Bibliometric Analysis

for the U.S. Environmental Protection Agency/Office of Research and Development's Particulate Matter Research

This is a bibliometric analysis of the papers prepared by U.S. Environmental Protection Agency (EPA) intramural and extramural researchers on particulate matter (PM) research, which is a component of EPA's Air Research Program. For this analysis, 1,561 papers were reviewed, and they were published from 1998 to 2007. These publications were cited 27,449 times in the journals covered by Thomson Scientific's *Web of Science*[1] and Elsevier's Scopus[2]. Of these 1,561 publications, 1,369 (87.7%) have been cited at least once in a journal.

Searches of *Web of Science* and Scopus were conducted to obtain times cited data for the PM journal publications. 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. For this analysis, the *ESI* highly cited papers thresholds as well as the hot papers thresholds were used to assess the influence and impact of the PM papers. *JCR* is a recognized authority for evaluating journals. It 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. The two key measures used in this analysis to assess the journals in which the EPA PM papers are published are the Impact Factor and Immediacy Index. The Impact Factor 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 other journals in the same field. The Immediacy Index is a measure of how quickly the "average article" in a journal is cited. This index indicates how often articles published in a journal are cited within the same year and it is useful in comparing how quickly journals are cited.

The report includes a summary of the results of the bibliometric analysis, an analysis of the 1,561 PM research papers analyzed by *ESI* field (e.g., Clinical Medicine, Environment/ Ecology, and Geosciences), an analysis of the journals in which the PM papers were published, a table of the highly cited researchers publishing on PM research, and a list of patents that have resulted from the program.

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1 Thomson Scientific's *Web of Science* provides access to current and retrospective multidisciplinary information from approximately 8,830 of the most prestigious, high impact research journals in the world. *Web of Science* also provides cited reference searching.

2 Scopus is a large abstract and citation database of research literature and quality Web sources designed to support the literature research process. Scopus offers access to 15,000 titles from 4,000 different publishers, more than 12,850 academic journals (including coverage of 535 Open Access journals, 750 conference proceedings, and 600 trade publications), 27 million abstracts, 245 million references, 200 million scientific Web pages, and 13 million patent records.

SUMMARY OF RESULTS

1. **More than one-third of the PM publications are highly cited papers.** 578 (37.0%) of the PM papers qualify as highly cited when using the *ESI* criteria for the top 10% of highly cited publications. This is 3.7 times the 10% of papers expected to be highly cited. 96 (6.2%) of the PM papers qualify as highly cited when using the *ESI* criteria for the top 1%, which is 6.1 times the number expected. 14 (0.9%) of these papers qualify as very highly cited when using the criteria for the top 0.1%, which is 9 times the number anticipated. None of the papers actually meets the 0.01% threshold for the most highly cited papers, which is not surprising given that the expected number for this program is 0.2 papers.

2. **The PM papers are more highly cited than the average paper.** Using the *ESI* average citation rates for papers published by field as the benchmark, in 13 of the 18 fields in which the 1,561 EPA PM papers were published, the ratio of actual to expected cites is greater than 1, indicating that the PM papers are more highly cited than the average papers in those fields. For all 18 fields combined, the ratio of total number of cites to the total number of expected cites (27,449 to 10,856.34) is 2.5, indicating that the PM papers are more highly cited than the average paper.

3. **More than one-third of the PM papers are published in high impact journals.** 537 of the 1,561 papers were published in the top 10% of journals ranked by *JCR* Impact Factor, representing 34.4% of EPA's PM papers. This number is 3.4 times higher than the expected 156 papers. Nearly one-half of the papers are published in high impact journals as determined by *JCR Immediacy Index*. 762 of the 1,561 papers appear in the top 10% of journals ranked by *JCR* Immediacy Index, representing 48.8% of EPA's PM papers. This number is 4.9 times higher than the expected 156 papers.

4. **Forty-five of the PM papers qualify as hot papers.** Using the hot paper thresholds established by *ESI* as a benchmark, 45 hot papers, representing 2.9% of the PM papers, were identified in the analysis. Hot papers are papers that were highly cited shortly after they were published. The number of PM hot papers identified is 29 times higher than the expected 2 hot papers.

5. **The authors of the PM papers cite themselves much less than the average author.** 1,227 of the 27,449 cites are author self-cites. This 4.5% author self-citation rate is well below the accepted range of 10-30% author self-citation rate.

6. **Forty (1.5%) of the 2,710 authors of the PM papers are included in *ISIHighlyCited.com***, which is a database of the world's most influential researchers who have made key contributions to science and technology during the period from 1981 to 1999.

7. **There were 6 patents issued** to investigators from 1998 to 2007 for research that was conducted under EPA's PM research. Two of these patents were cited by a total of 9 other patents.

Highly Cited PM Publications

All of the journals covered by *ESI* are assigned a field, and to compensate for varying citation rates across scientific fields, different thresholds are applied to each field. Thresholds are set to select highly cited papers to be listed in *ESI*. Different thresholds are set for both field and year of publication. Setting different thresholds for each year allows comparable representation for older and younger papers for each field.

The 1,561 PM research papers reviewed for this analysis were published in journals that were assigned to 18 of the 22 *ESI* fields. The distribution of the papers among these 18 fields and the number of citations by field are presented in Table 1.

Table 1. PM Papers by *ESI* Fields

***ESI* Field**	**No. of Citations**	**No. of PM Papers**	**Average Cites/Paper**
Biology & Biochemistry	486	34	14.3
Chemistry	1,056	78	13.5
Clinical Medicine	6,346	243	26.1
Computer Science	6	2	3.0
Economics & Business	25	3	8.3
Engineering	3,628	272	13.3
Environment/Ecology	6,507	333	19.5
Geosciences	5,527	350	15.8
Immunology	372	13	28.6
Materials Science	1	1	1.0
Mathematics	31	6	5.2
Molecular Biology & Genetics	25	3	8.3
Multidisciplinary	389	9	43.2
Neuroscience & Behavior	185	11	16.8
Pharmacology & Toxicology	2,642	179	14.8
Physics	164	11	14.9
Plant & Animal Science	32	5	6.4
Social Sciences, general	27	8	3.4
	Total = 27,449	**Total = 1,561**	**17.6**

There are 578 (37.0% of the papers analyzed) highly cited EPA PM papers in 13 of the 18 fields—Biology & Biochemistry, Chemistry, Clinical Medicine, Economics & Business, Engineering, Environment/Ecology, Geosciences, Immunology, Mathematics, Multidisciplinary, Pharmacology & Toxicology, Physics, and Social Sciences—when using the *ESI* criteria for the

top 10% of papers. Table 2 shows the number of EPA PM papers in those 13 fields that meet the **top 10% threshold in *ESI***. Ninety-six (6.2%) of the papers analyzed qualify as highly cited when using the *ESI* criteria for the **top 1% of papers**. These papers cover 8 fields—Chemistry, Clinical Medicine, Economics & Business, Engineering, Environment/ Ecology, Geosciences, Multidisciplinary, and Pharmacology & Toxicology. Table 3 shows the 96 papers by field that meet the **top 1% threshold in *ESI*.** The citations for these 96 papers are provided in Tables 4 through 11. Table 12 shows the 14 (0.9%) papers by field that meet the **top 0.1% threshold in *ESI***. These 14 very highly cited PM papers in the fields of Chemistry, Clinical Medicine, Economics & Business, Engineering, Environment/Ecology, and Geosciences are listed in Table 13. None of the PM papers meet the **top 0.01% threshold in *ESI***, which is not surprising because the expected number of papers that should meet this threshold for this analysis is 0.2. The highly cited papers in Tables 4 through 11 are presented in order of year of publication with the oldest papers appearing first. Within the year of publication, the papers are ordered by increasing number of times cited.

