Bibliometric Analysis for Papers on Topics Related to Pollution Prevention (P2)

This is a bibliometric analysis of the papers prepared by intramural and extramural researchers of the U.S. Environmental Protection Agency (EPA) on topics related to pollution prevention (P2). For this analysis, 509 papers were reviewed. These 509 papers, published from 1995 to 2005, were cited 8,277 times in the journals covered by Thomson's Web of Science.[1] Of these 509 papers, 401 (79%) have been cited at least once in a journal.

The analysis was completed using Thomson's Essential Science Indicators (ESI) and Journal Citation Reports (JCR) as benchmarks. ESI provides access to a unique and comprehensive compilation of essential science performance statistics and science trends data derived from Thomson's databases. The chief indicators of output, or productivity, are journal article publication counts. For influence and impact measures, ESI employs both total citation counts and cites per paper scores. The former reveals gross influence while the latter shows weighted influence, also called impact. JCR presents quantifiable statistical data that provide a systematic, objective way to evaluate the world's leading journals and their impact and influence in the global research community.

Summary of Analysis

More than one-third of the P2 publications are highly cited papers. A review of the citations indicates that 174 (34.2%) of the P2 papers qualify as highly cited when using the ESI criteria for the top 10% of highly cited publications. Thirty-one (6.1%) of the P2 papers qualify as highly cited when using the criteria for the top 1%. Nine (1.8%) of these papers qualify as very highly cited (in the top 0.1%), and two papers actually meet the top 0.01% threshold.

The P2 papers are more highly cited than the average paper. Using the ESI average citation rates for papers published by field as the benchmark, in 8 of the 12 fields in which the EPA P2 papers were published, the ratio of actual to expected cites is greater than 1, indicating that the P2 papers are more highly cited than the average papers in those fields.

Nearly one-third of the P2 papers are published in very high impact journals. One-hundred fifty-five (155) of 509 papers were published in the top 10% of journals ranked by JCR Impact Factor, representing 30.4% of EPA's P2 papers. Nearly one-third of the P2 papers are published in the top 10% of journals ranked by JCR Immediacy Factor. One-hundred fifty-seven (157) of the 509 papers appear in the top 10% of journals, representing 30.8% of EPA's P2 papers.

Twelve of the P2 papers qualify as hot papers. Using the hot paper thresholds established by ESI as a benchmark, 12 hot papers, representing 2.4% of the P2 papers, were identified in the analysis.

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[1] Thomson's *Web of Science* provides access to current and retrospective multidisciplinary information from approximately 8,700 of the most prestigious, high impact research journals in the world. *Web of Science* also provides cited reference searching.

The author self-citation rate is below average. Three-hundred sixty-four (364) of the 8,277 cites are author self-cites. This 4.4% author self-citation rate is below the accepted range of 10-30% author self-citation rate.

Highly Cited P2 Publications

The 509 P2 papers reviewed for this analysis covered 12 of the 22 ESI fields. The distribution of the papers among these 12 fields and the number of citations by field are presented in Table 1.

Table 1. P2 Papers by ESI Fields

No. of Citations	ESI Field	No. of EPA P2 Papers	Average Cites/Paper
6,099	Chemistry	317	19.24
1,358	Engineering	92	14.76
258	Biology & Biochemistry	28	9.21
215	Multidisciplinary	1	215.00
102	Environment/Ecology	27	3.78
83	Materials Science	26	3.19
80	Computer Science	8	10.00
40	Economics & Business	2	20.00
36	Physics	3	12.00
4	Mathematics	2	2.00
1	Pharmacology & Toxicology	2	0.50
1	Social Science, general	1	1.00
Total = 8,277		**Total = 509**	

