identified as a high-production-volume chemical, it is on the Minnesota Department of Health's list of priority chemicals.

The Centers for Disease Control reports that people working in retail industries have 30% more BPA in their bodies than the average US adult, and 34% more BPA than workers in other fields. A study conducted by the University of Missouri, Division of Biological Sciences laboratory showed that BPA levels in receipt paper are 250 to 1,000 times higher than typically found in food from a BPA-laden can. While ingesting food and water from containers made with BPA accounts for higher BPA concentrations in humans, absorption of BPA from receipts through the skin is a contributor as well.

BPA has also been linked to environmental concerns and impacts on aquatic life (Kang, et al., 2007). The chemical has been found in Minnesota surface waters and in landfill leachate. The MPCA (2008) has written:

> *"In animals, exposure to EDCs (endocrine disrupting compounds) has been associated with reduced reproductive success, reduced survival, altered sex typing and developmental abnormalities. Effects seen in individuals could result in population-level effects if reproduction is adversely affected. Population-level effects following exposure to EDCs have been documented in a variety of fish and wildlife populations."*

While BPA breaks down quickly, it is found at low levels in surface-water, sediments, soils, plants and animals. It is "pseudo-persistent" in the environment because of continual inputs (Flint et. al, 2012).

In addition to the FDA and Minnesota bans on BPA in children's products mentioned above, the Suffolk County Legislature in New York enacted a law to ban BPA from cash register receipts in January 2013.

With the mounting concern about BPA in a number of common products, the thermal paper industry has been pushing to find a preferable alternative. The EPA's Design for Environment program recently completed an alternatives assessment of a number of possible functional chemicals for thermal paper applications. (For a list of the 19 chemical assessed, see the report, pages vi and vii.) The EPA's BPA Alternatives in Thermal Paper partnership final report notes that none of the 19 chemicals assessed are a clearly safe alternative to BPA.

As mentioned above, the most commonly used alternative, BPS, has now been found to be endocrine active at low concentrations. So using a paper marketed as "BPA-free" may be a marketing boon, but buying the alternative products doesn't necessarily increase consumer and employee safety. Due to the lack of safe chemical alternatives, the MPCA is promoting use of paperless receipts as the best option for employees, consumers and the environment.

Study and results

The MPCA and the Stratford Company recruited Minnesota hospitality businesses to participate in this project. The self-selected participants tended to be organizations with an interest in health, environment and sustainability issues and many had general knowledge of BPA-related concerns and were seeking to minimize exposure to employees and customers. The participating businesses included co-ops, government and university entities and several restaurants.

Methodology

To find businesses to participate, the project team developed relationships across many industry associations, government tourism programs and private business partnerships. After nearly 70 hospitality businesses indicated interest in the project, they were sent emails with a link to an online survey and two three-minute videos that described the program, why BPA in receipt paper is of concern and paperless POS product options. Links to the survey and videos were also posted onto the MPCA web page about the project.

The online survey questions were:

1. What's your business name
2. What kind of receipt paper do you use?
3. Who is the manufacturer of your paper?
4. Where do you get your paper?
5. How much paper is bought per week, month or year (whichever is easiest)?
6. How long have you been using this receipt system?
7. Have you looked at going to paperless products? If so, what types?
8. Any other information about your receipt paper we should know?

Ultimately, 19 hospitality businesses, nonprofits and government entities agreed to participate, completed the questionnaire, and submitted samples of their receipt paper for testing. Additionally, one recycling facility was selected to test for presence of BPA and BPS in recycled cardboard taken "off the line" and samples from purchased reams of 30% and 100% post-consumer office paper were tested.

All paper samples were tested using the following method:

1. A trained member of the research team collected two samples of receipt paper from each participating business and from the copy paper to be tested by the Minnesota Department of Health (MDH). A collection protocol was developed by MPCA in conjunction with MDH and EPA to ensure clean, uncontaminated samples. Samplers wore nitrile gloves, secured samples in labeled glass vials and tracked with a chain of custody until analyzed at the MDH Environmental Laboratory.
2. MDH staff took uniform punches from each sample and tested for BPA and BPS content using liquid chromatography/tandem mass spectrometry. The chemicals were reported in micrograms of BPA/BPS per square centimeter ($\mu g/cm^2$).

Note: Quality Assurance Project Plans, including detailed sampling and laboratory testing operating procedure for both BPA and BPS, are available upon request from the MPCA. Please contact Madalyn Cioci or Phyllis Strong at 651-296-6300.

Results

There were no quality assurance issues with the data. All quality control (QC) acceptance criteria were met and the sample results were usable for their intended purpose.

Table 1 indicates that nine tests of thermal paper indicated presence of BPA in quantities ranging from 54–79 mg /cm^2. Nine tests indicated presence of BPS in quantities ranging from 37–75 mg /cm^2.