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

***ESI* Field**	**No. of Citations**	**No. of Papers**	**Average Cites/Paper**	**% of Papers in Field**
Biology & Biochemistry	179	5	35.8	14.7%
Chemistry	663	21	31.6	26.9%
Clinical Medicine	4,954	90	55.0	37.0%
Economics & Business	7	1	7.0	33.3%
Engineering	3,159	123	25.7	45.2%
Environment/Ecology	5,070	152	33.4	45.6%
Geosciences	3,871	126	30.7	36.0%
Immunology	303	5	60.6	38.5%
Mathematics	25	2	12.5	33.3%
Multidisciplinary	366	5	73.2	62.5%
Pharmacology & Toxicology	1,588	44	36.4	24.6%
Physics	117	3	39.0	27.3%
Social Sciences, general	6	1	6.0	12.5%
	Total = 20,308	**Total = 578**	**35.1**	**37.0%**

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

***ESI* Field**	**No. of Citations**	**No. of Papers**	**Average Cites/Paper**	**% of PM Papers in Field**
Chemistry	62	2	31.0	2.6%
Clinical Medicine	1,513	8	189.1	3.3%

ESI Field	No. of Citations	No. of Papers	Average Cites/Paper	% of PM Papers in Field
Economics & Business	7	1	7.0	33.3%
Engineering	1,746	31	56.3	11.4%
Environment/Ecology	1,549	31	50.0	9.3%
Geosciences	1,416	19	74.5	5.4%
Multidisciplinary	272	2	136.0	22.2%
Pharmacology & Toxicology	259	2	129.5	1.1%
	Total = 6,824	**Total = 96**	**71.1**	**6.2%**

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

No. of Cites	*ESI* Threshold	First Author	Paper
59	43	Gao S	Low-molecular-weight and oligomeric components in secondary organic aerosol from the ozonolysis of cycloalkenes and alpha-pinene. *Journal of Physical Chemistry A* 2004;108(46):10147-10164.
3	2	Rudich Y	Aging of organic aerosol: bridging the gap between laboratory and field studies. *Annual Review of Physical Chemistry* 2007;58:321-352.

Table 5. Highly Cited PM Papers in the Field of Clinical Medicine (top 1%)

No. of Cites	*ESI* Threshold	First Author	Paper
187	144	Abbey DE	Long-term inhalable particles and other air pollutants related to mortality in nonsmokers. *American Journal of Respiratory and Critical Care Medicine* 1999;159(2):373-382.
216	133	Gold DR	Ambient pollution and heart rate variability. *Circulation* 2000;101(11):1267-1273.
249	115	Peters A	Increased particulate air pollution and the triggering of myocardial infarction. *Circulation* 2001;103(23):2810-2815.
634	99	Pope CA	Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. *Journal of the American Medical Association* 2002;287(9):1132-1141.
89	54	Peters A	Exposure to traffic and the onset of myocardial infarction. *New England Journal of Medicine* 2004;351(17):1721-1730.
131	54	Pope CA	Cardiovascular mortality and long-term exposure to particulate air pollution: epidemiological evidence of general pathophysiological pathways of disease. *Circulation* 2004;109(1):71-77.

No. of Cites	*ESI* Threshold	First Author	Paper
2	2	Baccarelli A	Effects of exposure to air pollution on blood coagulation. *Journal of Thrombosis and Haemostasis* 2007;5(2):252-260.
5	2	Miller KA	Long-term exposure to air pollution and incidence of cardiovascular events in women. *New England Journal of Medicine* 2007;356(5):447-458.

Table 6. Highly Cited PM Papers in the Field of Economics & Business (top 1%)

No. of Cites	*ESI* Threshold	First Author	Paper
7	4	Peng RD	Model choice in time series studies of air pollution and mortality. *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 2006;169(2):179-203.

Table 7. Highly Cited PM Papers in the Field of Engineering (top 1%)

No. of Cites	*ESI* Threshold	First Author	Paper
54	46	Zhang Y	Simulation of aerosol dynamics: a comparative review of algorithms used in air quality models. *Aerosol Science and Technology* 1999;31(6):487-514.
45	44	Wilson WE	Estimating separately personal exposure to ambient and non-ambient particulate matter for epidemiology and risk assessment; why and how. *Journal of the Air & Waste Management Association* 2000;50(7):1167-1183.
52	44	Tobias HJ	Real-time chemical analysis of organic aerosols using a thermal desorption particle beam mass spectrometer. *Aerosol Science and Technology* 2000;33(1-2):170-190.
75	44	Sarnat JA	Assessing the relationship between personal particulate and gaseous exposures of senior citizens living in Baltimore. *Journal of the Air & Waste Management Association* 2000;50(7):1184-1198.
78	44	Long CM	Characterization of indoor particle sources using continuous mass and size monitors. *Journal of the Air & Waste Management Association* 2000;50(7):1236-1250.
207	44	Jayne JT	Development of an aerosol mass spectrometer for size and composition analysis of submicron particles. *Aerosol Science and Technology* 2000;33(1-2):49-70.
209	44	Richter H	Formation of polycyclic aromatic hydrocarbons and their growth to soot– a review of chemical reaction pathways. *Progress in Energy and Combustion Science* 2000;26(4-6):565-608.

No. of Cites	*ESI* Threshold	First Author	Paper
38	37	Vette AF	Characterization of indoor-outdoor aerosol concentration relationships during the Fresno PM exposure studies. *Aerosol Science and Technology* 2001;34(1):118-126.
42	37	Lewtas J	Comparison of sampling methods for semi-volatile organic carbon associated with $PM_{2.5}$. *Aerosol Science and Technology* 2001;34(1):9-22.
57	37	Tolocka MP	East versus West in the US: chemical characteristics of $PM_{2.5}$ during the winter of 1999. *Aerosol Science and Technology* 2001;34(1):88-96.
92	37	Woo KS	Measurement of Atlanta aerosol size distributions: Observations of ultrafine particle events. *Aerosol Science and Technology* 2001;34(1):75-87.
105	37	Weber RJ	A particle-into-liquid collector for rapid measurement of aerosol bulk chemical composition. *Aerosol Science and Technology* 2001;35(3):718-727.
31	31	Cabada JC	Sources of atmospheric carbonaceous particulate matter in Pittsburgh, Pennsylvania. *Journal of the Air & Waste Management Association* 2002;52(6):732-741.
34	31	Zhang Z	Cyclic micron-size particle inhalation and deposition in a triple bifurcation lung airway model. *Aerosol Science and Technology* 2002;33(2):257-281.
37	31	Kim S	Size distribution and diurnal and seasonal trends of ultrafine particles in source and receptor sites of the Los Angeles basin. *Journal of the Air & Waste Management Association* 2002;52(3):297-307.
40	31	Zhang X	A numerical characterization of particle beam collimation by an aerodynamic lens-nozzle system: Part I. an individual lens or nozzle. *Aerosol Science and Technology* 2002;36(5):617-631.
63	31	McMurray PH	The relationship between mass and mobility for atmospheric particles: A new technique for measuring particle density. *Aerosol Science and Technology* 2002;36(2):227-238.
130	31	Zhu YF	Concentration and size distribution of ultrafine particles near a major highway. *Journal of the Air & Waste Management Association* 2002;52(9):1032-1042.
31	25	Lewis CW	Source apportionment of Phoenix PM2.5 aerosol with the Unmix receptor model. *Journal of the Air & Waste Management Association* 2003;53(3):325-338.
23	18	Zhang XF	Numerical characterization of particle beam collimation: Part II integrated aerodynamic-lens-nozzle system. *Aerosol Science and Technology* 2004;38(6):619-638.
23	18	Zhu Y	Seasonal trends of concentration and size distribution of ultrafine particles near major highways in Los Angeles. *Aerosol Science and Technology* 2004;38(S1):5-13.