There were 174 (34.2% of the papers analyzed) highly cited EPA P2 papers in 9 of the 12 fields—Chemistry, Engineering, Multidisciplinary, Biology & Biochemistry, Computer Science, Economics & Business, Materials Science, Physics, and Environment/Ecology—when using the ESI criteria for the **top 10% of papers**. Table 2 shows the number of EPA papers in those 9 fields that met the **top 10% threshold in ESI**. Thirty-one (6.1%) of the papers analyzed qualified as highly cited when using the ESI criteria for the **top 1% of papers**. These papers covered three fields—Chemistry, Engineering, and Multidisciplinary. Table 3 shows the 31 papers by field that met the **top 1% threshold in ESI**. There were nine very highly cited EPA

P2 papers in two fields—Chemistry and Engineering. These nine papers met the **top 0.1% threshold in ESI** (1.8% of the papers analyzed). Two of these nine P2 papers actually met the **top 0.01% threshold in ESI** (i.e., the papers by Savage and Blanchard).

Table 2. Number of Highly Cited P2 Papers by Field (top 10%)

Citations	ESI Field	No. of Papers	Average Cites/Paper	% of EPA Papers in Field
4,837	Chemistry	113	42.80	35.65%
1,282	Engineering	43	29.81	46.74%
215	Multidisciplinary	1	215.00	100.00%
102	Biology & Biochemistry	3	34.00	10.71%
72	Computer Science	6	12.00	75.00%
27	Economics & Business	1	27.00	50.00%
26	Materials Science	5	5.20	19.23%
19	Physics	1	19.00	33.33%
1	Environment/Ecology	1	1.00	3.70%
	Total =	**174**		

Table 3. Number of Highly Cited P2 Papers by Field (top 1%)

Citations	ESI Field	No. of Papers	Average Cites/Paper	% of EPA Papers in Field
2,188	Chemistry	19	115.16	5.99%
838	Engineering	11	76.18	11.96%
215	Multidisciplinary	1	215.00	100.00%
	Total =	**31**		

The citations for the highly cited papers in the top 1% are presented in Tables 4 through 6. The citations for the very highly cited papers (top 0.1%) are listed in Table 7.

Table 4. Highly Cited P2 Papers in the Field of Chemistry (top 1%)

No. of Cites	First Author	Paper
296	Li CJ	Aqueous Barbier-Grignard type reaction: scope, mechanism, and synthetic applications. *Tetrahedron* 1996;52(16):5643-5668.
83	Mesiano AJ	Supercritical biocatalysis. *Chemical Reviews* 1999;99(2):623-633.
119	Hudlicky T	Enzymatic dihydroxylation of aromatics in enantioselective synthesis: expanding asymmetric methodology. *Aldrichimica Acta* 1999;32(2):35-62.
152	Matyjaszewski K	Transition metal catalysis in controlled radical polymerization: atom transfer radical polymerization. *Chemistry–A European Journal* 1999;5(11):3095-3102.
190	Patten TE	Copper(I)-catalyzed atom transfer radical polymerization. *Accounts of Chemical Research* 1999;32(10):895-903.
293	Li CJ	Organic syntheses using indium-mediated and catalyzed reactions in aqueous media. *Tetrahedron* 1999;55(37):11149-11176.
380	Varma RS	Solvent-free organic syntheses – using supported reagents and microwave irradiation. *Green Chemistry* 1999;1(1):43-55.
42	Varma RS	An expeditious solvent-free route to ionic liquids using microwaves. *Chemical Communications* 2001;7:643-644.
66	Varma RS	Solvent-free accelerated organic syntheses using microwaves. *Pure and Applied Chemistry* 2001;73(1):193-198.
81	Blanchard LA	High-pressure phase behavior of ionic liquid/CO_2 systems. *Journal of Physical Chemistry B* 2001;105(12):2437-2444.
236	Huddleston JG	Characterization and comparison of hydrophilic and hydrophobic room temperature ionic liquids incorporating the imidazolium cation. *Green Chemistry* 2001;3(4):156-164.
31	Li CJ	Quasi-nature catalysis: developing C-C bond formations catalyzed by late transition metals in air and water. *Accounts of Chemical Research* 2002;35(7):533-538.
33	Li CJ	Highly efficient Grignard-type imine additions via C-H activation in water and under solvent-free conditions. *Chemical Communications* 2002;3:268-269.
51	Varma RS	Clay and clay-supported reagents in organic synthesis. *Tetrahedron* 2002;58(7):1235-1255.
57	Wei CM	Enantioselective direct-addition of terminal alkynes to imines catalyzed by copper(I)pybox complex in water and in toluene. *Journal of the American Chemical Society* 2002;124(20):5638-5639.

