LEVELS OF POLYBROMINATED DIPHENYL ETHERS IN THE LAKE TAHOE WATERSHED BASIN.

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Introduction

The Lake Tahoe Watershed Basin is a unique ecosystem that straddles the border of the states California and Nevada, USA. The basin is unique in its geological characteristics as well as its breadth of year-round recreational uses. These activities include a variety of water sports, snow sports, fishing, hiking, camping, and the area is also a mecca for gambling and gaming of all types. The watershed basin area covers approximately 500 square miles, of which approximately 191 square miles is the surface area of Lake Tahoe itself. The basin is situated in a high alpine environment, which ranges in elevation from 6225 ft at the lake surface to nearly 11,000 ft at the top of Freel Peak. Lake Tahoe is approximately 22 miles in length, 12 miles in width, and has 72 miles of shoreline. Lake Tahoe is the second deepest lake in the United States, with a maximum depth of 1,645 feet and an average depth of approximately 1000 feet. Many small streams and creeks feed into the lake, but the lake is drained at only a single location by the Truckee River. It is estimated that approximately 40% of the total precipitation that falls into the Lake Tahoe Basin lands directly on the lake surface due to it's large surface area relative to total area of the watershed basin[1]. This combination of factors along with an average water temperature of 39 ^{o}C at depths below 600 feet, creates a very long residence time for water in the lake, some estimates as long as 600 years.

The Lake Tahoe Basin is a very valuable economic and environmental resource that has attracted the interest of many over the years. Early industry in the area consisted mainly of logging for lumber and firewood used to support the growing areas of Sacramento, San Francisco, and others. The population of the area was very small up to the 1950's, when the growth of tourism and recreation began in the area. The award of the Olympic Winter Games to Squaw Valley in 1960 continued to fuel the growth of the area. The permanent population of the area grew from an estimated 10,000 in 1960 to approximately 56,000 in 2004[2]. The growth of tourism saw an even greater increase and the basin is now estimated to have an annual visitation of 23 million visitor days per year, and highs in excess of 200,000 people on busy summer weekends[3]. This growth in permanent and tourist populations has lead to an impact on the environment from construction and use. This impact is most notable in the loss of water clarity that Lake Tahoe has experienced. The water clarity of the lake has dropped significantly since 1971, and is continuing to drop, due to an increase in sediment and algal content in the lake. This loss of water clarity is of interest to many, and attracted the attention of the US federal government in 1997. An executive order was signed in 1997 by President Clinton, that established an interagency partnership to coordinate the efforts of the Secretaries of Agriculture, Interior, Transportation, EPA, Army, and state and local agencies studying and working on issues relating the Lake Tahoe Basin.

The unique geographical aspects of the Lake Tahoe Basin result in a fairly closed ecosystem with little introduction of outside contaminants, other than those introduced directly by humans. The high mountain peaks surrounding the basin limit the airborne transport of contaminants from surrounding regional industrial areas, and the water sources that feed the lake originate from within the watershed basin. The increase in sediment concentration in the lake as well as the potential for air and water contamination caused by the increased permanent and visitor use of the lake caused Severn Trent Laboratories to initiate a study of the Polybrominated Diphenyl Ether concentrations in snow, water, and sediment samples collected from different locations around the Lake Tahoe Basin.

Material and Methods

The samples analyzed for the predominant PBDE congeners (PBDE-28, 47, 66, 85, 99, 100, 138, 153, 154, 183, and 209) were collected at twelve locations around the Lake Tahoe Watershed Basin during the months of March and April 2006. The sampling locations selected were areas of public access and typically high use for all or part of the year. Some of the sampling locations were right on the lake and others were several hundred yards to miles upslope from the lake. They included state and local park and recreation areas offering a variety of recreational activities including hiking, biking, swimming, boating, fishing, camping, snow mobiling, etc., as well as sources of water flowing into the lake from the surrounding watershed basin. The sampling locations included Brockway Summit, Kings Beach, Incline Village, Sand Harbor, Spooner Summit, Cave Rock State Beach, Zephyr Cove, Regan Beach, Pope Beach area, D.L. Bliss State park, Sugar Pine Point State park, and Tahoe City State Recreation area. The samples included upslope surface snow, upslope surface sediment, shoreline lake water surface samples, and shoreline (1-3 meters from water edge) lake sediment samples. The samples were extracted and analyzed by Severn Trent Laboratories in Sacramento California using EPA Method 1614. The aqueous samples were extracted using separatory funnel extraction, and the sediment samples were extracted using soxhlet extraction. The sample analysis was performed by high-resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) for 11 predominant PBDE congeners. These congeners include the predominant congeners listed in Method 1614 as well as 2 additional congeners included in the Lake Michigan Study protocol. The reporting limits used for the study were established using a combination of the method calibration curve and the historical background levels observed for various congeners in the laboratory. The reporting limits for PBDE 47, 99, 100, and 209 were elevated due to the historical background levels observed in laboratory method blanks. The results for congeners that are below the reporting limit but greater than half of the reporting limits are *italicized*.