No. of Cites	*ESI* Threshold	First Author	Paper
24	18	Cabada JC	Estimating the secondary organic aerosol contribution to $PM_{2.5}$ using the EC tracer method. *Aerosol Science and Technology* 2004;38(S1):140-155.
25	18	Drewnick F	Measurement of ambient aerosol composition during the PMTACS-NY 2001 campaign using an aerosol mass spectrometer. Part II: Chemically speciated mass distribution. *Aerosol Science and Technology* 2004;38(S1):104-117.
26	18	Cho A	Determination of four quinones in diesel exhaust particles, SRM 1649a and atmospheric $PM_{2.5}$. *Aerosol Science and Technology* 2004;38(S1):68-81.
33	18	Stanier CO	Nucleation events during the Pittsburgh Air Quality Study: description and relation to key meteorological, gas phase, and aerosol parameters. *Aerosol Science and Technology* 2004;38(S1):253-264.
34	18	Drewnick F	Measurement of ambient aerosol composition during the PMTACS-NY 2001 campaign using an aerosol mass spectrometer. Part I: Mass concentrations. *Aerosol Science and Technology* 2004;38(S1):92-103.
39	18	Subramanian R	Positive and negative artifacts in particulate organic carbon measurements with denuded and undenuded sampler configurations. *Aerosol Science and Technology* 2004;38(S1):27-48.
55	18	Canagaratna M	Chase studies of particulate emissions from in-use New York City vehicles. *Aerosol Science and Technology* 2004;38(6):555-573.
13	10	Kim E	Estimation of organic carbon blank values and error structures of the speciation trends network data for source apportionment. *Journal of the Air & Waste Management Association* 2005;55(8):1190-1199.
14	4	Byun D	Review of the governing equations, computational algorithms, and other components of the Models-3 Community Multiscale Air Quality (CMAQ) modeling system. *Applied Mechanics Reviews* 2006;59:51-77.
17	4	Bond TC	Light absorption by carbonaceous particles: an investigative review. *Aerosol Science and Technology* 2006;40(1):27-67.

Table 8. Highly Cited PM Papers in the Field of Environment/Ecology (top 1%)

No. of Cites	*ESI* Threshold	First Author	Paper
175	103	Liao D	Daily variation of particulate air pollution and poor cardiac autonomic control in the elderly. *Environmental Health Perspectives* 1999;107(7):521-525.
208	88	Laden F	Association of fine particulate matter from different sources with daily mortality in six U.S. cities. *Environmental Health Perspectives* 2000;108(10):941-947.

No. of Cites	*ESI* Threshold	First Author	Paper
83	77	Fine PM	Chemical characterization of fine particle emissions from the fireplace combustion of woods grown in the northeastern United States. *Environmental Science & Technology* 2001;35(13):2665-2675.
83	77	Jang M	Atmospheric secondary aerosol formation by heterogeneous reactions of aldehydes in the presence of a sulfuric acid aerosol catalyst. *Environmental Science & Technology* 2001;35(24):4758-4766.
94	77	Dockery DW	Epidemiologic evidence of cardiovascular effects of particulate air pollution. *Environmental Health Perspectives* 2001;109(S4):483-486.
67	48	Park K	Relationship between particle mass and mobility for diesel exhaust particles. *Environmental Science & Technology* 2003;37(3):577-583.
144	48	Li N	Ultrafine particulate pollutants induce oxidative stress and mitochondrial damage. *Environmental Health Perspectives* 2003;111(4):455-460.
34	34	Landrigan PJ	Health and environmental consequences of the World Trade Center disaster. *Environmental Health Perspectives* 2004;112(6):731-739.
40	34	Chow JC	Equivalence of elemental carbon by thermal/optical reflectance and transmittance with different temperature protocols. *Environmental Science & Technology* 2004;38(16):4414-4422.
44	34	Xia T	Quinones and aromatic chemical compounds in particulate matter induce mitochondrial dysfunction: implications for ultrafine particle toxicity. *Environmental Health Perspectives* 2004;112(14):1347-1358.
45	34	Zhang Q	Insights into the chemistry of new particle formation and growth events in Pittsburgh based on aerosol mass spectrometry. *Environmental Science & Technology* 2004;38(18):4797-4809.
58	34	Pope CA	Ambient particulate air pollution, heart rate variability, and blood markers of inflammation in a panel of elderly subjects. *Environmental Health Perspectives* 2004;112(3):339-345.
59	34	Gao S	Particle phase acidity and oligomer formation in secondary organic aerosol. *Environmental Science & Technology* 2004;38(24):6582-6589.
17	17	Reisen F	Atmospheric reactions influence seasonal PAH and nitro-PAH concentrations in the Los Angeles Basin. *Environmental Science & Technology* 2005;39(1):64-73.
18	17	Delfino RJ	Potential role of ultrafine particles in associations between airborne particle mass and cardiovascular health. *Environmental Health Perspectives* 2005;113(8):934-946.
19	17	Dockery DW	Association of air pollution with increased incidence of ventricular tachyarrhythmias recorded by implanted cardioverter defibrillators. *Environmental Health Perspectives* 2005;113(6):670-674.
22	17	Zanobetti A	The effect of particulate air pollution on emergency admissions for myocardial infarction: a multicity case-crossover analysis. *Environmental Health Perspectives* 2005;113(8):978-982.