No. of Cites	First Author	Paper
18	Holbrey JD	Crystal polymorphism in 1-butyl-3-methylimidazolium halides: supporting ionic liquid formation by inhibition of crystallization. *Chemical Communications* 2003;14:1636-1637.
20	Kaar JL	Impact of ionic liquid physical properties on lipase activity and stability. *Journal of the American Chemical Society* 2003;125(14):4125-4131.
32	Swatloski RP	Ionic liquids are not always green: hydrolysis of 1-butyl-3-methylimidazolium hexafluorophosphate. *Green Chemistry* 2003;5(4):361-363.
8	Li ZG	Three-component coupling of aldehyde, alkyne, and amine catalyzed by silver in ionic liquid. *Tetrahedron Letters* 2004;45(11):2443-2446.

Table 5. Highly Cited P2 Papers in the Field of Engineering (top 1%)

No. of Cites	First Author	Paper
405	Savage PE	Reactions at supercritical conditions – applications and fundamentals. *AIChE Journal* 1995;41(7):1723-1778.
45	Fan L	Supercritical-phase alkylation reaction on solid acid catalysts: mechanistic study and catalyst development. *Industrial & Engineering Chemistry Research* 1997;36(5):1458-1463.
47	Chandler K	Alkylation reactions in near-critical water in the absence of acid catalysts. *Industrial & Engineering Chemistry Research* 1997;36(12):5175-5179.
37	Hua JZ	Enhanced interval analysis for phase stability: Cubic equation of state models. *Industrial & Engineering Chemistry Research* 1998;37(4):1519-1527.
47	Clancy JL	UV light inactivation of Cryptosporidium oocysts. *Journal American Water Works Association* 1998;90(9):92-102.
55	Bukhari Z	Medium-pressure UV for oocyst inactivation. *Journal American Water Works Association* 1999;91(3):86-94.
26	Taylor JD	Experimental measurement of the rate of methyl tert-butyl ether hydrolysis in sub- and supercritical water. *Industrial & Engineering Chemistry Research* 2001;40(1):67-74.
121	Blanchard LA	Recovery of organic products from ionic liquids using supercritical carbon dioxide. *Industrial & Engineering Chemistry Research* 2001;40(1):287-292.

No. of Cites	First Author	Paper
31	Visser AE	Task-specific ionic liquids incorporating novel cations for the coordination and extraction of Hg^{2+} and Cd^{2+}: synthesis, characterization, and extraction studies. *Environmental Science & Technology* 2002;36(11):2523-2529.
18	Abraham MH	Some novel liquid partitioning systems: water-ionic liquids and aqueous biphasic systems. *Industrial & Engineering Chemistry Research* 2003;42(3):413-418.
6	Suh S	System boundary selection in life-cycle inventories using hybrid approaches. *Environmental Science & Technology* 2004;38(3):657-664.

Table 6. Highly Cited P2 Papers in the Field of Multidisciplinary (top 1%)

No. of Cites	First Author	Paper
215	Blanchard LA	Green processing using ionic liquids and CO_2. *Nature* 1999;399(6731):28-29.