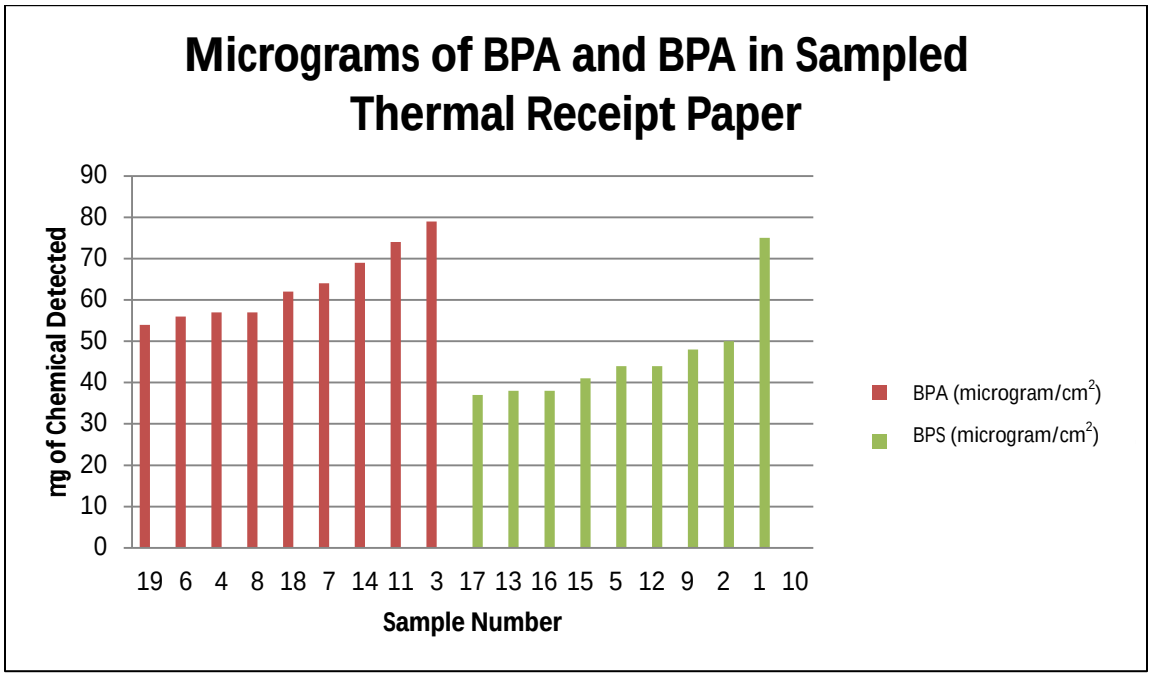
Table 1: Business and Recycled Paper Sample Testing Data & Extrapolated Estimates of Annual BPA/S Use

		BPA (mg /cm^2)	BPS (mg /cm^2)	rolls/year	cm^2/roll	BPA/S (kg/year) (est.)	BPA/S (pounds/year) (est.)
1	Business C	<	75	10,400	66,048.26	51.51	113.58 BPS
2	Business D	<	50	3,250**	62,322.15	10.13**	22.33 BPS**
3	Business E	79	<	550	55,645.02	2.42	5.33 BPA
4	Business F	57	<	100	49,879.64	0.28	0.63 BPA
5	Business G	<	44	104	14,806.42	0.068	0.15 BPS
6	Business H	56	<	No data provided by business			
7	Business I	64	<	900	74,515.67	4.29	9.46 BPA
8	Business J	57	<	1,200	53,224.15	3.64	8.02 BPA
9	Business K	<	48	18,000	14,806.42	12.79	28.2 BPS***
10	Business L*	<	<	NA	NA	NA	NA
11	Business M	74	<	3,750	55,645.02	15.65	34.50 BPA
12	Business N	<	44	1,560	48,386.97	3.32	7.32 BPS
13	Business O	0.0099	38	30	28,741.88	0.03	.07 BPS
14	Business P	69	<	200	13,935.45	0.19	.42 BPA***
15	Business Q	<	41	2,600	53,224.15	5.67	12.51 BPS
16	Business R	<	38	5,200	53,224.15	10.52	23.19 BPS
17	Business S	<	37	600	74,515.67	1.68	3.70 BPS
18	Business T	62	<	1,200	55,645.02	4.14	9.13 BPA
19	Business U	54	<	450	74,515.67	1.81	3.99 BPA
20	30% recycled content copy paper – B	<	<	NA	NA	NA	NA
21	100% recycled content copy paper – V	<	<	NA	NA	NA	NA
22	100% recycled content paperboard – A	0.12	0.053	NA	NA	NA	NA

< Indicates less than reporting limit
* Sample was not a thermal paper.
** Quantity reported is not per year, but per summer season for this recreational/parks entity.
*** This business had two different thermal papers in use. Because of a gap in sampling records, it was unclear which of the papers was tested. The results reported are for the lesser used paper, thus any error results in underestimating rather than overestimating the chemical use.