No. of Cites	*ESI* Threshold	First Author	Paper
23	17	Lim H	Isoprene forms secondary organic aerosol through cloud processing: model simulations. *Environmental Science & Technology* 2005;39(12):4441-4446.
25	17	Park SK	Effects of Air Pollution on Heart Rate Variability: The VA Normative Aging Study. *Environmental Health Perspectives* 2005;113(3):304-309.
26	17	Bahreini R	Measurements of secondary organic aerosol from oxidation of cycloalkenes, terpenes, and m-xylene using an Aerodyne aerosol mass spectrometer. *Environmental Science & Technology* 2005;39(15):5674-5688.
27	17	Lough GC	Emissions of metals associated with motor vehicle roadways. *Environmental Science & Technology* 2005;39(3):826-836.
40	17	Zhang Q	Deconvolution and quantification of hydrocarbon-like and oxygenated organic aerosols based on aerosol mass spectrometry. *Environmental Science & Technology* 2005;39(13):4938-4952.
133	17	Oberdorster G	Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles. *Environmental Health Perspectives* 2005;113(7):823-839.
6	6	Selgrade MK	Induction of asthma and the environment: what we know and need to know. *Environmental Health Perspectives* 2006;114(4):615-619.
7	6	Dubowsky SD	Diabetes, obesity, and hypertension may enhance associations between air pollution and markers of systematic inflammation. *Environmental Health Perspectives* 2006;114(7):992-998.
7	6	Elder A	Translocation of inhaled ultrafine manganese oxide particles to the central nervous system. *Environmental Health Perspectives* 2006;114(8):1172-1178.
7	6	Okin GS	Multi-scale controls on and consequences of aeolian processes in landscape change in arid and semi-arid environments. *Journal of Arid Environments* 2006;65(2):253-275.
8	6	Shrivastava MK	Modeling semivolatile organic aerosol mass emissions from combustion systems. *Environmental Science & Technology* 2006;40(8):2671-2677.
8	6	Donahue NM	Coupled partitioning, dilution, and chemical aging of semivolatile organics. *Environmental Science & Technology* 2006;40(8):2635-2643.
9	6	Presto AA	Investigation of α-pinene + ozone secondary organic aerosol formation at low total aerosol mass. *Environmental Science & Technology* 2006;40(11):3536-3543.
13	6	McConnell R	Traffic, susceptibility, and childhood asthma. *Environmental Health Perspectives* 2006;114(5):766-772.

Table 9. Highly Cited PM Papers in the Field of Geosciences (top 1%)

No. of Cites	*ESI* Threshold	First Author	Paper
149	114	Nenes A	ISORROPIA: a new thermodynamic equilibrium model for multiphase multicomponent inorganic aerosols. *Aquatic Geochemistry* 1998;4:123-152.
166	98	Griffin RJ	Organic aerosol formation from the oxidation of biogenic hydrocarbons. *Journal of Geophysical Research–Atmospheres* 1999;104(D3):3555-3567.
170	98	Yu J	Gas-Phase ozone oxidation of monoterpenes: gaseous and particulate products. *Journal of Atmospheric Chemistry* 1999;34(2):207-258.
188	98	Simoneit BRT	Levoglucosan, a tracer for cellulose in biomass burning and atmospheric particles. *Atmospheric Environment* 1999;33(2):173-182.
92	69	Sokolik IN	Introduction to special section: outstanding problems in quantifying the radiative impact of mineral dust. *Journal of Geophysical Research–Atmospheres* 2001;106(D16):18015-18027.
178	69	Huser RB	Asian dust events of April 1998. *Journal of Geophysical Research–Atmospheres* 2001;106(D16):18317-18330.
121	54	Zhu Y	Study of ultrafine particles near a major highway with heavy-duty diesel traffic. *Atmospheric Environment* 2002;36(27):4323-4335.
42	41	Binkowski FS	Models-3 Community Multiscale Air Quality (CMAQ) model aerosol component. 1. Model description. *Journal of Geophysical Research–Atmospheres* 2003;108(D6):4183.
53	41	Orsini DA	Refinements to the particle-into-liquid sampler (PILS) for ground and airborne measurements of water soluble aerosol composition. *Atmospheric Environment* 2003;37(9-10):243-1259.
85	41	Jiminez JL	Ambient aerosol sampling using the Aerodyne Aerosol Mass Spectrometer. *Journal of Geophysical Research–Atmospheres* 2003;108(D7):8425.
29	29	Zhang KM	Evolution of particle number distribution near roadways: Part II: The “road-to-ambient” process. *Atmospheric Environment* 2004;38(38):6655-6665.
31	29	Wittig AE	Pittsburgh Air Quality Study overview. *Atmospheric Environment* 2004;38(20):3107-3125.
31	29	Kim E	Improving source identification of Atlanta aerosol using temperature resolved carbon fractions in positive matrix factorization. *Atmospheric Environment* 2004;38(20):3349-3362.
27	18	Edney EO	Formation of 2-methyl tetrols and 2-methylglyceric acid in secondary organic aerosol from laboratory irradiated isoprene/NO_x/SO_2/air mixtures and their detection in ambient $PM_{2.5}$ samples collected in the eastern United States. *Atmospheric Environment* 2005;39(29):5281-5289.

No. of Cites	*ESI* Threshold	First Author	Paper
32	18	Zhang Q	Hydrocarbon-like and oxygenated organic aerosols in Pittsburgh: insights into sources and processes or organic aerosols. *Atmospheric Chemistry and Physics* 2005;5(12):3289-3311.
8	7	Offenberg JH	Thermal properties of secondary organic aerosols. *Geophysical Research Letters* 2006;33(3):L03816.
8	7	Takegawa N	Seasonal and diurnal variations of submicron organic aerosol in Tokyo observed using the Aerodyne aerosol mass spectrometer. *Journal of Geophysical Research–Atmospheres* 2006;111(D11206).
3	3	Kondo Y	Oxygenated and water-soluble organic aerosols in Tokyo. *Journal of Geophysical Research–Atmospheres* 2007;112(D1):D01203.
3	3	Pathak RK	Ozonolysis of a-pinene at atmospherically relevant concentrations: Temperature dependence of aerosol mass fractions (yields). *Journal of Geophysical Research–Atmospheres* 2007;112(D3):D03201.

Table 10. Highly Cited PM Papers in the Field of Multidisciplinary (top 1%)

No. of Cites	*ESI* Threshold	First Author	Paper
117	55	Gard EE	Direct Observation of Heterogeneous Chemistry in the Atmosphere. *Science* 1998;279(5354):1184-1187.
155	93	Jang M	Heterogeneous Atmospheric Aerosol Production by Acid-Catalyzed Particle-Phase Reactions. *Science* 2002;298(5594):814-817.

Table 11. Highly Cited PM Papers in the Field of Pharmacology & Toxicology (top 1%)

No. of Cites	*ESI* Threshold	First Author	Paper
157	99	Oberdorster G	Pulmonary effects of inhaled ultrafine particles. *International Archives of Occupational and Environmental Health* 2001;74(1):1-8.
102	44	Oberdorster G	Translocation of inhaled ultrafine particles to the brain. *Inhalation Toxicology* 2004;16(6-7):437-445.