Results and Discussion

The sediment and aqueous samples, whether lake level or upslope samples all had very low concentrations of PBDEs detected. The levels in most of the samples were not significantly from the levels detected in the associated laboratory Method Blanks, and only a few were above the reporting limits established by the laboratory. The results for the sediment samples showed little variability across the eight sampling locations, whether they were lake sediment or upslope sediment samples. The sample results for the aqueous lake and creek water samples generally showed little variability across the congeners from different locations around the basin, but several of the snow samples showed consistently higher concentration across the congeners. While the levels were higher, they were still generally below the reporting limit. The snow samples were collected on different dates and at opposite ends of the lake, but were collected using the sample containers used for the aqueous samples. The higher trend observed in some of the snow samples was likely due to the samples themselves, and not sampling containers or technique. The overall low levels of PBDEs detected in the aqueous and sediment samples would appear to indicate that the large increase in the permanent and tourist populations over the past 40 years has not contributed to a significant source of PBDE contamination of the lake. The water and sediment predominantly originate from within the lake basin, so they are not significantly impacted by pollution sources outside the basin. This would indicate that the contamination of water bodies in surrounding metropolitan areas outside of the basin is mainly from industrial sources, which are minimal or absent within the basin area. Studies of employment in the basin indicate that just over 1% (617 of 49,513 jobs) of the jobs in the Lake Tahoe Basin are in the manufacturing sector[4].

References

1. USGS- Lake Tahoe Data Clearinghouse.
2. U.S. Department of Transportation.
3. California Tahoe Conservancy
4. Dean Runyan & Associates (TIIMS Website)

Levels of PBDE Congeners in Lake Tahoe Watershed Basin

mpling ocation	BDE-28	BDE-47	BDE-66	BDE-85	BDE-99	BDE-100	BDE-138	BDE-153	BDE-154	BDE-183	BDI
ockway nit (snow)	ND	ND	ND	ND	ND	*72*	ND	ND	ND	ND	N
ockway ummit diment)	*9*	**500**	**12**	**16**	*421*	*96*	ND	**35**	**30**	ND	N
gs Beach k H20)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	N
gs Beach k Sed.)	*7*	*449*	**11**	**16**	*423*	*96*	ND	**41**	**34**	ND	N
e Village eek H20)	ND	ND	ND	ND	ND	*57*	ND	ND	ND	ND	N
e Village snow)	ND	ND	ND	ND	ND	*64*	ND	ND	ND	ND	N
e Village eek Sed.)	*8*	*472*	**10**	**10**	*257*	*65*	ND	**13**	**14**	ND	N
Harbor k H20)	ND	ND	ND	ND	ND	*75*	ND	ND	ND	ND	N
Harbor k Sed.)	*6*	*304*	*6*	*8*	ND	*51*	ND	**12**	**12**	ND	N
pooner nit (snow)	ND	ND	ND	ND	ND	100	ND	ND	ND	ND	N

Levels of PBDE Congeners in Lake Tahoe Watershed Basin (cont')

mpling ocation	BDE-28	BDE-47	BDE-66	BDE-85	BDE-99	BDE-100	BDE-138	BDE-153	BDE-154	BDE-183	BD
Rock (Lk H20)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	N
Rock (Lk Sed)	6	*356*	*8*	**13**	*302*	*71*	ND	**19**	**19**	ND	N
r Cove k H20)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	N
r Cove k Sed)	*8*	*297*	*6*	*8*	ND	ND	ND	**13**	**13**	ND	N
an Beach k H20)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	N
an Beach k Sed)	*7*	*326*	*7*	**10**	ND	*58*	ND	**14**	**14**	ND	N
Beach (Lk H20)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	N
Beach (Lk Sed)	ND	ND	*5*	**11**	*256*	58	ND	**20**	**19**	ND	N
L. Bliss Snow)	ND	ND	ND	ND	ND	*160*	ND	*64*	*51*	ND	N
r Pine Pt. snow)	ND	ND	ND	ND	ND	*66*	ND	ND	ND	ND	N
City SRA snow)	ND	ND	ND	ND	ND	*61*	ND	ND	ND	ND	N

indicates results greater than the reporting limit

- indicates results are greater than half of the reporting limit.

esults detected at less than one-half the reporting limit.

esults reported in units of pg/g dry weight

us samples reported in units on pg/L.