That half the samples contained BPA and half the samples contained BPS suggests that BPS is a common alternative. When asked during the sampling process, the businesses were unaware that BPS could also be of concern. Moreover, business 14 had specifically purchased BPA-free thermal paper and testing found presence of 69 mg /cm^2 of BPA.

Figure 1: Concentration of BPA/BPS in Receipt Samples



Of the 19 samples of receipt paper, only one tested (business 10) contained neither of these substances in noticeable quantities. It was determined that the paper samples from business 10 (L) were traditional bond paper not thermal paper.

The number and area of rolls used per year (reported by participating businesses) was used to convert the mg/cm^2 of BPA or BPS into estimated kilograms and pounds per year. Data regarding the volume of recycled paperboard produced per year was not obtained and therefore total annual chemical weight could not be estimated.

Businesses get multiple shipments of thermal paper each year from a variety of global manufacturers, and the chemical developer in the papers may change through the year. Thus, the data do not allow a firm conclusion as to the amount of BPA and BPS used by these particular businesses. However, the testing results, which are in the same range and order of magnitude of prior lab tests (Lunder et al, 2010) do allow for rough extrapolation. Assuming the tests are representative of amount of chemical throughout the rolls, and based on reported paper use by the 17 businesses using thermal paper *and* reporting their paper use, the paper would contain about 282 pounds of chemicals (71.48 lbs of BPA and 211.05 of BPS).

Even if there were clearly safe alternatives to BPA and BPS, a major barrier to reducing BPA and BPS-laden receipt paper arises from thermal paper supply-chain processes. When receipt paper is purchased, final users typically have no way of confirming the paper's manufacturer or chemical content. There are many converters of paper that cut, re-label, repack and kit papers from different manufactures as their own brand. There is no required chain of custody for the thermal paper industry. Distributors of receipt paper may not know where the paper was produced, which makes knowing the BPA or BPS content difficult for both suppliers and end users in the hospitality industry.

Another concern is the potential contamination of recycled paper stocks from thermal paper in the recycling stream. The project collected a finished-product sample from a recycled paperboard producer who accepts mixed paper (including any thermal receipts in this material) as feedstock. Testing detected BPA and BPS at levels two and three orders of magnitude (respectively) less than found in thermal papers. BPA was detected at 0.12mg /cm^2 and BPS was detected at 0.053mg /cm^2. Finally, testing of 30% and 100% post-consumer recycled copy paper samples (whose producers do not accept mixed paper as feedstock) did not find BPS or BPA above reporting limits.

Conclusion

The findings of the testing affirm that BPA and BPS are present in thermal papers in Minnesota businesses. The test results also affirm previous findings that BPS is being used as a common alternative to BPA in thermal paper applications (Liao et al., 2012) and in comparable concentrations. The data suggest that while not a major concern, any BPA-free claims would need to be verified by testing.

Because BPS has also been found to be an endocrine active chemical, the MPCA recommends that Minnesota hospitality industries move to paperless POS systems that provide digital receipts to customers. If digital POS systems cannot be implemented, it is recommended that businesses and employees implement paper use and handling reduction strategies. Currently, there are a number of strategies that can reduce the amount of thermal receipt paper used and lessen the potential BPA and BPS exposure for both employees and customers. These strategies are part of the tool kit of resources being developed for this project and are available on the project web page.

Because this application of BPA is not widely known, businesses and local governments can educate consumers and workers about the potential exposure pathway for endocrine active chemicals represented by thermal receipt paper.

As for the fate of BPA and BPS when it enters the recycling stream, more research is necessary before issuing any guidance about the environmentally preferable method for end-of-life management of thermal papers. Whether recycling, incineration, or landfill is the best method of management involves questions that science has not yet answered, such as what happens when these chemicals are combusted, the fate of the chemicals when they are captured in wastewater treatment plants or how much of the chemicals may be in recycling process wastewater.

The limited testing reported here found no BPA or BPS detected in the recycled copy paper and only minute amounts of BPA and BPS in the recycled paperboard sample. These single samples are not sufficient for drawing firm conclusions about the amount of the chemicals in these papers overall. However, at this time, the MPCA is feels that the recycled paper is not of significant concern. Emphasis should continue on reduction of thermal paper use and handling at the places where receipts are commonly issued. Reduction of use of thermal paper will not only directly reduce human exposures to BPA and BPS but will also minimize future recycling of the chemicals through the recycled paper manufacturing process and environmental impacts through end-of-life disposal.

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