Table 12. Number of Very Highly Cited Papers by Field (Top 0.1%)

ESI Field	No. of Citations	No. of Papers	Average Cites/Paper	% of PM Papers in Field
Chemistry	3	1	3.0	1.3%
Clinical Medicine	639	2	319.5	0.8%

ESI Field	No. of Citations	No. of Papers	Average Cites/Paper	% of PM Papers in Field
Economics & Business	7	1	7.0	33.3%
Engineering	671	7	95.8	2.6%
Environment/Ecology	277	2	138.5	0.6%
Geosciences	178	1	178.0	0.3%
	Total = 1,775	**Total = 14**	**126.8**	**0.9%**

Table 13. Very Highly Cited PM Papers (top 0.1%)

ESI Field	*ESI* Threshold	No. of Cites	First Author	Paper
Chemistry	3	3	Rudich Y	Aging of organic aerosol: bridging the gap between laboratory and field studies. *Annual Review of Physical Chemistry* 2007;58:321-352.
Clinical Medicine	288	634	Pope CA	Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. *Journal of the American Medical Association* 2002;287(9):1132-1141.
	4	5	Miller KA	Long-term exposure to air pollution and incidence of cardiovascular events in women. *New England Journal of Medicine* 2007;356(5):447-458.
Economics & Business	7	7	Peng RD	Model choice in time series studies of air pollution and mortality. *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 2006;169(2):179-203.
Engineering	116	207	Jayne JT	Development of an aerosol mass spectrometer for size and composition analysis of submicron particles. *Aerosol Science and Technology* 2000;33(1-2):49-70.
	116	209	Richter H	Formation of polycyclic aromatic hydrocarbons and their growth to soot – a review of chemical reaction pathways. *Progress in Energy and Combustion Science* 2000;26(4-6):565-608.
	76	130	Zhu YF	Concentration and size distribution of ultrafine particles near a major highway. *Journal of the Air & Waste Management Association* 2002;52(9):1032-1042.
	39	39	Subramanian R	Positive and negative artifacts in particulate organic carbon measurements with denuded and undenuded sampler configurations. *Aerosol Science and Technology* 2004;38(S1):27-48.

ESI Field	*ESI* Threshold	No. of Cites	First Author	Paper
Engineering	39	55	Canagaratna M	Chase studies of particulate emissions from in-use New York City vehicles. *Aerosol Science and Technology* 2004;38(6):555-573.
	9	14	Byun D	Review of the governing equations, computational algorithms, and other components of the Models-3 Community Multiscale Air Quality (CMAQ) modeling system. *Applied Mechanics Reviews* 2006;59:51-77.
	9	17	Bond TC	Light absorption by carbonaceous particles: an investigative review. *Aerosol Science and Technology* 2006;40(1):27-67.
Environment/ Ecology	116	144	Li N	Ultrafine particulate pollutants induce oxidative stress and mitochondrial damage. *Environmental Health Perspectives* 2003;111(4):455-460.
	43	133	Oberdorster G	Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles. *Environmental Health Perspectives* 2005;113(7):823-839.
Geosciences	176	178	Huser RB	Asian dust events of April 1998. *Journal of Geophysical Research–Atmospheres* 2001;106(D16):18317-18330.

Ratio of Actual Cites to Expected Citation Rates

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 13 of the 18 fields in which the EPA PM papers were published, the ratio of actual to expected cites is greater than 1, indicating that the PM papers are more highly cited than the average papers in those fields (see Table 14). For one field, the ratio is equal to 1, indicating that the papers in that *ESI* field are cited the same as the average paper. For all 18 fields combined, the ratio of total number of cites to the total number of expected cites (27,449 to 10,856.34) is 2.5, indicating that the PM papers are more highly cited than the average paper.

Table 14. Ratio of Actual Cites to Expected Cites for PM Papers by Field

ESI Field	Total Cites	Expected Cite Rate	Ratio
Biology & Biochemistry	486	497.14	1.0
Chemistry	1,056	642.11	1.6
Clinical Medicine	6,346	2,274.10	2.8

ESI Field	Total Cites	Expected Cite Rate	Ratio
Computer Science	6	5.14	1.2
Economics & Business	25	7.29	3.4
Engineering	3,628	815.40	4.4
Environment/Ecology	6,507	2,250.50	2.9
Geosciences	5,527	2,091.43	2.6
Immunology	372	213.76	1.7
Materials Science	1	3.20	0.3
Mathematics	31	11.07	2.8
Molecular Biology & Genetics	25	82.44	0.3
Multidisciplinary	389	39.00	10.0
Neuroscience & Behavior	185	220.51	0.8
Pharmacology & Toxicology	2,642	1,542.98	1.7
Physics	164	100.75	1.6
Plant & Animal Science	32	38.05	0.8
Social Sciences, general	27	21.47	1.2
TOTAL	**27,449**	**10,856.34**	**2.5**

JCR Benchmarks

Impact Factor. The *JCR* 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 15 indicates the number of PM papers published in the top 10% of journals, based on the *JCR* Impact Factor. Five hundred thirty-seven (537) of 1,561 papers were published in the top 10% of journals, representing 34.4% of EPA's PM papers. This indicates that more than one-third of the PM papers are published in the highest quality journals as determined by the *JCR* Impact Factor, which is 3.4 times higher than the expected percentage.

Table 15. PM Papers in Top 10% of Journals by *JCR* Impact Factor

EPA PM Papers in that Journal	Journal	Impact Factor (IF)	*JCR* IF Rank
2	New England Journal of Medicine	51.296	2
6	Science	30.028	9
3	Lancet	25.800	18
4	JAMA—Journal of the American Medical Association	23.175	23
1	Journal of Clinical Investigation	15.754	42
1	Annual Review of Physical Chemistry	11.250	83
10	Circulation	10.940	88
1	Nano Letters	9.960	110
2	Proceedings of the National Academy of Sciences of the United States of America	9.643	116
27	American Journal of Respiratory and Critical Care Medicine	9.091	131
6	Journal of Allergy and Clinical Immunology	8.829	136
1	Advanced Drug Delivery Reviews	7.977	156
2	Cancer Research	7.656	172
1	Journal of Neuroscience	7.453	177
1	FASEB Journal	6.721	206
1	Critical Care Medicine	6.599	211
5	Journal of Immunology	6.293	223
5	Thorax	6.064	237
1	American Journal of Pathology	5.917	249
117	Environmental Health Perspectives	5.861	255
4	Journal of Biological Chemistry	5.808	260
12	Analytical Chemistry	5.646	276
5	Free Radical Biology & Medicine	5.440	289
1	Stroke	5.391	293
12	American Journal of Epidemiology	5.241	308
1	Journal of Thrombosis and Haemostasis	5.138	325
4	European Respiratory Journal	5.076	335
1	TrAC - Trends in Analytical Chemistry	5.068	337

EPA PM Papers in that Journal	Journal	Impact Factor (IF)	*JCR* IF Rank
1	Cellular Signalling	4.887	363
1	Faraday Discussions	4.731	393
25	Toxicology and Applied Pharmacology	4.722	397
16	American Journal of Respiratory Cell and Molecular Biology	4.593	412
1	Journal of Leukocyte Biology	4.572	415
1	Journal of Catalysis	4.533	418
1	International Journal of Epidemiology	4.517	424
1	Antioxidants & Redox Signaling	4.491	431
2	Atmospheric Chemistry and Physics	4.362	449
23	Epidemiology	4.339	452
2	American Journal of Physiology - Cell Physiology	4.334	455
1	Progress in Energy and Combustion Science	4.333	456
34	American Journal of Physiology - Lung Cellular and Molecular Physiology	4.250	472
2	Journal of Physical Chemistry B	4.115	501
120	Environmental Science & Technology	4.040	518
2	Applied Catalysis B: Environmental	3.942	548
3	Chest	3.924	552
1	Experimental Cell Research	3.777	596
1	Human Reproduction	3.769	599
1	Bulletin of the American Meteorological Society	3.728	614
1	American Journal of Physiology - Heart and Circulatory Physiology	3.724	616
1	American Journal of Public Health	3.698	626
1	Journal of Cellular Physiology	3.638	646
2	Clinical Immunology	3.606	659
31	Toxicological Sciences	3.598	662
1	Journal of Chromatography A	3.554	678
3	Journal of Neuroscience Research	3.476	704
11	Journal of Applied Physiology	3.178	807