Table 7. Very Highly Cited P2 Papers (Top 0.1%)

Field	No. of Cites	First Author	Paper
Chemistry	190	Patten TE	Copper(I)-catalyzed atom transfer radical polymerization. *Accounts of Chemical Research* 1999;32(10):895-903.
	293	Li CJ	Organic syntheses using indium-mediated and catalyzed reactions in aqueous media. *Tetrahedron* 1999;55(37):11149-11176.
	380	Varma RS	Solvent-free organic syntheses – using supported reagents and microwave irradiation. *Green Chemistry* 1999;1(1):43-55.
	236	Huddleston JG	Characterization and comparison of hydrophilic and hydrophobic room temperature ionic liquids incorporating the imidazolium cation. *Green Chemistry* 2001;3(4):156-164.
Engineering	405	Savage PE[2]	Reactions at supercritical conditions – applications and fundamentals. *AIChE Journal* 1995;41(7):1723-1778.

Field	No. of Cites	First Author	Paper
Engineering	121	Blanchard LA[2]	Recovery of organic products from ionic liquids using supercritical carbon dioxide. *Industrial & Engineering Chemistry Research* 2001;40(1):287-292.
	31	Visser AE	Task-specific ionic liquids incorporating novel cations for the coordination and extraction of Hg^{2+} and Cd^{2+}: synthesis, characterization, and extraction studies. *Environmental Science & Technology* 2002;36(11):2523-2529.
	18	Abraham MH	Some novel liquid partitioning systems: water-ionic liquids and aqueous biphasic systems. *Industrial & Engineering Chemistry Research* 2003;42(3):413-418.
	6	Suh S	System boundary selection in life-cycle inventories using hybrid approaches. *Environmental Science & Technology* 2004;38(3):657-664.

<u>Ratio of Actual Cites to Expected Citation Rates</u>

The expected citation rate is the average number of cites that a paper published in the same journal in the same year and of the same document type (article, review, editorial, etc.) has received from the year of publication to the present. Using the ESI average citation rates for papers published by field as the benchmark, in 8 of the 12 fields in which the EPA P2 papers were published, the ratio of actual to expected cites is greater than 1, indicating that the EPA papers are more highly cited than the average papers in those fields (see Table 8).

Table 8. Ratio of Average Cites to Expected Cites for P2 Papers by Field

ESI Field	Total Cites	Expected Cite Rate	Ratio
Chemistry	6,099	2,023.23	3.01
Engineering	1,358	220.45	6.16
Biology & Biochemistry	258	243.53	1.06
Multidisciplinary	215	4.87	44.15
Environment/Ecology	102	130.29	0.78
Materials Science	83	92.2	0.90

[2] These papers also met the **top 0.01% threshold in ESI**.

ESI Field	Total Cites	Expected Cite Rate	Ratio
Computer Science	80	20.12	3.98
Economics & Business	40	11.24	3.56
Physics	36	20.91	1.72
Mathematics	4	2.75	1.45
Pharmacology & Toxicology	1	19.94	0.05
Social Science, general	1	3.07	0.03

JCR Benchmarks

The Impact Factor is a well known metric in citation analysis. It is a measure of the frequency with which the *average article* in a journal has been cited in a particular year. The Impact Factor helps evaluate a journal's relative importance, especially when compared to others in the same field. The Impact Factor is calculated by dividing the number of citations in the current year to articles published in the 2 previous years by the total number of articles published in the 2 previous years.

Table 9 indicates the number of P2 papers published in the top 10% of journals, based on the JCR Impact Factor. One-hundred fifty-five (155) of 509 papers were published in the top 10% of journals, representing 30.4% of EPA's P2 papers.

Table 9. P2 Papers in Top 10% of Journals by JCR Impact Factor

EPA P2 Papers in that Journal	Journal	Impact Factor (IF)	JCR IF Rank
25	Green Chemistry	2.820	767
21	Journal of Organic Chemistry	3.297	573
19	Chemical Communications	4.031	376
16	Macromolecules	3.621	470
12	Journal of the American Chemical Society	6.516	174
10	Environmental Science & Technology	3.592	487
7	Organic Letters	4.092	368
4	Journal of Physical Chemistry B	3.679	454