EPA PM Papers in that Journal	Journal	Impact Factor (IF)	*JCR* IF Rank
1	Journal of Chemical Physics	3.166	814
3	Chemical Research in Toxicology	3.162	818
1	Remote Sensing of Environment	3.064	855
4	Journal of Physical Chemistry A	3.047	863
1	American Journal of Cardiology	3.015	876
Total = 537			

Immediacy Index. The *JCR* 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 16 indicates the number of PM papers published in the top 10% of journals, based on the *JCR* Immediacy Index. Seven hundred sixty-two (762) of the 1,561 papers appear in the top 10% of journals, representing 48.8% of the PM papers. This indicates that nearly one-half of the PM papers are published in the highest quality journals as determined by the *JCR* Immediacy Index, which is 4.9 times higher than the expected percentage.

Table 16. PM Papers in Top 10% of Journals by *JCR* Immediacy Index

EPA PM Papers in that Journal	Journal	Immediacy Index (II)	*JCR* II Rank
2	New England Journal of Medicine	12.743	2
4	JAMA - Journal of the American Medical Association	7.781	4
3	Lancet	7.419	6
6	Science	5.555	16
1	Journal of Clinical Investigation	3.911	29
1	Faraday Discussions	2.766	59
10	Circulation	2.674	63
1	International Journal of Epidemiology	2.200	84
27	American Journal of Respiratory and Critical Care Medicine	2.006	98
6	Journal of Allergy and Clinical Immunology	1.790	118
1	Annual Review of Physical Chemistry	1.762	124

EPA PM Papers in that Journal	Journal	Immediacy Index (II)	*JCR* II Rank
2	Proceedings of the National Academy of Sciences of the United States of America	1.758	126
1	Critical Care Medicine	1.641	146
4	Philosophical Transactions of the Royal Society of London Series A: Mathematical and Physical Sciences	1.534	166
1	Nano Letters	1.485	177
5	Thorax	1.460	184
23	Epidemiology	1.437	187
1	Journal of Thrombosis and Haemostasis	1.397	194
1	Journal of Neuroscience	1.319	216
1	Stroke	1.242	237
1	FASEB Journal	1.241	238
2	Cancer Research	1.220	246
1	Cellular Signalling	1.213	249
1	Antioxidants & Redox Signaling	1.131	281
4	Journal of Biological Chemistry	1.110	291
3	Chest	1.110	291
4	European Respiratory Journal	1.108	294
12	American Journal of Epidemiology	1.091	306
11	Journal of Applied Physiology	1.026	343
2	Atmospheric Chemistry and Physics	1.015	350
117	Environmental Health Perspectives	0.994	373
1	Environmental Science and Pollution Research	0.982	376
16	American Journal of Respiratory Cell and Molecular Biology	0.925	404
2	American Journal of Physiology - Cell Physiology	0.906	417
5	Journal of Immunology	0.886	435
1	Journal of Cellular Physiology	0.867	453
1	Physical Chemistry Chemical Physics	0.866	454
1	American Journal of Pathology	0.833	487
34	American Journal of Physiology - Lung Cellular and Molecular Physiology	0.832	493

EPA PM Papers in that Journal	Journal	Immediacy Index (II)	*JCR* II Rank
12	Analytical Chemistry	0.795	524
1	American Journal of Physiology - Heart and Circulatory Physiology	0.777	547
1	TrAC - Trends in Analytical Chemistry	0.752	578
5	Free Radical Biology & Medicine	0.751	580
1	Journal of Catalysis	0.751	580
1	American Journal of Public Health	0.740	588
1	Human Reproduction	0.734	597
31	Toxicological Sciences	0.734	597
4	Journal of Physical Chemistry A	0.730	602
1	Journal of Chemical Physics	0.721	616
103	Journal of Geophysical Research	0.684	673
1	Agricultural and Forest Meteorology	0.669	690
1	Journal of Leukocyte Biology	0.668	691
3	Chemical Research in Toxicology	0.663	703
120	Environmental Science & Technology	0.646	729
1	Bulletin of the American Meteorological Society	0.646	729
1	Journal of Environmental Pathology, Toxicology and Oncology	0.639	742
2	Journal of Physical Chemistry B	0.637	746
4	Boundary-Layer Meteorology	0.629	758
1	American Journal of Cardiology	0.615	781
1	Equine Veterinary Journal	0.611	790
2	Clinical Immunology	0.604	804
6	Journal of Exposure Science and Environmental Epidemiology	0.596	821
6	Environmental Research	0.583	844
132	Aerosol Science and Technology	0.571	872
Total = 762			

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., March-April 2007), but there were a number of hot papers identified from previous periods.

Using the hot paper thresholds established by *ESI* as a benchmark, 45 hot papers, representing 2.9% of the PM papers, were identified in six fields—Clinical Medicine, Engineering, Environment/Ecology, Geosciences, Multidisciplinary, and Pharmacology & Toxicology. The number of PM hot papers is 29 times higher than expected. The hot papers are listed in Table 17.

Table 17. Hot Papers Identified Using *ESI* Thresholds

Field	*ESI* Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
Clinical Medicine	7	7 cites in March-April 2002	Peters A, et al. Increased particulate air pollution and the triggering of myocardial infarction. *Circulation* 2001;103(23):2810-2815.
	12	21 cites in August-September 2003	Pope CA, et al. Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. *Journal of the American Medical Association* 2002;287(9):1132-1141.
	10	11 cites in November-December 2005	Peters A, et al. Exposure to traffic and the onset of myocardial infarction. *New England Journal of Medicine* 2004;351(17):1721-1730.
	13	19 cites in November-December 2005	Pope CA, et al. Cardiovascular mortality and long-term exposure to particulate air pollution: epidemiological evidence of general pathophysiological pathways of disease. *Circulation* 2004;109(1):71-77.
Engineering	4	4 cites in October-November 2001	Christoforou CS, et al. Trends in fine particle concentration and chemical composition in southern California. *Journal of the Air & Waste Management Association* 2000;50(1):43-53.
	4	4 cites in July 2001	Richter H, Howard JB. Formation of polycyclic aromatic hydrocarbons and their growth to soot - a review of chemical reaction pathways. *Progress in Energy and Combustion Science* 2000;26(4-6):565-608.
	3	3 cites in May 2001	Vanderpool RW, et al. Evaluation of the loading characteristics of the EPA WINSPM 2.5 separator. *Aerosol Science and Technology* 2001;34(5):444-456.

Field	*ESI* Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
Engineering	3	5 cites in May 2001	Peters TM, et al. Design and calibration of the EPA $PM_{2.5}$ well impactor ninety-six (WINS). *Aerosol Science and Technology* 2001;34(5):389-397.
	5	5 cites in March- April 2003	Weber RJ, et al. A particle-into-liquid collector for rapid measurement of aerosol bulk chemical composition. *Aerosol Science and Technology* 2001;35(3):718-727.
	4	4 cites in November-December 2005	McMurry PH, et al. The relationship between mass and mobility for atmospheric particles: A new technique for measuring particle density. *Aerosol Science and Technology* 2002;36(2):227-238.
	2	3 cites in March- April 2003	Weber R, et al. Short-term temporal variation in $PM_{2.5}$ mass and chemical composition during the Atlanta Supersite Experiment, 1999. *Journal of the Air & Waste Management Association* 2003;53(1):84-91.
	3	3 cites in November-December 2003	Lewis CW, et al. Source apportionment of Phoenix $PM_{2.5}$ aerosol with the Unmix receptor model. *Journal of the Air & Waste Management Association* 2003;53(3):325-338.
	3	3 cites in February 2004	Vette A, et al. Environmental research in response to 9/11 and homeland security. *EM: Air & Waste Management Association's Magazine for Environmental Managers* 2004;Feb:14-22.
	4	4 cites in March-April 2005	Russell M, et al. Daily, seasonal, and spatial trends in $PM_{2.5}$ mass and composition in Southeast Texas. *Aerosol Science and Technology* 2004;38(S1):14-26.
	4	4 cites in March-April 2005	Zhu YF, et al. Seasonal trends of concentration and size distribution of ultrafine particles near major highways in Los Angeles. *Aerosol Science and Technology* 2004;38(S1):5-13.
	3	3 cites in September-October 2004	Cho AK, et al. Determination of four quinones in diesel exhaust particles, SRM 1649a and atmospheric $PM_{2.5}$. *Aerosol Science and Technology* 2004;38(S1):68-81.
	4	4 cites in November-December 2004	Drewnick F, et al. Measurement of ambient aerosol composition during the PMTACS-NY 2001 campaign using an aerosol mass spectrometer. Part I: Mass concentrations. *Aerosol Science and Technology* 2004;38(S1):92-103.
	3	4 cites in November-December 2005	Canagaratna MR, et al. Chase studies of particulate emissions from in-use New York City vehicles. *Aerosol Science and Technology* 2004;38(6):555-573.

Field	*ESI* Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
Environment/ Ecology	3	3 cites in March-April 2001	Lumley T, Levy D. Bias in the case-crossover design: implications for studies of air pollution. *Environmetrics* 2000;11(6):689-704.
	3	3 cites in August 2000	Stolzenburg MR, Hering SV. Method for the automated measurement of fine particle nitrate in the atmosphere. *Environmental Science & Technology* 2000;34(5):907-914.
	6	6 cites in September-October 2001	Schwartz J. Assessing Confounding, Effect modification, and thresholds in the association between ambient particles and daily deaths. *Environmental Health Perspectives* 2000;108(6):563-568.
	6	6 cites in September-October 2003	Jang MS, et al. Atmospheric secondary aerosol formation by heterogeneous reactions of aldehydes in the presence of a sulfuric acid aerosol catalyst. *Environmental Science & Technology* 2001;35(24):4758-4766.
	5	5 cites in November-December 2004	Jang MS, et al. Particle growth by acid-catalyzed heterogeneous reactions of organic carbonyls on pre-existing aerosols. *Environmental Science & Technology* 2003;37(17):3828-3837.
	5	7 cites in May-June 2004	Li N, et al. Ultrafine particulate pollutants induce oxidative stress and mitochondrial damage. *Environmental Health Perspectives* 2003 ;111(4) :455-460.
	2	2 cites in August 2004	Landrigan PJ, et al. Health and environmental consequences of the World Trade Center Disaster. *Environmental Health Perspectives* 2004;112(6):731-739.
	5	9 cites in June-July 2006	Gao S, et al. Particle Phase Acidity and Oligomer Formation in Secondary Organic Aerosol. *Environmental Science & Technology* 2004;38(24):6582-6589.
	3	4 cites in May-June 2006	Thurston GD, et al. Workgroup report: workshop on source apportionment of particulate matter health effects—intercomparison of results and implications. *Environmental Health Perspectives* 2005;113(12):1768-1774.
	3	3 cites in September 2005	Koenig JQ, et al. Pulmonary effects of indoor- and outdoor-generated particles in children with asthma. *Environmental Health Perspectives* 2005;113(4):499-503.
	3	4 cites in March-April 2006	Presto AA, et al. Secondary organic aerosol production from terpene ozonolysis. 1. Effect of UV radiation. *Environmental Science & Technology* 2005;39(18):7036-7045.

Field	*ESI* Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
Environment/ Ecology	6	6 cites in August-September 2006	Dockery DW, et al. Association of air pollution with increased incidence of ventricular tachyarrhythmias recorded by implanted cardioverter defibrillators. *Environmental Health Perspectives* 2005;113(6):670-674.
	6	7 cites in December 2005-January 2006	Zanobetti A, Schwartz J. The effect of particulate air pollution on emergency admissions for myocardial infarction: a multicity case-crossover analysis. *Environmental Health Perspectives* 2005;113(8):978-982.
	6	6 cites in July-August 2006	Park SK, et al. Effects of air pollution on heart rate variability: The VA Normative Aging Study. *Environmental Health Perspectives* 2005;113(3):304-309.
	4	6 cites in March-April 2006	Bahreini R, et al. Measurements of secondary organic aerosol from oxidation of cycloalkenes, terpenes, and m-xylene using an Aerodyne Aerosol Mass Spectrometer. *Environmental Science & Technology* 2005;39(15):5674-5688.
	5	5 cites in March-April 2006	Lough GC, et al. Emissions of metals associated with motor vehicle roadways. *Environmental Science & Technology* 2005;39(3):826-836.
	6	12 cites in December-2006-January 2007	Zhang Q, et al. Deconvolution and quantification of hydrocarbon-like and oxygenated organic aerosols based on aerosol mass spectrometry. *Environmental Science & Technology* 2005;39(13):4938-4952.
	10	24 cites in March-April 2007	Oberdorster G, et al. Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles. *Environmental Health Perspectives* 2005;113(7):823-839.
	4	4 cites in February-March 2007	Elder A. Translocation of inhaled ultrafine manganese oxide particles to the central nervous system. *Environmental Health Perspectives* 2006;114(8):1172-1178.
Geosciences	5	5 cites in June-July 2003	Huser RB, et al. Asian dust events of April 1998. *Journal of Geophysical Research-Atmospheres* 2001;106(D16):18317-18330.
	10	10 cites in June-July 2004	Orsini DA, et al. Refinements to the particle-into-liquid sampler (PILS) for ground and airborne measurements of water soluble aerosol composition. *Atmospheric Environment* 2003;37(9-10):1243-1259.
	4	4 cites in June-July 2006	Grell GA, et al. Fully coupled “online” chemistry within the WRF model. *Atmospheric Environment* 2005;39(37):6957-6975.