EPA P2 Papers in that Journal	Journal	Impact Factor (IF)	JCR IF Rank
4	Journal of Catalysis	3.276	581
4	Applied Catalysis A–General	2.825	764
3	Journal of Bacteriology	4.175	358
3	Langmuir	3.098	641
2	Accounts of Chemical Research	15.000	41
2	Chemistry of Materials	4.374	329
2	Chemistry–A European Journal	4.353	332
2	Applied Catalysis B-Environmental	3.476	523
2	Biomacromolecules	2.824	765
1	Nature	30.979	8
1	Chemical Reviews	21.036	23
1	Angewandte Chemie-International Edition	8.427	108
1	Advances in Catalysis	7.889	122
1	Aldrichimica Acta	7.077	151
1	Advances in Polymer Science	6.955	157
1	Analytical Chemistry	5.250	248
1	Journal of Medicinal Chemistry	4.820	278
1	International Review of Cytology – A Survey of Cell Biology	4.286	340
1	Applied and Environmental Microbiology	3.820	418
1	Advanced Synthesis & Catalysis	3.783	426
1	Environmental Health Perspectives	3.408	538
1	Metabolic Engineering	3.397	540
1	Inorganic Chemistry	3.389	544
1	Organometallics	3.375	546
1	Bioscience	3.266	584
1	Biotechnology Advances	2.875	739

EPA P2 Papers in that Journal	Journal	Impact Factor (IF)	JCR IF Rank
Total = 155			

Immediacy Index

The journal Immediacy Index is a measure of how quickly the *average article* in a journal is cited. It indicates how often articles published in a journal are cited within the year they are published. The Immediacy Index is calculated by dividing the number of citations to articles published in a given year by the number of articles published in that year.

Table 10 indicates the number of EPA papers published in the top 10% of journals, based on the JCR Immediacy Index. One-hundred fifty-seven (157) of the 509 papers appear in the top 10% of journals, representing 30.8% of EPA's P2 papers.

Table 10. P2 Papers in Top 10% of Journals by JCR Immediacy Index

EPA P2 Papers in that Journal	Journal	Immediacy Index (II)	JCR II Rank
35	Tetrahedron Letters	0.522	700
21	Journal of Organic Chemistry	0.716	425
19	Chemical Communications	0.783	375
16	Macromolecules	0.583	594
12	Journal of the American Chemical Society	1.212	168
7	Organic Letters	0.835	331
5	Synlett	0.607	563
4	Journal of Physical Chemistry B	0.582	595
4	Journal of Catalysis	0.514	721
3	Journal of Bacteriology	0.972	245
3	Current Organic Chemistry	0.674	471
3	Langmuir	0.523	694
2	Accounts of Chemical Research	2.168	69
2	Chemistry–A European Journal	0.935	268
2	New Journal of Chemistry	0.670	475

EPA P2 Papers in that Journal	Journal	Immediacy Index (II)	JCR II Rank
2	Chemistry of Materials	0.609	560
2	Journal of Chemical Information and Computer Sciences	0.567	612
1	Nature	6.679	6
1	Chemical Reviews	2.955	40
1	Angewandte Chemie-International Edition	1.655	106
1	Bioscience	1.205	169
1	Advanced Synthesis & Catalysis	1.135	186
1	Environmental Health Perspectives	0.869	304
1	Advances in Polymer Science	0.857	310
1	Journal of Medicinal Chemistry	0.817	342
1	Organometallics	0.716	425
1	Aldrichimica Acta	0.667	478
1	Annals of Occupational Hygiene	0.661	487
1	Analytical Chemistry	0.657	493
1	Inorganic Chemistry	0.623	546
1	Crystal Growth & Design	0.532	670
1	European Journal of Organic Chemistry	0.530	677
Total = 157			

Hot Papers

ESI establishes citation thresholds for hot papers, which are selected from the highly cited papers in different fields, but the time frame for citing and cited papers is much shorter—papers must be cited within 2 years of publication and the citations must occur in a 2-month time period. Papers are assigned to 2-month periods and thresholds are set for each period and field to select 0.1% of papers. There were no hot papers identified for the current 2-month period (i.e., January-February 2005), but there were a number of hot papers identified from previous periods.