Field	*ESI* Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
Multidisciplinary	6	10 cites in May-June 2004	Jang MS, et al. Heterogeneous atmospheric aerosol production by acid-catalyzed particle-phase reactions. *Science* 2002;298(5594):814-817.
Pharmacology & Toxicology	5	6 cites in April 2005	Lippmann M, et al. Effects of subchronic exposures to concentrated ambient particles (CAPs) in mice: I. Introduction, objectives, and experimental plan. *Inhalation Toxicology* 2005;17(4-5):177-187.
	5	7 cites in April 2005	Maciejczyk P, et al. Effects of subchronic exposures to concentrated ambient particles (CAPs) in mice: II. The design of a CAPs exposure system for biometric telemetry monitoring. *Inhalation Toxicology* 2005;17(4-5):189-197.
	2	2 cites in September-October 2006	Costa DL, et al. Comparative pulmonary toxicological assessment of oil combustion particles following inhalation or instillation exposure. *Toxicological Sciences* 2006;91(1):237-246.
	2	2 cites in July 2003	Kodavanti UP, et al. Inhaled environmental combustion particles cause myocardial injury in the Wistar Kyoto rat. *Toxicological Sciences* 2003;71(2):237-245.

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 PM papers. Of the 27,449 total cites, 1,227 are author self-cites—a 4.5% 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. Kovacic and Misak[5] recently reported a 20% author self-citation rate for medical literature. Therefore, the 4.5% self-cite rate for the PM papers is well below the range for author self-citation.

Highly Cited Researchers

A search of Thomson's *ISIHighlyCited.com* revealed that 40 (1.5%) of the 2,710 authors of the PM papers are highly cited researchers. *ISIHighlyCited.com* is a database of the world's most

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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):195-210.

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.

5 Kavaci N, Misak A. Author self-citation in medical literature. *Canadian Medical Association Journal* 2004;170(13):1929-1930.

influential researchers who have made key contributions to science and technology during the period from 1981 to 1999. The highly cited researchers identified during this analysis of the PM publications are presented in Table 18.

Table 18. Highly Cited Researchers Authoring PM Publications

Highly Cited Researcher	Affiliation	*ESI* Field
Arey, Janet	University of California–Riverside	Environment/Ecology
Atkinson, Roger	University of California–Riverside	Environment/Ecology
Cass, Glen R.	Georgia Institute of Technology	Environment/Ecology
Corey, Lawrence	University of Washington	Clinical Medicine
Dickey, David A.	North Carolina State University	Mathematics Economics & Business
Dockery, Douglas W.	Harvard University	Environment/Ecology
Fehsenfeld, Fred C.	National Oceanic and Atmospheric Administration	Geosciences
Folsom, Aaron R.	University of Minnesota	Clinical Medicine
Fuster, Valentin	Mount Sinai Medical Center	Clinical Medicine
Garcia, Rolando R.	National Center for Atmospheric Research	Geosciences
Giorgi, Filippo	Abdus Salam International Centre for Theoretical Physics (Trieste, Italy)	Geosciences
Holben, Brent N.	National Air and Space Administration Goddard Space Flight Center	Geosciences
Jacob, Daniel J.	Harvard University	Geosciences
Karl, Thomas R.	National Oceanic and Atmospheric Administration	Geosciences
Kaufman, Yoram J.	National Air and Space Administration Goddard Space Flight Center	Geosciences
Kawachi, Ichiro	Harvard School of Public Health	Social Sciences, general
Kloner, Robert A.	Good Samaritan Hospital	Clinical Medicine
Koutrakis, Petros	Harvard School of Public Health	Environment/Ecology
Likens, Gene E.	Institute of Ecosystem Studies	Environment/Ecology
Liotta, Lance A.	National Cancer Institute	Clinical Medicine
Lioy, Paul J.	University of Medicine & Dentistry of New Jersey	Environment/Ecology
Lippmann, Morton	New York University School of Medicine	Environment/Ecology
Madronich, Sasha	National Center for Atmospheric Research	Geosciences

Highly Cited Researcher	Affiliation	*ESI* Field
Mannucci, Pier M.	Università degli Studi di Milano	Clinical Medicine
Mazurek, Monica A.	Rutgers University	Environment/Ecology
Pankow, James F.	Oregon Health and Science University	Environment/Ecology
Richards, James H.	University of California–Davis	Environment/Ecology
Rogge, Wolfgang F.	Florida International University	Environment/Ecology
Schwartz, Joel D.	Harvard School of Public Health	Environment/Ecology Pharmacology
Schwartz, Stephen E.	Brookhaven National Laboratory	Geosciences
Seinfeld, John H.	California Institute of Technology	Geosciences Environment/Ecology Engineering
Simoneit, Bernd R.T.	Oregon State University	Environment/Ecology Engineering
Speizer, Frank E.	Harvard Medical School	Clinical Medicine
Spengler, John D.	Harvard University	Environment/Ecology
Turco, Richard P.	University of California–Los Angeles	Geosciences
Wang, Jun	National Centers for Environmental Prediction, National Oceanic and Atmospheric Administration	Geosciences
Watson, John G.	Desert Research Institute	Environment/Ecology
Winer, Arthur M.	University of California–Los Angeles	Environment/Ecology
Wolff, George T.	General Motors Corporation	Environment/Ecology
Zeger, Scott L.	Johns Hopkins University	Mathematics
Total = 40		

Patents

There were 6 patents issued by investigators from 1998 to 2007 for PM research that was conducted by EPA intramural and extramural researchers. The patents are listed in Table 19. Two of the 6 patents (33.3%) were referenced by a total of 9 other patents.

Table 19. Patents Resulting From PM Research (1998-2007)

Patent or Patent Application No.	Inventor(s)	Title	Patent/Patent Application Date	Patents that Referenced This Patent
U.S. Patent No. 6,890,372	Dasgupta PK Morris KJ Li J	Denuder assembly for collection and removal of soluble atmospheric gases	May 2005	None
U.S. Patent No. 5,763,360	Gundel L Daisey JM Stevens RK	Quantitative organic vapor-particle sampler	June 1998	Referenced by 6 patents: (1) 7,122,065 Adapter for low volume air sampler (2) 6,604,406 Human portable preconcentrator system (3) 6,523,393 Human portable preconcentrator system (4) 6,502,450 Single detector differential particulate mass monitor with intrinsic correction for volatilization losses (5) 6,403,384 Device and method for analyzing a biologic sample (6) 6,035,701 Method and system to locate leaks in subsurface containment structures using tracer gases
U.S. Patent No. 6,226,852	Gundel L Daisey JM Stevens RK	Method for fabricating a quantitative integrated diffusion vapor-particle sampler for sampling, detection and quantitation of semi-volatile organic gases, vapors and particulate components	May 2001	Referenced by 3 patents: (1) 7,159,475 Apparatus and method of sampling semivolatile compounds (2) 7,122,065 Adapter for low volume air sampler (3) 7,089,747 Pressure reduction apparatus and method
U.S. Patent No. 6,780,818	Gundel L Daisey JM Stevens RK	Quantitative organic vapor-particle sampler	August 2004	None
U.S. Patent No. 7,168,292	Gundel LA Apte MG Hansen AD Black DR	Apparatus for particulate matter analysis	January 2007	None

Patent or Patent Application No.	Inventor(s)	Title	Patent/Patent Application Date	Patents that Referenced This Patent
U.S. Patent No. 7,168,292	Gundel LA Apte MG Hansen AD Black DR	Apparatus for particulate matter analysis	January 2007	None

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