Using the hot paper thresholds established by ESI as a benchmark, 12 hot papers, representing 2.4% of the P2 papers, were identified in two fields—Chemistry and Engineering. The hot papers are listed in Table 11.

Table 11. Hot Papers Identified Using ESI Thresholds

Field	ESI Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
Chemistry	8	11 cites in May-June 2003	Huddleston JG, Visser AE, et al. Characterization and comparison of hydrophilic and hydrophobic room temperature ionic liquids incorporating the imidazolium cation. *Green Chemistry* 2001;3(4):156-164.
		10 cites in March-April 2001	Matyjaszewski K. Transition metal catalysis in controlled radical polymerization: atom transfer radical polymerization. *Chemistry–A European Journal* 1999;5(11):3095-3102.
		10 cites in September-October 2000	Li CJ, Chan TH. Organic syntheses using indium-mediated and catalyzed reactions in aqueous media. *Tetrahedron* 1999;55(37):11149-11176.
		10 cites in October-November 2001	Patten TE, Matyjaszewski K. Copper(I)-catalyzed atom transfer radical polymerization. *Accounts of Chemical Research* 1999;32(10):895-903.
		9 cites in March-April 2004	Wei CM, Li CJ. Enantioselective direct-addition of terminal alkynes to imines catalyzed by copper(I)pybox complex in water and in toluene. *Journal of the American Chemical Society* 2002;124(20):5638-5639.
		9 cites in August-September 2001	Hudlicky T, Gonzalez D, et al. Enzymatic dihydroxylation of aromatics in enantioselective synthesis: expanding asymmetric methodology. *Aldrichimica Acta* 1999;32(2):35-62.
		8 cites in July-August 2004	Swatloski RP, Holbrey JD, et al. Ionic liquids are not always green: hydrolysis of 1-butyl-3-methylimidazolium hexafluorophosphate. *Green Chemistry* 2003;5(4):361-363.
		8 cites in January-February 2001	Varma RS. Solvent-free organic syntheses – using support reagents and microwave irradiation. *Green Chemistry* 1999;1(1):43-55.
Engineering	4	9 cites in June-July 1996	Savage PE, Gopalan S, et al. Reactions at supercritical conditions – applications and fundamentals. *AIChE Journal* 1995;41(7):1723-1778.

Field	ESI Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
		4 cites in August-September 2004	Abraham MH, Zissimos AM, et al. Some novel liquid partitioning systems: water-ionic liquids and aqueous biphasic systems. *Industrial & Engineering Chemistry Research* 2003;42(3):413-418.
		9 cites in May-June 2003	Blanchard LA, Brennecke JF. Recovery of organic products from ionic liquids using supercritical carbon dioxide. *Industrial & Engineering Chemistry Research* 2001;40(1):287-292.
		4 cites in July-August 2002	Taylor JD, Steinfeld JI, et al. Experimental measurement of the rate of methyl tert-butyl ether hydrolysis in sub- and supercritical water. *Industrial & Engineering Chemistry Research* 2001;40(1):67-74.

Author Self-Citation

Self-citations are journal article references to articles from that same author (i.e., the first author). Because higher author self-citation rates can inflate the number of citations, the author self-citation rate was calculated for the P2 papers. Of the 8,277 total cites, 364 are author self-cites—a 4.4% author self-citation rate. Garfield and Sher[3] found that authors working in research-based disciplines tend to cite themselves on the average of 20% of the time. MacRoberts and MacRoberts[4] claim that approximately 10% to 30% of all the citations listed fall into the category of author self-citation. Therefore, the 4.4% self-cite rate for the P2 papers is below the range for author self-citation.

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3 Garfield E, Sher IH. New factors in the evaluation of scientific literature through citation indexing. *American Documentation* 1963;18(July):195-201.

4 MacRoberts MH, MacRoberts BR. Problems of citation analysis: a critical review. Journal of the American Society of Information Science 1989;40(5):342-349.